Estimated average demand per capita per day	300 liters
Estimated maximum daily supply (including requirements for commercial, industrial and public use)	21,950 m.cu./day
Estimated number of wells to be drilled	10
Designed production capacity	21,950 m.cu./day
Designed discharge rate per well	34 l/sec
Daily operational time per well	18 hours

7.3 Capacity of Facilities

7.3.1 Intake Facilities

1) Deep well

Design discharge	34 l/sec
Number of wells	10
Depth of wells	100 m
Borehole diameter	550 mm
Casing diameter	350 mm
Strainer	Wire-wound slotted type effective length 30 m slit width 0.5 mm Opening ratio 20 %
Gravel wall	3 - 10 mm thick

2) Intake pump house

Structure	4.0 m x 4.0 m with brick construction
Floor area	16.0 m.sq.
Number of pump houses	10

3) Calculation of intake pump and collection pipe

See following table of wells. Table 7.2

Table 7.1 List of Well

Number of Wells	Ground Level	Static Water Level	Draw down	Pumping Water Level
	m	m	m	m
No. 1	199.7	194.0	15.0	179.0
No. 2	208.1	196.0	15.0	181.0
No. 3	216.5	198.0	15.0	183.0
No. 4	190.1	189.0	15.0	174.0
No. 5	202.5	193.0	15.0	178.0
No. 6	213.4	196.0	15.0	181.0
No. 7	200.7	192.0	15.0	177.0
No. 8	189.9	186.0	15.0	171.0
No. 9	197.9	189.0	15.0	174.0
No. 10	233.1	200.0	15.0	185.0

Collection pipe No. ① ----------(No. 1, No. 2, No. 3)

" No. ② ----------(No. 6, No. 10)

" No. ③ ----------(No. 7, No. 8, No. 9)

" No. ④ ----------(No. 4, No. 5)

Table 7.2 List of Collection Pipes

Route No.	Section	Distance (m)	Dia (mm)	Quantity (m.cu./min)	Hydraulic Gradient (‰)	Velocity (m/s)
No. (1)	No.3 - No.2	650	ϕ200 (ϕ8")	2.04 (34 1/s)	8.6	1.08
	No.2 - No.1	670	ϕ300 (ϕ12")	4.08 (68 1/s)	4.3	0.96
	No.1 - P.S	790.	ϕ350 (ϕ14")	6.12 (102 1/s)	4.3	1.06
No. (2)	No. 10 - No. 6	1560	ϕ200 (ϕ8")	2.04 (34 1/s)	8.6	1.08
	No. 6 - No. 10 P.I.	170	ϕ200 (ϕ8")	2.04 (34 1/s)	8.6	1.08
	P.I. - P.S.	690	ϕ250 (ϕ10")	4.08 (68 1/s)	10.5	1.38
No. (3)	No. 8 - No. 9 P.I.	710	ϕ200 (ϕ8")	2.04 (34 1/s)	8.6	1.08
	No. 9 - No. 8 P.I.	420	ϕ200 (ϕ8")	2.04 (34 1/s)	8.6	1.08
	P.I. - No.7	720	ϕ300 (ϕ12")	4.08 (68 1/s)	4.3	0.96
	No.7 - P.S.	2030	ϕ350 (ϕ14")	6.12 (102 1/s)	4.3	1.06
No. (4)	No.4 - P.S.	1050	ϕ200 (ϕ8")	2.04 (34 1/s)	8.6	1.08

Note) P.I. ------- Point of Intersection

P.S. ------- Pumping Station

Velocity Coefficient ------- 110

No. 3 Intake Pump

Actual pumping head H' = Junction well H.W.L - P.W.L

= 205.500 - 183.0 = 22.5 (m)

Friction loss of head by pipeline

$$\Delta h_1 = \frac{8.6}{1000} \times 650 + \frac{4.3}{1000} \times 670 + \frac{4.3}{1000} \times 790 = 11.87 \text{ (m)}$$

Residual head required $\Delta h_2 = 5.0$ (m)

Other head losses $\Delta h_3 = 5.63$ (m)

Total head required $H = H' + \Sigma\Delta h$

$= 22.5 + 11.87 + 5.0 + 5.63$

$= 45$ (m)

Diameter of pump $D = 146\sqrt{\frac{Q}{V}}$ (mm)

V ; Velocity at suction pipe = $146 \times \sqrt{\frac{2.04}{3.0}}$ (m/s)

Q ; Discharge (m^3/min) = 120 (mm) approx. ϕ125 (mm)

Output of motor $Pm = \frac{16.3 \cdot \gamma \cdot Q \cdot H}{y} (1 + \alpha)$ (Kw)

γ ; Unit weight of water (kg/l)

Q ; Discharge (m.cu./min)

H ; Total head (m)

y ; Pump efficiency (%)

α ; Allowance

$$Pm = \frac{16.3 \times 1.0 \times 2.04 \times 45}{65} \times (1 + 0.15)$$

= 26.47 (Kw) approx. 30 (Kw)

Specification of pump ϕ125 mm x 2.04 m.cu./min x 45 m x 30 Kw

No. 2 Intake Pump

Dynamic water head at No. 2 well :

$$(183.0 + 45.0 - 5.63) - (\frac{8.6}{1000} \times 650) = 216.78 \text{ (m)}$$

Total pumping head $H = 216.78 + 5.63 - 181.0$

$= 41.41$ (m) approx. 42 (m)

Output of motor $Pm = \frac{16.3 \times 1.0 \times 2.04 \times 42}{65} \times 1.15$

$= 24.71$ (Kw) approx. 30 (Kw)

Sepcification of pump ϕ125 mm x 2.04 m.cu./min x 42 m x 30 Kw

No. 1 Intake Pump

Dynamic water pressure at No. 1 well :

$$216.78 - (\frac{4.3}{1000} \times 670) = 213.90 \text{ (m)}$$

Total pumping head $H = 213.90 + 5.63 - 179.0$

$= 40.53$ (m) approx. 41 (m)

Output of motor $Pm = \frac{16.3 \times 1.0 \times 2.04 \times 41}{65} \times 1.15$

$= 24.12$ (Kw) approx. 30 (Kw)

Specification of pump ϕ125 mm x 2.04 m.cu./min x 41 m x 30 Kw

No. 10 Intake Pump

Highest point of pipelines 235.9 (m)

Distance from No. 10 well to the heighest point : Approx. 50 m

Actual pump head $H' = 235.9 - 185.0$

$= 50.9$ (m)

$\Delta h_1 = \frac{8.6}{1000} \times 50 = 0.43$ (m)

$\Delta h_2 = 5.0$ (m) $\Delta h_3 = 3.67$ (m)

Total pumping head $H = 50.9 + 0.43 + 8.67$

$= 60$ (m)

$$Pm = \frac{16.3 \times 1.0 \times 2.04 \times 60}{65} \times 1.15$$

$= 35.30$ (Kw) approx. 37 (Kw)

Specification of pump ϕ125 mm x 2.04 m.cu./min x 60 m x 37 Kw

No. 6 Intake Pump

Dynamic water head at the junction of transmission main with the collection pipe of No. 6 well :

$$(185.0 + 60.0 - 3.67) - (\frac{8.6}{1000} \times 1.560) = 227.91 \text{ (m)}$$

Dynamic pressure required at No. 6 well :

$$227.91 + \frac{8.6}{1000} \times 170 = 229.37 \text{ (m)}$$

Total pumping head $H = 229.37 + 3.67 - 181.0$

$= 52.04$ (m) approx. 52 (m)

$$Pm = \frac{16.3 \times 1.0 \times 2.04 \times 52}{65} \times 1.15$$

$= 30.59$ (Kw) approx. 37 (Kw)

Specification of pump ϕ125 m.cu./min x 52 m x 37 Kw

No. 8 Intake Pump

$H' = 205.5 - 171.0 = 34.5$ (m)

$$\Delta h_1 = \frac{8.6}{1000} \times 710 + \frac{4.3}{1000} \times 720 + \frac{4.3}{1000} \times 2030 = 17.93 \text{ (m)}$$

$\Delta h_2 = 5.0$ (m)

$\Delta h_3 = 7.57$ (m)

Total pumping head $H = 34.5 + 17.93 + 5.0 + 7.57$

$= 65$ (m)

$$Pm = \frac{16.3 \times 1.0 \times 2.04 \times 65}{65} \times 1.15$$

= 38.24 (Kw) approx. 37 (Kw)

Specification of pump ϕ125 mm x 2.04 m.cu./min x 65 m x 37 Kw

No. 9 Intake Pump

Dynamic pressures at the junctions of the transmission main with collection pipes of Nos. 8 and 9 wells :

$$(171.0 + 65.0 - 7.57) - (\frac{8.6}{1000} \times 710) = 222.32 \quad (m)$$

Dynamic pressure required at No. 9 well :

$$222.32 + (\frac{8.6}{1000} \times 420) = 225.93 \quad (m)$$

Total pumping head $H = 225.93 + 7.57 - 174.0$

$= 59.50$ (m) approx. 60 (m)

$$Pm = \frac{16.3 \times 1.0 \times 2.04 \times 60}{65} \times 1.15$$

= 35.30 (Kw) approx. 37 (Kw)

Specification of pump ϕ125 mm x 2.04 m.cu./min x 60 m x 37 Kw

No. 7 Intake Pump

Dynamic pressure at No. 7 well :

$$(236.0 - 7.57) - (\frac{8.6}{1000} \times 710 + \frac{4.3}{1000} \times 720) = 219.22 \quad (m)$$

Total pumping head $H = 219.22 + 7.57 - 177.0$

$= 49.79$ (m) approx. 50 (m)

$$Pm = \frac{16.3 \times 1.0 \times 2.04 \times 50}{65} \times 1.15$$

= 29.42 (Kw) approx. 30 (Kw)

Specification of pump ϕ125 mm x 2.04 m.cu./min x 50 m x 30 Kw

No. 4 Intake Pump

$H' = 205.5 - 174.0 = 31.5$ (m)

$\Delta h_1 = \frac{8.6}{1000} \times 1050 = 9.03$ (m)

$\Delta h_2 = 5.0$ (m)

$\Delta h_3 = 4.47$ (m)

Total pumping head $H = 31.5 + 9.03 + 5.0 + 4.47$

$= 50$ (m)

$$Pm = \frac{16.3 \times 1.0 \times 2.04 \times 50}{65} \times 1.15$$

$= 29.42$ (Kw) approx. 30 (Kw)

Specification of pump ϕ125 mm x 2.04 m.cu./min x 50 m x 30 Kw

No. 5 Intake Pump

$H' = 205.5 - 178.0 = 27.5$ (m)

$\Delta h_2 = 5.0$ (m)

$\Delta h_3 = 7.5$ (m)

Total pumping head $H = 27.5 + 5.0 + 7.5$

$= 40$ (m)

$$Pm = \frac{16.3 \times 1.0 \times 2.04 \times 40}{65} \times 1.15$$

$= 23.53$ (Kw) approx. 22 (Kw)

Specification of pump ϕ125 mm x 2.04 m.cu./min x 40 m x 22 Kw

Table 7.3 Summary of Well Pumps

Well Number	Discharge Volume (m.cu./min)	Total Head (m)	Diameter of Suction Pipe (mm)	Power of Electric Motor (Kw)	Type
No. 1	2.04 (34 l/s)	41.0	ϕ125 (ϕ5")	30	Submergible Motor Pump
No. 2	"	42.0	"	30	"
No. 3	"	45.0	"	30	"
No. 4	"	50.0	"	30	"
No. 5	"	40.0	"	22	"
No. 6	"	52.0	"	37	"
No. 7	"	50.0	"	30	"
No. 8	"	65.0	"	37	"
No. 9	"	60.0	"	37	"
No. 10	"	60.0	"	37	"

Fig. 7.3.1 No. (1) Raw Water Pipe Line

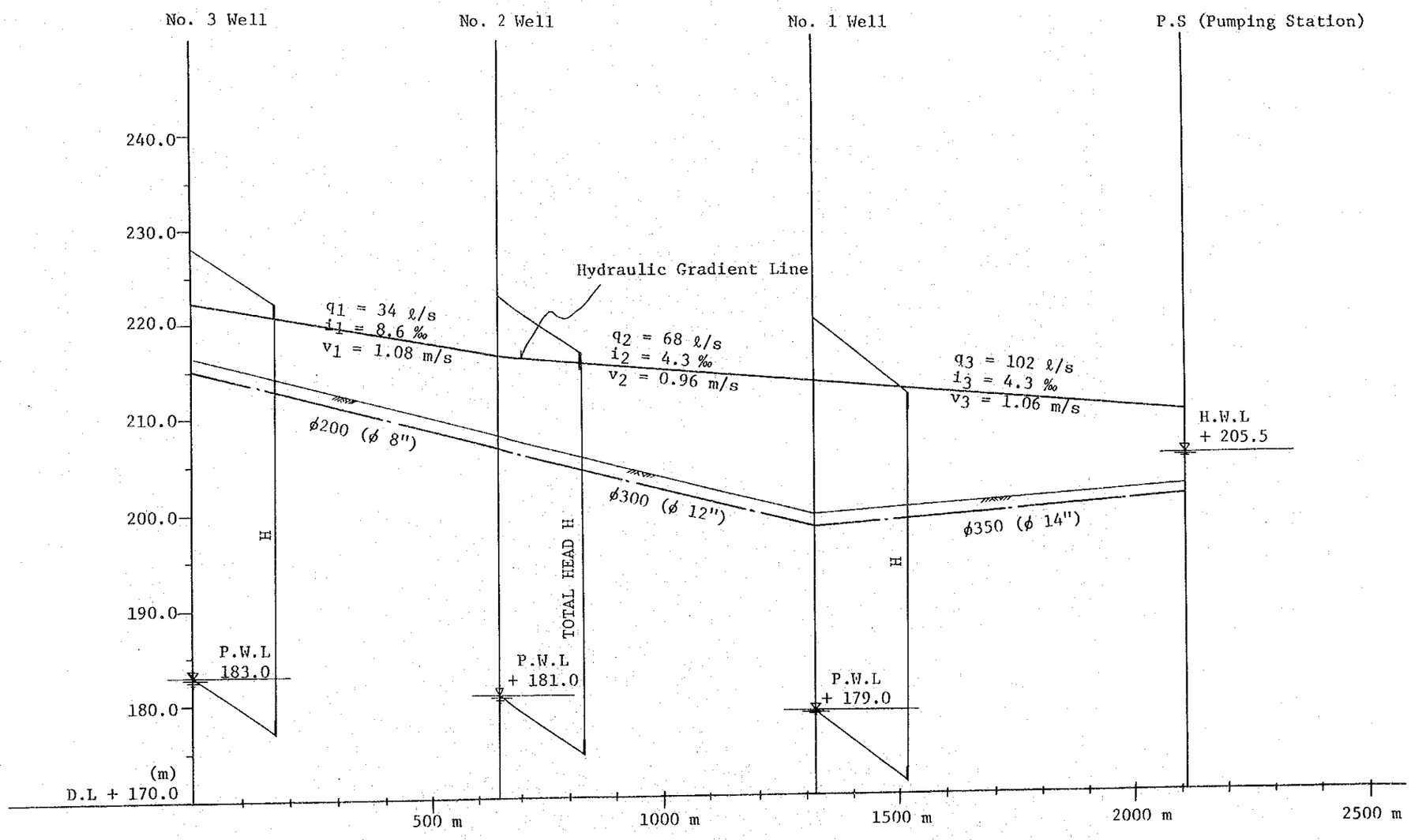


Fig. 7.3.2 No. (2) Raw Water Pipe Line

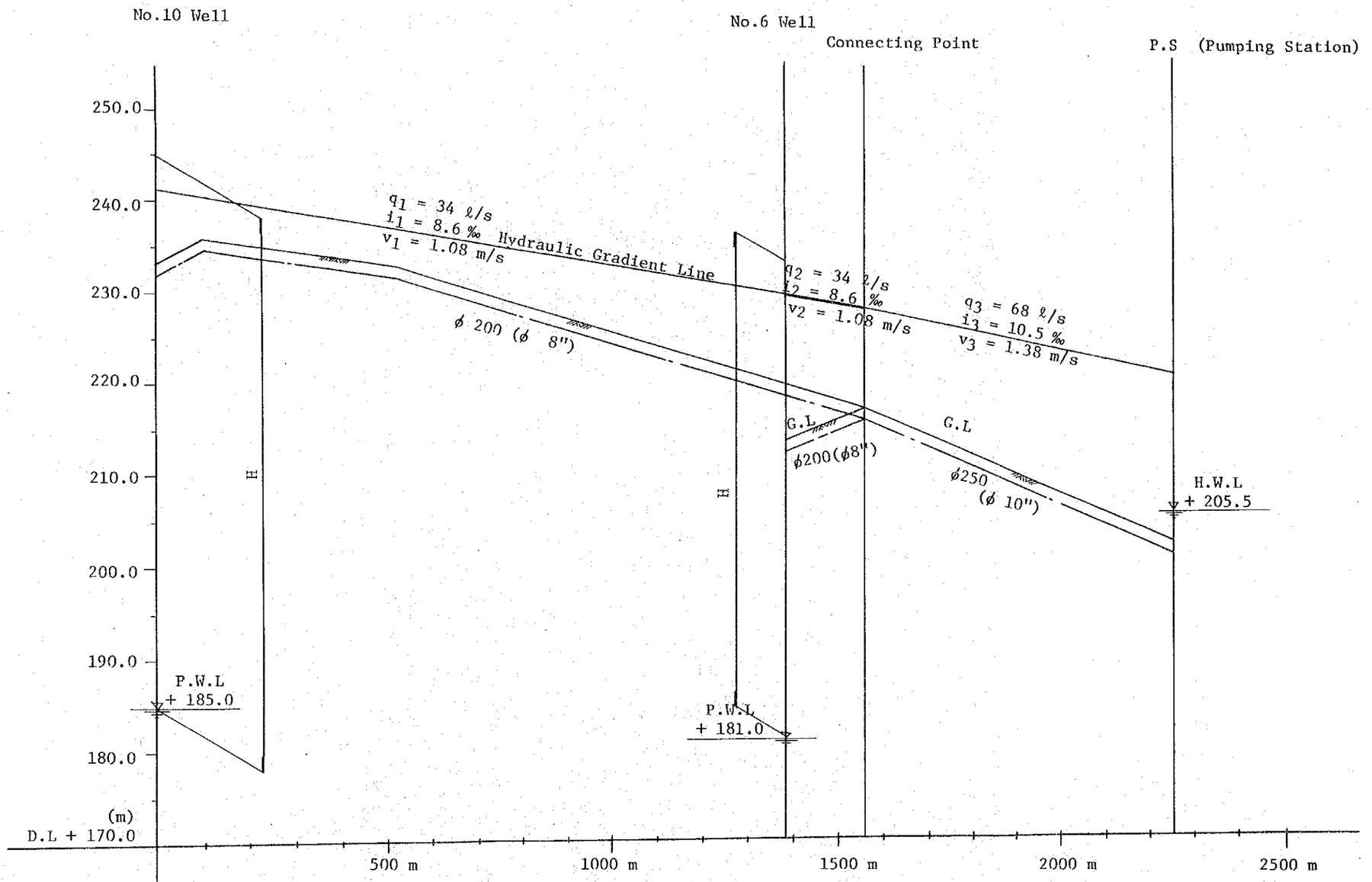


Fig. 7.3.3 No. (3) Raw Water Pipe Line

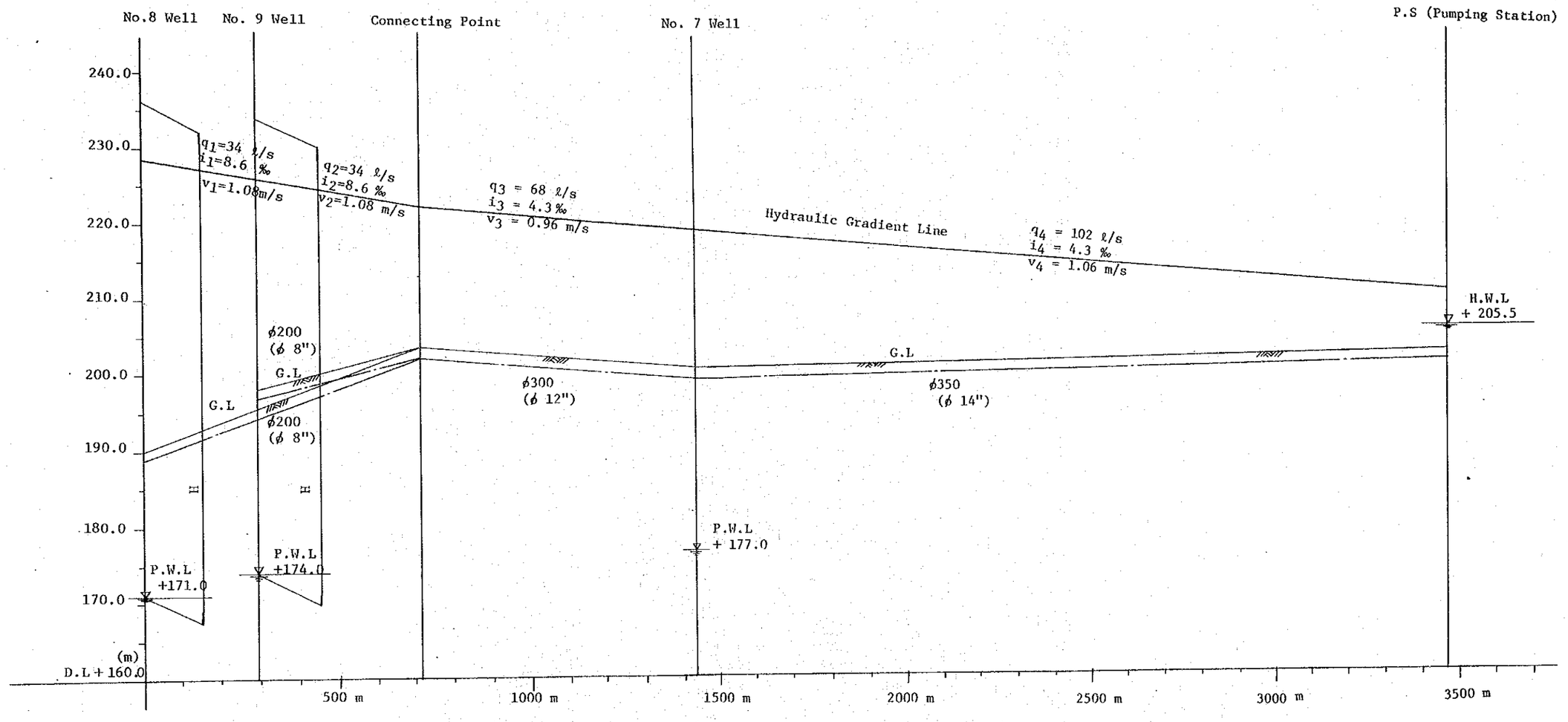
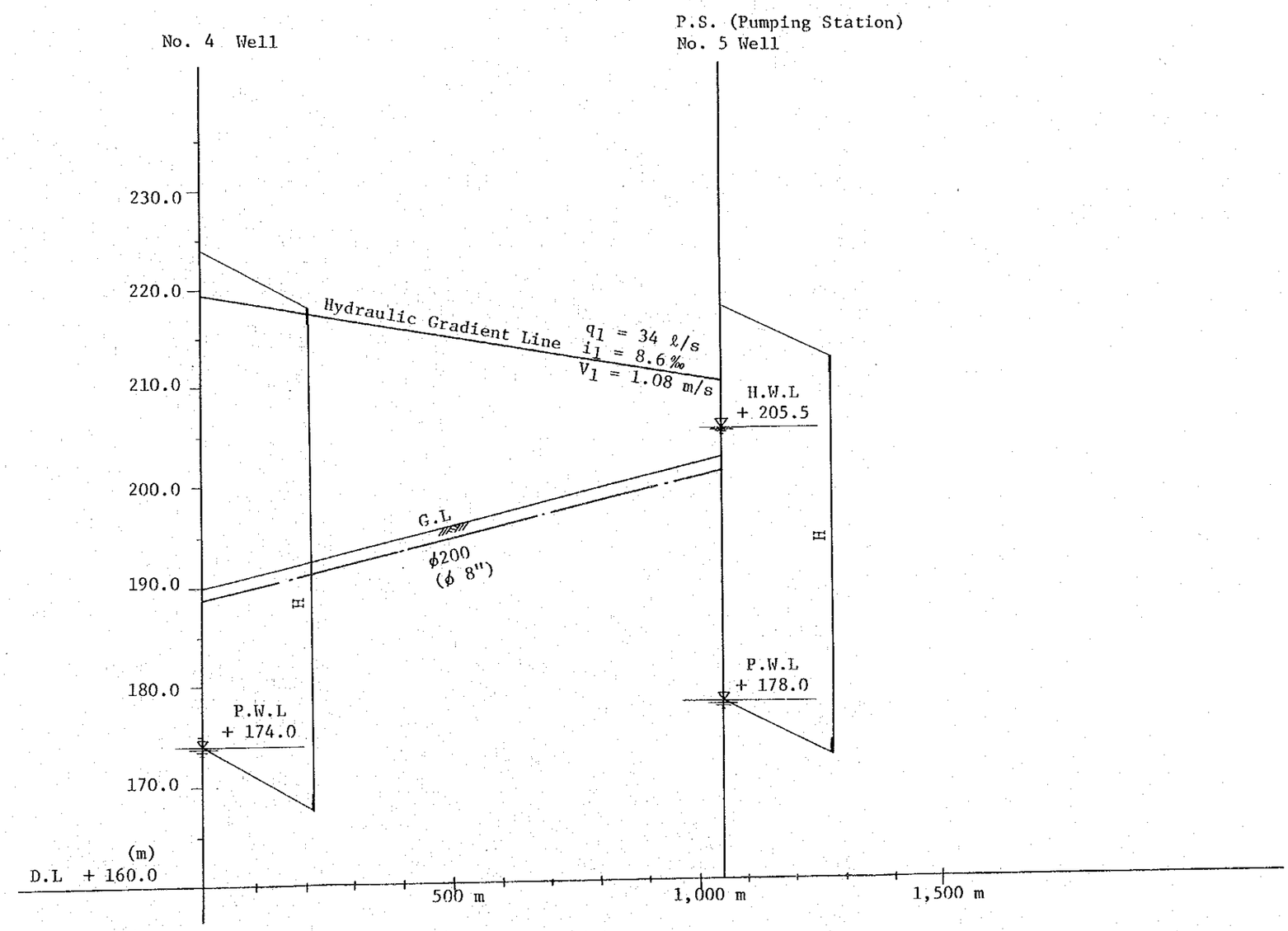


Fig. 7.3.4 No. (4) Raw Water Pipe Line



4) Drilling Machine

Type : Tophead driven rotary type (mounted on a truck)

Method of Drilling : Reverse-circulation

Depth of drill	100 m
Borehole dia	500 - 600 mm
Drill pipe	ϕ6" (ϕ150 mm)
Diameter of casing	300 - 400 mm

Accessories :

Truck for loading drilling machine	1 No.
Suction pump	
Tools for reverse-circulation	1 set

Transportation : Tanker Lorry 1 No.

Pumping test equipment :

Generator	70 - 80 KVA	1 No.
Submersible pump	45 Kw	1 No.
Accessories		1 set

7.3.2 Collection Facilities

Collection pipes

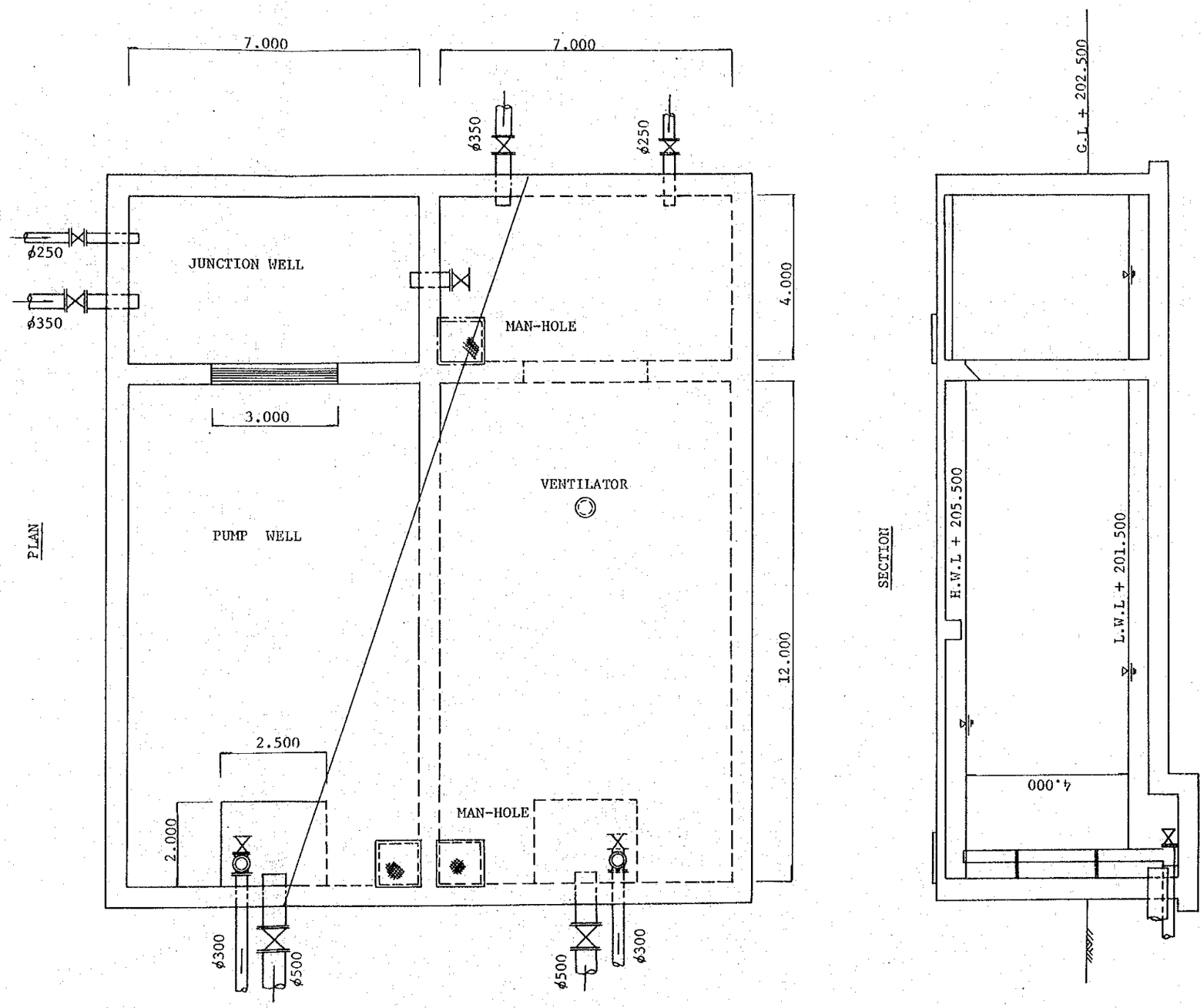
Dia	Material	Class	Length
ϕ200 mm (ϕ8")	A.C.P.	A-7.5	4,560 m
ϕ250 mm (ϕ10")	"	"	690 m
ϕ300 mm (ϕ12")	"	"	1,390 m
ϕ350 mm (ϕ14")	"	"	2,910 m

7.3.3 Transmission Facilities

1) Junction well

Structure : RC construction (connected to the pump well in one body)

Fig. 7.4 Structural Drawing of Junction and Pump Well



Dimension : 4.0 m x 7.0 m x 4.0 m x 2 Nos.
(Effective depth)

Effective capacity : 112 m.cu./each x 2 Nos. = 224 m.cu.

Retention time : 14.7 minutes

2) Transmission pump well

Structure : RC construction

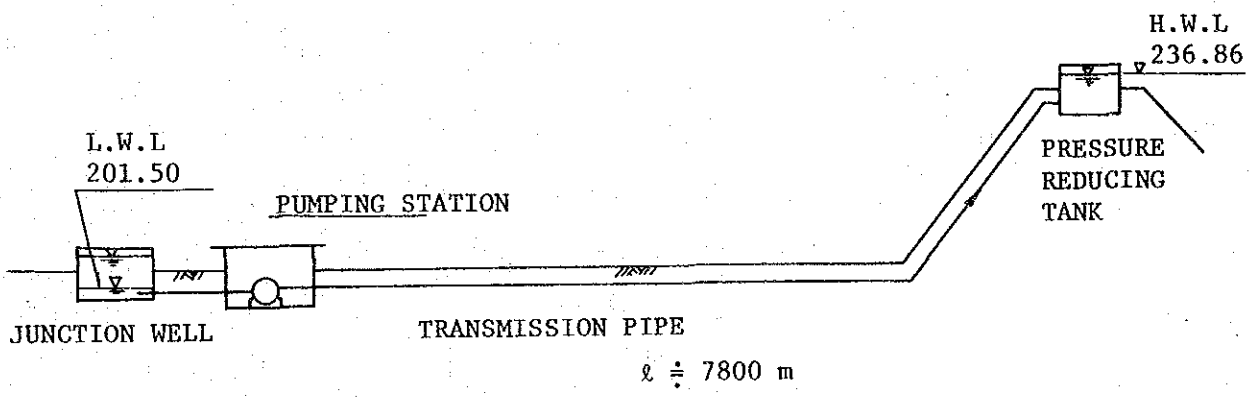
Dimensions : 7.0 m x 12.0 m x 4.0 m x 2 Nos.
(Effective depth)

Effective capacity : 336 m.cu./each x 2 Nos. = 672 m.cu.

Retention time : 44.1 minutes

3) Calculation of transmission pumps and pipe lines.

a. Condition



Planned transmission quantity : 21,950 m.cu./day

Length of pipeline : 7,760 m

Pipe material : AC pipe

Diameter of pipe : ϕ600 mm (ϕ24")

b. Number of pumps

The quantity of water transmitted is to be controlled by the number of pumps. Four of which are to be operated at maximum.

Pumping quantity per pump = 21,950 m.cu./1440 min ÷ 4
= 3.81 m.cu./min

c. Diameter of pump

$$D = 146 \sqrt{\frac{Q}{V}} \quad (mm)$$

Q ; 3.81 m.cu./min
V ; 3.5 m/s

$$D = 146 \sqrt{\frac{3.81}{3.5}}$$

= 152 (mm) approx. ϕ150 mm

d. Pumping head

Actual pump head H' = Junction well H.W.L.
- Transmission pump well L.W.L.
= 236.86 - 201.50 = 35.36 (m)

Friction loss of head by pipeline

$$\Delta h_1 = \frac{1.7}{1000} \times 7800 = 13.26 \text{ (m)}$$

Residual head Δh_2 = 5.0 (m)

Other losses of head

$$\Delta h_3 = 6.38 \text{ (m)}$$

Total pumping head H = H' + $\Sigma\Delta h$
= 35.36 + 13.26 + 5.0 + 6.38
= 60 (m)

e. Motor output

$$Pm = \frac{16.3 \times \gamma \times Q \times H}{y} \times (1 + \alpha) \quad (Kw)$$

$$= \frac{16.3 \times 1.0 \times 3.81 \times 60}{70} \times (1 + 0.15)$$

$$= 61.2 \text{ (Kw)} \qquad \text{approx.} \quad 75 \text{ (Kw)}$$

f. Comparative revolution

$$Ns = N \times \frac{Q^{1/2}}{H^{3/4}}$$

$$= 1800 \times \frac{3.81^{1/2}}{60^{3/4}}$$

$$= 163$$

N ; Specified revolution of pump (r.p.m)

Q ; Specified discharge (m.cu./min)

H ; Specified pump head (m)

g. Specifications of pump

ϕ150 mm x 3.81 m.cu./min x 60 m x 75 Kw

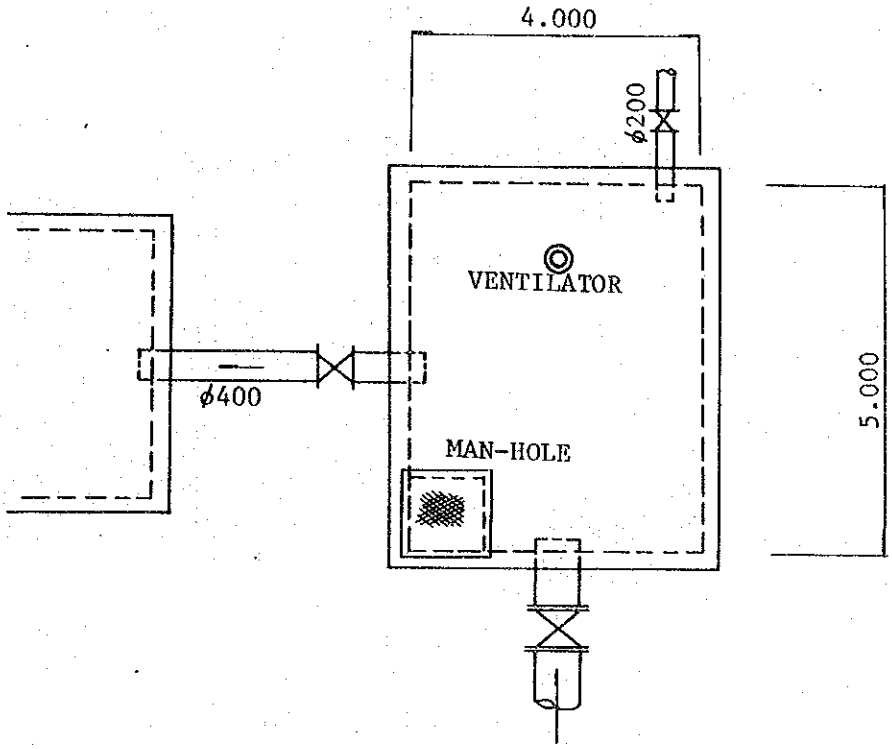
Single suction volute pump 5 Nos. including 1 standby

4) Transmission pipe

Diameter	:	ϕ600 mm (ϕ24")
Material	:	A.C.P. Class A-10
Length	:	7,760 m
Velocity	:	0.90 m/sec
Dynamic hydraulic gradient	:	1.7 o/oo

Fig. 7.5 NO. 1 PRESSURE REDUCING TANK

PLAN



SECTION

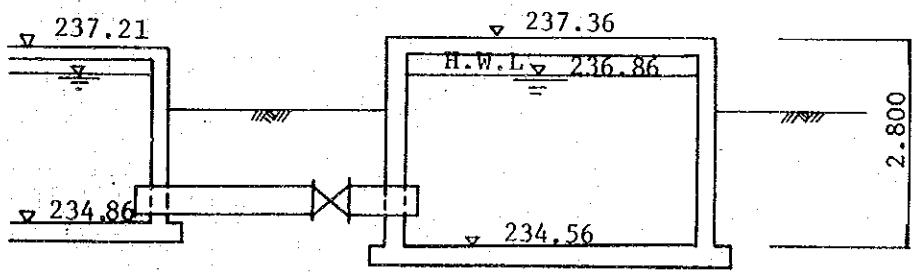
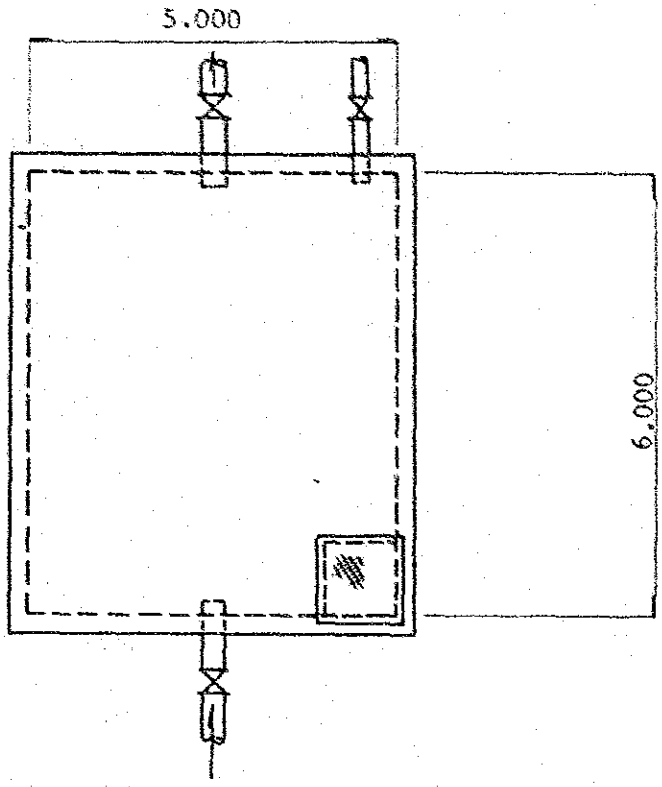


Fig. 7.6 No. 2 PRESSURE REDUCING TANK

PLAN



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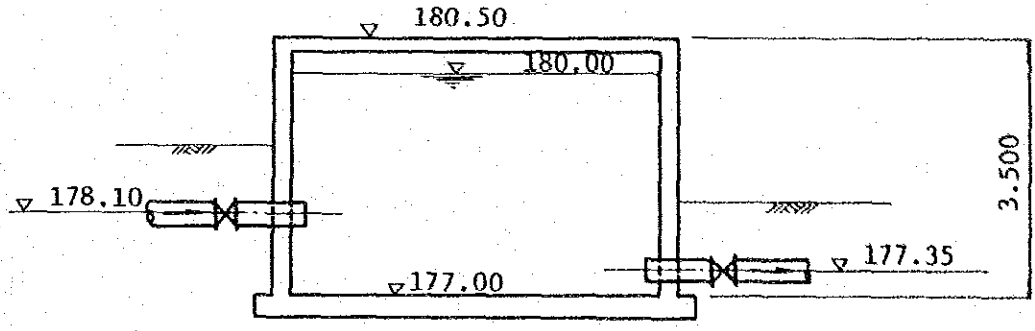


5) Pressure reducing tank

First tank

Structure	:	RC construction
Dimensions	:	4.0 m x 5.0 m x 2.0 m (Effective depth)
Effective capacity	:	40 m.cu. x 1 No.
Retention time	:	2.6 min.

Second tank

Structure	:	RC construction
Dimensions	:	5.0 m x 6.0 m x 2.7 m (Effective depth)
Effective capacity	:	80 m.cu. x 1 No.

7.3.4 Storage Facilities

1) Storage reservoir

The storage capacity is taken as 10 hours equivalent of the maximum daily supply plus an allowarance for fire fighting.

Total storage capacity

$$= 21{,}950 \text{ m.cu.} \times \frac{10}{24} + 500 \text{ m.cu.}$$

$$= 9650 \text{ m.cu.} \quad \text{approx.} \quad 10{,}000 \text{ m.cu.}$$

Existing storage capacity

$$= 1{,}000 \text{m.cu./reservoir} \times 2 \text{ reservoirs} + 2000 \text{m.cu/reservoir}$$

$$= 4{,}000 \text{ m.cu.}$$

Additional storage capacity required

$$= 10{,}000 - 4{,}000$$

$$= 6{,}000 \text{ m.cu.}$$

Taking into account the area served and its topographical conditions, three 2,000 m.cu. reservoirs will be built.

Structure	:	Cylindrical type with PC construction
Inside diameter	:	18.0 m
Effective depth	:	7.9 m
Effective capacity	:	2,000 m.cu.
Number of reservoir	:	3 Nos.
Structure of supporting foundation	:	Fixed support
Foundations	:	Direct foundation

2) Connection pipe

No. 4 reservoir to No. 6 reservoir

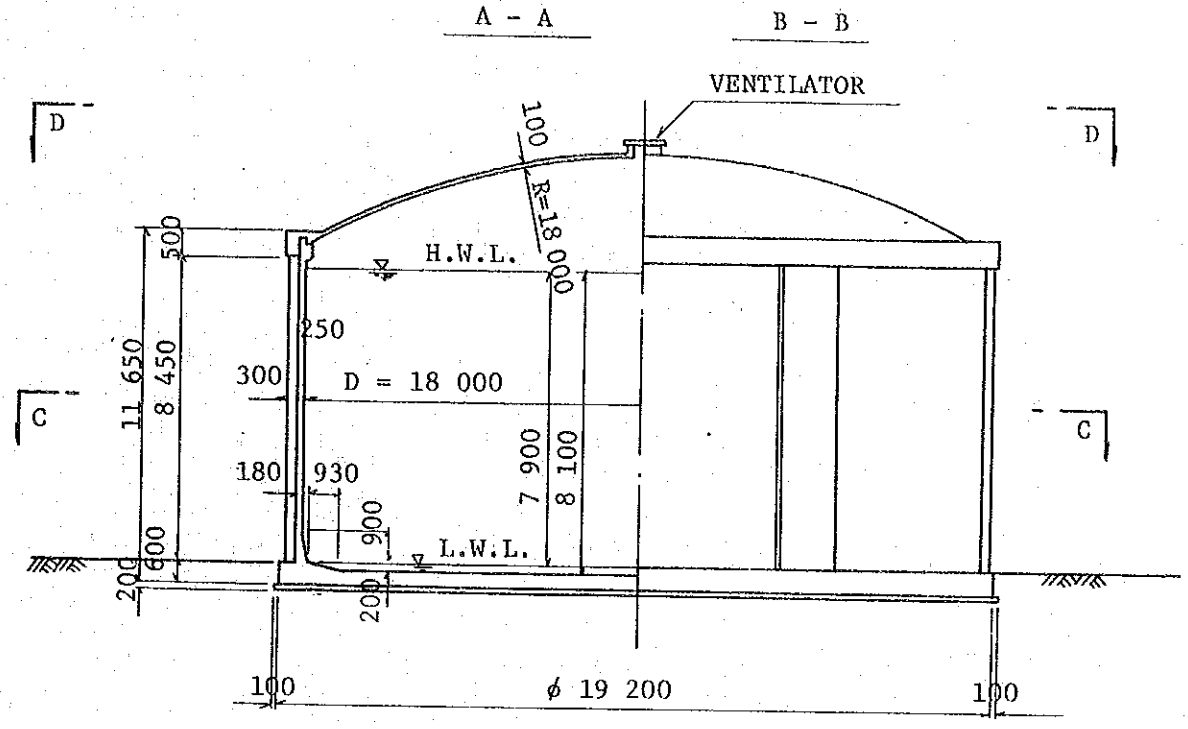
Pipe dia	:	ϕ200 mm (ϕ8")
Material	:	A.C.P. Class A - 10
Length	:	870 m

No. 4 reservoir to No. 5 reservoir

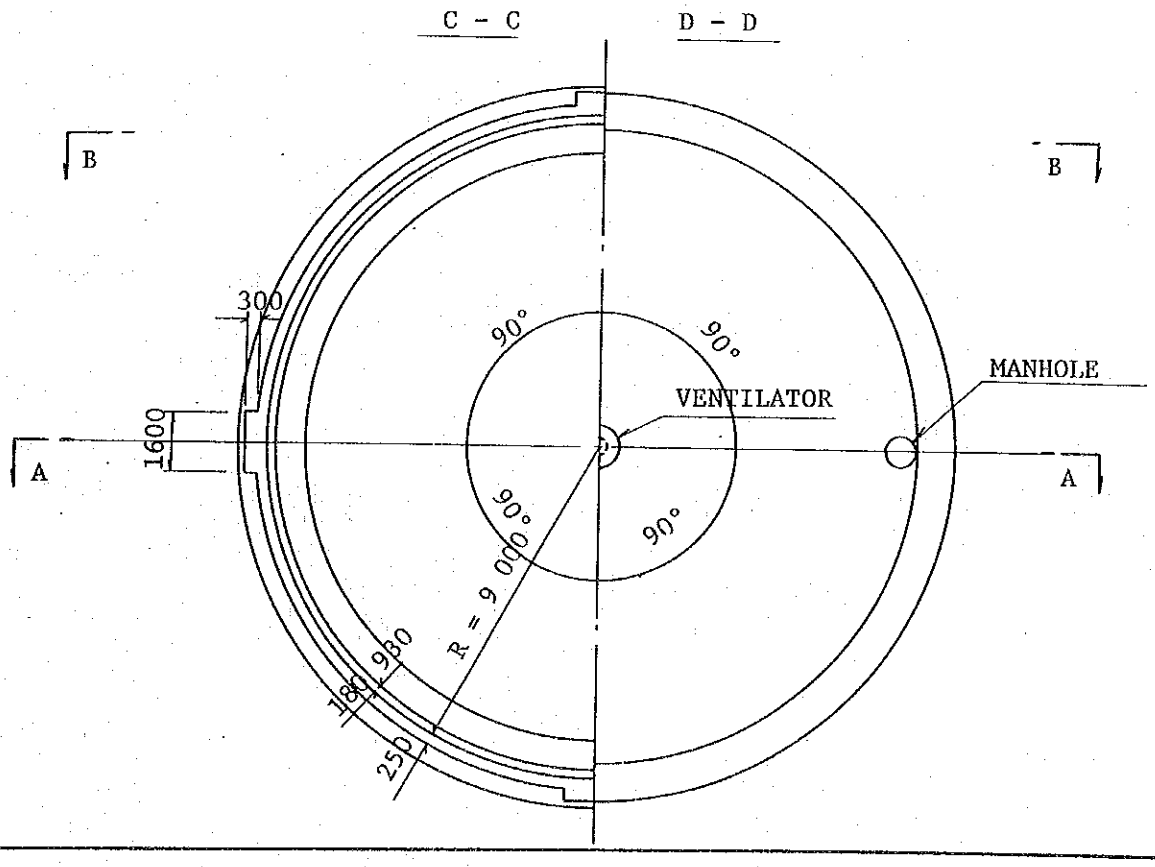
Pipe dia	:	ϕ300 mm (ϕ12")
Material	:	A.C.P. Class A - 10
Length	:	2600 m

Fig. 7.7 Storage Reservoir

SIDE VIEW



PLAN



LIST OF PROPOSED FACILITY

	Facility / Item				
INTAKE FACILITY	Type	Deep Well	Submergible Pump	Brick building	Top-head Drive Type Rotary Machine
	Capacity or Size	Bore hole; 550mm Depth; 100 m Casing diameter; 350mm	D Q H Pm Set ø125mm x 34ℓ/s x 30 - 65m x 22 kw ... 1 " " " 30 ... 5 " " " 37 ... 4	4.0 m x 4.0 m 16m^2	Reverse Circulation Method Capacity ; 150m Bore hole ; 500 ∿ 600m Drill Pipe ; 6" Casing Diameter ; 300 ∿ 400mm
	Quantity	10 Wells		10 rm.	

	Facility / Item	
COLLECTING FACILITY (RAW WATER MAIN)	Type	R A W W A T E R P I P E Asbestos Cement Pipe (A.C.P.)
	Size & Length	Diameter Class length ø 8" ..... A - 7.5 ..... 4,560 m ø 10" ..... " ..... 690 m ø 12" ..... " ..... 1,390 m ø 14" ..... " 2,910

	Facility / Item	JUNCTION WELL & PUMPING WELL	PUMP STATION (includes Electric Rm. etc.)	TRANSMISSION PUMP	TRANSMISSION PIPE	PRESSURE REDUCING TANK
TRANSMISSION MAIN	Type	Reinforced Concrete (R.C) Construction	R.C. & Brick Building	Centrifugal Pump	A.C.P.	R.C. Structure
	Capacity or Size	e.d. J.W.4.0m x 7.0m x 4.0m x 2 P.W.12.0m x 70m x 4.0m x 2 Total 900m^3	Pump rm. ..... 165 m^2 Electric rm. ...) 67.5 m^2 Control rm. ... Office rm. ... 22.5 m^2	D Q H Pm ø150mm x 63.5ℓ/s x 60m x 75kw	Diameter ... ø24" Class ... A-10	(A) ..... 80m^3 (B) ..... 40m^3
	Quantity	J.W. .... 2 well P.W. .... 2 well	1 house (Pump Rm. is semi-basement)	5 sets (include a spare pump)	approx. 7,760 m	(A) ..... 1 tank (B) ..... 1 tank

	Facility / Item	RESERVOIR	CONNECTION PIPES
STORAGE FACILITY	Type	Cylindrical P.C. Structure	A.C.P. Class A-10
	Capacity or Size	Inside diameter ; 18.0 m Effective depth ; 7.9 m e.c. - 2,000 m^3	Dia. ø8", ø12"
	Quantity	3 tanks	ø 8" ..... 870 m ø12" ..... 2,250 m

SECTION 8 COST ESTIMATES OF THE PROJECT

SECTION 8 COST ESTIMATES OF THE PROJECT

Cost estimates for the work for which financial aid was requested includes the cost of construction, i.e. cost of materials and equipment, labour, technical training required, and fees for design work and construction supervision.

In total, the project cost for supplying water to an estimated population of 40,000 amounts to about 1,100 million Japanese Yen.

8.1.1 Intake Facilities

1 - 01 construction of deep wells 10 wells

1 - 02 installation of pump facilities 10 Nos.

1 - 03 construction of well pump facilities 10 Nos.

8.12. Collection Facilities

2 - 01 installation of collection pipes 9,550 m

8.1.3 Transmission Facilities

3 - 01 construction of transmission pump well and junction well

3 - 02 construction of transmission pump house

3 - 03 installation of transmission pump facilities

3 - 04 installation of electrics and measuring equipment

3 - 05 installation of connection pipes

3 - 06 installation of transmission pipes, 7,760 m

3 - 07 construction of pressure breaking chamber, 2 Nos.

3 - 08 leveling and cleaning of the site

8.1.4 Storage Facilities

4 - 01 construction of storage reservoirs, 3 Nos

4 - 02 installation of connection pipes, 3,250 m

8.2 Drilling Machine

Rotary drilling machine, 1 Nos.

8.3 Technical Training

8.4 Design and Supervision