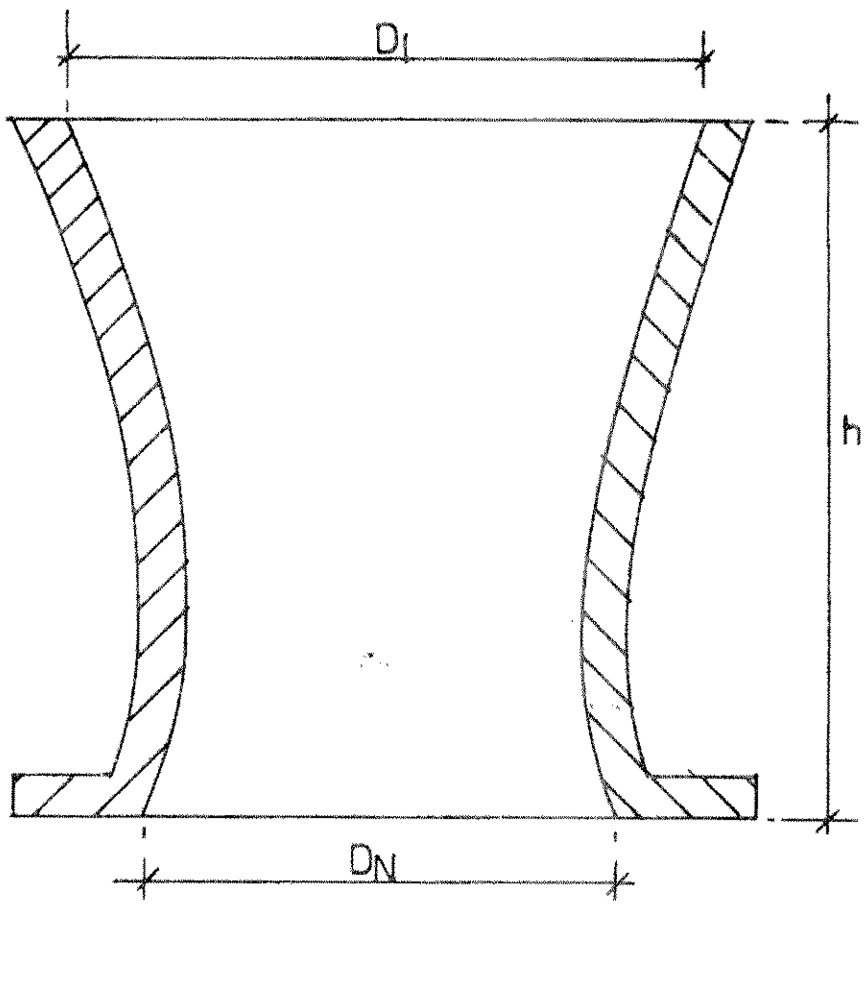
TABLE 2

SHOWING CAPACITY OF SERVICE RESERVOIR FOR DIFFERENT HOURS OF PUMPING

Pumping hours	Maximum Cumulative surplus	Maximum Cumulative deficit	Capacity of Storage reservoir	Capacity of Storage Reservoir in mL. Substituting Values of a = 0.09 mL
(1)	(2)	(3)	(4) = (2) + (3)	(5)=(4) x 0.09ml
16	1.80a (2.10a)	7.60a (1.55a)	9.40a (3.65a)	0.8460(0.3285)
8	4.80a (4.80a)	6.20a (3.05a)	11.00a (7.85a)	0.9900 (0.7065)



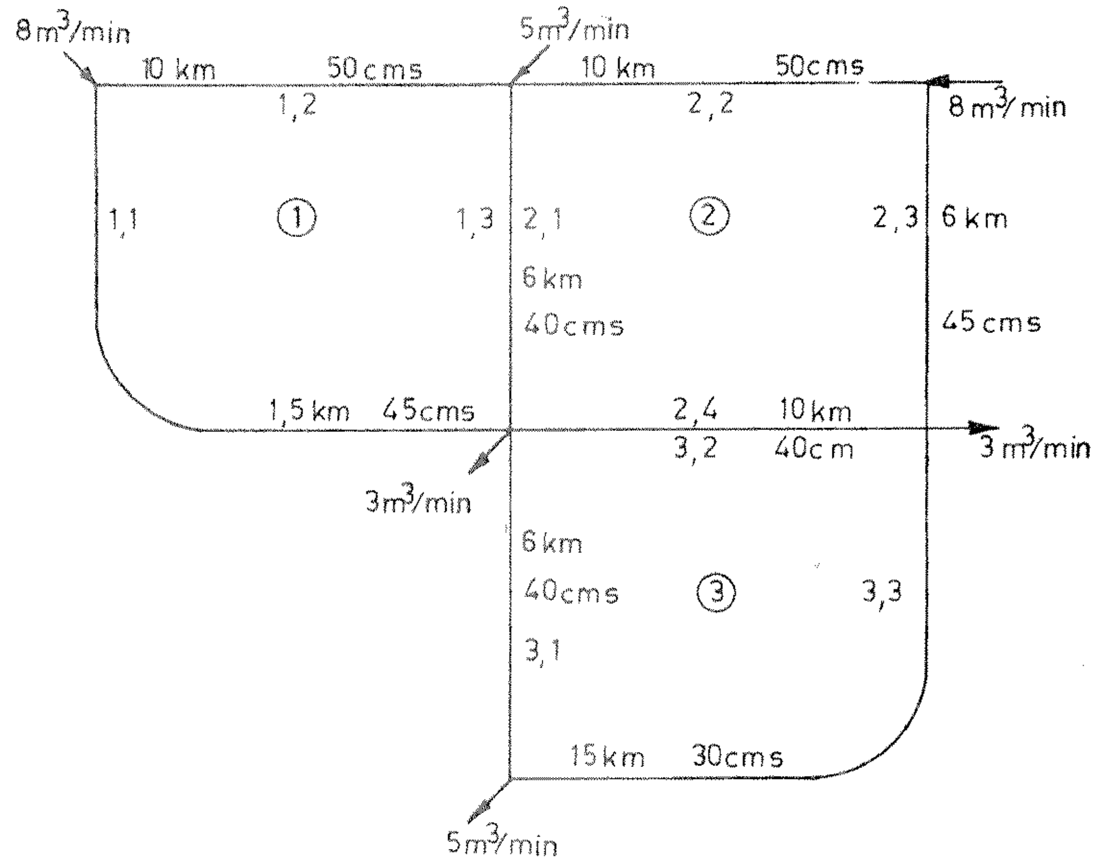
APPENDIX 10.2

NOMINAL DIAMETER D_N (mm)	ENLARGED END DIA D_1 (mm)	HEIGHT OF BELL MOUTH h (mm)	WEIGHT (APPROX.) (kg)
80	125	100	7
100	150	150	9
125	175	150	12
150	200	150	15
200	285	200	23
250	350	200	31
300	450	250	45
350	525	250	58
400	600	300	80
450	650	300	93
500	750	300	120
600	900	410	201
700	1050	470	304
800	1200	520	435
900	1350	590	575
1000	1500	650	792
1100	1650	710	965
1200	1800	770	1243
1500	2250	950	2092
1800	2700	1150	3320

DETAILS OF BELL MOUTH FOR OUTLET CONNECTIONS IN SERVICE RESERVOIRS

APPENDIX 10.3

PROBLEM TO ANALYSE THE LOOPED NETWORK GIVEN BELOW



NOTE ALL "C" VALUES ARE 100(BRITISH)

2962 UA&E/97—45A

SOLUTION TO THE PROBLEM ON HARDY CROSS METHOD OF BALANCING HEAD LOSSES BY CORRECTING ASSUMED FLOWS

Loop i	Pipe (i,j)	Length kms	Dia D cms	C	First iteration Flow m^3/min	Slope $s. ^0/_{00}$	Head H.m	H/Q
1.	1.1	15	45	100	4.0	-0.67	10.0	2.50
	1.2	10	50	100	4.0	0.39	3.9	0.98
	1.3*	6	40	100	3.0	0.69	4.1	1.37
							-2.0	4.85
2.	2.1*	6	40	100	-3.0	-0.69	-4.1	1.37
	2.2	10	50	100	-4.0	-0.39	-3.9	0.98
	2.3	6	45	100	4.0	0.67	4.0	100
	2.4†	10	40	100	0	0	0	0
							-4.0	3.35
3.	3.1	6	40	100	-4.0	-1.15	-6.9	1.73
	3.2†	10	40	100	0	0	0	0
	3.3	15	30	100	1.0	0.36	5.4	5.40
							-1.5	7.13

*,† indicate common pipes

	First iteration (Contd.) Flow Correction m^3/min	Corrected flow m^3/min	Second iteration Slope $s, ^0/_{00}$	Head H.m	H/Q	Flow correction m^3/min	Corrected flow m^3/min
1.1	+0.02	-3.78	-0.61	-9.1	2.41	+0.19	-3.59
1.2	+0.22	4.22	0.45	4.5	1.07	+0.19	4.41
1.3	+0.22 – 0.65	2.57	0.50	3.0	1.17	+0.19 – 0.01	2.75
	-(-2.0)/(1.85 x 4.85)=0.22			-1.6	4.65	-(-1.6)/ (1.85 x 4.65) = 0.19	

2.1*	+0.65 – 0.22	-2.57	-0.50	-3.0	1.17	+0.01 – 0.19	-2.75
2.2	+0.65	-3.35	-0.28	-2.8	0.84	+0.01	-3.34
2.3	+0.65	4.65	0.90	5.4	1.16	+0.01	4.66
2.4	+0.65 – 0.11	0.54	0.03	0.3	0.56	+0.01 – 0.04	0.51
(-(-4.0)/1.85 x 3.35) = 0.65				-0.1	3.73	-(-0.1)/(1.85 x 3.73) = 0.01	
3.1	+0.11	-3.89	-1.10	-6.6	1.70	+0.04	-3.85
3.2+	+0.11 – 0.65	-0.54	-0.03	-0.3	0.56	+0.04 – 0.01	-0.51
3.3	+0.11	1.11	0.42	6.3	5.68	+0.04	1.15
-(-1.5)/(1.85 x 7.13) = 0.11				-0.6	7.94	-(-0.6)/(1.85 x 7.94) = 3.44	

Pipe (i,j)	Third iteration		At Balance	
	Slope s, $^0/_{00}$	Head m	Flow m^3/min	Headlosses m
1.1	-0.56	-8.4	-3.59	-8.4
1.2	0.49	4.9	4.41	4.9
1.3*	0.56	3.4	2.75	3.4
		-0.1∂		
2.1*	-0.56	-3.4	-2.75	-3.4
2.2	-0.27	-2.7	-3.34	-2.7
2.3	0.91	5.5	4.66	5.5
2.4+	0.03	0.3	0.51	0.3
		-0.3∂		
3.1	-1.10	-6.6	-3.85	-6.6
3.2+	-0.03	-0.3	-0.51	-0.3
3.3	0.45	6.8	1.15	6.8
		-0.1∂		

∂ Absolute values of all unbalanced headlosses are less than or equal to 0.3 m, the tolerance limit set

APPENDIX 11.1

DESIGN CALCULATIONS FOR A PUMPING PLANT

DATA OF THE SCHEME

1.1	Daily demand of water	116 mld
1.2	Hours of pumping, considering loss of one hour due to tripping and other minor interruptions	23 hrs per day
1.3	Water levels in the sump, by RLs	
	1.3.1 Maximum (High flood level)	11.0 m
	1.3.2 Mean	9 m
	1.3.3 Minimum	7 m
1.4	Rising main	
	1.4.1 Length	2575 m
	1.4.2 Diameter	1.2m
	1.4.3 Friction coefficient for m.s., mortar lined pipeline	110 m
1.5	RL of point of discharge	59.0 m
1.6	No. of pumps	
	1.6.1 Duty pumps	4
	1.6.2 Stand bye pumps	2
1.7	RL of ground level at the pumping station	8.25 m
1.8	RL of high food level	10.5 m
1.9	Altitude of the site above HSL	1250m
1.10	Ambient temperature	40° C
2.0	Size of pipes and fittings for the pumping system	
2.1	Inlet bell mouth	
	Design velocity	1.5 m/s
	Bell mouth diameter	0.545 m
		Say 550 mm
2.2	Column pipes	
	Design velocity	2.5 to 3 m/s
		Say, 2.75 m/s
	Column pipe diameter	0.402 m
		Say 400 mm

2.3	Delivery pipes and valves	
	Design velocity	2.5 m/s
	Diameter of delivery pipe ,delivery valve & NRV	0.422 m
		Say 450 mm
2.4	Bell mouth at discharging point	
	Design velocity	0.8 m/s
	Bell –mouth diameter	1.49 m
		Say 1500mm
3.0	Hydraulic calculations	
3.1	Combined discharge of 4 pumps	
In parallel (116 mld x 24 hrs)/23 hrs		121.01 mld
3.2	Rate of total flow with 23 hrs running of pumps per day	1.4 cubic m/s
3.3	Discharge of each pump	0.35 m^3/s
3.4	Mean static head (59m – 9m)	50 m
3.5	Frictional loss in straight pipe of rising main for combined discharge .	3.495 m
3.6	Frictional losses in bends , valves & in rising main @ 10% of (3.5)	0.3495m
3.7	Frictional loss in taper, delivery valve,NRV & individual delivery pipe of Nb 450 mm	0.35 m
3.8	Velocity head lost at atmosphere at the exit , as $v^2/2g$,where v = 0.5 m/s	0.013m
3.9	Design head = (3.4)+(3.5)+(3.6)+(3.7)+(3.8)	54.207m

3.10 System Resistance Curves

System resistance curves are prepared by calculating total head of flows and based on following level conditions in sump at minimum, mean and maximum WL's. The head losses as they work out in example are as tabulated :-

a. Combined Q m^3/hr.	0.25	0.50	0.75	1.00	1.25	1.50
b. Max. Static Head		52 m				
c. Mean static head		50 m				
d. Min static head		48 m				

e. Friction in rising main	0.144	0.519	1.101	1.876	2.836	3.976
f. Friction in valves and fittings @ 10% of (e)	0.014	0.052	0.110	0.187	0.284	0.397
g. Velocity	0.001	0.004	0.009	0.016	0.025	0.036
h. Total friction (e)+(f)+(g)	0.159	0.575	1.220	2.079	3.145	4.109
i. Total head based on						
Min WH	52.16	52.57	53.22	54.08	55.14	56.41
Head WL	50.16	50.57	51.22	52.08	53.14	54.41
Max WL	48.16	48.57	49.22	50.08	51.14	52.41

Note:- Station losses in individual delivery pipe taper and valves should not be added for system resistance curve but should not be deducted from pumps H-Q curve. When the losses are very small , they may be neglected .

Thus , design duties and Head variations shall be as under :-

(i) Discharge Q = 0.35 m^3/s i.e. 350 l/s

(ii) Duty head H = 54.207 m

≈ 54.25 m

(ii) Head range :Pump should be suitable for operation in all variations from solo operation to 4 pumps in parallel and level variation in sump from min. WL to max. WL.

4.0 Selection Of Type ,Number Of Stages And Running Speed

Pump Head as per 3 (h), H= 54.25 m

Head loss at enterance to bell-mouth

$Hi = 0.05\ V^2/2g = 0.006$ m

Head loss in column pipe , assuming presently ,10 m length of column and as per Figure (3) in IS: 1710-1972

Hc=0.45 m

Head loss in discharge bend/ tee =0.15 m

Hence bowl Head ,H=54.25+0.006+0.45+0.15=54.856 m

In case of horizontal centrifugal pumps, bowl head is not required to be calculated. Hence for these pumps, pump Total Head will be 54.25 m. However, since the difference between the head for horizontal Centrifugal pump and the bowl head for vertical pumps is marginal in this case, the pump head as54.856 m is considered in this exercise.

For selecting the suitable pump , the following options in combinations of type of pump, number of stages as running speed are taken into accounts -

Option	Type	Stages	Suctions	Speed
a.	Vertical turbine or Hor. End-suction	1	1	1480,980
b.	Hor. Double suction	1	2	1480,980
c.	Vertical turbine	2	1	1480,980
d.	Vertical turbine	3	1	1480,980
e.	Vertical turbine	4	1	1480,980

Typical calculations for (a) and (c) are as under :

Single stage, single suction, 1480 rpm

n_q=3.65.N.$Q^{0.5}$/$H^{0.75}$=3.65 x 1480 x $0.35^{0.5}$/$(54.856)^{0.75}$=158.75

Attainable efficiency as per Figure 11.1=0.87

Suction head required as per Figure 11.3 = 1.5m @ 30 degree C.

Considering allowance of 0.5 m for field conditions, required suction

head = 2m @ 30 degree C.

Add say 0.2m for frictional losses in suction pipes.

Add 0.3 m for difference in vapour pressures at 30 degree C and site ambient 40 degree C(ref : Table 11.2).

Add 0.75m for difference in atmospheric pressures at mean sea level and site altitude 1250m (ref : Table 3).

Hence minimum suction head required @ site condition for

a) Centrifugal pump =2+0.2+0.3+0.75=3.25m

b) V T Pump = 2+0.3+0.75=3.05m

Thus eye of impeller of centrifugal pump will have to be located 3.25m below minimum WL. As GL is 8.25m RL and min. W is 7.0m RL , impeller eye will be at 3.75 MRL i.e. 4.5 m below GL , and pump floor at approximately 0m RL. Minimum water depth will equal to min. Suction head , length of bend and bell–mouth and bottom clearance is equal to 3.25 + 1.275 = 4.525m.

In case of VT pump, eye of impeller will be above bottom of pump by distance= bottom Clearance + Length of bellmouth & bowl upto impeller eye

=D/2 + 0.75 = 1.025m above bottom of sump

Thus minimum water depth required upto minimum WL to satisfy NPSHR for VT pump= 1.035 + 3.05 = 4.075

(c) Two stage, single suction, 1480 r.p.m.

H,head per stage=54.856/2=27.428m

$n_q = 3.65 \times N \times Q^{0.5}/H^{0.75} = 3.65 \times 1480 \times 0.35^{0.5}/(27.428)^{0.75}$

=266.65

Attainable efficiency as per figure 11.1=0.87

Suction head required as per figure 11.3 = 0.5m at 30^0C

Working out as for (a) above for field condition allowance, head loss in suction appurtenances, difference in vapour pressures at 30^0C and site ambient and difference in vapour atmospheric pressure at mean sea level and site altitude, suction head required at site condition =2.05m

Location of eye of impeller below minimum WL and minimum water depth required to satisfy NPSHR can be worked out as for (a) above .

The final value are tabulated in the table attached .

Observations : Possible feasible choices considering excavation cost etc. are

(a) Double suction horizontal centrifugal pump with depth of excavation of 3.0m but added construction cost of pump house (and land)which is required to be located at site of pump.

(b) 2/3 stage VT pump with depth of excavation of 4.325m but reduced construction cost of pump house which will be located above sump.

(c) Difference between efficiency of pumps a & b is very insignificant.

From observations and remarks it is seen that final choice is limited to either double suction horizontal centrifugal pump with pump house at site but with some risk of flood as HFL is at RL 10.50 m,CL 8.25 m and pump house floor will be at RL 8.5 m (approx).

2 or 3 stage VT pump with pump house above sump but with 1.25 m extra excavation .

Cost of two alternative will be almost at par .Considering flood risk , alternative with VT pump is selected .In order to keep operating floor free from obstruction and pipe work, delivery is taken below floor level .The pump shall be self water lubricated .

5. Sump Dimensions

(a) Clearance between bottom of sump and lip of suction bellmouth,

C=D/3=550/3=185.3 mm Say 185 mm

(b) Distance between rear well and center of bell mouth,

B=3D/4=3/4x550=412.5=400 mm

(c) Spacing between pumps

Desirable spacing between pumps is 2.5 D i.e. 1375 mm. However, size of lower flange of headgear /discharge head (accommodating stuffing box, thrust bearing and flexible coupling) would be approximately 3.5 times column pipe diameter i.e. 1400 mm. Keeping about 600 mm clearance,spacing will be 2000 mm

(d) Slope

As seen minimum depth of water required is 3.075m below minimum WL.In order to minimize excavation cost, permissible slope of 14 degree is taken .The slope will terminate upstream of pump at a distance equal to 3 D i.e. 1650 mm from pump center.

(e)Straight Approach

The portion under the pump will be flat from line of termination of slope upto atleast rear false wall.

(f) Rear False Wall

Size of base of discharge head will be 1400 mm. i. e. 700 mm from center of pump, whereas dimension B is 400 mm (max). Therefore, column and rear wall of sump will have to be located at least 1000 mm away from pump center keeping 300 mm margin for nut fastening, etc. Therefore, rear false wall is necessary at a distance of 400 mm(clear) from pump center.Top or false wall will be upto maximum water level.

(g) Baffles/ Dividing Walls

Dividing walls will be constructed between pumps to above mutual interference. Both ends of each dividing wall shall be rounded . Front edge of dividing wall shall be in line with front edge of suction bellmouth. At rear end opening 150-200 mm size shall be kept at least upto minimum WL. Top of dividing wall will be upto maximum WL.

5. Sizes Of Important Components/Equipment

(a) As calculated in 2 above

Column Pipe	400 mm
Inlet bellmouth	550 mm

(b) Line shaft diameter using empirical formula

$$KW = \frac{fNd^3}{5.01 \times 10^8}$$

Where f = Safe stress in Kgf/cm^2

= 400 kgf/cm^2 for EN 8/c – 40 shaft

d = 55.68 mm

Adding corrosion allowance of 3.4 mm

Minimum line shaft diameter = 59 mm

(c) Thickness of column pipe

The column pipe will act as a closed pressure vessel when pump is started under shut off condition. Considering specific speed and pattern of pump characteristics, shut off head is likely to be 80 m.

Hence design pressure(@ 1.5 times shut off pressure)

P = (80 /10) x 1.5= 12 kgf/cm^2.

For pressure vessel as per IS 2825-1969

t = $(PD_i)/(200f.j - p)$

where p, design pressure =12 kgf /cm^2

D_i , internal diameter =400mm

f, safe stress =10kgf /mm^2

j, welding factor =0.7

Hence t = 3.45mm

Adding 4mm corrosion allowance as pipe is subject to corrosion from both inside and outside.

Thickness of column pipe = 7.5mm = 8mm

(d)Motor

Lowest bowl efficiency as per 4 above is 0.87

Allowing 3% margin, quoted bowl efficiency is 0.84

Input to bowl assembly (clause 3.17 of IS 1710)

= (54.856 x 350 x 60)/ 6120 x 0.84 = 224kw

Power loss in thrust bearing and line shaft bearing	3 KW
Input to pump	227 KW
Considering 10% margin of power in motor , rating of motor required	249.7 KW
i.e.	250 KW

Note: Calculations for motor rating is to be done to enable detailing specifications for associated electrical equipment .Motor rating should not be specified in the specifications.

As motors are to be installed indoors, SPDP motors with IP 23 protection shall be suitable. As rating is 250 kW, as seen from article E. 2.3 either 415 v or 3.3 kV can be adopted. However, as maintenance problems are less in 3.3 kV installation, 3.3 kV motors are selected.

(e) Transformer

Total load of 4 pump motor sets 250x4 = 1000 KW

Hence transformer KVA required at 0.85 P.F. and 10% margin.

= (1000 x 1.1)/0.85 = 1294 KVA

Hence provide next commercial rating 1600 KVA

(f) Motor Control Gear

As motors are of 3.3 KV, either MDCB or vacuum contactors can be selected.

(i) Current at 0.85 P.F. and lowest voltage 3.3 KV-10% i.e. 2.97 KV

$$= \frac{250}{0.85 \times \sqrt{2.97}} = 57.17A$$

As minimum available rating is 100/200 A, a 100 A breaker shall be specified.

(ii) Short Circuit current rating

Normal impedence for 1600 KVA transformer, Z=6%

Minimum impedence with 10% tolerance in impedence as per IS 2026,

$Z_{min} = 5.4\%$

Therefore short circuit MVA

= (1600 x 100)/(5.4 x 1000) = 29.62 MVA

As motor contributes 10 times its normal full load current during fault, contribution of 4 motors.

S.C. current = 57.17 x 10 x 4 = 2.28 KA

S.C. MVA = 11.76 MVA

Hence total S.C. MVA = 41.38 MVA

say , 50 MVA

Hence breaking capacity of breaker

= 41.38/ { 2.97 x (3)½} = 8.04 KA

(g) Incoming Breaker to HT Panel

Normal current = 57.17 x 4 = 228.68 A

say, 400 A

S.C. MVA = 41.38 MVA, say, 50 MVA, as before.

(h) Breaker On Incoming to Transformer

Say power supply authorities supply system is 22 nv and characteristic is of 500 MVA.

Therefore S.C. current $\frac{500}{\sqrt{3} \times (22 - 2.2)} = 14.57KA$

The breaker shall be suitable for 500 MVA at 22 KV.

Table Showing The Various Alternatives

Sl. No.	Type	No.	Suction stages	Speed N	n_q	n	Suction Head/Lift	Min Water Depth	Depth of Excavation below GL for sump	RL of location of impeller eye	Remarks
1	Centrifugal	1	Single	1480	158.55	0.87	+3.25	4.525	5.775	3.75	Excavation very deep
2	VT	1	Single	1480	158.55	0.87	+3.05	4.075	5.325	-	-do-
3	Centrifugal	1	Double	1438	158.55	0.88	-2.25	1.750	3.0	9.250	Min required vortex free operation
4	VT	2	Single	1480	266.65	0.87	+2.05	3.075	4.325	-	Excavation deeper than case 2.
5	VT	3	Single	1480	361.44	0.87	+1.75	2.775	4.025	-	-do-
6	VT	4	Single	1480	440.48	0.85	+7.0	8.025	9.275	-	Excavation abnormal

Note : 980 r.p.m. is not considered further as sump with 1480 r.p.m. are suitable@

+ indicates suction head required

- indicates suction lift permissible.

APPENDIX 13.1

RECOMMENDED MINIMUM OPERATION AND MAINTENANCE STAFF PATTERN SURFACE SOURCE: TYPICAL STAFF PATTERN (UPTO 5 MLD SYSTEM) WITH CONVENTIONAL TREATMENTS

System component as per flow line		1 Pump house	2 Raw water rising main	3 Treatment works and clear water pump	4 Clear water rising main	5 Service reservoir	6 Gravity main	7 Distribution system
Sl. No.	Category of staff							
1	Superintendent Manager (A.E.E)	-	-	-	-	-	-	-
2	Supervisor/ Asstt Manager(A.E)	-	-	1	-	-	-	-
3	Assistant Supervisor/Junior Manager.	-	-	-	-	-	-	-
4	Operators	4	-	3	-	-	-	-

System component as per flow line		1 Pump house	2 Raw water rising main	3 Treatment works and clear water pump	4 Clear water rising main	5 Service reservoir	6 Gravity main	7 Distribution system
5	Helpers/Fitters	2	1* (for every 8Km.)	2	1* (for every 8 Km.)	-	-	Fitter –1 Helper –2 (for every 10-15 Km.)
6	Electrician/ Mechanic	-	-	2	-	-	-	-
7	Watchman	1	-	3	-	1	1	-

Note : 1. The above staffing pattern does not include personnel for billing, collection and accounting for water charges.

2. Above staffing pattern includes the operating staff required for one off-day in a week for staff. Suitable adjustments may have to be made between personnel in pump House and Treatment works.

3. *In case the total length of the pipe line has been less than 8 Km. Under 2 and 4 one Helper/Fitter would be adequate.

APPENDIX 13.2

RECOMMENDED MINIMUM OPERATION AND MAINTENANCE STAFF PATTERN SURFACE SOURCE: TYPICAL STAFF PATTERN (FOR 5 TO 25 MLD SYSTEM) WITH CONVENTIONAL TREATMENTS

System component as per flow line		1 Pump house	2 Raw water rising main	3 Treatment works and clear water pump	4 Clear water rising main	5 Service reservoir	6 Gravity main	7 Distribution system
Sl. No.	Category of staff							
1	Superintendent Manager (A.E.E)	-	-	-	-	-	-	-
2	Supervisor/ Asstt Manager(A.E)	-	-	1	-	-	-	-
3	Assistant Supervisor/Junior Manager.	-	-	-	-	-	-	-
4	Operators	3	-	4	-	-	-	-

System component as per flow line		1 Pump house	2 Raw water rising main	3 Treatment works and clear water pump	4 Clear water rising main	5 Service reservoir	6 Gravity main	7 Distribution system
5	Helpers/Fitters	4	1* (for every 8Km.)	3-1	1* (for every 8 Km.)	-	-	Fitter –1 Helper –2 (for every 10-15 Km.)
6	Electrician/ Mechanic	-	-	2	-	-	-	-
7	Watchman	1	-	3	-	1	1	-

Note : 1. The above staffing pattern does not include personnel for billing, collection and accounting for water charges.

2. Above staffing pattern includes the operating staff required for one off-day in a week for staff. Suitable adjustments may have to be made between personnel in pump House and Treatment works.

3. *In case the total length of the pipe line has been less than 8 Km. Under 2 and 4 one Helper/Fitter would be adequate.

APPENDIX 13.3

RECOMMENDED MINIMUM OPERATION AND MAINTENANCE STAFF PATTERN SURFACE SOURCE: TYPICAL STAFF PATTERN (FOR 25 TO 50 MLD SYSTEM) WITH CONVENTIONAL TREATMENTS

System component as per flow line		1 Pump house	2 Raw water rising main	3 Treatment works and clear water pump	4 Clear water rising main	5 Service reservoir	6 Gravity main	7 Distribution system
Sl. No.	Category of staff							
1	Superintendent Manager (A.E.E)	-	-	1	-	-	-	-
2	Supervisor/ Asstt Manager(A.E)	-	-	-	-	-	-	-
3	Assistant Supervisor/Junior Manager.	-	-	1	-	-	-	-
4	Operators	7	-	7	-	-	-	-

System component as per flow line		1 Pump house	2 Raw water rising main	3 Treatment works and clear water pump	4 Clear water rising main	5 Service reservoir	6 Gravity main	7 Distribution system
5	Helpers/ Fitters	3	1* (for every 8Km.)	3+1(Lab.)	1* (for every 8 Km.)	-	-	Fitter –1 Helper –2 (for every 10-15 Km.)
6	Electrician/ Mechanic	-	-	3 Electrician -1 Mechanic - 2	-	-	-	-
7	Watchman	1	-	3	1	1	-	-

Note : 1. The above staffing pattern does not include personnel for billing, collection and accounting for water charges.

2. Above staffing pattern includes the operating staff required for one off-day in a week for staff. Suitable adjustments may have to be made between personnel in pump House and Treatment works.

3. The personnel for S1.1 & 2 should preferably be one from the Civil Engg. and other from the electrical & mechanical Engg. disciplines.

4. *In case the total length of the pipe line has been less than 8 Km. Under 2 and 4 one Helper/Fitter would be adequate.