8-3 Details of Maintenance and Administration

The administration of the water supplying facilities may be broken down under the following three headings.

(1) Facilities management
(2) Water Quality Control
(3) Sanitation Control

(1) Facilities Management

Water supplying facilities must always be able to respond to the demands put on them, and has to be so maintained that they can function properly. In order to do so, it is necessary to keep the drawings, ledgers, records etc., of the facilities in good order and preserve and maintain them. These data are necessary not only for routine of maintenance and operation, but are necessary for taking appropriate restoration measures in the events of accidents and natural calamities.

The water source for this Project is river water, which is treated in the purification plant and then supplied to the people. Various equipment such as intake pumps, conveyance pumps, gate valves etc. in the purification plant, must always be kept in operable condition, and the purification plant must be properly operated.

Pipelines are almost entirely laid beneath the roads, so that there is danger of the pipes being damaged or the joints becoming dislocated due to surface traffic. Again, leaks may occur from broken pipes etc., which have to be discovered with the utmost speed and taken care of promptly.

(2) Water Quality Control

The most important purpose of the water supplying facilities is to supply safe and clean water to residents at all times. Hence water quality control is one of the most important factors of maintenance and management. As the water source for this Project is river water, it is essential that the quality of the raw water and supplied water be checked every day. The water quality standard used in this Project is the standard of the Environment Pollution Control Board.

(3) Sanitation Control

As mentioned in the paragraph on water quality control, the purpose of the water supplying facilities is to supply safe and clean drinking water to as wide a segment of the population as possible in order to improve public health and contribute to the improvement of the living environment. In the light of this objective, sanitation control of staff, facilities and surroundings is most basic and important.

When maintenance and operation are not appropriately conducted, not only is the objective of water supplying facilities lost, but the water supplying facilities intended for the improvement of public health and the livelihood environment may on the contrary become media for spreading infectious diseases of the digestive system. It should be remembered that unlike many other public facilities and installed equipment, water supplying facilities, should the control level drop, have the potential danger of not only becoming a medium to spread infectious diseases but of shortening its own service life or causing a deterioration in its functional performance.

For this reason, the health control of engineers and staff engaged in the operation of water supplying facilities must be enforced. It is also desirable that the area surrounding wells which are used as sources of water supply be kept free from any sanitary problems.

8-4 Facilities and Equipment for Maintenance and Administration

Office space and place for storing parts, etc. are necessary for the maintenance and administration organization to perform their duties. If existing office and storage space are available for use, the Bangladesh Government is requested to make them available for the Project. If, however, they have to be constructed anew, the required space has been computed as follows by referring to the projects implemented by the assistance of the Asian Development Bank and the Government of the Netherlands.

(1) Main Administration Office building:
1,000 ft^2 (92.9 m^2) 2 bldgs. (West)

(2) Purification Plant Administration Office building:
500 ft^2 (46.4 m^2) 2 bldgs. (East, West)

(3) Storage building for Spare Parts, etc.:
3,000 ft^2 (278.7 m^2) 1 bldg. (West)

For maintenance and administration, the following vehicles are deemed necessary to patrol and inspect the water supplying facilities in the town.

(1) Ordinary jeep: 1 vehicle (West)
(2) Small jeep: 2 vehicles (East, West)
(3) Motorcycle: 4 vehicles (East, West)

Furthermore, it is also believed necessary to place one set of simple water quality testing apparatus at each purification plant.

8-5 Maintenance and Administration Costs

The rough costs for operation and maintenance have been estimated on the basis of the organization proposed in Paragraph 8-1 as follows.

(1)	Personnel costs:	198,100	TK/month
(2)	Office supplies etc.:	1,500	"
(3)	Fuel cost for vehicles: 300 liters x 17.5 TK/liter =	5,250	"
(4)	Maintenance costs of buildings:	1,500	"
(5)	Operating costs of purification plants and well pumps:	918,896	"
(6)	Cost of chemicals:	149,085	"
(7)	Cost of expendable supplies such as for pumps: (5% of (5) above)	46,000	"
	Total	1,320,331	"

Furthermore, the construction cost of the administration office and the purchasing cost of the vehicles are as follows.

(1) Construction cost of administration offices:
1,357,269 TK

(2) Purchasing cost of vehicles:
1,214,280 TK

(Personnel Cost Breakdown)

1.	Project Manager:	1 x 4,500 TK/mon	= 4,500 TK/mon
2.	Senior Engineer:	2	
	Senior Officer:	1	5 x 3,500 TK/mon = 17,500 TK/mon
	Purification Plant Manager:	2	
3.	Section Chief:	7 x 2,500 TK/mon	= 17,500 TK/mon
4.	Section Chief:	15 x 2,000 TK/mon	= 30,000 TK/mon
5.	Engineer/Officer	45 x 1,500 TK/mon	= 67,500 TK/mon
6.	Asst. Engineer/Pump Driver:		
		19 x 900 TK/mon	= 17,100 TK/mon
7.	Asst. P. Driver/ Asst.:		
		50 x 800 TK/mon	= 40,000
8.	Typist:	1 x 1,500 TK/mon	= 1,500 TK/mon
9.	Pion (odd jobs):	5 x 500 TK/mon	= 2,500 TK/mon
	Total		198,100 TK/mon

(Operating Cost of Purification Plant and Well Pumps)

1. Total Output
   (1) Well (Existing): 4
       11 kW + 22 kW + 26 kW + 22 kW = 81 kW
   (2) Purification Plant (West New):
       45 kW x 2 + 75 kW x 4 + 30 kW +5.5 kW = 425.5 kW
   (3) Purification Plant (West, Existing):
       25 kW x 2 + 60 kW x 2 = 170 kW
   (4) Vicinity of No. 4 and No. 5:
       3.7 kW x 2 + 15 kW x 2 = 37.4 kW
   (5) Purification Plant (East):
       30 kW x 2 + 5.5 kW x 2 + 2.7 kW x 1 + 11 kW x 2
       = 95.7 kW

   Total 809.6 kW

2. Basic Charge:
   809.6 kW x 10 TK/kW/mon = 8,096 TK/mon

3. Electric Charge:

809.6 kW x 15 h/day x 30 days/month x 2.5 TK/kWh
= 910,800 TK/mon

4. Total: 918,896 TK/mon

(Chemicals Cost)

1. Chemicals Consumption

(1) Ammonium Sulfate:

Purification Plant (West);
0.735 m^3/day x 5% ÷ 17% x 30 days = 6,485 kg

Purification Plant (Existing);
0.104 m^3/day x 5% ÷ 17% x 30 days = 917 kg

Purification Plant (East);
0.345 m^3/day x 5% ÷ 17% x 30 days = 3,044 kg

Total 10,446 kg

(2) Bleaching Powder:

Purification Plant (West);
0.256 m^3/day x 2 ppm x 10/60 x 30 = 2,560 kg

Purification Plant (Existing);
0.030 m^3/day x 2 ppm x 10/60 x 30 = 300 kg

Purification Plant (East);
0.109 m^3/day x 2 ppm x 10/60 x 30 = 1,090 kg

Total 3,950 kg

2. Chemicals Cost

Ammonium Sulfate: 10,446 kg x 5.73 TK/kg
= 59,855 TK/month

Bleaching Power: 3,950 kg x 22.59 TK/kg
= 89,230 TK/month

Total 149,085 TK/month

(Construction Cost of Administration Office, Storehouse, etc.)

Main Administration Office:

92.9 m^2 x 2 bldgs. x 3,250 TK/m^2 = 603,850 TK

Storehouse for spare parts:

278.7 m^2 x 1 bldg. x 1,620 TK/m^2 = 451,494 TK

Purification Plant Administration Office:

46.45 x 2 bldgs. x 3,250 TK/m^2 = 301,925 TK

Total 1,357,269 TK

(Cost of Vehicles for Administration)

Ordinary jeep:	1	219,407 TK
Small jeep:	2	213,776 TK
Motorcycle:	4	59,930 TK
Water Quality Tester:	2 sets	114,027 TK
Total		607,140 TK

Import duties, etc. of the above equipment:
607,140 TK

8-6 Technical Co-operation

The purification plants in this Project have been planned with a treatment capacity of 28,184 m^3/day (15 hours a day operation) for the West Side and 12,038 m^3/day (15 hours a day operation) for the East Side. In Narayanganj Town there are today two purification plants, one in the West Side with a treatment capacity of 3,640 m^3/day and another in the East Side with a capacity of 796 m^3/day, but the proposed plants under this Project are incomparably larger in scale. The fact that the capacity of the Dhaka WASA's purification plant is 27,300 m^3/day also indicates that the proposed plants under this Project are fairly large.

In order to efficiently administer and operate such purification plants and demonstrate the effect of this water-supply improvement project for a long time, it is necessary to provide not only sufficient technical guidance for operation and administration at the time of completion of these installation as a matter of course but also technical cooperation for fostering and general upgrading of technologists for operation and administration of water supplying facilities by dispatching Japanese experts and otherwise.

The specialized areas considered in selecting experts would include:

(1) Management

(2) Public Health Engineering

(3) Waterworks installations

(4) Electrical instrumentation and machinery

(5) Water distributing facilities

The experts dispatched will basically transfer appropriate technologies matched to the level of local facilities on the spot, and in conjunction with this, it is hoped that an integrated training system to develop all-round technologists by utilizing the training courses being offered by the Japan International Cooperation Agency, etc. will be established and implemented.

CHAPTER 9 PROJECT APPRAISAL

The Bangladesh Government has proclaimed in the Second 5-year Plan (1980-1985) that to provide all the people of the nation with safe and clean potable water is one of the most important policies for its top priority objective of improving the level and quality of the living standard of the people.

According to this basic policy, the Bangladesh Government has been constructing potable water supply systems by means of piping in the urban areas and of hand pumping in the rural areas under the supervision of DPHE and WASA.

With foreign aid, DPHE has been implementing construction and betterment of potable water supply facilities in 30 out of 62 district towns with the exception of two big cities. In the remaining 32 towns, the same works have been implemented with local funds.

However, due to the population growth in Bangladesh and especially its intensive concentration into local towns, it is becoming increasingly difficult to secure drinking water in those towns. Furthermore, the situation is aggravating the livelihood and public health environment of local townsfolks because the pace of constructing water supplying facilities is falling behind the rate of increase in the demand for potable water due to the lack of funds on the part of the Bangladesh Government, resulting in a widening of the gap between supply and demand.

Narayanganj Town already has clean water supplying facilities and the diffusion rate of house connections is about 30% now. However, as the water supplying facilities are already old, most of them having been constructed during the days of British rule and when the country was still called East Pakistan, coupled with the limited capacity of the water source facilities, timeworn distributing pipes, unplanned layout of distributing pipes and the imbalance between water distribution and the rapid increase in population, insufficient hydraulic pressure, jamming of pipes and other malfunctions are being generated. The waterworks cannot be claimed to be adequately fulfilling its function as deserving of its name.

If the potable water supplying facilities in Narayanganj Town are improved with Japan's grants-in-aid under the foregoing circumstances, following effects can be anticipated.

(1) Urgent Need

In Bangladesh today, WASA is implementing clean water supply improvement project with the assistance of the World Bank, and DPHE is implementing 9 projects out of 10 projects covering 64 towns which plan to establish waterworks Of these 9 projects, 6 projects are being implemented with the assistance of the Netherlands Government and the Asian Development Bank, and the remaining projects are being implemented with the country's own fund only. UNICEF is also assisting construction of tube wells for hand pump operation in the rural areas.

While the projects with foreign aid are making progress of more than 60%, the projects financed by the country's own fund are making progress of 25% to 35% only.

Particularly the improvement plan for Narayanganj Town is being withheld despite the fact that the town is the second largest (with estimated 1990 population of 470,000) among the 62 District Towns excluding Dhaka and Chittagong and occupies a geographic position adjacent to Dhaka, on the ground that, although old they may be, the town does have the old facilities that were constructed in the days of East Pakistan. If things are left as they are, the balanced growth of "supplying clean potable water evenly" which is the objective of the National Development Plan will likely face a big stumbling block. It is therefore strongly desired that Japan's grants-in-aid which is a highly effective form of financial cooperation be provided urgently for the foregoing project in Narayanganj Town in order to ensure social equity.

(2) Socio-economic Effect

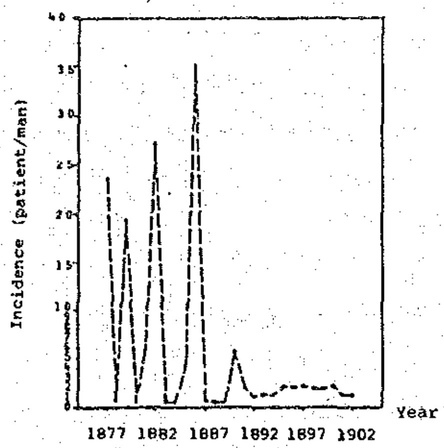
If potable water supplying facilities are improved and water is supplied steadily, the labor which had been spent daily for drawing water would no longer be necessary and can be dedicated to other productive activities (such as agriculture, manufacturing and commerce).

Eventually, this will greatly contribute to invigorating Narayanganj Town as a suburban municipality of Dhaka and to stabilizing the livelihood of the townspeople by improving their basic living condition.

(3) Public Health and Sanitation

It is said that in Bangladesh, 80% of the diseases are related to water and that 30% of child deaths are caused by diarrhea. If, however, safe and clean drinking water is supplied by improving the drinking water supplying facilities, the sanitary environment would be drastically improved and the incidence of infectious diseases of the digestive system would decrease greatly. As an example evidencing this, changes in the incidences of infectious diseases before and after the construction of water supplying facilities in Yokohama is illustrated below.

Incidence of Infectious Diseases before and after Construction (1887) of Yokohama Water Supply Facilities



The public health conditions of Narayanganj Town which is beginning to deteriorate due to unimproved drinking water supplying facilities and shortage of water supply would be improved greatly by this project and not only contribute greatly toward improvement of the town's health and sanitation environment but also exert a big impact on stabilizing the townspeople's living.

(4) Financial Management

The maintenance and administration expenses are 15,843,972 TK a year.

The capacity of the water supplying facilities is 36,566 m^3/day, and the population who will receive the benefit of these facilities is 47,000 (of which 50% will be supplied by house connections and 50% by public posts).

The price of water would be 4.73 TK (¥44.65) but if Japan's grants-in-aid are excluded, it would become 2.06 TK (¥19.4).

The annual expenses to operate the water-supply service are 26,082,186 TK, and these shall be covered by the national budget appropriated for DPHE and by the water rates charged at a rate of 20 TK a month per house connection on household consumption (the revenue from which is about 5% of annual operating expenses).

1) Review on the Price of Water

The price of water is calculated according to the following formula:

$$\text{Price of Water} = \frac{\text{Annual Repayment + Annual Expenses}}{\text{Total Annual Water Consumption}}$$

The construction cost shall be the combined project costs for the East and West sides of the town and shall be repaid in 20 years with annual interest of 3.0% according to the lending conditions of OECF of Japan.

The annual expenses shall be the cost of maintenance and operation stated in Chapter 8.

The total annual water consumption shall be the total amount of water supplied by house connections and public posts in 1990.

$$\text{Price of Water} = \frac{\frac{677,021,520}{15,337} + 15,843,972}{12,668,968} = 4.73$$

In which: Construction cost: 677,021,520 TK
Interest rate: 3% a year
Annual expenses: 15,843,972 TK
Repayment period: 20 years

Total annual water consumption:
Estimated population supplied: 470,000

Q = 235,000 persons x 113.7 ℓ/day-person x 365 days
+ 235,000 persons x 34 ℓ/day-person x 365 days
= 12,668,968 m^3

The price of water excluding the portion covered by Japan's grants-in-aid is as follows:

$$\text{Price of Water} = \frac{\frac{157,023,520}{15,337} + 15,843,972}{12,668,968} = 2.06 \text{ TK}$$

2) Approximate Benefits and B/C Ratio

The Project for improving the drinking water supplying facilities will manifest its beneficial effects in various aspects, but the only calculable benefit is the water charges that are collectable from the house connections.

Under the present system in Narayanganj, it is difficult to estimate the water charges on a per household basis or per cubic meter basis. Also, it is difficult for the town to operate its water supplying facilities with the present water charges alone.

In this Project, the approximate benefit is estimated on the basis of 20 TK per month per house connection as per the water charges which DPHE is planning for other projects.

Assuming that 100% of the 10,706 households which is the total number of households existing today will have installed house connections by 1990, the annual water charges that would be collected from them would be as follows:

B = 10,706 households x 20 TK/month/household x 12 months
= 2,569,440 TK

The total construction cost calculated by adding the construction cost of house connections to be installed in future to the construction cost under this project is as follows:

$$C = 677,021,520 + 2,148 \times 2,534 = 682,464,552 \text{ TK}$$

Accordingly, the annual expenses C_o would be as follows:

$$C_o = \frac{682,464,552}{15,337} + 15,843,972 = 60,341,889$$

The annual expenses C_o' excluding the portion covered by Japan's grants-in-aid would be as follows:

$$C_o' = \frac{162,466,552}{15,337} + 15,843,972 = 26,437,081$$

Thus, the B/C_o ratio and B/C_o' ratio would become as follows, respectively.

$$B/C_o \text{ ratio} = \frac{2,569,440}{60,341,889} = 0.0426$$

$$B/C_o' = \frac{2,569,440}{26,437,081} = 0.0972$$

CHAPTER 10 CONCLUSION AND RECOMENDATION

10-1 Conclusion

In Narayanganj Town, water supply service by waterworks is operated even now, but adequate water supply is not secured due to aging and deterioration of facilities, shortage in the absolute volume of water supply and imbalance of water pressure due to haphazard extension works.

If, however, water purification facilities and distributing facilities are improved by the implementation of this project, the objective of the government of Bangladesh of supplying safe and clean drinking water steadily to its residents will become attainable.

This will undoubtedly contribute greatly to the betterment of the health and sanitation environment of the residents of Narayanganj Town and invigoration of the town's economy and eventually result in the improvements of the people's livelihood.

Since the project will remarkably contribute to the improvement of basic living as above, Japan's grants-in-aid for this project is judged to be meaningful and reasonable.

10-2 Recomendation

As stated above, the implementation of this project is anticipated to play a big role in improving the health and sanitation environment of the area and the people's living and also in invigorating the local economy.

In order to administer and operate the proposed facilities satisfactorily, however, it is crucial that the Government of Bangladesh establish the necessary systems and organizations. Adequate consideration is particularly necessary on the following matters.

(1) Water Rate

In order to properly maintain and operate watersupply works, it is important to secure the maintenance and administration expenses by collecting water rates. As estimated on a trial basis in Paragraph (4) of Chapter 9, the estimated revenues from water rates in 1990 at the ongoing water rate schedule would only amount to around 16% of the necessary maintenance and administration expenses. The Government of Bangladesh explains that any shortfall in the funds to cover expenses would be defrayed out of the national budget of Bangladesh. However, as it is preferable to operate and administer the facilities with the revenues from water rates as much as possible, it is important to establish a proper rate schedule and an effective water charge collection system in the future.

(2) Technical Cooperation

The importance of maintenance and administration of watersupply works has already been discussed in Chapter 8, and in order to carry out proper maintenance and administration of water supplying facilities, expansion and improvement of the organization for maintenance and administration, guidance and training of required personnel for administration of facilities and fostering of waterworks engineers from the longer range perspective are necessary. As the concrete methods to accomplish the foregoing, dispatching of Japanese experts, participation in the training course (on waterworks sector) offered by the Japan International Cooperation Agency, etc. may be considered.

Satisfactory maintenance and administration of facilities are the essential prerequisites for stable supply of drinking water, and a stable water supply will also lead to gaining the trust of local residents and stable revenue from water rates which in turn will lay the foundation for satisfactory operation of the watersupply services. Accordingly, it will be necessary to foster the technological staff as early as possible.

(3) Improvement of Sewerage

If this project is implemented and the waterworks begin to supply safe and clean drinking water steadily as aimed for, the health and sanitation environment of the local residents would be improved greatly. We must also consider, however, that with the stable supply of drinking water, wastewater would also be generated.

Unless this wastewater is adequately treated, we cannot claim the sanitary environment to have been improved in its true sense. The future task of the Government of Bangladesh would be to attempt for improvement of sewerage along with the improvement of waterworks.

ANNEX I LOCAL ADMINISTRATIVE UNITS

ANNEX I Local Administrative Units

Local Administrative Units

The Administrative Units of the People's Republic of Bangladesh have been changed as follows effective since February, 1984.

Conventional Administrative Units		New Administrative Units
Divisions (4)	→	Divisions (4)
Districts (22)	→	Districts (64)
Sub-divisions (46)	(42) →	Districts (64)
	(4) →	Upazilas (Thana Parished)
Thanas (493)	→	Upazilas (Thana Parished)
Unions (4,472)	→	Unions (Unions Parished)
Mouzas (60,315)	→	Mouzas
Villages (85,650)	→	Villages

* Statistical Year Book of Bangladesh, 1982

ANNEX II LOCATION MAP OF TEST WELLS

(Wells used in additional tests conducted in Narayanganj Town)

Fig. A-2-1 Location Map (West Site)

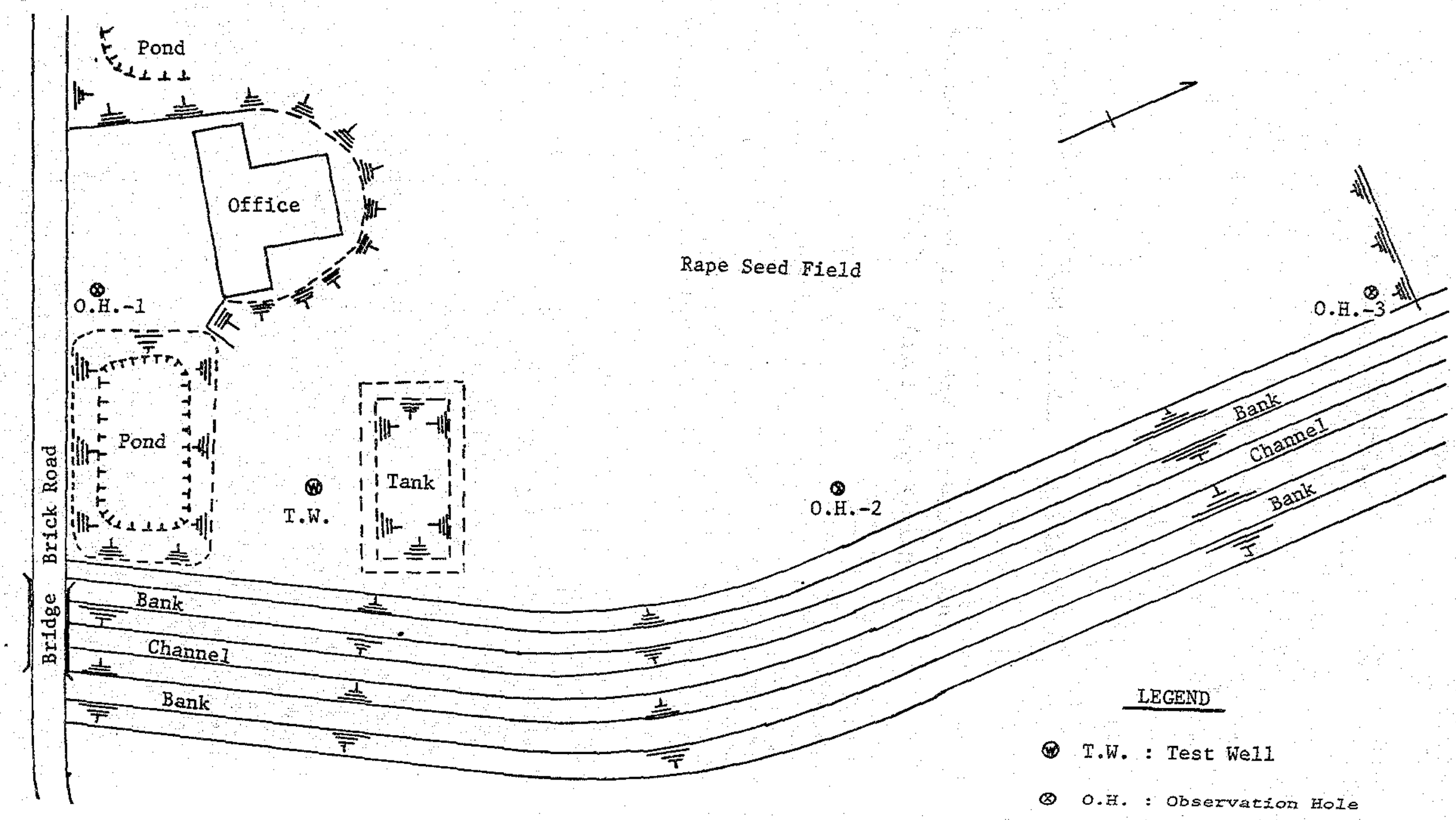
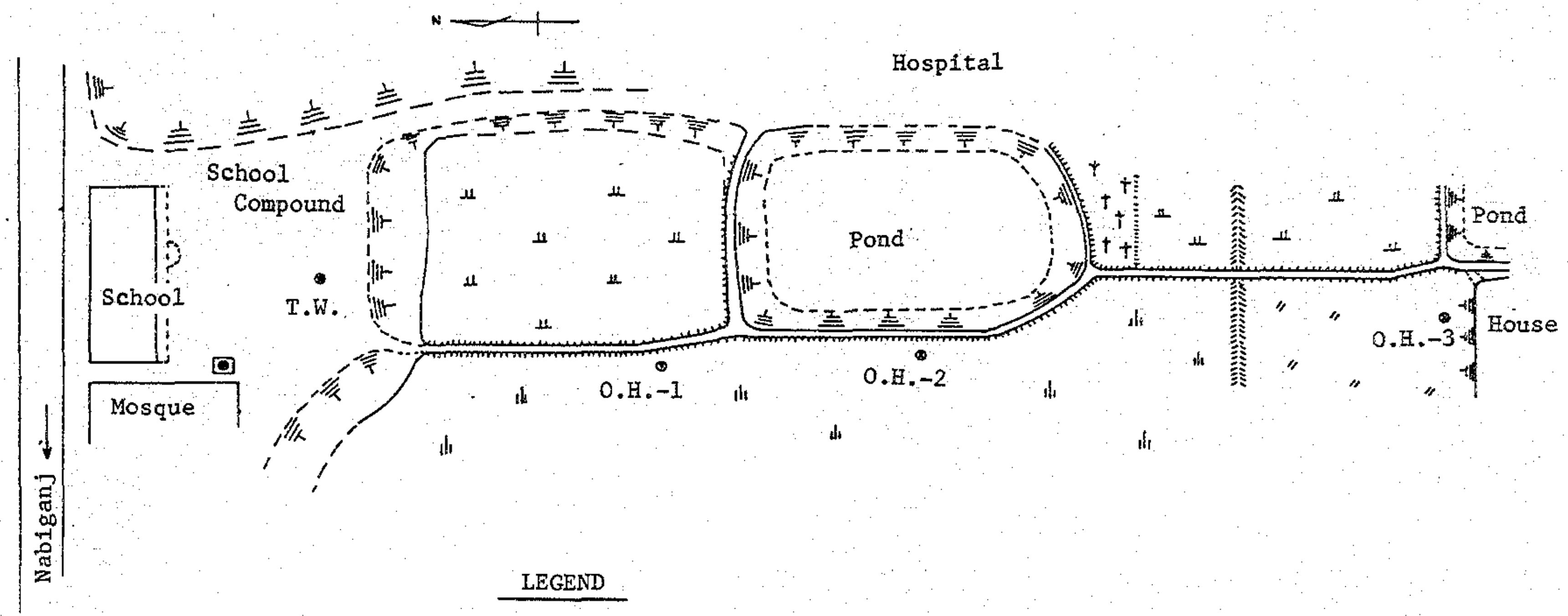


Fig. A-2-2 Location Map (East Site)



LEGEND

O.H. : Observation Hole

T.W. : Test Well

: Rice Field   : Waste Field

: Rape Field   : Wheat Field

ANNEX III WATER QUALITY TEST DATA OF RIVER SITALAKHYA

(Results of Tests Conducted Near the Existing Purification Plants in Narayanganj by EPCD, Bangladesh Between 1975 and 1983)

Table A-3-1 Water Quality Data of River Sitalakhya, Near Narayanganj, Water Works

1975

Months	pH	EC micro cm^{-1}	Chloride mg/ℓ	P-alka mg/ℓ	T-alka mg/ℓ	DO mg/ℓ	BOD mg/ℓ	T.S. mg/ℓ	S.S. mg/ℓ	TDVS mg/ℓ	Temp °F	Coliform nos/100mℓ	Remarks
JAN.	7.1	311.4	18.4	0	170.8	8.7	2.6	257	48.2	83.4	78	1,466	
FEB.	7.5	319	24.8	0	192	9.08	4.9	316	110.1	114	78.5	16,100	
MARCH	8.0	344.4	25	0	151.2	7.5	2.3	363.6	88.6	96	79	6,400	
APRIL	7.3	321.4	37.2	0	124.2	8.3	5.1	209.6	52.8	80	79	16,882	
MAY	6.8	207.4	8.8	0	85.4	4.4	2.5	190.2	76.2	65.2	81	21,970	
JUNE	6.7	123.4	39.4	0	79	6.5	3.7	110.8	33.8	35	83	2,136	
JULY	7.1	24.4	14	0	55.2	8.0	3.2	316	31.2	37.4	83	22,130	
AUG.	7.0	19.4	14.4	0	59.2	7.4	3.9	107.6	30.6	24.4	84	11,870	
SEPT.	7.0	88	33.0	0	54.8	8.7	4.1	180.6	31.8	36.1	86	8,416	
OCT.	7.1	150	4.41	0	59.3	4.2	0.75	107.5	13.1	67.8	89	10,912	
NOV.	7.0	221.6	3.41	0	83.3	5.3	4.54	163.6	26.8	101.1	78	5,580	
DEC.	7.7	253.6	4.83	0	116.6	7.15	3.65	227.5	55.5	102.1	78.1	1,466	

Table A-3-2 Water Quality Data of River Sitalakhya, Near Narayanganj, Water Works

1976

Months	pH	EC micro cm^{-1}	Chloride mg/ℓ	P-alka mg/ℓ	T-alka mg/ℓ	DO mg/ℓ	BOD mg/ℓ	T.S. mg/ℓ	S.S. mg/ℓ	TDVS mg/ℓ	Temp °F	Coliform nos/100mℓ	Remarks
JAN.	7.6	280.8	7.92	0	137.3	6.15	5.96	204.1	17.8	138.6	73.1	2,350	
FEB.	7.7	315	9.3	5.0	133.6	6.0	6.13	219.1	26.1	123.33	80.1	2,433.3	
MARCH	7.69	229.1	7.16	0	72	7.25	3.1	120.1	29.6	94.6	86.5	2,016.6	
APRIL	7.1	317	33.4	0	84	120.4	10.1	4.7	206	67	85	2,184	
MAY	7.9	189	4.2	0	76.8	6.1	2.82	132.4	22.6	81.6	85	1,440	
JUNE	6.96	180.5	6.89	0	64.0	5.53	3.05	136	20	58	84.8	2,083.3	
JULY	7.42	102	1.40	0	41.6	5.84	1.95	72.8	9.2	40.6	84.2	4,000	
AUG.	7.02	128	3.78	0	48	6.02	4.1	93.1	17.7	45.5	89.7	1,092	
SEPT.	6.8	117.4	12	0	51.4	7.04	3.9	80.8	31.8	46.0	88	5,060	
OCT.	6.7	86	14.4	0	55.4	8.5	2.9	65	31.8	39.0	88	5,000	
NOV.	7.0	88.8	29.0	0	50.1	4.8	2.3	104.6	31.6	67.2	87.5	6,362	
DEC.	7.1	27.0	19.0	0	63.6	6.7	3.4	97.1	56	26.5	87	2,944	

Table A-3-3 Water Quality Data of River Sitalakhya, Near Narayanganj, Water Works

1977

Months	pH	EC micro cm^{-1}	Chloride mg/ℓ	P-alka mg/ℓ	T-alka mg/ℓ	DO mg/ℓ	BOD mg/ℓ	T.S. mg/ℓ	S.S. mg/ℓ	TDVS mg/ℓ	Temp °F	Coliform nos/100mℓ	Remarks
JAN.	7.1	331	18	0	170	2.4	2.0	246	83	84	79	2,440	
FEB.	7.3	321	26	0	168.2	4.8	3.1	304	101	116	80	1,860	
MARCH	7.6	343.4	26.4	0	153	2.2	2.0	351.4	86.6	89.1	81	6,100	
APRIL	7.0	320	36	0	169.1	5.0	2.4	197	66.4	88	84	5,466	
MAY	6.9	208	18.8	0	164.8	2.4	4.0	186.8	38	67.8	83	6,454	
JUNE	6.5	122	10.12	0	128	3.1	3.0	128.1	39.4	84.6	83.5	60,106	
JULY	6.96	161	3.8	0	48	5.48	2.86	124.4	20.8	66.6	83	1,060	
AUG.	7.0	164	1.25	0	53.6	6.2	2.08	64.0	6.6	70.2	86	4,560	
SEPT.	6.9	161	3.8	0	48	5.48	2.86	124.4	20.8	66.6	83	1,060	
OCT.	7.04	190	8.0	0	62.4	5.88	2.58	127.4	16.4	66.4	84	2,400	
NOV.	6.7	152	10.9	0	38	4.7	1.6	130.8	20.0	60.3			
DEC.	7.16	299	5.2	0	125	3.48	1.2	177.8	21.6	123.8	77	460	

Table A-3-4 Water Quality Data of River Sitalakhya, Near Narayanganj, Water Works

1978

Months	pH	EC micro cm^{-1}	Chloride mg/ℓ	P-alka mg/ℓ	T-alka mg/ℓ	DO mg/ℓ	BOD mg/ℓ	T.S. mg/ℓ	S.S. mg/ℓ	TDVS mg/ℓ	Temp °F	Coliform nos/100mℓ	Remarks
JAN.	7.1	442	12.8	0	127.2	4.2	2.92	255.2	39.6	137.6	76	72,010	
FEB.	6.8	261	18.3	0	100.0	6.2	2.1	278	41	140	78	2,743	
MARCH	7.2	502	28	0	132.8	5.7	2.3	316.6	68.7	157	80	9,630	
APRIL	7.08	460	15.2	0	144.8	5.18	2.9	226	35.6	154.4	82	14,340	
MAY	6.92	257	7.2	0	72.8	6.65	2.58	156	23.4	77.6	87	450	
JUNE	7.32	184	4.2	0	40.0	5.5	2.12	118.2	19	64.4	84	3,040	
JULY	7.0	180	6.6	0	41	6.0	3.0	141	34	70	84	5,344	
AUG.	6.84	520	23.8	0	117.6	3.72	1.52	309.5	45.6	196.2	85	4,360	
SEPT.	7.22	216	8.1	0	64.4	2.89	12.9	220.6	43	154.6	86	4,360	
OCT.	6.84	220	8.7	0	58.4	6.08	2.29	112.2	24.6	52	85	5,160	
NOV.	6.8	179	6.3	0	80.8	5.56	2.28	130.4	64.6	145.2	77	3,960	
DEC.	7.3	216	6.0	0	78	5.2	1.8	144	38	64.4	78	53,180	

Table A-3-5 Water Quality Data of River Sitalakhya, Near Narayanganj, Water Works

1979

Months	pH	EC micro cm⁻¹	Chloride mg/ℓ	P-alka mg/ℓ	T-alka mg/ℓ	DO mg/ℓ	BOD mg/ℓ	T.S. mg/ℓ	S.S. mg/ℓ	TDVS mg/ℓ	Temp °F	Coliform nos/100mℓ	Remarks
JAN.	6.9	258	10.0	0	82.4	2.8	0.8	316	74	181	78	4,256	
FEB.	6.9	244	5.6	0	120.0	3.0	1.8	298	34	95.6	81	2,548	
MARCH	6.9	314	12.0	0	116.0	6.12	2.72	190.4	16.8	64.4	80	5,420	
APRIL	6.58	245	13.9	0	89.6	6.76	4.58	155.4	15.4	43.4	83	6,360	
MAY	6.8	256	8.6	0	90.1	3.0	1.6	218	18	86.9	83	4,636	
JUNE	6.84	350	12.5	0	81.6	2.84	1.1	184.2	78.2	68.0	83	4,200	
JULY	6.4	124	7.20	0	45.4	3.12	1.42	184.2	17.0	3.12	83	5,060	
AUG.	7.06	213.3	6.33	0	44.0	3.96	1.26	136.3	11.3	89.3	82	5,000	
SEPT.	7.1	412	12.0	0	48.3	4.6	2.2	300	88.8	71.0	81.5	1,818	
OCT.	7.14	236	6.5	0	46.8	6.48	2.1	152.6	21.6	96.8	82	2,940	
NOV.	6.94	410	7.6	0	74.8	200.4	6.16	256.8	27.6	214.8	82	3,220	
DEC.	7.04	226	5.66	0	97.6	95.8	6.18	137	12.2	105.8	79	5,320	

Table A-3-6 Water Quality Data of River Sitalakhya, Near Narayanganj, Water Works

1980

Months	pH	EC micro cm⁻¹	Chloride mg/ℓ	P-alka mg/ℓ	T-alka mg/ℓ	DO mg/ℓ	BOD mg/ℓ	T.S. mg/ℓ	S.S. mg/ℓ	TDVS mg/ℓ	Temp °F	Coliform nos/100mℓ	Remarks
JAN.	7.5	327.4	10.8	0	183	2.0	2.88	226.8	61.7	44.8	23.5	2,420	
FEB.	7.1	288	8.4	0	187	8.3	2.4	255	64	62.4	23	42,610	
MARCH	7.0	318	23	0	120	9.04	4.8	318	99.2	82.0	23	21,880	
APRIL	7.4	327.5	31	0	79.2	7.5	2.2	360	50.8	85.4	27.0	21,384	
MAY	6.8	186	17.8	0	59.8	8.6	4.0	207.8	47.8	89.2	30.0	38,412	
JUNE	6.8	220	13.5	0	64.8	4.6	2.4	186.2	37.2	161.0	31	41,832	
JULY	7.0	316	20.8	0	49.3	7.8	3.5	128.4	82.6	67.0	28	63,842	
AUG.	7.1	410	35.0		122.2	7.02	3.1	216	29.8	38.5	29	3,677	
SEPT.	6.9	276.5	22.6	0	149.8	4.6	3.8	129.6	31.1	39.4	30.2	63,748	
OCT.	7.3	286	4.2	0	63.2	6.9	3.9	114.8	8.8	35.2	82^{OF}	3,660	
NOV.	6.9	254	6.0	0	91.2	6.5	3.8	182.2	56.0	26.4	26.0	4,738	
DEC.	7.1	219	5.65	0	111.5	7.6	2.4	145.2	16.4	41.0	25	2,020	

Table A-3-7 Water Quality Data of River Sitalakhya, Near Narayanganj, Water Works

1981

Months	pH	EC micro cm^{-1}	Chloride mg/ℓ	P-alka mg/ℓ	T-alka mg/ℓ	DO mg/ℓ	BOD mg/ℓ	T.S. mg/ℓ	S.S. mg/ℓ	TDVS mg/ℓ	Temp °F	Coliform nos/100mℓ	Remarks
JAN.	7.0	258.8	6.4	0	147	6.3	0.9	250	61.7	124.2	24	5,650	
FEB.	7.7	320	7.7	0	187	7.38	3.48	240.8	55.8	52.2	25	1,700	
MARCH	7.9	248.6	10.4	0	118	6.16	4.58	242.6	104.2	60.4	25	1,960	
APRIL	7.5	326	13.8	0	138.4	7.80	3.6	326.8	97.6	89.2	28.5	2,160	
MAY	6.9	360	10.6	0	130	7.8	2.0	250	40	133	28.5	3,260	
JUNE	6.7	136.6	3.80	0	62.4	3.34	0	326.6	140.2	94.4	29	2,920	
JULY	6.9	100	6.7	0	56.8	5.4	1.7	124	23.4	52	30	6,225	
AUG.	6.6	181.3	2.6	0	46.0	4.8	1.0	263	26.0	60.1	29	1,280	
SEPT.	6.8	156	4.1	0	62.0	6.2	1.8	240.8	81	90.2	29	4,860	
OCT.	6.6	210.6	2.5	0	82.7	7.2	1.0	381	97.8	134.9	30	1,697	
NOV.	6.6	295	8.6	0	82.6	5.6	2.6	234.4	79	99.0	29	7,818	
DEC.	7.0	198.5	4.6	0	96.0	5.0	3.1	621	153	281.0	29	1,274	

Table A-3-8 Water Quality Data of River Sitalakhya, Near Narayanganj Water Works

1982

Months	pH	EC micro cm^{-1}	Chloride mg/ℓ	P-alka mg/ℓ	T-alka mg/ℓ	DO mg/ℓ	BOD mg/ℓ	T.S. mg/ℓ	S.S. mg/ℓ	TDVS mg/ℓ	Temp °F	C liform nos/100mℓ	Remarks
JAN.	7.04	259.8	6.56	0	148.8	6.2	0.82	248	62.8	122.2	23	5,560	
FEB.	6.8	285	9.5	0	152	5.6	3.0	224.5	31	146.7	23.5	2,800	
MARCH	7.1	295	13.1	0	144	5.0	1.9	239.2	38.8	121.8	27	12,080	
APRIL	7.1	233	6.9	0	96	6.6	0.9	247.4	49.5	92.6	23.5	4,000	
MAY	6.8	306	10.9	0	131.2	7.9	2.1	251.4	37	137.4	28.5	3,260	
JUNE	6.6	198.4	9.7	0	81	3.92	1.7	191.8	42.6	85.2	28.5	14,880	
JULY	6.9	90.8	2.4	0	65.6	5.4	0.9	91.4	18.6	32.4	30	19,840	
AUG.	6.5	99	4.0	0	56.8	4.6	1.0	80	23	32.6	29	4,942	
SEPT.	6.8	118.3	2.5	0	48.0	6.14	3.0	131	40	83	28.5	6,625	
OCT.	6.5	156	8.8	0	62.8	4.8	3.5	122.4	33.2	140.8	28	7,400	
NOV.	6.7	208.1	7.0	0	82.8	6.1	4.8	181.2	46.8	120.6	28	9,823	
DEC.	7.05	258.4	6.4	0	118.8	7.2	3.6	147.4	45.4	102.1	24.5	8,000	

Table A-3-9 Water Quality Data of River Sitalakhya, Near Narayanganj, Water Works

1983

Months	pH	EC micro cm⁻¹	Chloride mg/ℓ	P-alka mg/ℓ	T-alka mg/ℓ	DO mg/ℓ	BOD mg/ℓ	T.S. mg/ℓ	S.S. mg/ℓ	TDVS mg/ℓ	Temp °F	Coliform nos/100mℓ	Remarks
JAN.	7.08	309.4	16.4	0	168.8	8.5	2.4	255	46.2	85.4	23	4,700	
FEB.	7.3	317	22.8	0	190	9.06	4.7	314	99.8	116	22	5,121	
MARCH	7.8	342.4	23	0	149.2	7.3	2.1	361.6	86.6	98	27.5	9,316	
APRIL	7.1	319.4	35.2	0	122.4	8.1	4.9	207.6	50.8	82	30.5	11,000	
MAY	6.6	205.4	8.8	0	83.2	4.2	2.3	188.2	74.2	67.2	29	6,298	
JUNE	6.5	121.4	39.4	0	77	6.3	3.5	108.8	31.8	37	31	3,844	
JULY	6.9	122.4	12	0	53.2	7.8	3.0	114	29.2	39.4	28	5,446	
AUG.	6.3	117.4	12.4	0	57.2	7.02	3.7	105.6	28.6	26.4	30	4,656	
SEPT.	6.8	86	31.0	0	52.8	8.7	3.9	80.6	32.4	21.0	29	12,414	
OCT.	6.8	88.8	28.2	0	61.2	4.68	2.1	67	29.8	37.9	28	4,564	
NOV.	6.6	127.6	17.8	0	49.2	6.7	3.7	108.6	31.6	40.1	27	4,638	
DEC.	7.1	232.6	22.4	0	91.2	5.6	2.3	199.8	65	34.8	22	9,445	

ANNEX IV TIDAL COMPARTMENT IN BANGLADESH, DISCHARGE IN THE DOWNSTREAM OF MEGHNA RIVER AND SALT CONCENTRATION

Fig. A-4-1 Tidal Compartment in Bangladesh

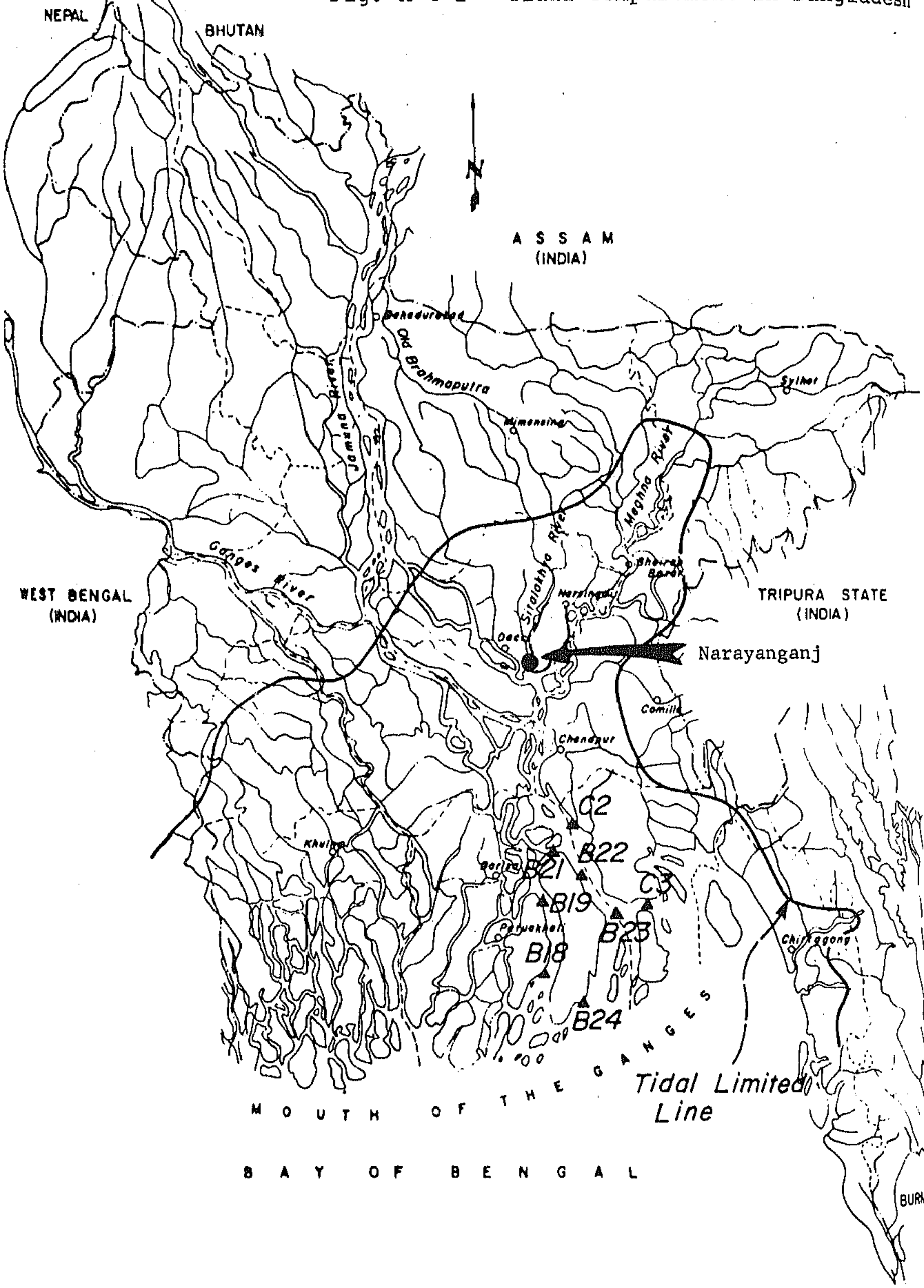


Table A-4-1 Discharge and Salinity in the Downstream Area of the Meghna River

Month	Discharge at Bhagyakul (cfs)	Estimated 1/ Discharge at Chandpur (cfs)	Conductivity of Water Samples in Micromhos							
			Station No.							
			C3	B24	B23	B22	C2	B21	B19	B18
Dec. '66	288,000	320,000	22,000	3,500	1,550	250	455	200	200	195
Jan. '67	215,000	233,000	2/	2/	3/	3/	8,000+	n	215	220
Feb. '67	224,000	245,000	2/	2/	8,000+	2,800	5,000	260	3/	3/
Mar. '67	239,000	265,000	2/	2/	8,000+	2,450	1,100	540	370	300
Apr. '67	323,000	360,000	2/	2/	8,000+	2,100	3/	430	440	330
May '67	422,000	500,000	2/	2/	2,800	240	1,300	150	3/	3/

1/ Discharge at Bhagyakul Station 93.5 on Padma River augmented by inflow in the Upper Meghna estimated from average monthly data.

2/ Station dropped from further study.

3/ Sample not taken during month.

Source: IBRD/IDA Technical Report, Information on conductivity obtained from "Operation and Maintenance Manual for the Coastal Embankment" by Leedshill-Delew Engineers.

ANNEX V COMPARISON OF WATER SOURCES

(Skeleton Design of the Well Alternative)

ANNEX V Skeleton Design of the Well Alternative

1. Water Supplying System of the Well Alternative

The current water supplying system in the Western district of Narayanganj Town basically takes the form of conveying water from the purification plant located in the northern part of the town to the overhead tank installed on the northern tip of the central part of the town, and regulating the hydraulic pressure by means of this overhead tank from which water is distributed to the central part of the town; and to supplement this system, production wells are distributed along the periphery of the town. Although the central part of town has a high population density and the demand for water is also high, it is impossible to install production wells there for reasons of space. The new production wells therefore must be installed in the suburbs of the town. The suburbs of Narayanganj Town are delineated by the Dhaleswari River on the south and the community developed along the said river on the west so that the available sites for constructing production wells are somewhat limited. The area in which production wells can be constructed is therefore mainly the paddy field zone extending on the north of the town. Production wells will be distributed 10 on the west of town and 17 on the north of town, as shown in Fig. A-4-1. Distribution of water to the central part of the town will be from the production wells on the north of town, and the proposed water supplying system would not be much different from the existing one. The water from the existing purification plant will be conveyed to the existing overhead tank through the existing conveyance pipe and distributed to the northern side near the existing overhead tank. The distribution of water to the central part of the town will be made by constructing a new overhead tank for distribution at the northern tip of the central part of town, to which the water will be conveyed from the 14 production wells distributed on the north of town.

The new production wells on the west of the town, coupled with the existing production wells, will be used for distributing water to the peripheral areas on the west and south of the town.

The current water supply to the Eastern district of Narayanganj Town is carried out by the purification plant located to the south of the town center and three production wells. As the Town has been developed along the river, the distributing pipelines of the current water supplying system are laid approximately in the south-north direction along the town. The proposed locations of the production wells are dispersed over a wider range than in the Western district as shown in Fig. A-5-1, and since the town extends itself in a narrow strip, the town is split into three segments under the proposed water supplying system.

2. Required Number of Production Wells

The pumping rate per production well was determined as follows based on the results of hydrogeologic study.

In the Western district: $Q = 80\ m^3/hr$

In the Eastern district: $Q = 100\ m^3/hr$

Since the estimated population supplied in the Western district of Narayanganj Town is 356,000 persons, the estimated daily amount of supply is:

$356{,}000$ persons x $96\ \ell/day/capita = 34{,}176\ m^3/day$

Of this, the amount of water available from the existing purification plant and production wells is:

From the existing purification plant	:	3,640 m^3/day
From the four existing production wells	:	4,914 m^3/day
Total		8,554 m^3/day

Accordingly, the required amount of water that must be newly developed is 25,622 m^3/day. Assuming that the pumps will be operated 12 hours a day, the required number of production wells was obtained from the above as follows:

$$n = \frac{25,622}{80 \times 12} = 27$$

The estimated population supplied in the Eastern district of Narayanganj Town is 114,000 persons, and the estimated daily amount of water supply is:

114,000 persons x 96 ℓ/day/capita = 10,944 m^3/day

As the existing purification plant and production wells in the Eastern district are remarkably aged and their use in the new plan is judged inappropriate, it was assumed that all of the estimated daily amount of water supply would be newly developed. As with the Western district, pumps were assumed to be operated 12 hours a day, and the required number of production wells was calculated as follows:

$$n = \frac{10,944}{100 \times 12} = 10$$

3. Layout of Production Wells

The radius of the sphere of influence of well in Narayanganj Town was determined as follows based on the results of the hydrogeological study.

In the Western district: R = 400 m
In the Eastern district: R = 1,100 m

In order to avoid mutual interference, the production wells must be spaced wider apart than the sphere of influence and laid out as shown in Fig. A-5-1.

4. Method of Conveying Water

The method of conveying water from the production wells to the overhead tank installed within town is determined according to the locations of each well relative to the overhead tank. The following are some of the methods available:

(1) Method of conveying water from each well through the independent pipeline
(2) Method of merging the conveyance pipes from each well en route
(3) Method of collecting water from each well into a gathering well from which water is pumped up and conveyed to the overhead tank

In the Western district of Narayanganj Town, 27 new production wells will have to be constructed. As has been stated already, a water supplying system already exists in the Western district. When the method of conveying water is studied on the basis of the location of each production well relative to the overhead tank and also with consideration to the above water supplying system and the distribution pattern of the population supplied, Figs. A-5-3/4 result. In case where the number of conveyance pipes to the overhead tank is small or the pipes run in different directions, water from each production well is to be conveyed independently, and in case where the number of wells per overhead tank is large and the production wells are remote from the overhead tank, it seems preferable to collect water into a gathering well once, then pump up again and convey to the overhead tank. The method of conveying water to the overhead tank while merging the conveyance pipes from each production well en route requires complicated mechanism in preventing backlash when the well pump is stopped and in controlling pump operation when the overhead tank is filled up, and is therefore considered inappropriate for the current level of operating technique in Bangladesh. Accordingly, it was decided that water should be conveyed by the proper combination of the methods (1) and (3) in this plan.

5. Facilities Plan

(1) Production well: According to the results of hydrogeologic survey, the production wells to be newly installed shall be 180 m in depth, 150 mm in caliber and 30 m in strainer length as illustrated in Fig. A-5-5.
The number of production wells to be constructed will be 27 in the Western district and 10 in the Eastern district.

(2) Drawing pump: For the drawing pump of production well, multi-stage turbine pump produced in Bangladesh will be used. As the pumping rate per well is 80 m^3/hr in the Western district and 100 m^3/hr in the Eastern district, Model B8D pump will be adopted. The number of stage, motor output and other data of pump are as shown in Table A-5-1.

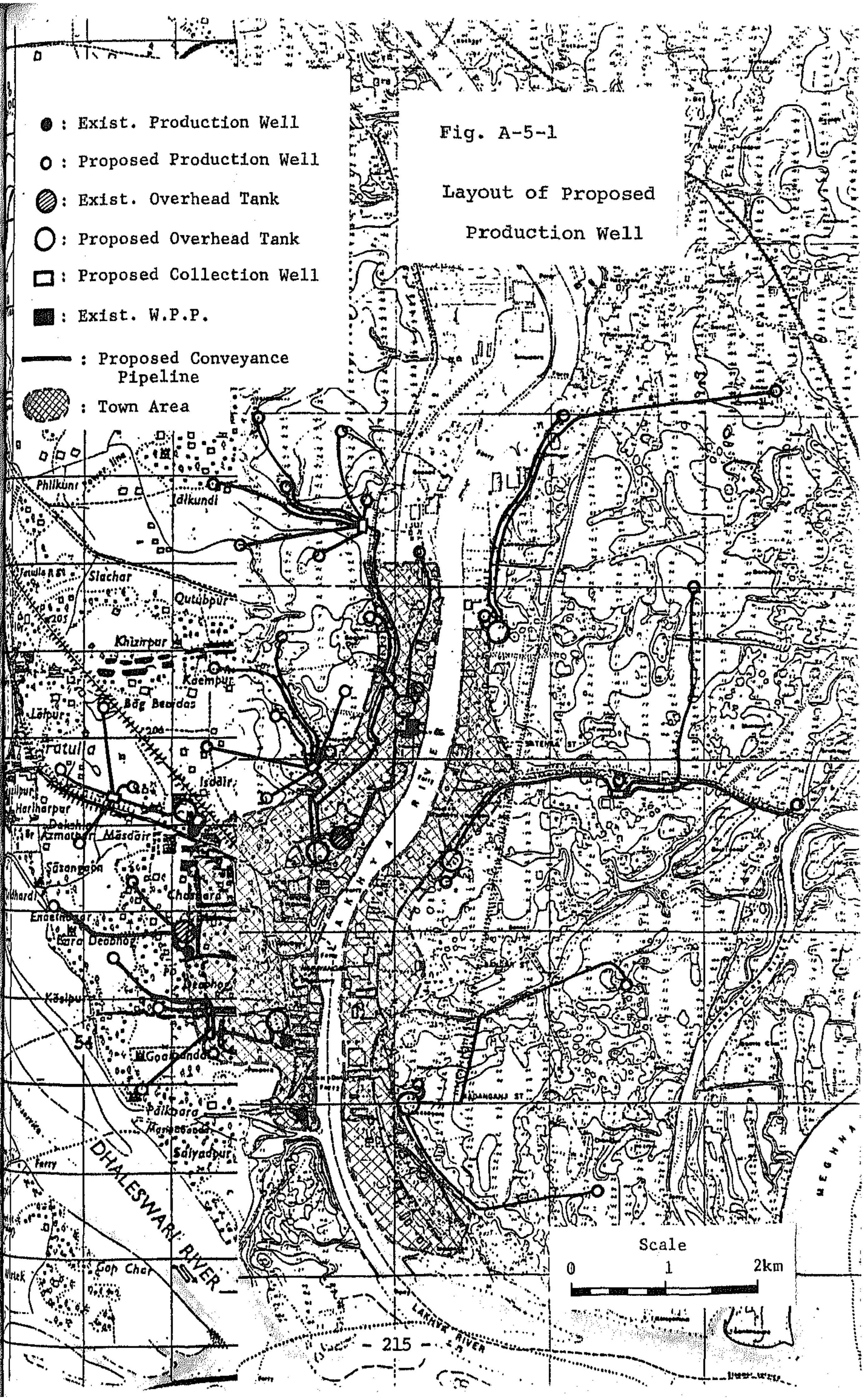


Fig. A-5-1

Layout of Proposed Production Well

Fig. A-5-2 Water Supply Network

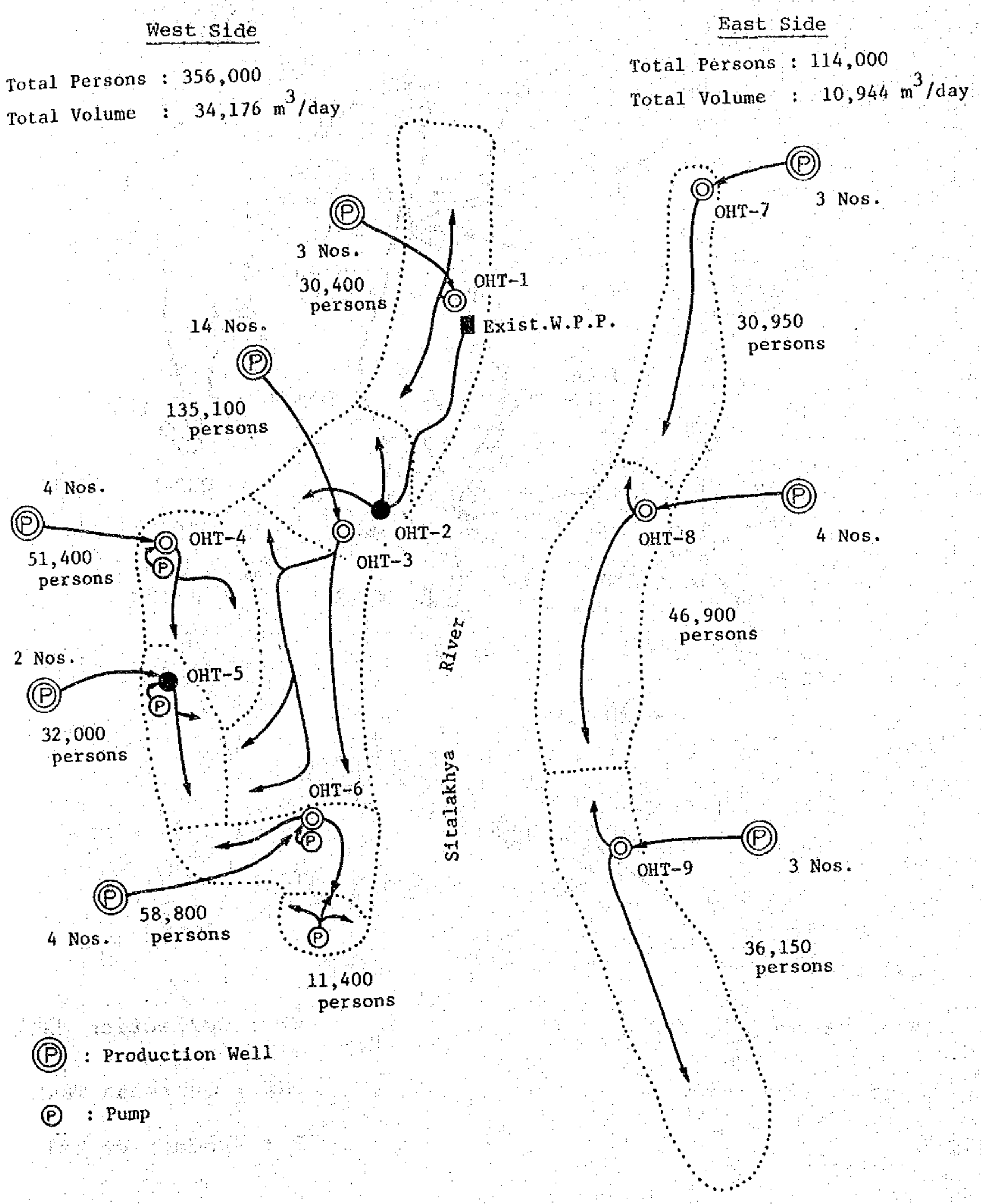
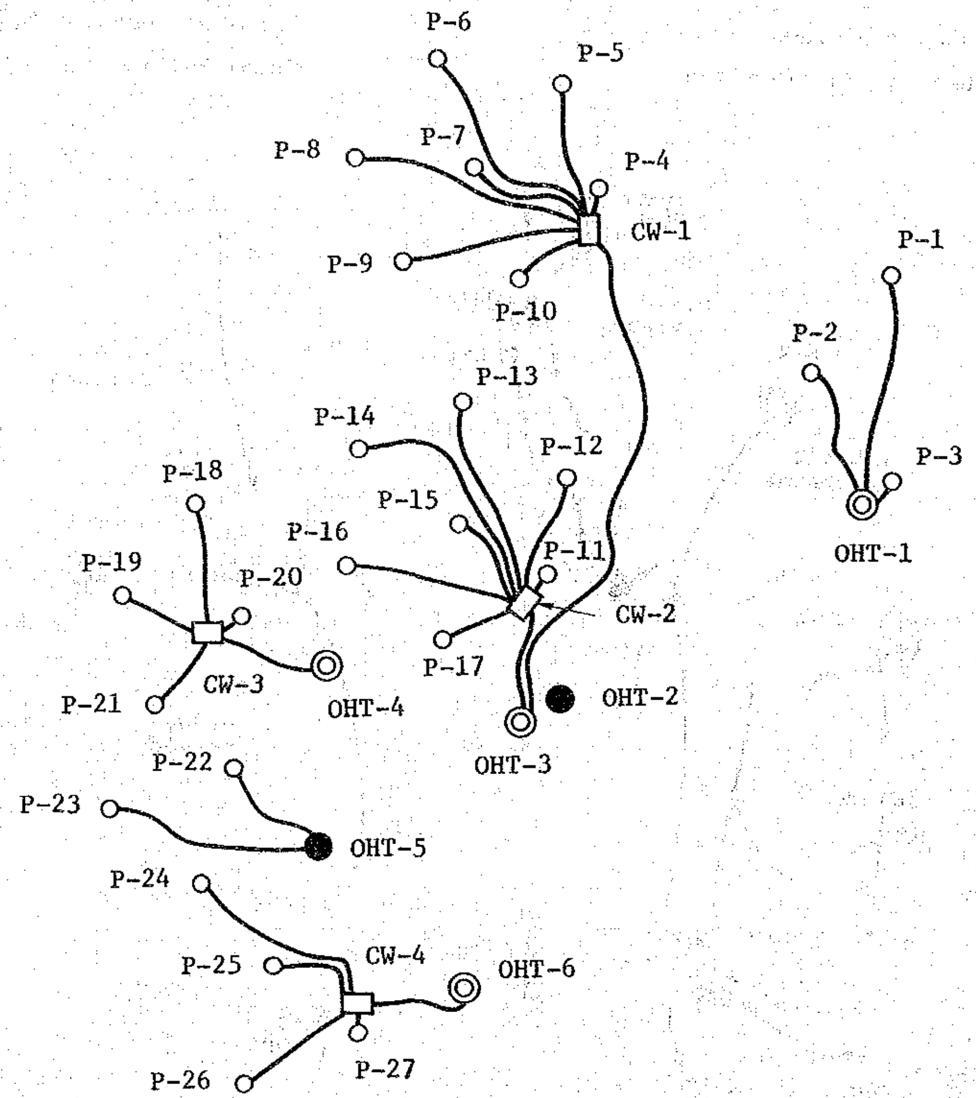


Fig. A-5-3 Layout of Proposed Production Well (West Side)



CW ; Collection Well

OHT ; Overhead Tank

P ; Production Well

Fig. A-5-4 Layout of Proposed Production Well (East Side)

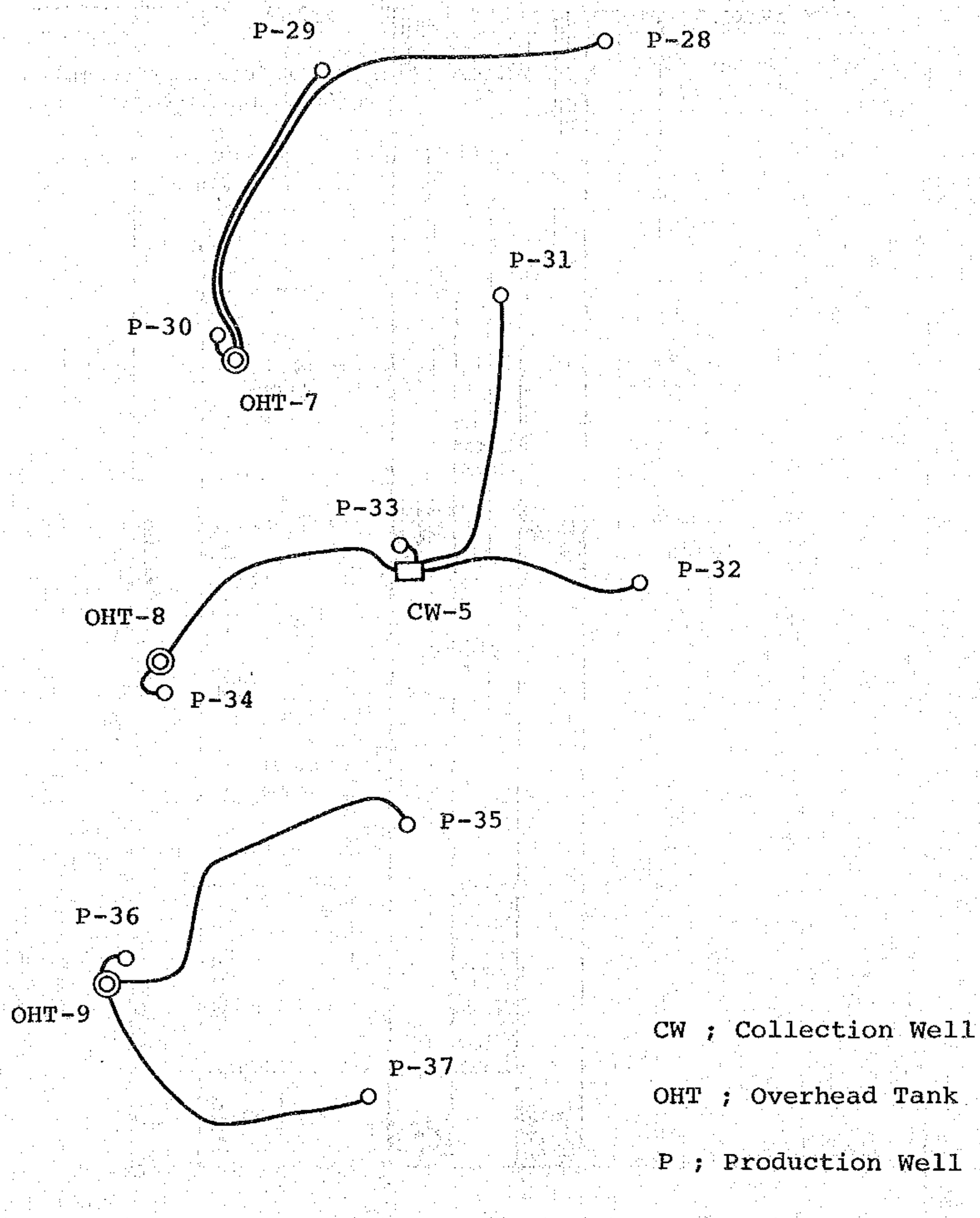
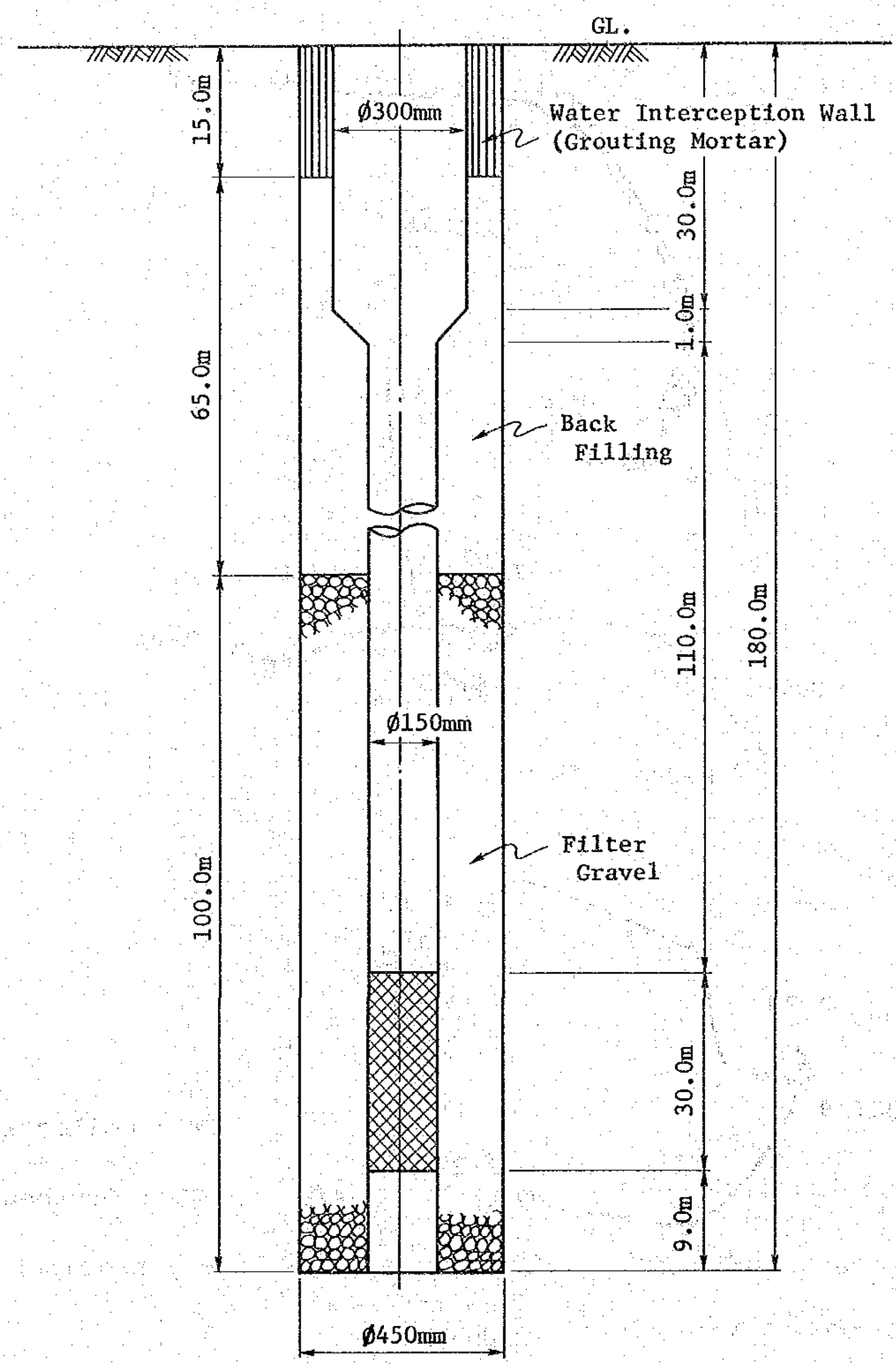


Fig. A-5-5 Profile of Proposed Production Well



80 m^3/hr = 22.2 ℓ/sec
100 m^3/hr = 27.8 ℓ/sec

Table A-5-1 Specifications of Intake Pumps of Production Wells to be digged anew

Well No.	Conveyance Pipe Ext'n (m)	Caliber (mm)	*1 Total Head (m)	Type	Stage	Motor Output (kW)	Remarks
P - 1	2,000	ø200	30.6	B8D	8	15	West
2	1,200	ø200	27.2	"	7	"	"
3	50	ø150	23.0	"	6	"	"
4	50	ø150	23.0	"	6	"	"
5	1,200	ø200	27.2	"	7	"	"
6	2,000	ø200	30.6	"	8	"	"
7	1,200	ø200	27.2	"	7	"	"
8	2,000	ø200	30.6	"	8	"	"
9	1,600	ø200	28.9	"	7	"	"
10	900	ø200	25.9	"	7	"	"
11	50	ø150	23.0	"	6	"	"
12	1,200	ø200	27.2	"	7	"	"
13	1,800	ø200	29.8	"	7	"	"
14	2,000	ø200	30.6	"	8	"	"
15	1,200	ø200	27.2	"	7	"	"
16	1,600	ø200	28.9	"	7	"	"
17	900	ø200	25.9	"	7	"	"
18	1,200	ø200	27.2	"	7	"	"
19	900	ø200	25.9	"	7	"	"
20	50	ø150	23.0	"	6	"	"
21	900	ø200	25.9	"	7	"	"
22	1,200	ø200	27.2	"	7	"	"

Well No.	Conveyance Pipe Ext'n (m) Caliber (mm)		*1 Total Head (m)	Type	Stage	Motor Output (kW)	Remarks
P - 23	1,800	ø200	29.8	B8D	7	15	West
24	2,000	ø200	30.6	"	8	"	"
25	1,200	ø200	27.2	"	7	"	"
26	1,200	ø200	27.2	"	7	"	"
27	50	ø150	23.0	"	6	"	"
P - 28	5,300	ø250	35.3	B8D	9	19	East
29	3,000	ø200	43.0	"	11	"	"
30	50	ø200	22.2	"	6	15	"
31	3,300	ø200	45.1	"	12	19	"
32	2,200	ø200	37.4	"	10	"	"
33	50	ø200	22.2	"	6	15	"
34	50	ø200	22.2	"	6	"	"
35	3,900	ø200	49.3	"	13	19	"
36	50	ø200	22.2	"	6	15	"
37	3,300	ø200	45.1	"	12	19	"

*1 The actual head is Ha = 22.0 m, from GL(-) 20 m to GL(+) 2.0 m.

Pipeline Length	Pump Total	Motor Total
ø250 - 5,300	B8D - 6 Stages - 9 Units	15 kW - 31 Units
	7 " - 17 "	
ø200 - 47,100	8 " - 5 "	19 kW - 6 "
	9 " - 1 Unit	
ø150 - 250	10 " - 1 "	
	11 " - 1 "	
Total: 52,650 m	12 " - 2 Units	
	13 " - 1 Unit	

(3) Gathering well: The size of gathering well shall be equivalent to the quantity of water conveyed in two hours, and the well shall concurrently serve as the priming water well of the feed pump to the overhead tank.

The required size, type of feed pump, caliber, motor output, etc. of each gathering well are as shown in Table A-5-2.

Table A-5-2 Principal Particulars of Gathering Well

G.Well No.	Qty Conveyed (m^3/hr)	Gathering well size			Conveyance Pipe Ext'n (m) Caliber (mm)	Feed Pump Particulars				
		Req'd size (m^3)	Design dimensions (m)	Design capacity (m^3)		Type	Total Head (m)	Caliber (mm)	Qty	Motor output (kw)
G-1	560	1,120	20x20x3	1,200	4,400m ø450	Vertical shaft mixed flow type	41.7	ø300	1	110
2	560	1,120	20x20x3	1,200	1,000m ø450	"	31.5	ø300	1	90
3	320	640	20x10x3	600	1,000m ø350	"	32.3	ø250	1	55
4	320	640	20x10x3	600	1,000m ø350	"	32.3	ø250	1	55
5	300	600	20x10x3	600	2,800m ø350	"	39.1	ø250	1	75

* The effective pump head shall be 21.5m + 5.0m (water depth) + 2.0m = 28.5m.

When ø=450mm, Q=560 m^3/hr., 3/1,000

When ø=350mm, Q=320 m^3/hr., 3.8/1,000

(4) Overhead tank: The overhead tank size shall be 20% of the estimated daily amount of water supply.
The size and other factors of each overhead tank are as shown in Table A-5-3.

Table A-5-3 Principal Partculars of Overhead Tank

O.Tank No.	No.of wells associated	Daily Qty., of water supply (m^3/day)	O.Tank capacity (m^3)	Structure		Remark
				Height (up to L.W.L)	Struc-ture	
S-1	New-3	2,918	583→ 600	*1 21.5m	RC	West
2	Purifi-cation plant	3,640	(900)	"	"	"
3	New-14	13,440	2,688→3,000	"	"	"
4	New-4 Exist.-1	4,920	984→1,000	"	"	"
5	New-2 Exist.-1	3,000	(680)	"	"	"
6	New-4 Exist.-1	5,472	1,094→1,000	"	"	"
7	New-3	3,600	720→ 700	"	"	East
8	New-4	4,800	960→1,000	"	"	"
9	New-3	3,600	720→ 700	"	"	"

*1 The height from GL to LWL.

2 RC means reinforced concrete construction.

3 Water from one existing well is directly conveyed into the pipe. (West) 90 m^3/hr.

(5) Patrol road: Production wells will be arranged along the existing roads within villages with due regards to the sphere of influence. However, as the number of roads is small and the suburbs of the town have low ground surface (of about 10 ft. in elevation) which would submerge under the water during the rainy season, roads which would not submerge even during the rainy season are necessary for the maintenance and control of installations.

If patrol roads are constructed along the water conveyance pipelines, it would be convenient for the control of pipelines, too. The current ground level in the suburbs of town is about 9 to 10 ft. (approximately 3 m) in elevation, and the flood level during the rainy season reaches as high as 20 ft. (6 m) or so. For the patrol roads, routes with relatively high ground level shall be chosen and banking of 2.0 m above the existing ground level be built.

The sectional view of the road shall be as illustrated below.

Fig. A-5-6 Typical Cross Section of Maintenance Road

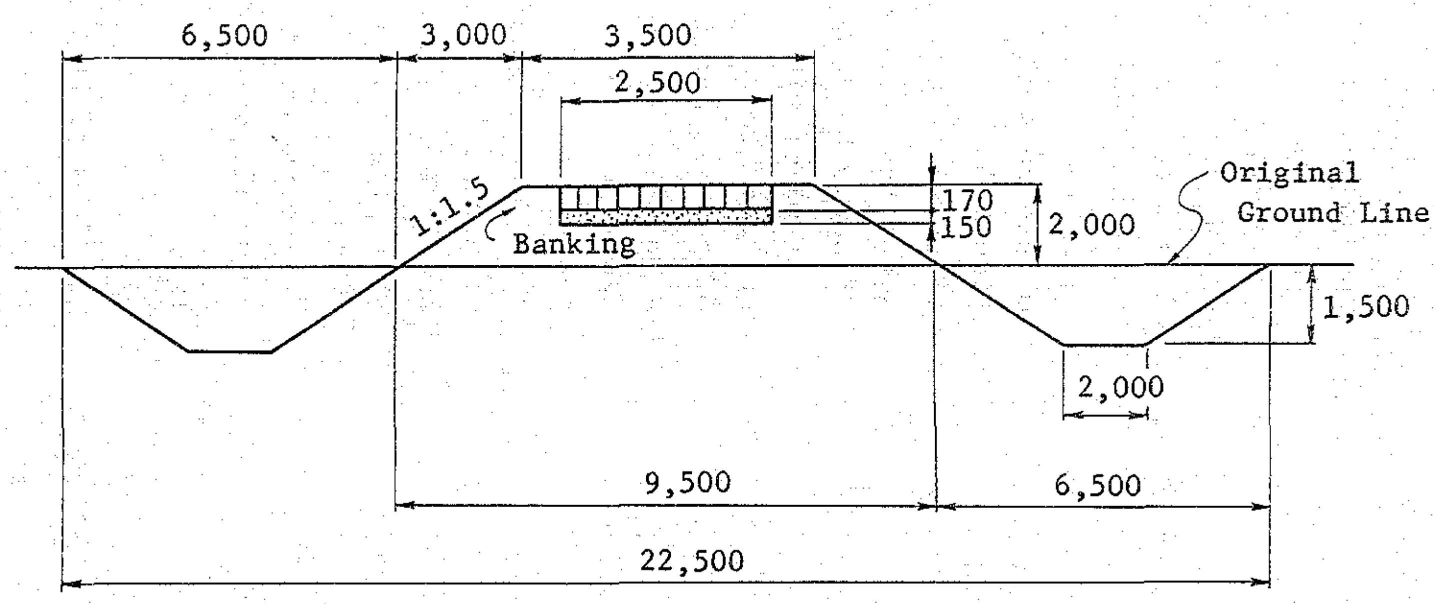


Fig. A-5-7 Layout of Operation and Maintenance Road

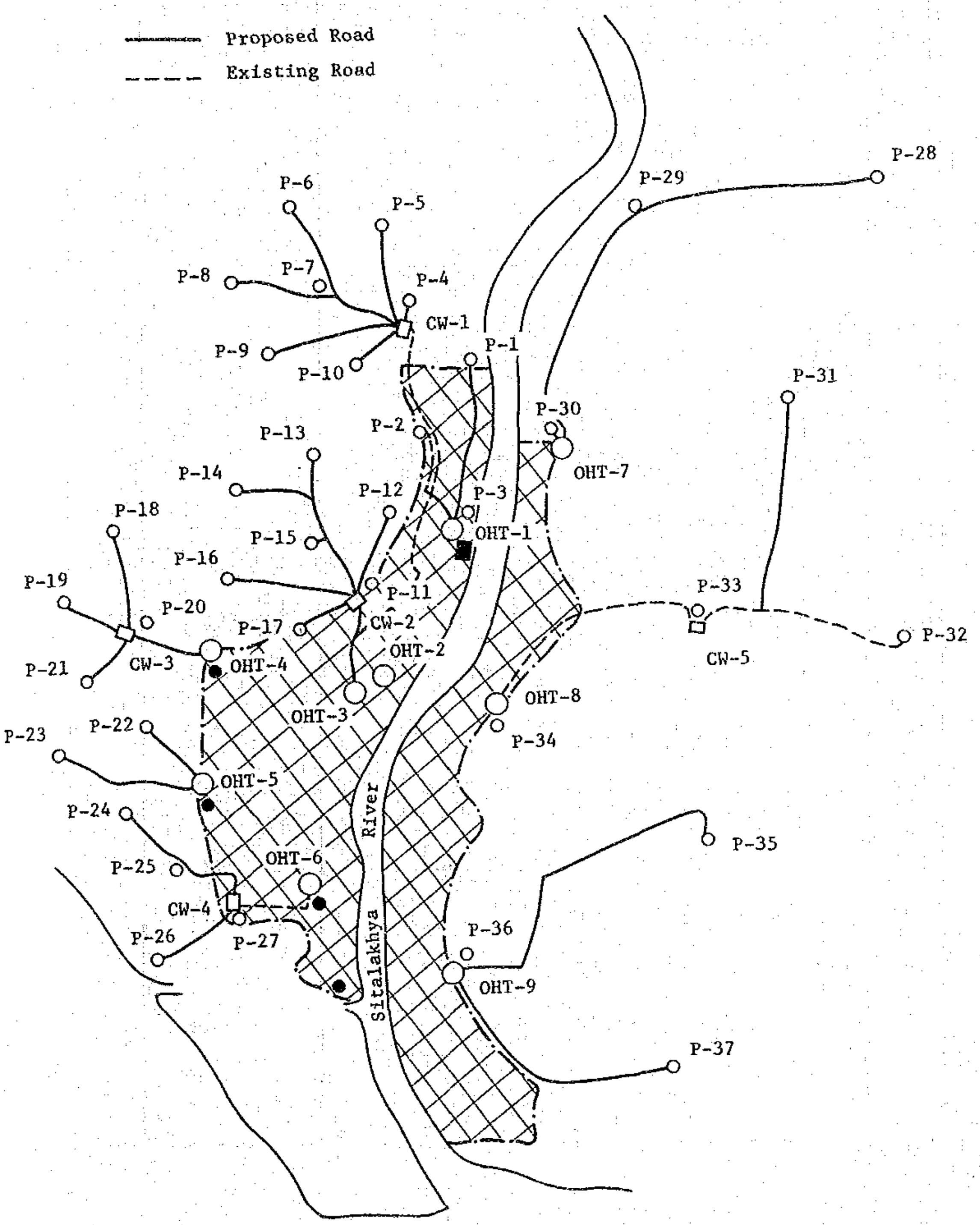


Table A-5-4 List of Patrol Roads

No.	Section	Length (m)	Remarks
1	P-1 ∿ Overhead tank 1	2,000	West
2	(P-2) Existing road ∿ Overhead tank 1	500	"
3	P-4 ∿ Collecting well 1	50	"
4	P-5 ∿ Collecting well 1	1,200	"
5	P-6 ∿ P-7 ∿ Collecting well 1	2,000	"
6	P-8 ∿ P-7	800	"
7	P-9 ∿ Collecting well 1	1,600	"
8	P-10 ∿ Collecting well 1	900	"
9	P-11 ∿ Collecting well 2	50	"
10	P-12 ∿ Collecting well 2	1,200	"
11	P-13 ∿ P-15 ∿ Collecting well 2	1,800	"
12	P-14 ∿ (P-13/P-15)	800	"
13	P-16 ∿ Collecting well 2	1,600	"
14	P-17 ∿ Collecting well 2	900	"
15	(Collecting well 1) Existing road ∿ (Collecting well 2/Overhead tank 3)	1,100	"
16	Collecting well 2 ∿ Overhead tank 3	1,000	"
17	P-18 ∿ Collecting well 3	1,200	"
18	P-19 ∿ Collecting well 3	900	"
19	P-20 ∿ Collecting well 3	50	"
20	P-21 ∿ Collecting well 3	900	"

No.	Section	Length (m)	Remarks
21	Collecting well 3 ∿ Overhead tank 4	1,000	West
22	P-22 ∿ Overhead tank 5	1,200	"
23	P-23 ∿ Overhead tank 5	1,800	"
24	P-24 ∿ P-25 ∿ Collecting well 4	2,000	"
25	P-26 ∿ Collecting well 4	1,200	"
26	P-27 ∿ Collecting well 4	50	"
27	P-28 ∿ P-29 ∿ Overhead tank 7	5,300	East
28	P-30 ∿ Overhead tank 7	50	"
29	P-31 ∿ (P-33/P-32) Existing road	2,200	"
30	P-34 ∿ Overhead tank 8	50	"
31	P-35 ∿ Overhead tank 9	3,900	"
32	P-36 ∿ Overhead tank 9	50	"
33	P-37 ∿ Overhead tank 9	3,300	"
	Total	42,650 m	

(6) Power transmission line and substation: Refer to Fig. A-5-8, Planimetric View of the Power Transmission Line.

Fig. A-5-8 Layout of Power Line

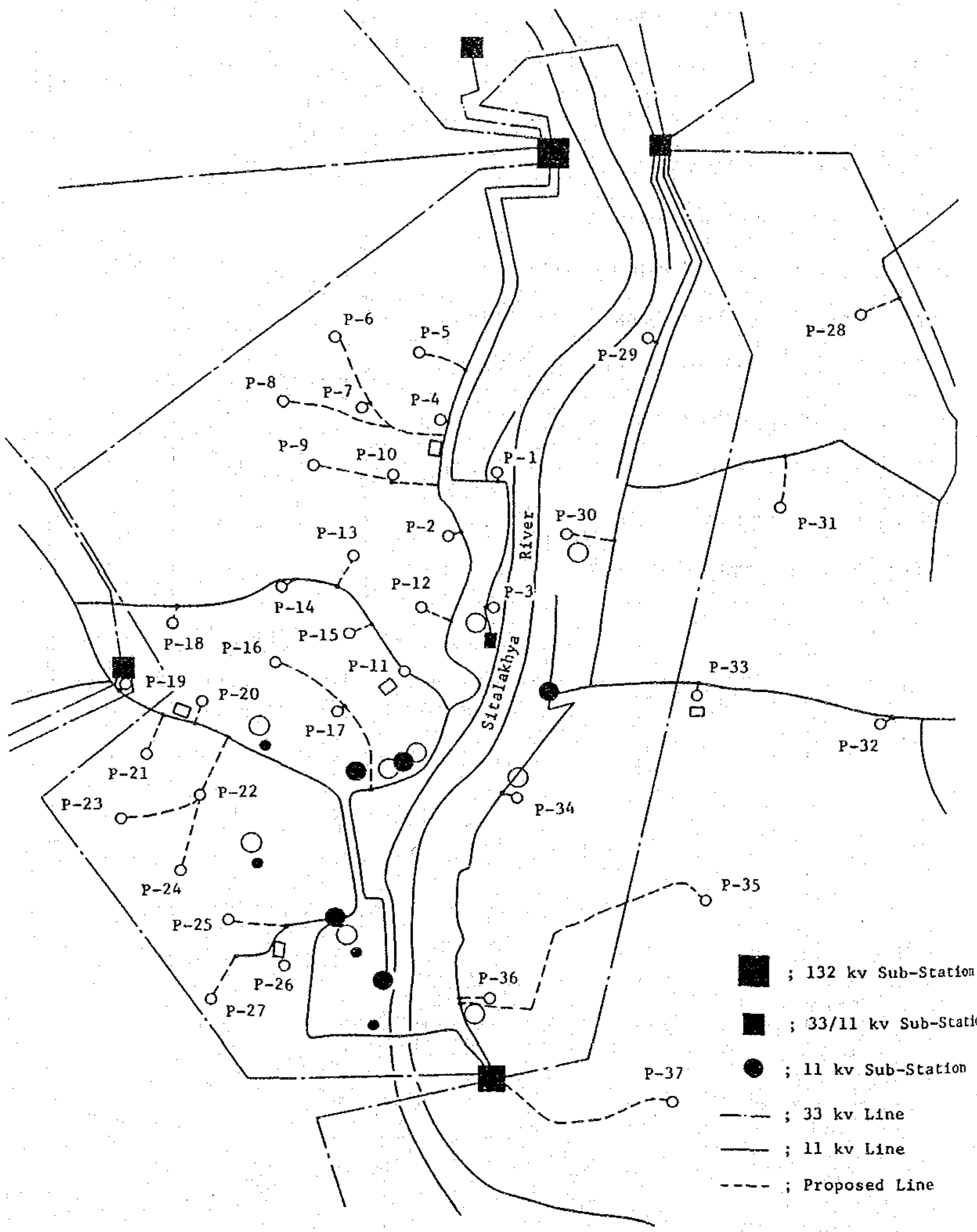


Table A-5-5 Length of Transmission Lines, Power-receiving Facilities and Substations

Pump No.	Length (m)	Power-receiving & Substation Facilities	Pump No.	Length (m)	Power-receiving & Substation Facilities
P - 1	100	○	P - 23	2,000	○
2	100	○	24	900	○
3	100	○	25	800	○
4	100	○	26	500	○
5	700	○	27	200	○
6	2,000	○	28	700	○
7	100	○	29	200	○
8	1,200	○	30	500	○
9	1,500	○	31	700	○
10	100	○	32	100	○
11	100	○	33	100	○
12	400	○	34	100	○
13	400	○	35	3,500	○
14	100	○	36	100	○
15	200	○	37	2,300	○
16	1,800	○			
17	100	○			
18	100	○			
19	100	○			
20	300	○			
21	600	○			
22	100	○			

(7) Iron removal device: All of the results of water quality tests conducted on test wells this time satisfied the water quality standards of WHO. However, since the test was conducted only on one spot each in the East and West this time, it is impossible to render any judgement on the water quality of the entire area.

The results of water quality tests in test drilling conducted by DPHE in the past are as presented in Table 4-2-1. [The locations of these test drillings, however, cannot be accurately entered on the map. (Even the DPHE staff in charge say that they cannot identify the spots.)].

According to above data, iron contents were high in a fairly large number of places. Test drilling was conducted in the suburbs some distance from the town this time, and iron contents were found to be 0.5 ppm and 0.19 ppm, both of which are below standards. Judging from these, it is conceivable that iron contents in the wells close to the town may be high. In such an event, it is necessary to plan for the iron removal device.

6. Maintenance and Administration Expenses
(The Well Alternative)

(1) Maintenance and Administration Organization

The maintenance and administration organization shall be as shown in Fig. A-5-9.

(2) Maintenance and Administration Expenses

The breakdown of the maintenance and administration expenses is as follows:

1)	Personnel expenses	222,900	TK/month
2)	Office supplies	1,500	
3)	Automotive fuels 600 ℓ x 17.5 TK/ℓ	10,500	
4)	Maintenance expense of buildings	1,500	
5)	Operating expense of pumps	1,105,650	
6)	Cost of chemicals	0	
7)	Expendable supplies for pumps, etc. (5% of 5) above)	55,300	
	Total	1,397,350	TK/month

(Breakdown of personnel expenses, the Well Alternative)

1.	Superintendent	1 x 4,500	TK/month	=	4,500 TK/month
2.	Chief Engineer / Chief Officer	3 x 3,500	"	=	10,500
3.	Section Chief	8 x 2,000	"	=	16,000
4.	Engineer/Officer	9 x 1,500	"	=	13,500
5.	Asst. Engineer/Pump Driver	112 x 900	"	=	100,800
6.	Asst. P.D./Asst.	92 x 800	"	=	73,600
7.	Typist	1 x 1,500	"	=	1,500
8.	Pion (odd jobs)	5 x 500	"	=	2,500
	Total	231 persons			222,900 TK/month

(Operating expense of pumps)

1. Total output

   (1) 4 existing wells

   11 kW + 22 kW + 26 kW + 22 kW = 81 kW

   (2) West, pump house group

   15 kWx27 + 110 + 90 + 55x2 = 715 kW

   (3) West, existing purification plant

   25 kWx2 + 60 kWx2 = 170 kW

   (4) East, pump house group

   15 kWx4 + 19x6 + 75 = 249 kW

   Total 1,215 kW

2. Basic charges

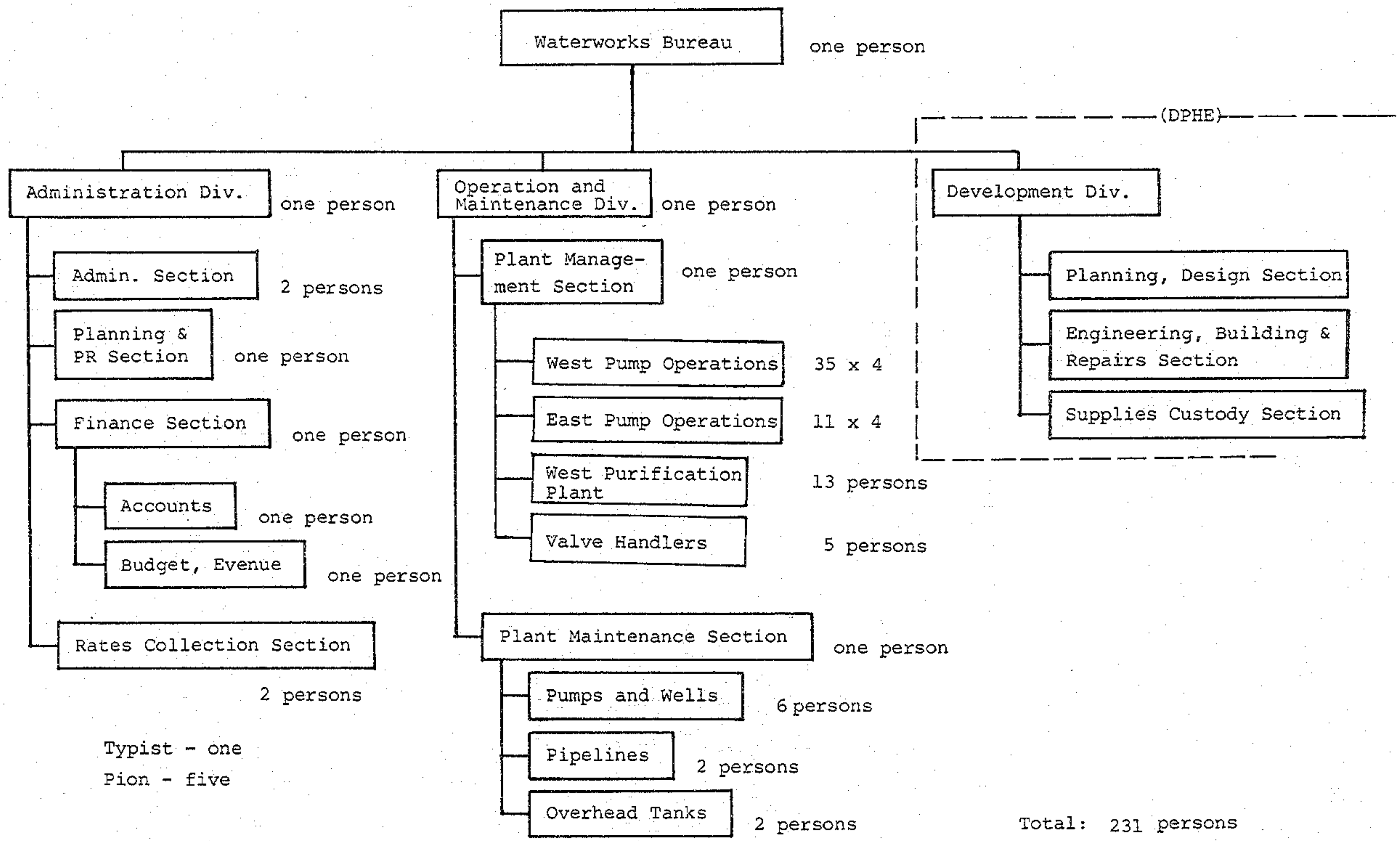
   1,215 kW x 10 TK/kW/month = 12,150 TK/month

3. Usage charges

   1,215 kW x 12 hr x 30 day x 2.5 TK/kWh
   = 1,093,500 TK/month

4. Total 1,105,650 TK/month

Fig. A-5-9 Proposed Maintenance and Supervision Organization (Well Alternative)



ANNEX VI COMPARISON OF WATER SOURCES

(Skeleton Design of the Purification Plant Alternative)

ANNEX VI Skeleton Design of the Purification Plant Alternative

1. The Water Supplying System of the Purification Plant Alternative

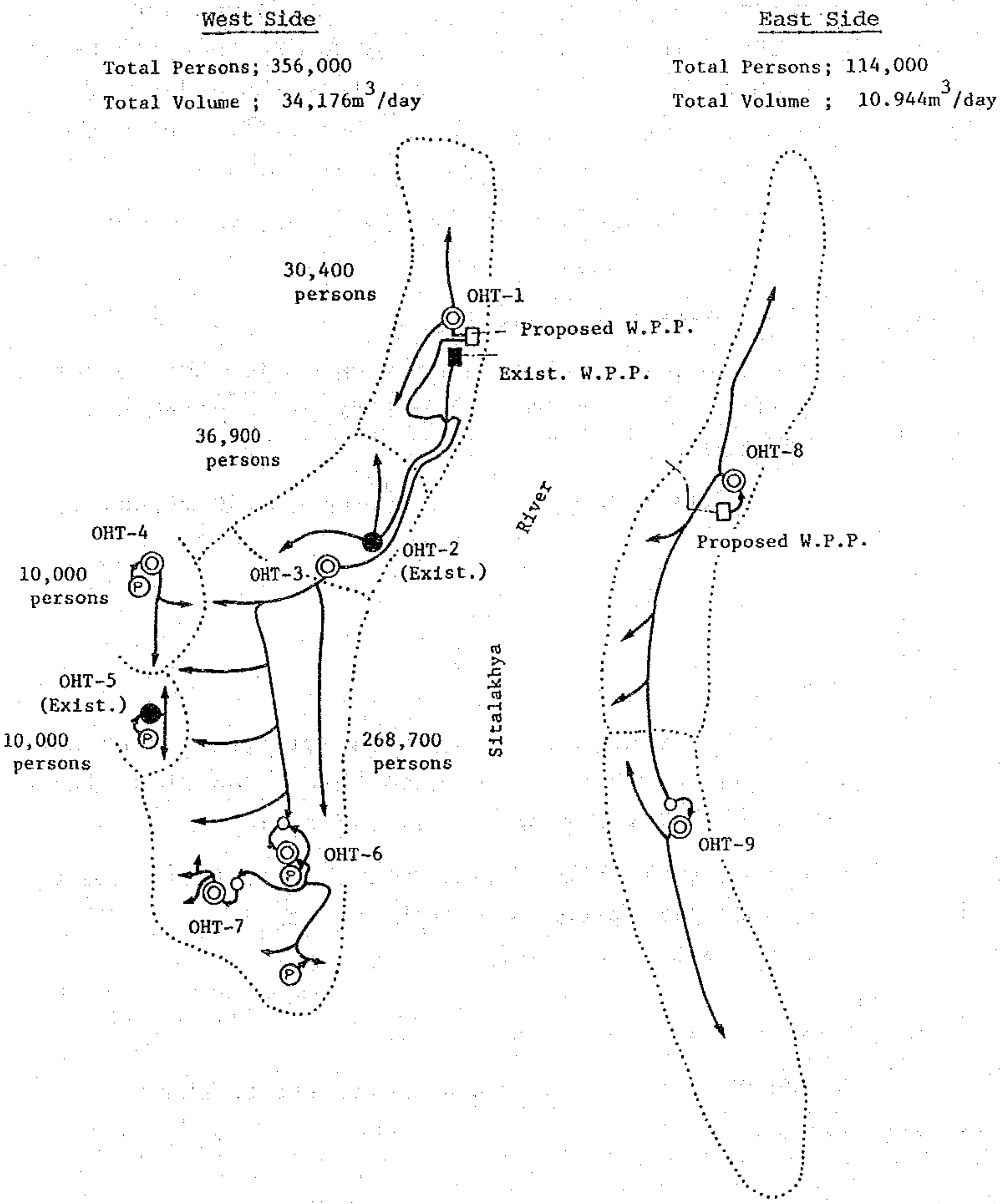
The existing water supplying system is as stated in the paragraph on the Well Alternative. The new purification plant is planned to be constructed next to the existing purification plant which is located on the north of the town. The site has already been acquired by DPHE.

The spheres of water supply in the neighborhood of the purification plant and from the existing purification plant in the west side of Narayanganj Town are the same as in the Well Alternative. Water from the new purification plant will be conveyed to the overhead tank planned on the north of the Town center and will be distributed from the tank to the central zone of the town by gravity flow. As the hydraulic pressure will become insufficient at the terminal ends of the central zone of the town, water will be pumped up to the overhead tank once again and then distributed. Wells located in the west side of the town which are still usable will be used for supplying water to the inhabitants in the neighborhood of each well.

As the town has been developed along the Sitalakhya River in the Eastern district of Narayanganj Town, a new purification plant will be constructed on the north of the center of the town, and the distributing pipeline will be laid along the road of the town. As the hydraulic pressure will become insufficient in the south side of the town, an overhead tank will be erected there to pump up water once again and distribute water from there.

The planimetric view of the water supplying plan under the purification plant alternative is as shown in Fig. A-6-1.

Fig. A-6-1 Water Supply Network



2. Size of the Purification Plants

The size of the purification plants will be as follows:

(1) Western district

As has been already stated in the paragraph on the Well Alternative, the quantity of water which must be newly developed is 25,622 m^3/day. Assuming that the purification plant will be operated 15 hours a day and captive consumption of water at the plant will be 10%, the size of the plant shall be as follows:

$$25{,}622 \ m^3/day \times 1.1 \times \frac{24}{15} = 45{,}095 \ m^3/day$$

(2) Eastern district

Along the same line of reasoning as for the Western district, the size of the purification plant shall be as follows:

$$10{,}944 \ m^3/day \times 1.1 \times \frac{24}{15} = 19{,}260 \ m^3/day$$

3. Facilities plan

(1) Purification plant

Since the details of facilities for intake work to the main report, they are omitted here. The flow within the purification plant is as follows:

Intake work →Receiving well →Flocculation basin →Coagulation basin →Rapid filter → Clear water reservoir

(2) Plan for overhead tank

The capacities of overhead tanks are as shown in Table A-6-1.

Table A-6-1 List of Overhead Tanks

O.Tank No.	Daily amount of water supply (m^3/day)	O. Tank Capacity m^3	Structure		Remarks
			Height	Structure	
S - 1	2,918	583 → 600	21.5 m	R.C.	West
2	3,640	Exist. (900)	"	"	"
3	25,795	(5,159) 4,000	"	"	"
4	960	192 → 300	"	"	"
5	960	Exist. (680)	"	"	"
6	incl. in 3.	1,000	"	"	"
7	incl. in 3.	300	"	"	"
8	5,472	1,094 → 1,000	"	"	East
9	5,472	1,094 → 1,000	"	"	"

(Note) RC : Reinforced concrete

4. Maintenance and Administration Expenses
(for the Purification Plant Alternative)

(1) The maintenance and administration organization is shown in Fig. A-6-2.

(2) The maintenance and administration expenses

The breakdown is as follows:

1)	Personnel expenses	178,100 TK/month
2)	Office supplies	1,500
3)	Automotive fuels 300 ℓ x 17.5 TK/ℓ = 5,250	
4)	Maintenance expense of buildings	1,500
5)	Operating expense of purification plant and pumps	918,896
6)	Cost of chemicals	149,085
7)	Expendable supplies for pumps, etc. (5% of 5) above)	46,000
	Total	1,300,331 TK/month

(Breakdown of personnel expenses)

1. Superintendent
   1 x 4,500 TK/month = 4,500 TK/month
2. Chief Engineer 1
   Chief Officer 1
   Purification Plant Manager 2
   4 x 3,500 TK/month = 14,000
3. Section Chief
   4 x 2,500 " = 10,000
4. Section Chief
   15 x 2,000 " = 30,000
5. Engineer/Officer
   39 x 1,500 " = 58,500

6. Asst. Engineer/Pump Driver
19 x 900 TK/month = 17,100 TK/month
7. Asst. P. Driver/Asst.
50 x 800 " = 40,000
8. Typist 1 x 1,500 " = 1,500
9. Pion (odd jobs)
5 x 500 " = 2,500

Total 178,100 TK/month

(Operating expenses for purification plants and well pumps)

1. Total output

(1) 4 existing wells
11 kW + 22 kW + 26 kW + 22 kW = 81 kW
(2) West, purification plant
45kWx2 + 75 kWx4 + 30 kW + 5.5 kW
= 425.5 kW
(3) West, existing purification plant
25 kWx2 + 60 kWx2 = 170 kW
(4) Around No. 4 and No. 5
3.7 kWx2 + 15 kWx2 = 37.4 kW
(5) East, purification plant
30 kWx2 + 5.5 kWx2 + 2.7 kW
x1 + 11 kWx2 = 95.7 kW

Total 809.6 kW

2. Basic charges
809.6 kWx10 TK/kW/month = 8,096 TK/month

3. Usage charges for power consumed
809.6 kW x 15 hr x 30 days x 2.5 TK/kWh
= 910,800 TK/month

4. Total = 918,896 TK/month

(Cost of chemicals)

1. Chemicals used

(1) Aluminium sulfite

West purification plant

0.735 m³/day x 5% ÷ 17% x 30 days = 6,485 kgs.

Existing purification plant

0.104 m³/day x 5% ÷ 17% x 30 days = 917 kgs.

East purification plant

0.375 m³/day x 5% ÷ 17% x 30 days = 3,044 kgs.

Total 10,446 kgs.

(2) Bleaching powder

West purification plant

$0.256\ m^3/day \times 2\ ppm \times \frac{10}{60} \times 30\ days = 2,560\ kgs.$

Existing purification plant

$0.030\ m^3/day \times 2\ ppm \times \frac{10}{60} \times 30\ days = 300\ kgs.$

East purification plant

$0.109\ m^3/day \times 2\ ppm \times \frac{10}{60} \times 30\ days = 3,950\ kgs.$

2. Cost of chemicals

Aluminium sulfite

10,446 kgs x 5.73 TK/kg = 59,855 TK/month

Bleaching powder

3,950 kgs x 22.59 TK/kg = 89,230 TK/month

Total 149,085 TK/month

Fig. A-6-2 Proposed Maintenance and Supervision Organization

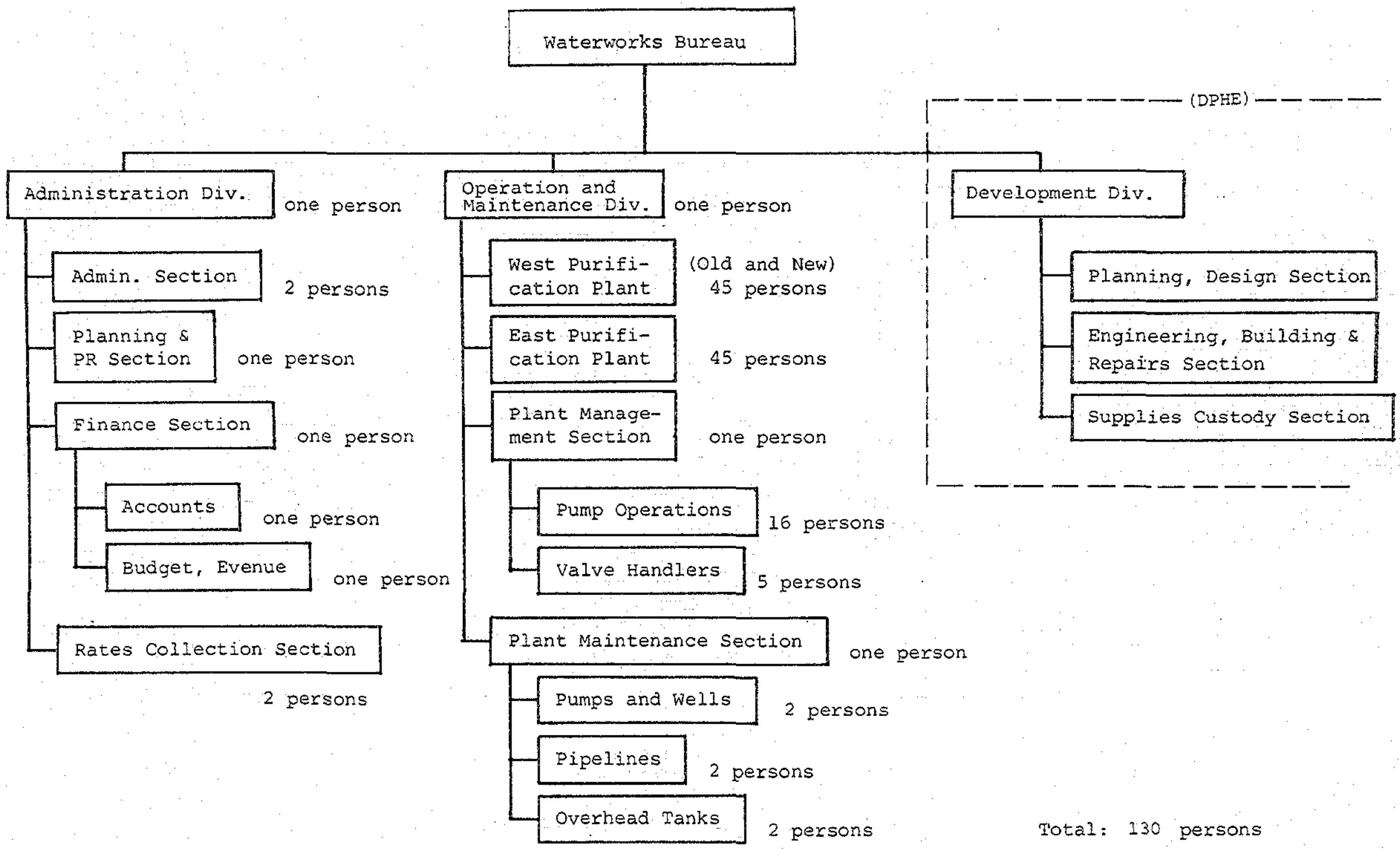
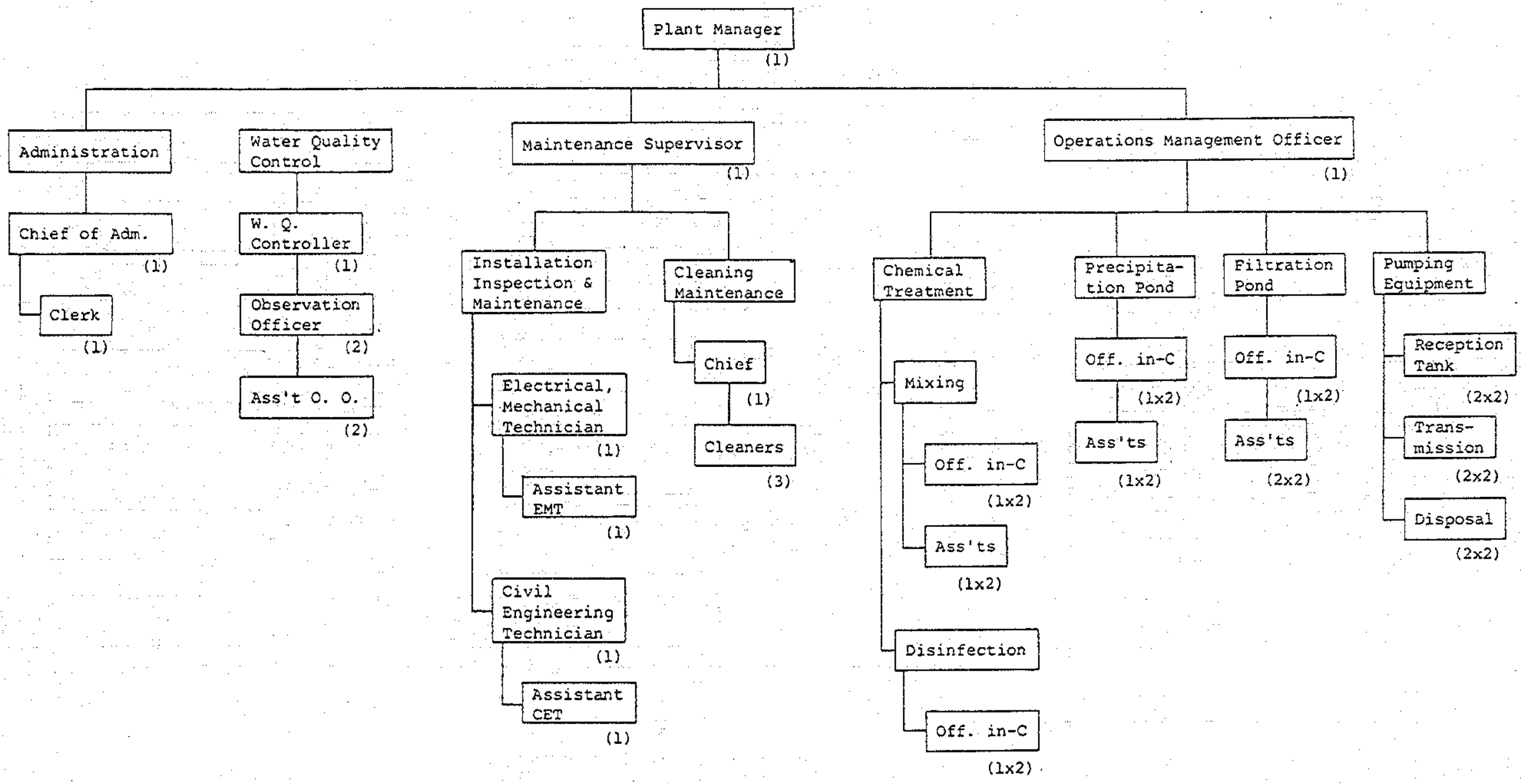


Fig. A-6-3 Organizational Chart of Purification Plant



Notes: Former working house -- 15 hours, 2 shifts
No. of staff -- 45 persons
Figure in ( ) is number of person required.

ANNEX VII REVIEW ON THE ESTIMATED AMOUNT OF WATER SUPPLY

Annex VII Review on the Estimated Amount of Water Supply

Following values are the estimated amount of water supply adopted for this plan.

Description	Water Consumption	Ratio to Population
(1) House connection	113.7 ℓ/head/day	50% (80%)
(2) Public post	34 "	50% (20%)
(3) Leakage & other losses	30% of the sum of (1) and (2)	

From the above table, the mean water consumption per head per day for the population would be as follows:

Portion supplied through house connection:
113.7 ℓ/head/day x 50% = 56.8 ℓ/day

Portion supplied through public post:
34 ℓ/head/day x 50% = 17 ℓ/day

Lost water:
(56.8 + 17) x 30% = 22.1 ℓ/day

Total 95.9 ≑ 96 ℓ/day

Accordingly, the quantity of water supply in this plan was calculated on the basis of 96 ℓ/day per capita.

We consider that the estimated amount of water supply adopted as above can be broken down as follows.

1. Using the breakdown of the estimated amount of water supply under the projects which are being implemented by the assistance of ADB and the Government of Netherlands, following breakdown was assumed.

(1) Domestic water (ordinary households and public posts)

House connection 75 ℓpcd*

Public post 28 ℓpcd

20 ℓpcd x $(1 + \alpha)$

α was assumed to be α = 40% in view of particularly heavy losses due to breakdown and other failures of public posts.

* PCD = per capita per day

(2) Non-domestic water

(Non-domestic water is the amount of water used in restaurants, hospitals, schools, government offices, shops and domestic industries. Installations such as factories and research institutions have their own water supplying facilities.)

(3) Loss of water due to leakage and other reasons

((1) + (2) x 30%)

2. If we assume that 50% of the population will be supplied with water through house connections and another 50% of the population through public posts, the mean water consumption per head per day for the population would be as follows:

(1) Water supplied through house connections:

75 ℓ/day x 0.5 = 37.5 ℓ/day

(2) Water supplied through public posts:

28 ℓ/day x 0.5 = 14.0 ℓ/day

Sub-total 51.5 ℓ/day

(3) Non-domestic water

51.5 x 0.4 = 20.6 ℓ/day

(4) Lost water

(51.5 + 20.6) x 0.3 = 21.63 ℓ/day

(5) Total 93.73 ≒ 96 ℓ/day

The above is approximately identical with the value calculated from the estimated amount of water supply which was adopted for the plan.

3. The estimated amount of water supply which was adopted for the plan is assumed to include the amount of water used by restaurants, hospitals, schools, shops, domestic industries and so forth.

ANNEX VIII RESULTS OF HYDRAULIC CALCULATIONS OF PIPELINE NETWORK

Hydraulic Calculation

< LOW WATER LEVEL > = 28.1

NO	Line No.	Point No.	C	L	D	Q	V	I	L*H	SUM-H	WL	GL	EH
101	0	14	110	750.00	0.600	238.23	0.84	1.511	1.133	1.98	26.12	6.09	20.03
102	601	13	110	360.00	0.300	42.73	0.60	1.839	0.662	2.64	25.46	5.78	19.68
103	201	13	110	550.00	0.600	-222.31	0.79	1.329	-0.731	2.64	25.46	5.78	19.68
104	0	12	110	250.00	0.600	-264.77	0.94	1.837	-0.459	1.91	26.19	6.04	20.15
105	0	11	110	180.00	0.600	-269.77	0.95	1.902	-0.342	1.45	26.65	6.15	20.50
106	0	10	110	130.00	0.600	-278.67	0.99	2.020	-0.263	1.11	26.99	6.36	20.63
		* * * SIGMA H = 0 * * *											
201	103	13	110	550.00	0.600	222.31	0.79	1.329	0.731	2.64	25.46	5.78	19.68
202	501	36	110	130.00	0.300	53.04	0.75	2.744	0.357	3.00	25.10	6.30	18.80
203	401	37	110	220.00	0.200	19.13	0.61	2.995	0.659	3.66	24.44	6.45	17.99
204	301	37	110	530.00	0.200	-14.61	0.47	1.821	-0.965	3.66	24.44	6.45	17.99
205	0	38	110	290.00	0.200	-18.07	0.58	2.696	-0.782	2.69	25.41	6.58	18.83
		* * * SIGMA H = -0.00003 * * *											
301	204	37	110	530.00	0.200	14.61	0.47	1.821	0.965	3.66	24.44	6.45	17.99
302	408	41	110	640.00	0.150	4.64	0.26	0.885	0.567	4.22	23.88	6.30	17.58
303	0	41	110	380.00	0.200	-15.45	0.49	2.019	-0.767	4.22	23.88	6.30	17.58
304	0	40	110	320.00	0.200	-17.65	0.56	2.583	-0.826	3.46	24.64	6.30	18.34
305	0	38	110	550.00	0.200	3.25	0.10	0.113	0.062	2.69	25.41	6.58	18.83
		* * * SIGMA H = -0.00006 * * *											
401	203	37	110	220.00	0.200	-19.13	0.61	2.995	-0.659	3.66	24.44	6.45	17.99
402	506	35	110	550.00	0.250	28.31	0.58	2.087	1.148	4.15	23.95	6.30	17.65

NO	Line No.	Point No.	C	L	D	Q	V	I	L*H	SUM-H	WL	GL	EH
403	505	34	110	300.00	0.200	12.81	0.41	1.427	0.428	4.58	23.52	6.30	17.22
404	701	44	110	380.00	0.250	31.46	0.64	2.537	0.964	5.54	22.56	6.30	16.26
405	0	44	110	170.00	0.250	-21.20	0.43	1.222	-0.208	5.54	22.56	6.30	16.26
406	0	43	110	50.00	0.250	-32.30	0.66	2.663	-0.133	5.33	22.77	6.30	16.47
407	0	42	110	510.00	0.200	-15.00	0.48	1.910	-0.974	5.20	22.90	6.30	16.60
408	302	41	110	640.00	0.150	-4.64	0.26	0.885	-0.567	4.22	23.88	6.30	17.58
		* * * SIGMA H = -0.00008 * * *											
501	202	36	110	130.00	0.300	-53.04	0.75	2.744	-0.357	3.00	25.10	6.30	18.80
502	604	16	110	490.00	0.500	182.29	0.93	2.238	1.097	3.74	24.36	5.96	18.40
503	801	33	110	180.00	0.400	73.87	0.59	1.248	0.225	3.96	24.14	5.96	18.18
504	702	34	110	220.00	0.250	33.06	0.67	2.780	0.612	4.58	23.52	6.30	17.22
505	403	34	110	300.00	0.200	-12.81	0.41	1.427	-0.428	4.58	23.52	6.30	17.22
506	402	35	110	550.00	0.250	-28.31	0.58	2.087	-1.148	4.15	23.95	6.30	17.65
		* * * SIGMA H = -0.00003 * * *											
601	102	13	110	360.00	0.300	-42.73	0.60	1.839	-0.662	2.64	25.46	5.78	19.68
602	0	15	110	450.00	0.500	152.40	0.78	1.607	0.723	2.70	25.40	6.12	19.28
603	901	16	110	300.00	0.300	60.05	0.85	3.452	1.036	3.74	24.36	5.96	18.40
604	502	16	110	490.00	0.500	-182.29	0.93	2.238	-1.097	3.74	24.36	5.96	18.40
		* * * SIGMA H = -0.00001 * * *											
701	404	44	110	380.00	0.250	-31.46	0.64	2.537	-0.964	5.54	22.56	6.30	16.26
702	504	34	110	220.00	0.250	-33.06	0.67	2.780	-0.612	4.58	23.52	6.30	17.22
703	806	32	110	380.00	0.250	31.90	0.65	2.603	0.989	4.95	23.15	6.34	16.81

NO	Line No.	Point No.	C	L	D	Q	V	I	L*H	SUM-H	WL	GL	EH
704	805	31	110	110.00	0.250	18.60	0.38	0.960	0.106	5.06	23.04	6.34	16.70
705	804	30	110	110.00	0.250	11.90	0.24	0.420	0.046	5.10	23.00	6.34	16.66
706	951	51	110	490.00	0.350	63.14	0.66	1.788	0.876	5.98	22.12	6.45	15.67
707	0	45	110	110.00	0.300	42.54	0.60	1.824	0.201	6.18	21.92	6.30	15.62
708	0	45	110	760.00	0.250	-17.36	0.35	0.845	-0.642	6.18	21.92	6.30	15.62
		* * * SIGMA H = -0.00003 * * *											
801	503	33	110	180.00	0.400	-73.87	0.59	1.248	-0.225	3.96	24.14	5.96	18.18
802	907	17	110	600.00	0.500	150.99	0.77	1.579	0.948	4.69	23.41	6.60	16.81
803	0	30	110	220.00	0.400	92.72	0.74	1.900	0.418	5.10	23.00	6.34	16.66
804	705	30	110	110.00	0.250	-11.90	0.24	0.420	-0.046	5.10	23.00	6.34	16.66
805	704	31	110	110.00	0.250	-18.60	0.38	0.960	-0.106	5.06	23.04	6.34	16.70
806	703	32	110	380.00	0.250	-31.90	0.65	2.603	-0.989	4.95	23.15	6.34	16.81
		* * * SIGMA H = -0.00001 * * *											
901	603	16	110	300.00	0.300	-60.05	0.85	3.452	-1.036	3.74	24.36	5.96	18.40
902	0	21	110	740.00	0.400	70.15	0.56	1.134	0.839	3.54	24.56	7.04	17.52
903	0	20	110	460.00	0.350	52.35	0.54	1.264	0.581	4.12	23.98	6.34	17.64
904	0	19	110	130.00	0.250	29.05	0.59	2.189	0.285	4.41	23.69	6.34	17.35
905	0	19	110	170.00	0.250	-4.25	0.09	0.063	-0.011	4.41	23.69	6.34	17.35
906	0	18	110	350.00	0.250	-41.55	0.85	4.245	-1.486	4.40	23.70	6.34	17.36
907	802	16	110	600.00	0.500	140.29	0.71	1.379	0.827	3.74	24.36	5.96	18.40
		* * * SIGMA H = -0.00001 * * *											
951	706	51	110	490.00	0.350	-63.14	0.66	1.788	-0.876	5.98	22.12	6.45	15.67

NO	Line No.	Point No.	C	L	D	Q	V	I	L*H	SUM-H	WL	GL	EH
952	0	29	110	300.00	0.300	39.29	0.56	1.575	0.473	5.58	22.52	6.30	16.22
953	0	49	110	270.00	0.250	31.49	0.64	2.542	0.686	6.26	21.84	6.30	15.54
954	0	49	110	440.00	0.200	-2.91	0.09	0.092	-0.040	6.26	21.84	6.30	15.54
955	0	50	110	110.00	0.200	-16.21	0.52	2.204	-0.242	6.22	21.88	6.45	15.43

* * * SIGMA H = 0 * * *

(West)

No. 1

Pipe-line net-work	Line	Dia-meter (mm)	Coeffi-cient of velocity	Dis-tance (m)	Cumu-lative dis-tance (m)	Dis charge (ℓ/s)	Hydrau-lic gradient (°/00)	Head loss h(m)	Cumu-lative head loss Σh(m)	Pres-sure head (m)	Grand height (m)	Effec-tive head (m)	Point
	-									LWL 27.18			
	0-66	300	110	50		68.1	4.35	0.21		26.97	5.70	21.2	66
	66-67	150	110	910		11.8	4.97	4.52		22.45	5.79	16.6	67
	67-68	150	110	660		5.1	1.05	0.69		21.76	6.30	15.4	68
	-									26.97			66
	66-69	300	110	660		56.3	3.06	2.01		24.96	6.06	18.9	69
	69-63	200	110	490		22.6	4.07	1.99		22.97	5.37	17.6	63
	63-62	200	110	510		11.5	1.16	0.59		22.38	7.91	14.4	62
	62-61	100	110	160		0.6	0.14	0.02		22.36	6.30	16.0	61
	-												
	-												
	-												
	-												

(West)

No. 2

Pipe-line net-work	Line	Dia-meter (mm)	Coeffi-cient of velocity	Dis-tance (m)	Cumu-lative dis-tance (m)	Dis-charge (ℓ/s)	Hydrau-lic gradient (°/00)	Head loss h(m)	Cumu-lative head loss Σh(m)	Pres-sure head (m)	Grand height (m)	Effec-tive head (m)	Point
	-									LWL 27.53			
	65-58	300	110	390		84.1	6.43	2.50		25.03	6.15	18.8	58
	58-59	300	110	159		72.1	4.84	0.76		24.27	6.15	18.12	59
	59-60	250	110	570		41.5	4.23	2.41		21.86	6.15	15.7	60
	60-61	200	110	220		28.2	6.14	1.35		20.51	6.30	14.2	61
	-									24.27			59
	59-57	200	110	240		25.0	4.91	1.17		23.10	6.45	16.6	57
	57-56	150	110	220		13.9	6.73	1.48		21.62	6.15	15.4	56
	56-11	100	110	640		2.8	2.50	1.60		20.02	6.15	13.8	11
	-									25.03			58
	58-9'	100	110	330		0.9	0.30	0.09		24.94	6.41	18.5	8
	-												
	-												

(West) No. 3

Pipe-line net-work	Line	Dia-meter (mm)	Coeffi-cient of velocity	Dis-tance (m)	Cumu-lative dis-tance (m)	Dis charge (ℓ/s)	Hydrau-lic gradient (°/00)	Head loss h(m)	Cumu-lative head loss Σh(m)	Pres-sure head (m)	Grand height (m)	Effec-tive head (m)	Point
	-									LWL 27.84			
	23-24	250	110	80		75.2	12.70	1.01		26.83	6.34	20.4	24
	24-25	250	110	230		59.6	8.27	1.90		24.93	6.34	18.5	25
	25-26	250	110	730		54.0	6.89	5.02		19.91	6.34	13.5	26
	26-27	150	110	250		7.8	2.31	0.57		19.34	6.34	13.0	27
	-									19.91			26
	26-28	150	110	240		8.9	2.95	0.70		19.21	6.34	12.8	28
	-									26.83			24
	24-29	150	110	330		10.0	3.66	1.20		25.63	6.34	19.2	29
	-												
	-												
	-												
	-												

(West) No. 4

Pipe-line net-work	Line	Dia-meter (mm)	Coeffi-cient of velocity	Dis-tance (m)	Cumu-lative dis-tance (m)	Dis-charge (ℓ/s)	Hydrau-lic gradient (°/00)	Head loss h(m)	Cumu-lative head loss Σh(m)	Pres-sure head (m)	Grand height (m)	Effec-tive head (m)	Point
	-									LWL 21.84			49
	49-48	200	110	220		25.7	5.17	1.13		20.71	6.3	14.4	48
	-									27.80			
	-47	150	110	100		16.8	9.56	0.95		26.85	6.3	20.5	47
	47-46	100	110	160		4.4	5.77	0.92		25.93	6.3	19.6	46
	46-45	100	110	310		2.2	1.60	0.49		25.44	6.3	19.1	45
	-												
	-												
	-												
	-												
	-												
	-												
	-												

(East) No. 5

Pipe-line net-work	Line	Dia-meter (mm)	Coeffi-cient of velocity	Dis-tance (m)	Cumu-lative dis-tance (m)	Dis charge (ℓ/s)	Hydrau-lic gradient (°/00)	Head loss h(m)	Cumu-lative head loss Σh(m)	Pres-sure head (m)	Grand height (m)	Effec-tive head (m)	Point
	-									LWL 27.80			
	0-1	450	110	50		253.3	6.87	0.34		27.46	6.3	21.1	1
	1-9	450	110	220		181.7	3.71	0.81		26.65	6.3	20.3	9
	9-10	450	110	490		170.6	3.30	1.61		25.04	6.3	18.7	10
	10-11	450	110	470		163.6	3.06	1.43		23.61	6.3	17.3	11
	11-12	450	110	400		146.9	2.50	1.00		22.61	6.3	16.3	12
	12-13	400	110	410		104.4	2.36	0.96		21.65	6.3	15.3	13
	13-14	350	110	760		80.3	2.78	2.11		19.54	6.3	13.2	14
	14-15	300	110	280		58.1	3.24	0.90		18.64	6.3	12.3	15
	-												
	-									22.61			12
	12-21	200	110	720		20.3	3.34	2.40		20.21	6.3	13.9	21
	-												

(East) No. 6

Pipe-line net-work	Line	Dia-meter (mm)	Coeffi-cient of velocity	Dis-tance (m)	Cumu-lative dis-tance (m)	Dis-charge (ℓ/s)	Hydrau-lic gradient (°/00)	Head loss h(m)	Cumu-lative head loss Σh(m)	Pres-sure head (m)	Grand height (m)	Effec-tive head (m)	Point
	-									LWL 27.80			
	0-1	450	110	50		253.3	6.87	0.34		27.46	6.3	21.1	1
	1-2	300	110	250		71.6	4.78	1.19		26.27	6.3	19.9	2
	2-3	300	110	530		62.2	3.68	1.95		24.32	6.3	18.0	3
	3-4	250	110	270		40.1	3.97	1.07		23.25	6.3	16.9	4
	4-5	250	110	290		34.0	2.92	0.84		22.41	6.3	16.1	5
	5-6	200	110	380		21.2	3.62	1.37		21.04	6.3	14.7	6
	6-7	200	110	680		16.8	2.35	1.59		19.45	6.3	13.1	7
	7-8	200	110	550		12.4	1.34	0.73		18.72	6.3	12.4	8
	-												
	-									23.25			4
	4-19	100	110	420		3.9	4.62	1.94		21.31	6.3	15.0	19
	3-20	150	110	390		6.6	1.69	0.65		20.66	6.3	14.3	20

(East) No. 7

Pipe-line net-work	Line	Dia-meter (mm)	Coeffi-cient of velocity	Dis-tance (m)	Cumu-lative dis-tance (m)	Dis charge (ℓ/s)	Hydrau-lic gradient (°/00)	Head loss h(m)	Cumu-lative head loss Σh(m)	Pres-sure head (m)	Grand height (m)	Effec-tive head (m)	Point
	-									LWL 27.8			
	0-15	250	110	50		53.7	6.82	0.34	0.34	27.4	6.3	21.1	15
	15-16	250	110	840		53.7	6.82	5.72	6.06	21.7	6.3	15.4	16
	16-17	250	110	490		22.2	1.33	0.65	6.71	21.0	6.3	14.7	17
	17-18	200	110	600		11.1	1.09	0.65	7.36	20.4	6.3	14.1	18
	-												
	-												
	-												
	-												
	-												
	-												
	-												
	-												