The population that will be served by the water supply system is 470,000 which corresponds to approximately 95% of that total. The population supplied will be distributed as follows in the Eastern and Western districts of the town.

| | |
|---|---|
| Western District | 356,000 persons |
| Eastern District | 114,000 persons |

## 5-4 Water Consumption

### (1) Design Water Consumption

The design water consumption is determined as follows, by taking into consideration the water supply plans being implemented in district towns and sub-divisional towns with aid of the Netherlands and the ADB as well as the water consumption of Dhaka WASA.

| | Water Consumption | Percentage of Population |
|---|---|---|
| (1) House connection | 25 gpcd (113.7 liter/ man-day) | 50% (80) |
| (2) Public post | 7.5 gpcd (34 liter/ man-day) | 50% (20) |
| (3) Loss due to leak, etc. | 30% of (1) + (2) | |

Notes:
1. The figures enclosed with parenthesis in the column "percentage of population" are the long-term target for the year 2000.
2. The water volumes contained in the table include the consumption in such establishments as restaurants, hospitals, schools, shops, cottage industries, etc.

As can be seen, the design water consumption per capita of this project will be as follows:

(1) By house connection
113.7 liter/man-day x 50% = 56.8 liter/man-day

(2) By public post
34 liter/man-day x 50% = 17.0 liter/man-day

(3) Water loss
(56.8 + 17.0) x 30% = 22.1 liter/man-day

Total 95.9 ≒ 96 liter/man-day

Therefore, the water supply plan is drawn up by assuming the daily consumption of 96 liters per capita.

Reference data for calculation of the design water consumption is shown in Annex VII.

(2) Water Consumption

The results of calculation of the water consumption of the town as a whole, based on the estimated population supplied, are shown in the followings:

| | | |
|---|---|---|
| Western District | 356,000 x 96 liter/man-day | = 34,176 $m^3$/day |
| Eastern District | 114,000 x 96 liter/man-day | = 10,944 $m^3$/day |
| Total | | 45,120 $m^3$/day |

Of the existing water supply facilities, those available for use and their supply capacities are as follows:

- Western District

| | |
|---|---|
| Production wells (4 units) | 4,914.0 $m^3$/day |
| Purification plant (1 location) | 3,640.0 $m^3$/day |
| Total | 8,554.0 $m^3$/day |

| | | |
|---|---|---|
| - Eastern District | | |
| Production well | None | Available supply capacity |
| Purification plant | None | 0 m³/day |

As things now stand in the East District there are two production wells and one purification plant which are supplying 1,615 m³/day of potable water, but both of purification plant and production wells are conspicuously timeworn and a new purification plant must be constructed. It is, however, impossible to build a new one near the existing plant because a proper site is unavailable. It is also considered desirable to discontinue the use of the existing plant from the viewpoint of maintenance and operation since its treatment capacity is only 800 m³/day or so. The use of the existing production wells is not considered in this project because their capacity is small, water quality not very good and they are conspicuously timeworn.

Therefore, the following quantities of water must be developed anew in this project.

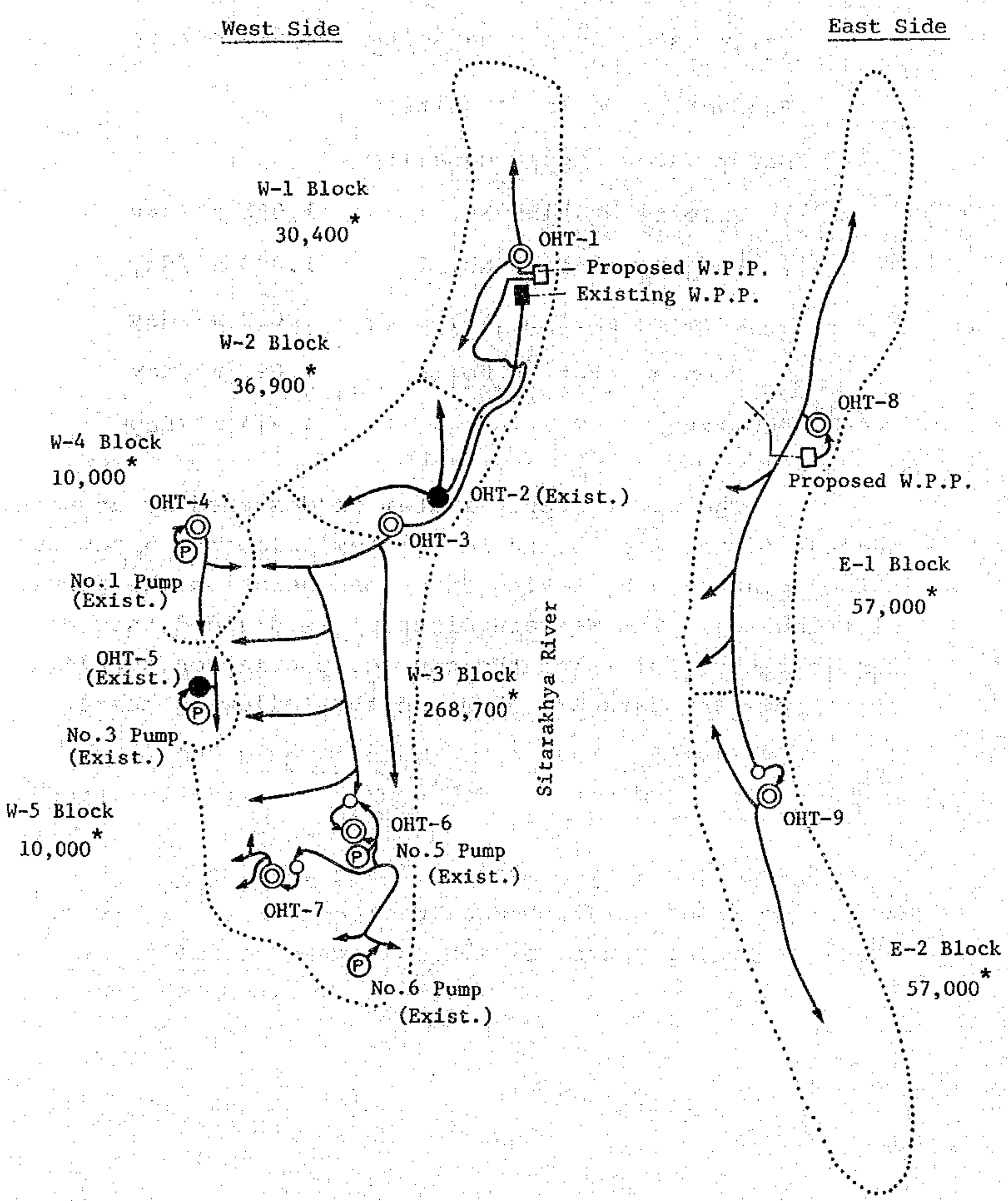
- Western District 34,176 - 8,554 = 25,622 m³/day
- Eastern District 10,944 m³/day
- Total 36,566 m³/day

In this project it is assumed that the said quantities of water to be developed anew will be pumped from the Sitalakhya River, and will be supplied to the town population after being treated in the purification plant.

## 5-5 Layout of the Water Supply Facilities

The system diagram of the water supply plan of this project is shown in the following figure.

Fig. 5-5-1 Water Supply System Diagram




* ; persons to be supplied with water

(1) Western District

Of the existing water supply facilities of the Western District, the following ones are regarded as available for future use.

- Purification plant (1 unit)

  Daily water supply capacity 3,640 $m^3$/day

- Production wells (4 units)

  Daily water supply capacity

  . Pumping station No. 1 1,092 $m^3$/day

  . Pumping station No. 2 1,093 $m^3$/day

  . Pumping station No. 5 1,638 $m^3$/day

  . Pumping station No. 6 1,092 $m^3$/day

  Sub-total 4,914 $m^3$/day

The water supply system is designed by assuming the use of these existing facilities, planning a new purification plant and by taking into consideration the population distribution. The Western District is divided into 5 subdistricts, for which the source, population supplied and other relevant data are shown in the following table:

Table 5-5-1 Sources, Population Supplied, etc. of the Western District

| Subdistrict | Population Supplied | Source facilities, Overhead Tank, etc. |
|---|---|---|
| West-1 | 30,400 | New purification plant, overhead tank No. 1 |
| West-2 | 36,900 | Existing Purification plant, overhead tank No. 2 (existing) |
| West-3 | 268,700 | New purification plant, No. 5 and No. 6 pumping stations, No. 3, No. 6 and No. 7 overhead tanks. Storage tanks from the distributing pipeline will be installed for each of No.6 and No.7 overhead tanks. |
| West-4 | 10,000 | Existing No. 1 pumping station, overhead tank No. 4 |
| West-5 | 10,000 | Existing No. 3 pumping station, overhead tank No. 5 |

(2) Eastern District

The existing water supply facilities of the Eastern District are not regarded as available for future use. All of the existing facilities are conspicuously timeworn, the production wells have low capacity and their future reliability is regarded as very bad.

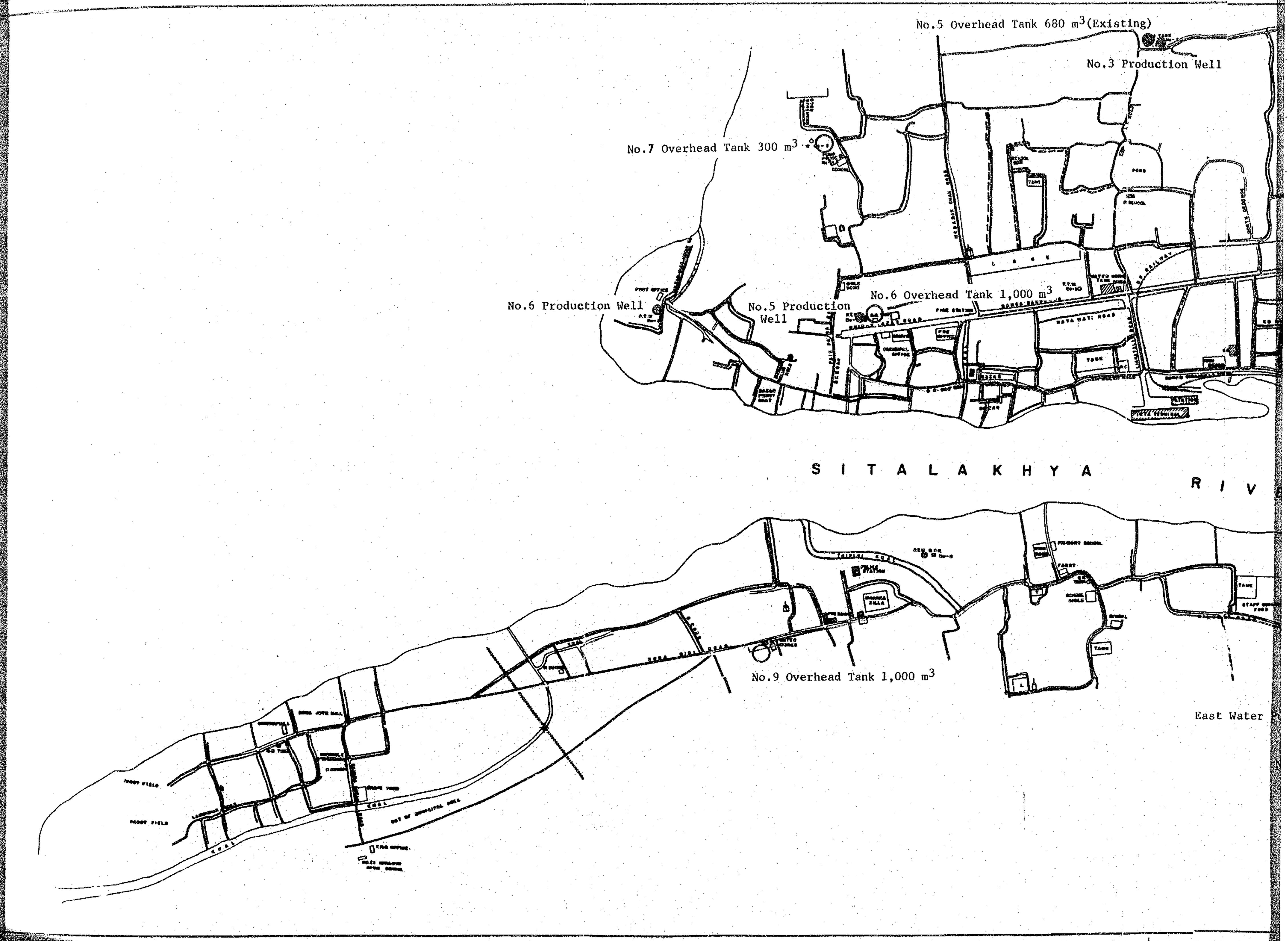
The water supply system is designed as shown in Fig. 5-5-1, by taking into consideration the location of the new purification plant, population distribution and other relevant factors.

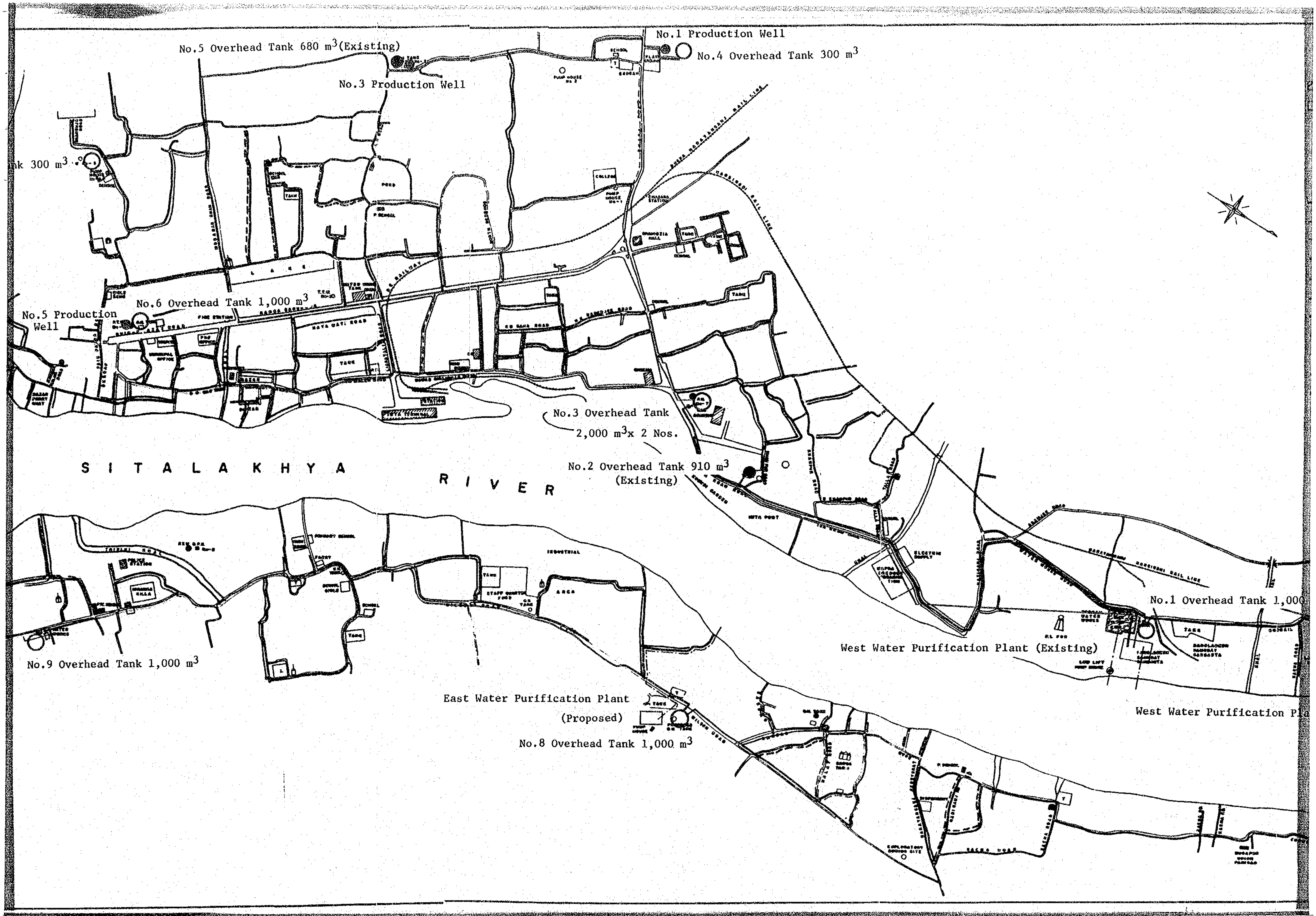
Table 5-5-2 Sources, Population Supplied, etc. of the Eastern District

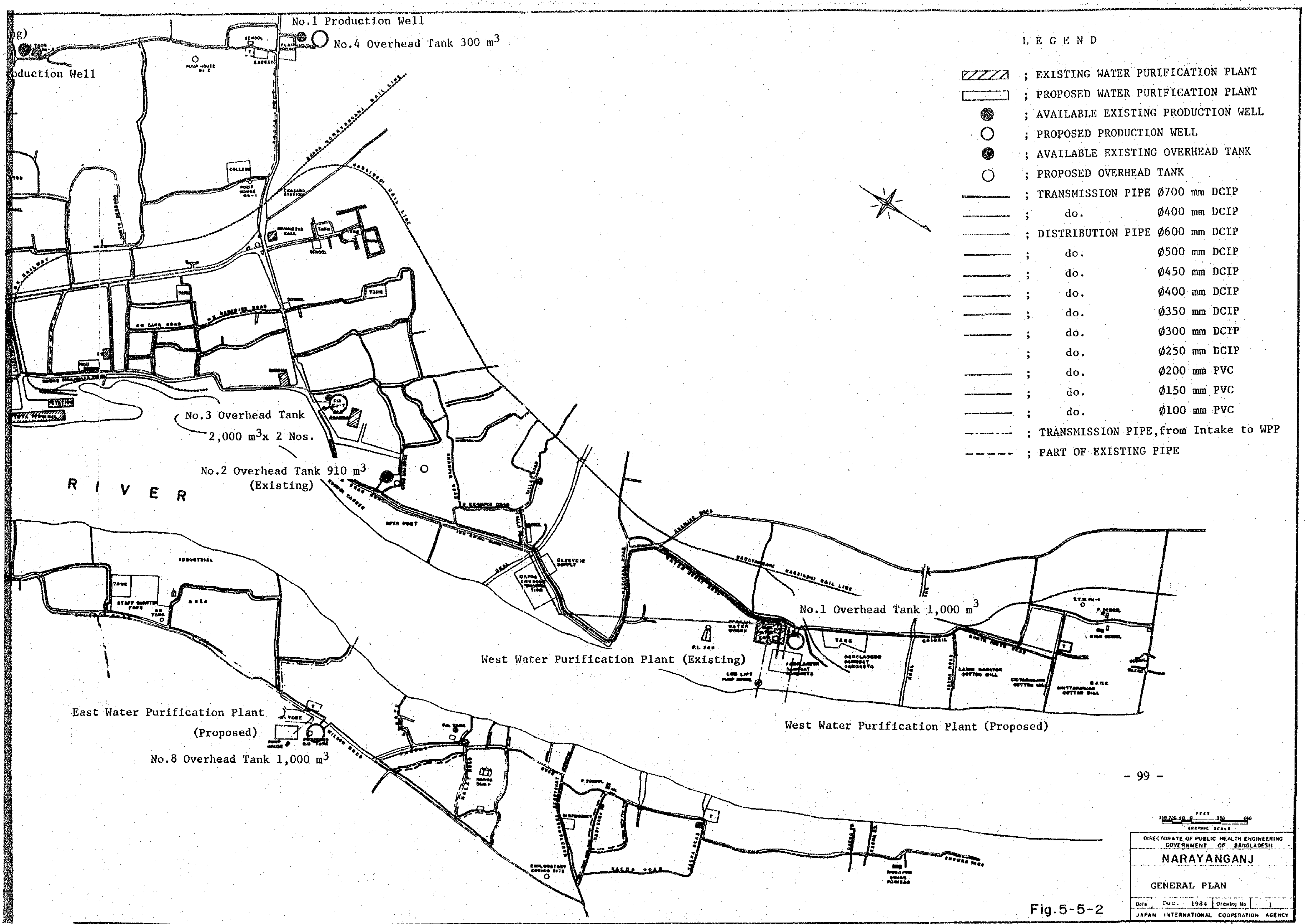
| Subdistrict | Population Supplied | Source Facilities and Overhead Tanks |
|---|---|---|
| East-1 | 57,000 | New purification plant, overhead tank No. 8 |
| East-2 | 57,000 | New purification plant, overhead tank No. 9 and storage tank from distribution pipe |

(3) Ground Plan of the Water Supply Project

Ground plan of the water supply project of Narayanganj Town is shown in Fig. 5-5-2.


No.5 Overhead Tank 680 m3(Existing)
No.3 Production Well
No.7 Overhead Tank 300 m3
No.6 Production Well
No.5 Production Well
No.6 Overhead Tank 1,000 m3
S I T A L A K H Y A
R I V
No.9 Overhead Tank 1,000 m3
East Water P


No.1 Production Well
No.5 Overhead Tank 680 m3(Existing)
No.4 Overhead Tank 300 m3
No.3 Production Well
nk 300 m3
No.6 Overhead Tank 1,000 m3
No.5 Production Well
No.3 Overhead Tank
2,000 m3x 2 Nos.
S I T A L A K H Y A
R I V E R
No.2 Overhead Tank 910 m3
(Existing)
No.1 Overhead Tank 1,000
West Water Purification Plant (Existing)
No.9 Overhead Tank 1,000 m3
East Water Purification Plant
(Proposed)
No.8 Overhead Tank 1,000 m3
West Water Purification Pl



No.1 Production Well
No.4 Overhead Tank 300 m³
LEGEND
; EXISTING WATER PURIFICATION PLANT
; PROPOSED WATER PURIFICATION PLANT
; AVAILABLE EXISTING PRODUCTION WELL
; PROPOSED PRODUCTION WELL
; AVAILABLE EXISTING OVERHEAD TANK
; PROPOSED OVERHEAD TANK
; TRANSMISSION PIPE Ø700 mm DCIP
; do. Ø400 mm DCIP
; DISTRIBUTION PIPE Ø600 mm DCIP
; do. Ø500 mm DCIP
; do. Ø450 mm DCIP
; do. Ø400 mm DCIP
; do. Ø350 mm DCIP
; do. Ø300 mm DCIP
; do. Ø250 mm DCIP
; do. Ø200 mm PVC
; do. Ø150 mm PVC
; do. Ø100 mm PVC
; TRANSMISSION PIPE, from Intake to WPP
; PART OF EXISTING PIPE
No.3 Overhead Tank
2,000 m³x 2 Nos.
No.2 Overhead Tank 910 m³
(Existing)
RIVER
No.1 Overhead Tank 1,000 m³
West Water Purification Plant (Existing)
West Water Purification Plant (Proposed)
East Water Purification Plant
(Proposed)
No.8 Overhead Tank 1,000 m³
DIRECTORATE OF PUBLIC HEALTH ENGINEERING
GOVERNMENT OF BANGLADESH
NARAYANGANJ
GENERAL PLAN
Date Dec. 1984 Drawing No. 1
JAPAN INTERNATIONAL COOPERATION AGENCY


Fig.5-5-2

# CHAPTER 6 WATER SUPPLYING FACILITIES PLAN

## 6-1 Plan for Purification Plant

### (1) Comparative Study of Water Purification Treatment System

When broadly classified, slow filtration or rapid filtration may be considered for the purification treatment system of raw water intaken from surface water.

Generally, the former is applicable to raw water having low turbidity (of 10° or less), while rapid filtration is more suited to raw water having the turbidity in excess of a certain range when the purification treatment capacity and maintenance and control are taken into account.

As the raw water for this project is surface water which is anticipated to have the turbidity of 80° on average and around 200° at the highest, rapid filtration will be adopted.

On this rapid filtration, unit processes enumerated below may be considered, from among which, those considered best in terms of ① performance, ② utilization of locally available materials and equipment to the maximum extent possible, ③ not requiring advanced technical competence, and ④ ease of maintenance and upkeep will be selected for plan.

#### (i) Chemical Sedimentation Basin

The following two types may be condidered as coagulation basin.

a) High rate coagulo sedimentation basin

b) Side channel type coagulation basin

Of these, the side channel type coagulation basin does not require any advanced technical competence and is easy to maintain, and can be constructed with locally available materials and equipment although the size of the structure may be larger. Thus, the side channel type coagulation basin will be adopted for this plan.

(ii) Mixing Basin

The following four types may be considered as mixing basin.

a) Rapid agitator (flash mixer)

b) Vertical baffling type

c) Circulating pump type

d) Overflow weir type

The overflow weir type was selected from among these to avoid mechanical structure and for its ease of maintenance and control. As the indices for mixing, G value (mean velocity gradient) and GT value, which respectively represents the quantity of work and shearing strength, shall be as follows:

G value = 300 - 500 $sec^{-1}$

GT value = 15,000 - 100,000

(iii) Flocculation Basin

The following three types may be considered as flocculation basin.

a) Vertical detour channel type

b) Horizontal detour channel type

c) Flocculator type

Of these, the flocculator type has smaller hydraulic loss so that pump head can be made smaller, and can respond to changes in the quality and quantity of water adequately, but in view of the technological environment, the vertical detour channel type which requires little maintenance and which can be built with locally available materials was selected. As the vertical detour channel type may have some difficulty in coping with fluctuations in the quantity of water, some adjustment is necessary when the quantity of water to be treated is small.

(iv) Settling Basin

The following two types may be considered as settling basin.

a) Side channel type common settling basin

b) Settling basin with sedimentation accelerating device

Of these, the volume of b) can be reduced to about 1/3 that of a) by placing settling velocity accelerating device such as inclined parallel plates or inclined tubes, but a) was selected as it is easy to maintain and relatively ample space is available.

As for the system of collecting and removing settled and separated sludge, the system of collecting sludge by the scraper into the hopper installed at the upstream end and removing at proper intervals, or the system of installing a hopper in the range of about one hour in terms of the detention period during which time most of the flocs are considered to have settled and separated, and removing the settled sludge accumulated on that hopper at proper intervals may be considered. In this project, the latter method was selected.

(v) Rapid Filter

The following three types may be considered as rapid filter.

a) Standard type

b) Self washing type (valve)

c) Self washing type (siphon)

Upon comparative study (refer to Table 6-1-1) of a) through c), the self washing type (siphon) was selected in consideration of its simple structure and ease of operation, inexpensive installation cost and small hydraulic loss.

Table 6-1-1 Comparison of Rapid Filter

| | Standard type | Self washing type (valve) | Self washing type (siphon) |
|---|---|---|---|
| Filtration area | $62m^2$/bed x 6 beds<br>= 372 $m^2$ | ditto<br>ditto | ditto<br>ditto |
| Rate of filtration | Normal : 121 m/day<br>Backwash: 145 m/day | ditto | ditto |
| Amount of backwashing water (make up volume) | $37.2m^3$/min x 6 min.<br>= 223.2 $m^3$ | $5.9m^3$/min. ∿ $21.5m^3$/min. x 6 min.<br>= 35.4 $m^3$ ∿ 129 $m^3$ | ditto |
| Equipment installed: | | | |
| Raw water inlet | Raw water inlet door □ 400 | Raw water inlet door □ 400<br>+<br>Distributing weir | Raw water siphon<br>250 x 520 siphon tube : 1<br>Diaphragm valve: 2<br>Solenoid valve : 2<br>+<br>Distributing weir |
| Backwashing water equipment | High tank | Self filtered water + make up water (high tank) | ditto |
| | Backwashing water pipe ø600<br>Backwashing water valve ø600 | Make up water pipe ø500<br>Make up water valve ø500<br>(common equipment) | ditto |
| Backwash drainage equipment | Drainage door<br>1000 x 800 | Drainage door<br>1000 x 800 | Drainage siphon<br>Siphon tube<br>700 x 1200 : 1<br>Diaphragm valve: 2<br>Solenoid valve : 2 |

| | Standard type | Self washing type (valve) | Self washing type (siphon) |
|---|---|---|---|
| Filtration adjustment device | Clear water valve ø600<br>Flow meter<br>Flow regulating valve ø300 | Filtration regulating weir (common equipment) | ditto |
| Inspection & maintenance equipment | - | Clear water valve ø900 | Clear water flat bottom valve ø900 |
| Others | | | Compressor<br>Vacuum pump<br>Vacuum tank (with flow regulating valve)<br>Air piping<br>Vacuum piping<br>(All of foregoing are common equipment) |
| (Construction cost) | | | |
| <u>Framework cost</u><br>Structure | 1<br>The pipe corridor section is complicated and quite deep while the basin is shallow. The bottom plate is uneven and difficult to work with. | 0.9 | 1.3 |
| Equipment area | | | |
| Equipment depth | Basin : 3.5m<br>Pipe corridor: 6.5m | Basin : 3.5m<br>Pipe corridor: 5.0m | Basin : 5m<br>Pipe corridor: 6m |
| Volume of concrete | | | |

| | Standard type | Self washing type (valve) | Self washing type (siphon) |
|---|---|---|---|
| Equipment cost | 1<br>Due to sophisticated apparatus like flow controller and large equipment like backwash system, equipment cost is high. | 0.75<br>Operable only with 3 valves per basin. No high technical or complex equipment. | 0.8<br>There are many complex devices related to the siphon system though small in size. |
| Maintenance and operation cost | 1<br>Many equipment requiring technical competence like flow controller. Many equipment must be operated. | 0.6<br>Very simple as operable only by fully opening or closing 3 valves: raw water inlet valve, washing drain valve and surface washing valve. | 1.0<br>Many equipment related to the inlet siphon and outlet siphon must be operated. Vacuum pump, compressor and other automated equipment are necessary. |
| Others | | | |
| Hydraulic loss | 3.75m | 1.5m | 2.0m |

(vi) Chemical Injection Device

(a) Coagulant

The following three chemicals may be considered as coagulant.

a) Solid aluminium sulfate

b) Liquid aluminium sulfate

c) PAC

PAC is considered best because it is easiest to handle and also because it easily coagulates, but in view of the special situation in Bangladesh, the inexpensive and readily available solid aluminium sulfate was selected.

(b) Sterilization agent

The following four types are available as sterilization agent.

a) Bleaching powder

b) Chlorine gas

c) Sodium hypochlorite

d) Formed sodium hypochlorite (by electrolysis of salt)

The formed sodium hypochlorite seems best in terms of cost, safety and ease of handling, but it poses some problem in machine maintenance so that the readily available bleaching powder was selected.

(2) Capacity of Treatment Facilities

As shown in 5-4 (2), the estimated quantity of water supply is:

West Side : 25,622 $m^3$/day

East Side : 10,944 $m^3$/day

Assuming that purification plant will be operated 15 hours a day and water consumption within the purification plant will be 10% upon consultation with the Government of Bangladesh, the treatment capacity of facilities planned this time was decided to be as follows:

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

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

(3) Design Criteria for Treatment Facilities

(i) Coagulation Basin

(a) Mixing basin

In view of the very fast hydrolysis and polymerization reaction of coagulant in water, the process must be able to quickly mix coagulant and let it generate many small colloidal particles of aluminium hydroxide, diffuse them uniformly and let them react with turbid colloidal substances diffused in water. However, since this process might be considered as interfacial electrochemical reaction process of very complex particles, electrochemical bonding of colloidal aluminium hydroxide once formed may be destroyed by shearing strength if agitated too strongly as to impede formulation of satisfactory flocs in the ensuing flocculation process.

As indices of mixing, G value (value of the mean velocity gradient) and GT value respectively representing the amount of work or magnitude of shearing strength are available.

The target G value and GT value vary depending on the quality and treatment quantity of raw water but in general, G value of 200 to 300 $sec^{-1}$ and GT value of 12,000 to 15,000 are aimed for.

G value = 300 - 400 $sec^{-1}$

GT value = 12,000 - 30,000

Detention period : about 1 minute

(b) Flocculation basin

The coagulation is the most important process in the rapid filtration purification system and fine flocs generated in the mixing process must be ripened into heavy, hard and uniform flocs.

In order to form satisfactory floc, it is advisable to gradually decrease the G value from G = 70 - 80 $sec^{-1}$ in the high velocity zone to G = 40 - 50 $sec^{-1}$ in the medium velocity zone and to G = 15 - 20 $sec^{-1}$ in the low velocity zone.

Vertical buffling type

Detention period : 30 minutes

G value : at influent end; 70 $sec^{-1}$
at effluent end; 15 $sec^{-1}$

(c) Settling basin

Horizontal channel coagulation and sedimentation basin

Detention period : 3 hours

Flow velocity within basin : 15 - 40 cm/min

Sludge removing hopper :

80% of flocs are presumably precipitated in 1/3 of the total area of basin in the influent side.

A hopper is installed there and sludge is removed at proper intervals.

Amount of sludge generated:
$25,622 \times 80 \times 10^{-6} = 2.05$ DST/day

Amount of sludge accumulated on hopper:
$2.05 \times 0.8 = 16.4$ DST/day
$16.4 \div 0.05$ (density of accumuluated sludge)
$= 32.8\ m^3$/day

Hopper capacity: $32.8 \times 2 = 65.6\ m^3$ or more

(ii) Rapid Filter

Number of basins : 6 basins

Rate of filtration : 120 m/day (for 6 basin filtration)
150 m/day (for 5 basin filtration)

Backwash : $0.6\ m^3/m^2/min \times 6$ min

Surface wash : $0.2\ m^3/m^2/min \times 4$ min, stationary type

Minimum treatable quantity : 1/2 the treatment capacity

Sand layer : Effective diameter 0.6 mm, uniformity coefficient below 1.6, thickness of layer 0.6 m

Gravel layer : 2-4 mm, 4-6 mm, 6-10 mm, 10-20 mm, each layer to be 50 mm thick

Water collecting device : self washing type leopold (porous) block

Effective filtering head : 0.9 m

Chlorine is injected into the filtration adjustment tank.

(iii) Clear Water Reservoir

Installed capacity : 2 hour supply

Concurrently serves as the pump suction well.

(iv) Coagulant Injection Facility

Coagulant : Solid aluminium sulfate ($15\%\ Al_2O_3$)

Solid aluminium sulfate containing 15% of $Al_2O_3$ is diluted into 5% solution of $Al_2O_3$ and injected.
Injection ratio $P = 8.7 + 2.2\sqrt{T}$ (T: turbidity)

Solution tank capacity : 1 m³ x 2 tanks

Main daily usage (as 5% solution)
$25{,}622\ m^3/day \times (8.7 + 2.2\sqrt{83}) \times 10^{-6} = 0.736\ m^3/day$

Maximum daily usage (as 5% solution)
$25{,}622\ m^3/day \times (8.7 + 2.2\sqrt{200}) \times 10^{-6} = 1.02\ m^3/day$

(v) Disinfection Facilities

Disinfection agent : Bleaching powder (with effective chlorine content of 50%)

Bleaching powder with effective chlorine content of 50% is diluted into 10% effective chlorine solution and injected.
Injection ratio $P_{ave} = 10$ ppm, $P_{max} = 20$ ppm

Solution tank capacity : 0.5 m³ x 2 tanks

Mean daily usage (as 10% effective chlorine solution)

$25{,}622\ m^3/day \times 10 \times 10^{-6} = 0.256\ m^3/day$

Maximum daily usage

$25{,}622\ m^3/day \times 20 \times 10^{-6} = 0.512\ m^3/day$

## 6-2 Plan for the West Side Purification Plant

Quantity of water to be treated :

$45{,}095\ m^3/day = 1{,}879\ m^3/h = 31.3\ m^3/min = 0.522\ m^3/sec$

### (1) Receiving Well

Number of basin : 1 basin

Dimensions : 3.0 m (W) x 5.3 (L) x 3.0 m effective depth

Capacity : $47.7\ m^3$

Detention period : $\frac{47.7\ m^3}{31.3\ m^3/min} = 1.5\ min$

Velocity of flow within basin : $\frac{0.522\ m^3/s}{3\ m \times 3\ m} = 0.058\ m/s$

Metering weir : B = 3,000, d = 2,790, H = 210

### (2) Mixing Basin

Number of basins : 4 basins

Quantity of water treated per basin :

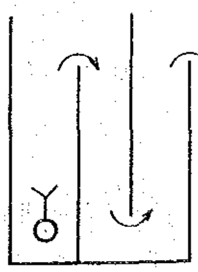
$11{,}274\ m^3/day = 470\ m^3/h = 7.83\ m^3/min = 0.130\ m^3/s$

Dimensions : 1.1 m (W) x 2.4 m (L) x 3.0 m effective depth

Capacity : $7.92\ m^3$

Detention period : $\frac{7.92\ m^3}{7.83\ m^3/min} = 1.0\ min$

Structure : Vertical detour channel type



Overflow weir : 2

Lower bent section: 1

(3) Flocculation Basin

Number of basins : 4 basins

Dimensions :

| | | |
|---|---|---|
| 1.1 m (W) x 7.6 m (L) x 3.0 m effective depth | 1 stream | 25.08 $m^3$ |
| 1.3 m (W) x 10.0 m (L) x 3.0 m effective depth | 1 stream | 39.0 $m^3$ |
| 1.6 m (W) x 10.0 m (L) x 3.0 m effective depth | 1 stream | 48.0 $m^3$ |
| 1.9 m (W) x 10.0 m (L) x 3.0 m effective depth | 1 stream | 57.0 $m^3$ |
| 2.2 m (W) x 10.0 m (L) x 3.0 m effective depth | 1 stream | 66.0 $m^3$ |

Capacity : 235.08 $m^3$

Dention period : $\dfrac{235.08\ m^3}{7.83\ m^3/min} = 30.0$ min

Structure : Vertical baffling type

| | | $sec^{-1}$ | m | m |
|---|---|---|---|---|
| 1st stream | Overflow weir (4) | G=66-54 | h=0.012-0.008 | t=0.24-0.29 |
| | Lower bent section (4) | G=64-52 | h=0.012-0.008 | t=0.46-0.57 |
| 2nd stream | Overflow weir (4) | G=50-42 | h=0.009-0.006 | t=0.24-0.29 |
| | Lower bent section (5) | G=49-43 | h=0.008-0.006 | t=0.46-0.52 |
| 3rd stream | Overflow weir (5) | G=40-34 | h=0.007-0.005 | t=0.22-0.26 |
| | Lower bent section (4) | G=41-33 | h=0.007-0.005 | t=0.40-0.50 |
| 4th stream | Overflow weir (4) | G=32-24 | h=0.005-0.003 | t=0.21-0.28 |
| | Lower bent section (5) | G=31-25 | h=0.005-0.003 | t=0.41-0.51 |
| 5th stream | Overflow weir (5) | G=22-16 | h=0.003-0.002 | t=0.25-0.34 |
| | Lower bent section (4) | G=23-15 | h=0.003-0.001 | t=0.45-0.69 |

Total head loss : 0.256 m

(4) Settling Basin

Number of basins : 4 basins

Dimensions : 10.0 m (W) x 47.1 m (L) x 3.0 m effective depth

Capacity : 1,413 $m^3$ per basin

Detention period : $\frac{1,413\ m^3}{470\ m^3/h} = 3.0$ hours

Velocity of flow within basin : $\frac{7.83\ m^3/min}{10\ m \times 3\ m} = 0.261$ m/min

Sludge removing pit : 35.56 $m^3$/pit x 6 pits = 213 $m^3$
Quantity of sludge removed
2.79 DST/day ≒ 93 $m^3$ (3% density)
213 ÷ 93 = 2.3 day quantity

(5) Rapid Filter (self washing type valve system)

Number of basins : 6 basins

Dimensions : 3.1 m (W) x 10.0 m (L) x 2 trains
(8.2 m (W) x 10.0 m (L) x 4.5 m (D))

Rate of filtration : at 6 basin operation 121.2 m/day
at 5 basin operation 145.5 m/day

Backwashing rate : 0.6 m/min x 6 min

Quantity of backwashing water :
62 $m^2$/basin x 0.6 $m^3/m^2$/min = 37.2 $m^3$/min
37.2 $m^2$/min x 6 min = 223.2 $m^3$

Quantity of make up water :
5.9 $m^3$/min (for 100% treatment)
- 21.6 $m^3$/min (for 50% treatment)
Water supplied from make up overhead tank

Surface washing rate: 0.2 $m^2$/min x 4 min, sanitary type

Lower water collecting device :
self washing type perforated block

| | | |
|---|---|---|
| Filter layer | : | Layer thickness 60 cm, effective diameter 0.6 mm, uniformity coefficient below 1.6. |
| Supporting layer | : | Gravel 2-4 mm, 4-6 mm, 6-10 mm, 10-20 mm, each layer to be 50 mm thick. |
| Raw water distribution | : | 1.5 m wide square weir + □400 sluice door |
| Drainage facility | : | 800 x 800 sluice door |
| Surface washing facility | : | ø300 surface washing main,<br>ø300 butterfly valve,<br>Stationary surface washing device inside basin |
| Make up water facility | : | ø400 pipe + ø400 butterfly valve from overhead tank |
| Chlorine injection facility | : | Injected in front of the filtration regulating weir |

(6) Clear Water Reservoir Com-water Feed Pump Well

| | | |
|---|---|---|
| Number of basins | : | 2 basins |
| Dimensions | : | 25.0 m (W) x 25.5 m (L) x 3.0 m effective depth |
| Capacity | : | 1,912.5 m³/basin |
| Detention period | : | $\frac{1,912.5\ m^3}{1,879\ m^3/h} = 2.04$ hours |

(7) Coagulant Chemicals Feeding Equipment

| | | |
|---|---|---|
| Coagulant | : | Solid aluminum sulfate, injected as 5% $Al_2O_3$ solution |

Injection ratio : As 5% $Al_2O_5$ solution,

$P = 8.7 + 2.2\sqrt{T}$

where T : Turbidity of raw water

Amount injected : Assuming 83° average turbidity of raw water, 28.7 ppm.

$25,622\ m^3/day \times 28.7 \times 10^{-6}$
$= 0.735\ m^3/day$ (as 5% $Al_2O_3$ solution)

Solution tank : $1\ m^3 \times 2$ tanks

(8) Disinfection Agent Feeding Facility

Sterilization agent : Bleaching powder (with 50% effective chlorine)

Feeding ratio : Max. 2 ppm,

average 1 ppm (as effective chlorine)

Feeding amount : $25,622\ m^3/day \times 1 \times 10^{-6}$
$= 25.6$ kg/day (as effective chlorine)

$25.6 \div 0.5 = 57.2$ kg/day (as bleaching powder)

Bleaching powder is dissolved into 10% effective chlorine solution and injected.

$25.6\ kg/day \times \frac{100}{10} = 0.256\ m^3/day$

(As 10% effective chlorine solution of bleaching powder)

Solution tank : $0.3\ m^3 \times 2$ tanks

## 6-3 Plan for the East Side Purification Plant

Quantity of water to be treated :

$19,260\ m^3/day = 802.5\ m^3/h = 13.38\ m^3/min = 0.223\ m^3/sec$

(1) Receiving Well

Number of basin : 1 basin

Dimensions : 2.5 m (W) x 5.1 (L) x 3.0 m effective depth

Capacity : 38.25 $m^3$

Detention period : $\frac{38.25\ m^3}{13.38\ m^3/min} = 2.86\ min$

Velocity of flow within basin : $\frac{0.223\ m^3/s}{2.5\ m \times 3\ m} = 0.029\ m/s$

Metering weir : B = 2,500, d = 2,800, H = 200

(2) Mixing Basin

Number of basins : 4 basins

Quantity of water treated per basin :

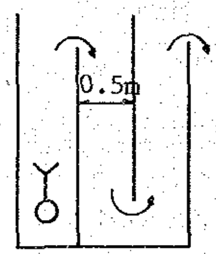
4,815 $m^3$/day = 200.6 $m^3$/h = 3.34 $m^3$/min = 0.056 $m^3$/s

Dimensions : 0.8 m (W) x 1.4 m (L) x 3.0 m effective depth

Capacity : 3.36 $m^3$

Detention period : $\frac{3.36\ m^3}{3.34\ m^3/min} = 1.0\ min$

Structure : Vertical baffling type




Overflow weir : 2

Lower bent section: 1

(3) Flocculation Basin

Number of basins : 4 basins

Dimensions :

| | | |
|---|---|---|
| 0.8 m (W) x 5.1 m (L) x 3.0 m effective depth | 1 stream | 12.24 $m^3$ |
| 1.0 m (W) x 6.5 m (L) x 3.0 m effective depth | 1 stream | 19.5 $m^3$ |
| 1.5 m (W) x 6.5 m (L) x 3.0 m effective depth | 1 stream | 29.25 $m^3$ |
| 2.0 m (W) x 6.5 m (L) x 3.0 m effective depth | 1 stream | 37.8 $m^3$ |

Capacity : 98.79 $m^3$

Detention period : $\frac{98.8\ m^3}{3.34\ m^3/min} = 29.6$ min

Structure : Vertical baffling type

| | | $sec^{-1}$ | m | m |
|---|---|---|---|---|
| 1st stream | Overflow weir (3) | G=64.5-54.5 | h=0.018-0.013 | t=0.12-0.14 |
| | Lower bent section (3) | G=62-52 | h=0.016-0.012 | t=0.23-0.28 |
| 2nd stream | Overflow weir (3) | G=49-41 | h=0.016-0.011 | t=0.10-0.12 |
| | Lower bent section (3) | G=47-39 | h=0.015-0.010 | t=0.19-0.23 |
| 3rd stream | Overflow weir (3) | G=37-29 | h=0.014-0.009 | t=0.07-0.09 |
| | Lower bent section (3) | G=35-27 | h=0.013-0.007 | t=0.14-0.18 |
| 4th stream | Overflow weir (3) | G=25-17 | h=0.009-0.004 | t=0.07-0.10 |
| | Lower bent section (3) | G=23-15 | h=0.007-0.003 | t=0.14-0.2 |

Total head loss : 0.266 m

(4) Settling Basin

Number of basins : 4 basins

Dimensions : 6.5m (W) x 31.0 m (L) x 3.0 m effective depth

Capacity : 604.5 $m^3$ per basin

Detention period : $\frac{604.5\ m^3}{206\ m^3/h} = 2.94$ hours

Velocity of flow within basin : $\frac{3.34\ m^3/min}{6.5\ m \times 3\ m} = 0.17$ m/min

Sludge removing pit : 9.9 $m^3$/pit x 6 pits = 59.4 $m^3$

Quantity of sludge removed
0.915 DST/day ≒ 30.5 $m^3$ (3% density)

59.4 ÷ 30.5 = 1.95 day quantity

(5) Rapid Filter (self washing type valve system)

Number of basins : 6 basins

Dimensions : 3.1 m (W) x 8.6 m (L) (= 26.66 $m^2$/basin)
(4.3 m (W) x 8.6 m (L) x 4.5 m (D))

Rate of filtration : at 6 basin operation 120.4 m/day
at 5 basin operation 144.5 m/day

Backwashing rate : 0.6 m/min x 6 min

Quantity of backwashing water :

26.66 $m^2$/basin x 0.6 $m^3/m^2$/min = 16.0 $m^3$/min

16.0 $m^3$/min x 6 min = 96 $m^3$/basin

Quantity of make up water :

2.62 $m^3$/min (for 100% treatment)
- 9.31 $m^3$/min (for 50% treatment)

Water supplied from make up overhead tank.

Surface washing rate: 0.2 m/min x 4 min, stationary type

Lower water collecting device :

self washing type perforated block

Filter layer : Silica sand,
effective diameter 0.6 mm,
uniformity coefficient below 1.6,
layer thickness 600 mm.

Supporting layer : Gravel 2-4 mm, 4-6 mm, 6-10 mm,
10-20mm, each layer to be 50 mm thick.

Raw water distribution :

0.95 m wide square weir + □250 sluice door

Drainage facility : □500 sluice door

Surface washing facility :

ø200 surface washing main +

ø200 surface washing valve,

Stationary surface washing device inside basin

Make up water facility :

ø300 main + ø300 butterfly valve from overhead tank

Chlorine injection facility :

Injected in front of the filtration regulating weir

(6) Clear Water Reservoir Com-water Feed Pump Well

Number of basins : 2 basins

Dimensions : 15.0 m (W) x 18.0 m (L) x 3.0 m effective depth

Capacity : 810 m³/basin x 2 basins = 1,620 m³

Detention period : $\frac{1,620 \text{ m}^3}{802.5 \text{ m}^3/\text{h}} = 2.01$ hours

(7) Coagulant Chemicals Feeding Equipment

Coagulant : Solid aluminum sulfate (with 15% $Al_2O_3$) is dissolved into 5% $Al_2O_3$ solution and injected.

Feeding ratio : As 5% $Al_2O_3$ solution,

$P = 8.7 + 2.2\sqrt{T}$

where T : Turbidity of raw water

Feeding amount : Assuming average turbidity of raw water to be 83°, 28.7 ppm.

$10,944 \text{ m}^3/\text{day} \times 28.7 \times 10^{-6}$
$= 0.314 \text{ m}^3/\text{day}$ (as 5% $Al_2O_3$ solution)

Solution tank : 0.5 m³ x two tanks

(8) Disinfection Agent Feeding Faclity

Sterilization agent : Bleaching powder (effective chlorine 50%)

Feeding ratio : Max. 2 ppm

average 1 ppm (as effective chlorine)

Bleaching powder is diluted into 10% effective chlorine solution and injected.

Feeding amount : $10,944\ m^3/day \times 1 \times 10^{-6} \times 10 = 0.109\ m^3/day$

Amount of bleaching powder used :

$10,944\ m^3/day \times 1 \times 10^{-6} \times 2 = 21.9\ kg/day$

Solution tank : $0.2\ m^3 \times 2$ tanks

## 6-4 Plan for Overhead Tanks

(1) Scale

The combined capacity of overhead tanks shall be about 20% of estimated quantity of daily water supply as in the case of the other seven towns. The estimated quantity of daily water supply for Narayanganj Town is 45,120 m³/day, consisting of 34,176 m³/day for the western district and 10,944 m³/day for the Eastern district.

The required capacity of the overhead tanks obtained from the estimated quantity of daily water supply is as follows:

Western district : $34,176 \times 0.20 = 6,835.2\ m^3$

Eastern district : $10,944 \times 0.20 = 2,188.8\ m^3$

When these are shown by water supply routes, the following table results.

Table 6-4-1 List of Overhead Tanks

| District | Overhead Tank No. | Population Supplied (persons) | Water Consumption ($m^3$/day) | Tank Capacity ($m^3$) | | Remark |
|---|---|---|---|---|---|---|
| | | | | Req'd | Det'd | |
| West | W-1 | 30,400 | 2,918 | 583 | 1,000 | Incl. water consumed within purification plant |
| | W-2 | 36,900 | 3,640 | (Existing) | ( 900) | |
| | W-3 | 268,700 | 25,795 | 5,159 | 4,000 | 2,000$m^3$x2 sets |
| | W-4 | 10,000 | 960 | 192 | 300 | |
| | W-5 | 10,000 | 960 | (Existing) | ( 680) | |
| | W-6 | Incl. in 3 above | Incl. in 3 above | | 1,000 | |
| | W-7 | Incl. in 3 above | Incl. in 3 above | | 300 | |
| East | W-8 | 57,000 | 5,472 | 1,094 | 1,000 | |
| | W-9 | 57,000 | 5.472 | 1,094 | 1,000 | |

Most of the existing overhead tanks, being made of steel and considerably worn out with age, are no longer in use. The only usable ones are the two ferro-concrete overhead tanks in the Western district, namely tanks 2 and 5 on Table 6-4-1.

The overhead tanks must be of such a height as to secure the hydraulic pressure of 15.0 m inside the distributing pipe. Although it would depend on the results of hydraulic calculation, the height of the new tanks - if they are to be used along with the existing ones - must be planned at 21.5 m, which is the height of the existing overhead tanks, to avoid problems in operation.

(2) Structure

As for the structure of the overhead tanks, both the steel and the ferro-concrete tanks have their respective advantages as shown in Table 6-4-2, but in view of the policy of this project that all facilities should be planned with the use of locally procurable materials and equipment to the maximum extent possible and also because steel tanks are expensive in that they have to be painted to prevent rusting after completion, the ferro-concrete tanks will be adopted.

Table 6-4-2 Comparison of the Structures of Overhead Tanks

| Item | Steel Tower | Reinforced Concrete Tower |
|---|---|---|
| Construction material | Steel must be imported from Japan. | Can be constructed with locally available materials like cement, gravel, sand and steel bar. |
| Water tightness of storage tank | Leakage unlikely as water tank is jointed by welding. | Waterproofing work with mortar or resin is necessary. |
| Maintenance and upkeep | Periodical coating of inside and outside of the water tank and struts is necessary to prevent corrosion. | Coating unnecessary. |
| Retention of water temperature | More susceptible to atmospheric temperature and exposure to direct heat than reinforced concrete tower. | Less susceptible to atmospheric temperature and exposure to direct heat than steel tower. |
| Foundation work | No. of foundation piles is less than reinforced concrete tower due to lighter weight to support. | No. of foundation piles is more than steel tower. |
| Construction period | Construction period is short as it can be constructed by assembling and welding steel materials. | Construction period is long as assembling of molds and timbering, placing and curing of concrete, etc. take time. |
| Construction cost | Generally inexpensive, but if tariff, etc. on imported materials are included as in Bangladesh, it may not necessarily be inexpensive. | Construction cost is high due to larger scale foundation works and other reasons. |

(3) Storage Tanks to be Installed alongside Overhead Tanks No.6, 7 and 9

Water to the West-3 District in the West Town will be distributed from Overhead Tank No.3, but as its internal pressure will not be sufficient to maintain the hydraulic pressure of 15 m at terminal points, the water pipe will be branched off from the distributing pipe to the storage tank and the pumped up to the overhead tank to adjust the hydraulic pressure. The pressure will be boosted twice in the West-3 District.

As hydraulic pressure in the East Town will likewise be inadequate at terminal points, the water pipe will be branched off to the storage tank near the existing purification plant and pumped up to the overhead tank to regulate the hydraulic pressure.

The principal particulars of the storage tanks to be installed at three locations in the East and West Town are as shown in the following table.

Table 6-4-3 Principal Particulars of Storage Tanks

| No. | Juxtaposed Overhead Tank No. | Storage Tank Capacity ($m^3$) | Principal Particulars of Water Pump | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Discharge ($m^3$/min) | Caliber (mm) | Total Uplift (m) | Q'ty | Type | Motor Output (kW) |
| 1 | W-6 | 216 | 1.8 | 100 | 29.1 | 2 | Centrifugal pump | 15 |
| 2 | W-7 | 48 | 0.4 | 65 | 27.9 | 2 | " | 3.7 |
| 3 | W-9 | Clear water reservoir of existing purification plant will be utilized. | 1.29 | 100 | 29.2 | 2 | " | 11 |

The storage tanks shall be made of ferro-concrete.

## 6-5 Water Conveyance Pipe

The caliber of water conveyance pipe is determined on the basis of the quantity of water conveyed, and the economic caliber which minimizes the sum of the construction cost of water conveyance facilities and the cost of operation and maintenance must be adopted.

From empirical performance, the relationship between economic caliber and economic velocity of flow is generally said to be 0.7 to 1.0 m/sec when the caliber of pipe is in the range of 75 to 150 mm, 0.8 to 1.0 m/sec for 200 to 300 mm, and 0.9 to 1.4 m/sec for 350 to 600 mm.

According to the proposed system diagram, the quantity of water to be conveyed from the purification plant to No.3 overhead tank is 478 liters/sec, but in the event that existing wells are to become unusable in future, the flow rate would become 529.4 liters/sec. The economic caliber of pipe for each of these flow rates are as follows.

(1) If the flow rate is 478 liters/sec, the caliber should be in the range of ø650 to 800 mm.

(2) If the flow rate is 529.4 liters/sec, then the caliber should be in the range of ø700 to 850 mm.

ø700 mm is therefore adopted in this project.

For the water conveyance pipe from the existing purification plant to the existing overhead tanks, the existing water conveyance pipe (ø400 mm) will be used.

As for the type of material for water conveyance pipe, cast iron pipe is considered better as the work is to be carried out in Bangladesh and also because, as Table 6-5-1 indicates, it has superior flexibility against expansion and contraction and better workability in jointing pipes than steel pipe. Steel pipe also has some problems in anti-corrosiveness of welded joint. Cast iron pipe is therefore adopted in this project.

Table 4-1-1 Comparative Characteristics of Steel Pipe and Ductile Cast Iron Pipe (ø250 - ø600/ø700)

| | | Steel Pipe (below ø300; JIS G 3452, above ø350; JIS G 3457) | Ductile Cast Iron Pipe (JIS G 5526) |
|---|---|---|---|
| Safety | 1. Pipe Body Strength | Diameter / Tensile Strength (kgf/mm²) / Bending Strength (kgf/mm²) / Elongation (%)<br>ø250,ø300: above 30 / above 30 / above 25<br>ø350-ø700: above 41 / above 41 / above 16 | Diameter / Tensile Strength (kgf/mm²) / Bending Strength (kgf/mm²) / Elongation (%)<br>ø250-ø700: above 42 / above 60 / above 10 |
| | 2. Resistance against External Pressure | Easily deflects due to large ductility and thin wall. Especially in back-filling, fill with sand and tamp the sides of pipe as a rule to prevent deformation of pipe. | Withstands large load due to thicker wall and larger bending rigidity than steel pipe. No particular consideration necessary in back-filling. |
| | 3. Resistance against Internal Pressure | Withstands high water pressure but inferior to ductile cast iron pipe. | Withstands high water pressure. Bursting water pressure varies depending on caliber and kind of pipe, but generally withstands water pressure of 100 kgf/cm² or more. |
| | 4. Water Tightness of Joint | Below ø300: Normally screwed joint. Both corrosion resistance and water tightness unreliable.<br>Above ø350: Normally welded joint, demanding highly trained skill and satisfactory welding conditions. | Highly water tight due to self sealing mechanism of the rubber ring. Leakage does not occur until pipe body ruptures. |
| | 5. Flexibility against Expansion and Contraction | Both screwed joint and welded joint lack flexibility against expansion and contraction, and generate excessive stress in the pipe body at the time of temperature change or change in foundation on soft ground. To moderate these stresses, expensive flexible expansion pipe must be used at every turn. | The joint of ductile cast iron pipe has excellent flexibility against expansion and contraction and can smoothly accommodate itself to changes in the ground foundation and temperature without generating stress in the pipe body. |
| Workability | 1. Excavated Ditch and Foundation | (1) Use of sand bed and adequate tamping around the pipe are necessary to prevent deformation of pipe.<br>(2) To secure proper position of weld, adequate space must be excavated around the joint intersection. | (1) In general, a flat bottom ditch is sufficient without requiring any special bed or work.<br>(2) In the case of a T shape, extra space by excavating around the joint intersection is hardly needed. |
| | 2. Pipe Jointing | (1) Welding work will take a long time. (centering, welding, inspection, painting, etc.)<br>(2) Licensed welder with sophisticated skill and experience is needed.<br>(3) Welding work is influenced by natural and climatic conditions and underground laying conditions. (rain, moisture, ground water, etc.)<br>(4) As jointing work by welding and coating or covering require long time, traffic may be disturbed. | (1) Jointing work possible in a short time by simply setting rubber rings and inserting the spigot into the receptacle.<br>(2) Jointing possible with only simple tools and without requiring advanced skill.<br>(3) Workable under varied conditions.<br>(4) Back-filling possible immediately after jointing. |
| Maintenance and Upkeep | 1. Anti-Corrosiveness (inner surface) | When the caliber is below ø600, coating of inner pipe surface is almost impossible and the pipe could be easily corroded. | Inner surface has an excellent anti-corrosive property by the alkaline anti-corrosive effect of cement mortar lining |
| | 2. Anti-Corrosiveness (outer surface) | Heavy anti-corrosive coating must be applied on the external surface of pipe. If handling flaws are buried as they are, pitting corrosion might result. Also, covering or coating of joint is done manually at the construction site which requires skill and experience and makes quality control difficult. To prevent these trouble, electrical corrosion protection becomes necessary. In the screwed joint, possible corrosion of the screwed portion poses a problem.<br>Repair work cannot be performed unless water has been completely drained. | Anti-corrosive property peculiar to cast iron is available (has the empirical proof of more than 300 years) Tar epoxy coating is applied in general. Repair and extension work can be easily done. |
| | 3. Depreciable Life | 25 years | 40 years |
| | 4. Ease of Repair & Maintenance | Repair work cannot be performed unless water is completely drained out. | Repair and extension work easily done. |

## 6-6 Distributing Pipe

### (1) Design Flow Rate

The design flow rate shall be the hourly maximum water consumption. The hourly maximum water consumption shall be assumed to be twice the hourly mean water consumption. This is represented in the following formula:

$$q_D = q_{max} = 2 \times \frac{Q}{24}$$

where $q_D$ : Design flow rate ($m^3/h$)
$q_{max}$ : Hourly maximum rate consumption ($m^3/h$)
$q_{av}$ : Estimated hourly amount of water supply ($m^3/h$)
$Q$ : Estimated daily amount of water supply ($m^3/h$)

### (2) Layout of Pipe

The layout of the distributing pipes shall be planned with due consideration to the layout of existing water pipes, population distribution pattern, planned locations of overhead tanks, road networks, future housing development trends, etc.

The layout of the distributing pipes shall be as shown in Fig. 5-5-2.

### (3) Caliber and Kind of Pipe

For distributing pipes of ø200 mm or less, PVC pipes will be used, and for pipes of ø250 mm or more cast iron pipe will be used.

The caliber of pipe will be determined on the basis of hydraulic calculations with respect to the design flow rate, internal pressure and other factors and also with due consideration to future expansion programs.

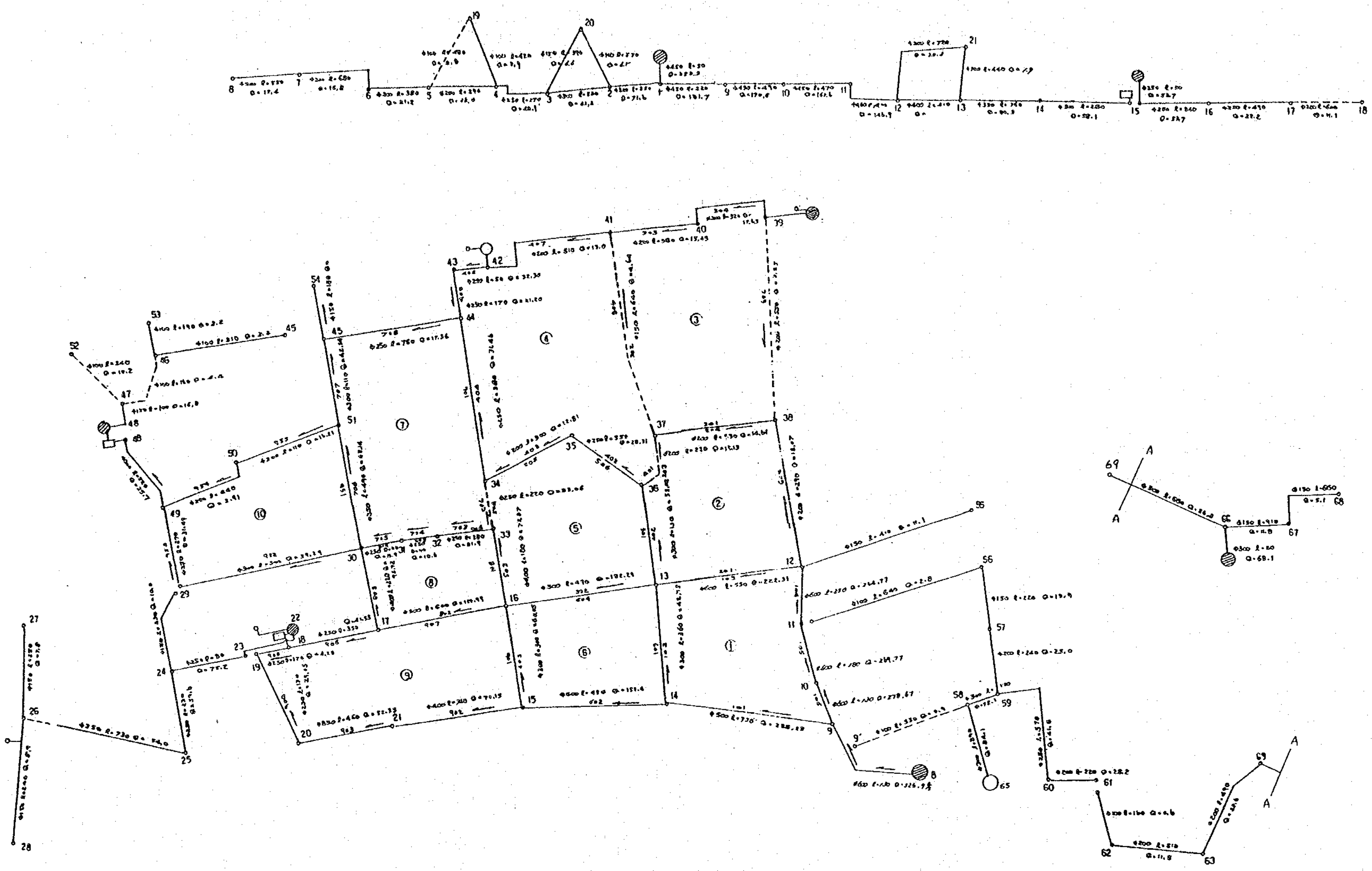
(4) Internal Pressure

The internal pressure at the terminal ends of the distributing pipe shall be maintained at 15.0 m (1.5 kg/cm²).

(5) Hydraulic Calculations

Hydraulic calculations will be carried out in accordance with Heisen-Williams' formula. The coefficient of velocity C shall include bend loss, etc. and shall be assumed as C = 110 regardless of the type of pipe. Hydraulic calculations will be made for pipeline network shown in Fig. 6-6-1.

The results of hydraulic calculations are as shown in Annex VIII.



| | | |
|---|---|---|
| 114,000ℓ | 10944 m³ | 253.3 ℓ/s |
| | | |
| 51200 | 4914 m³ | 113.7 ℓ/s |
| 236200ℓ | 22675 " | 524.9 |
| 37900ℓ | 3640 " | 84.1 |
| 30700ℓ | 2947 " | 68.1 |
| 356000ℓ | 34,176 m³ | |

Fig. 6-6-1 Pipe Line Network

## 6-7 House Connection and Public Post

There are in Narayanganj Town already some 3,200 house connections and 528 public posts. Regarding the effectiveness of water supply facilities, there would not seem to be the need to demonstrate their usefulness under this program as the people already know from actual experience with the currently existing facilities. Consequently, no provisions are made in this plan to construct house connections or public posts (for demonstration purposes).

From here onwards, the Bangladeshi Government will doubtless conduct public information activities and in compliance with the wishes of the town's people the facilities will be constructed with the planned target year in mind.

## 6-8 Metering Instruments

With water supply facilities, it is desirable that the maintenance and administrative costs be covered by the water rates. At the present time, the water rates of Narayanganj Town cover only 37% of the operational costs of the town's water supply facilities. Furthermore, the water rates are charged at 2% of the assessed value of the house and lot, regardless of the amount of water used.

It is believed that if this situation is allowed to continue it would make it difficult to manage the waterworks under a sound financial plan. Therefore, in the future, metering instruments should be installed in each house and the goal set to collect water rates which would be commensurate with the amount of water used. Under the present plan metering instruments will be installed at the discharge outlet of each facility, such as purification plant, production well, overhead tank, etc.

It is also desirable to have household metering instruments installed in the future.

## 6-9 Study for the Foundation of Structures

### (1) Condition of Foundation Ground in Each Town

As stated in Paragraph 3-2, the geology of Narayanganj Town consists of alternate layers of clay, silt and fine sand.

A geological columnar section in the suburbs of the town is as shown in Fig. 4-2-2 in Chapter 4.

### (2) Selection of Foundation Work Method

As foundation work methods, direct foundation, pile foundation, caisson foundation, ground improvement, etc. may be considered, but in view of the sizes of structures planned under this project, the direct foundation or pile foundation seem to be the most appropriate in terms of workability and economy.

For pile foundation, factory pre-fabricated concrete pile, steel pipe pile or cast-in-place concrete pile may be used, but factory pre-fabricated concrete pile is not produced in Bangladesh, and steel pipe pile must be imported and is therefore not suitable in terms of cost. Cast-in-place concrete pile is the most popularly used foundation pile for structures in Bangladesh, and can be executed by the same machine used for drilling production wells, with which the local construction contractors are quite capable of doing the work. In the case of factory pre-fabricated concrete pile or steel pipe pile, a pile driver for placing them would have to be imported.

In view of the foregoing, cast-in-place concrete pile shall be adopted as the foundation pile for this project. Where piles are unnecessary, the direct foundation work method shall be adopted.

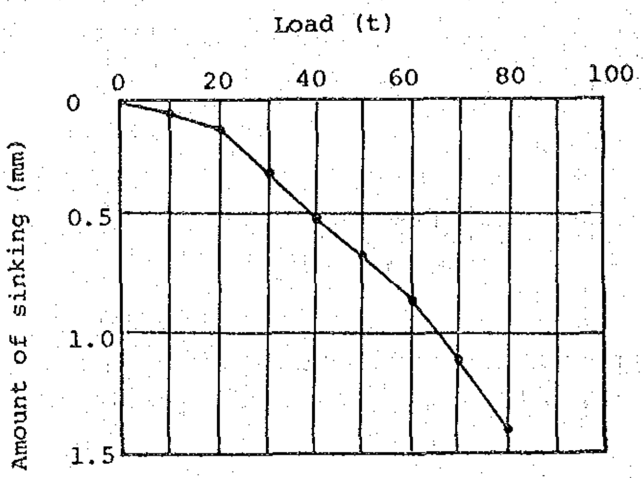
(3) Estimation of Soil Bearing Capacity and Bearing Capacity of Pile

The results of soil bearing capacity test which were conducted for Japan's grants-in-aid projects in Bangladesh are as follows:

| | | | | |
|---|---|---|---|---|
| Allowable bearing | capacity | at | Khulna | : $q_a = 6.4$ t/m² |
| " | " | " | Bogra | : $q_a = 6.1 - 6.9$ t/m² |
| " | " | " | Chittagong | : $q_a = 7.9 - 8.0$ t/m² |
| " | " | " | Mymensingh | : $q_a = 6.8 - 8.5$ t/m² |

A loading test of the piles has been conducted for the hospital project which is now under construction in Narayanganj Town. The foundation piles adopted here are ø400 mm in caliber and 16.0 m in length. Fig. 6-9-1 shows the load-sinking curve prepared on the basis of this loading test results.

Fig. 6-9-1 Load-Sinking Curve




As can be seen from the above figure, the curve has not reached the point of abrupt bend (load at yield point). This is because the test was stopped while within the allowable load of the pile itself which is ø400 mm in caliber.

The formula for estimating the allowable bearing capacity of the pile by loading test is as follows:

$$R_a = 1/3\ R_u = 1/2\ R_y,$$

in which $R_a$ : Allowable bearing capacity of pile (t)
$R_u$ : Ultimate bearing capacity of pile (t)
$R_y$ : Load at yield point of pile (t)

The test in Fig. 6-9-1 shows that the load is still short of the pile's yield point, but to be on the safe side, the load at yield point was assumed to be 80 t, from which the allowable bearing capacity of pile was calculated to be:

$$R_a = 1/2 \times 80 = 40 = 40\ t/pile$$

The ground formation at Narayanganj and Khulna, Bogra, Chittagong and Mymensingh consists of alternate layers of clay, sandy clay and fine sand as in the towns covered under this project.

Accordingly, the soil bearing capacity of the direct foundation was assumed to be 6.0 $t/m^2$ and the allowable bearing capacity of the cast-in-place concrete pile 400 mm in caliber and 16.0 m long to be 40 t/pile.

(4) Foundation of the Overhead Tank

The stability of the overhead tank was studied for the following two cases:

(a) When the water storage tank is empty and subject to wind load.

(b) When the water storage tank is filled to capacity and subject to wind load.

Accordingly, the study on foundation was also carried out for the foregoing two cases. For wind load, the data on wind velocity in Narayanganj Town are available as shown in Table 6-9-1. As can be seen from this table, the maximum wind velocity is relatively small compared to that of Dhaka, but as Narayanganj is only about 20 km away from Dhaka, the records of Dhaka were used for this project to be on the safe side. The maximum wind velocity was therefore assumed to be 60 knots (30.9 m/s).

The required number of piles, maximum load, etc. for overhead tanks by capacity were calculated on the basis of the foregoing conditions as summarized in the table below.

(Allowable bearing capacity
40 tons/pile)

| Description \ Capacity | | 300 m³ | 1,000 m³ | 2,000 m³ |
|---|---|---|---|---|
| Deadweight (t) | | 629.0 | 2,038.0 | 3,372.9 |
| Weight of water (t) | | 300.0 | 1,000.0 | 2,000.0 |
| Total vertical load (t) | | 929.0 | 3,038.0 | 5,372.9 |
| Wind load (horizontal load, t) | | 9.87 | 22.73 | 32.6 |
| No. of piles (pcs.) | | 27 | 91 | 148 |
| When empty | Tumbling moment (t.m) | 153 | 427.5 | 625.5 |
| | Resisting moment (t.m) | 1,887 | 12,228 | 23,160 |
| | Safety factor | 12.3 | 28.6 | 37.7 |
| | Reactive force of pile (max., t/pc.) | 29.5 | 25.7 | 25.9 |
| | Reactive force of pile (min., t/pc.) | 17.1 | 19.1 | 19.9 |
| When full | Tumbling moment (t.m) | 153 | 427.5 | 625.5 |
| | Resisting moment (t.m) | 2,787 | 18,228 | 37,610 |
| | Safety factor | 18.2 | 42.6 | 60.1 |
| | Reactive force of pile (max., t/pc.) | 40.6 | 36.7 | 39.3 |
| | Reactive force of pile (min., t/pc.) | 28.2 | 30.1 | 33.3 |

Note: A wind velocity of 60 knots corresponds to 30.9 m/sec, which is convereted into a horizontal load as follows:

$$q = 1/2\ \rho \cdot v^2 = 1/2 \times 0.125 \times 30.9^2 \fallingdotseq 60\ kg/m^2$$

in which $q$ : wind load
$\rho$ : air density, 0.125 $kg \cdot sec^2/m^4$
$v$ : wind velocity, 30.9 m/sec

As the foregoing has confirmed the pile reaction to be less than the allowable bearing capacity of 40 t/pile both when the tank is empty and when filled to capacity, the structure was judged to be adequately supportable with the diameter and the number of piles assumed.

(5) Foundation of Structures in the West Side Purification Plant

The required number of piles for the various structures at the purification plant was calculated on the basis of their deadweight, weight of water, load exerted by the pump, valve, pipe, etc. as tabulated below.

| Structure / Description | Intake work | Receiving well | Coagulation basin | Rapid filtration basin | Clear water reservoir | Sludge removal work |
|---|---|---|---|---|---|---|
| Deadweight (t) | 388 | incl. in coagulation basin | 8,064 | 2,572 | 4,325 | 455 |
| Weight of water (t) | 0 | | 4,880 | 590 | 4,463 | 300 |
| Pump, valve, pipe, etc. (t) | 12 | | 106 | 38 | 62 | 45 |
| Total weight (t) | 400 | | 13,050 | 3,200 | 8,850 | 800 |
| Bed plate area ($m^2$) | 36.0 | | 2,591.4 | 743 | 1,430 | 170 |
| Weight/$m^2$ ($t/m^2$) | 11.1 | | 5.0 | 4.3 | 6.2 | 4.7 |
| Need for foundation pile | Necessary | | Necessary to prevent uneven sinking | ditto | Necessary | Unnecessary |
| No. of piles | 10 | | 330 | 80 | 304 | 0 |

(6) Foundation of Structures in the East Side Purification Plant

The required number of piles for the various structures at the purification plant was calculated on the basis of their respective deadweight, weight of water, load exerted by the pump, valve, pipe, etc. as tabulated below.

| Description \ Structure | Intake work | Receiving well | Coagulation basin | Rapid filtration basin | Clear water reservoir | Sludge removal work |
|---|---|---|---|---|---|---|
| Deadweight (t) | 384 | incl. in coagulation basin | 4,368 | 1,261 | 2,224 | 625 |
| Weight of water (t) | 0 | | 2,906 | 399 | 1,620 | 180 |
| Pump, valve, pipe, etc. (t) | 12 | | 46 | 20 | 36 | 45 |
| Total weight (t) | 396 | | 7,320 | 1,680 | 3,880 | 850 |
| Bed plate area ($m^2$) | 36.0 | | 1,421 | 477 | 606 | 148 |
| Weight/$m^2$ ($t/m^2$) | 11.0 | | 5.2 | 3.5 | 6.4 | 4.7 |
| Need for foundation pile | Necessary | | Necessary to prevent uneven sinking | ditto | Necessary | Unnecessary |
| No. of piles | 10 | | 183 | 42 | 98 | 0 |

(7) Foundation of Other Structures

Structures other than the purification plants and overhead tanks are such as the valve rooms, but as their load is small, the direct foundation method will be used for these.

Table 6-9-1 Maximum Wind Velocity in Dhaka and Narayanganj

(Unit : Knots)

| Station / Year / Month | Dhaka | | | | | | | Narayanganj | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 |
| Jan. | - | NW 5 | SW 17 | NW 15 | V 14 | N 12 | W 6 | | NW 4 | SW 17 | NW 3 | V 2 | V 2 | V 2 |
| Feb. | - | S 9 | N/NW9 | W 28 | S 13 | SW 22 | N 60 | | S 3 | N/NW9 | V 2 | V 2 | NE 3 | V 10 |
| Mar. | - | SW 43 | W 30 | W 60 | - | SE 13 | NW 20 | | NW 6 | W 30 | S 4 | S 9 | V 4 | SE 5 |
| Apr. | - | NW 60 | NE 17 | NW 60 | - | E 60 | W 60 | | S 12 | NE 17 | SE 7 | - | V 8 | SW 14 |
| May | - | NE 60 | V 9 | NW 40 | NW 50 | SW 40 | W 40 | | NE 9 | V 9 | V 6 | - | S 10 | V 4 |
| Jun. | - | V 9 | S 13 | V 20 | E 25 | N 29 | N 13 | | ESE 7 | S 13 | V 6 | V 5 | V 4 | SE 3 |
| Jul. | - | SW 31 | V 9 | SSW28 | V 23 | SE 42 | - | | SE/SW16 | V 9 | SE 9 | SW 3 | SE 9 | - |
| Aug. | S 13 | S/SW 9 | E 13 | SSW18 | SSE20 | SE 26 | - | SE 6 | E/SE5 | E 13 | V 3 | SE 12 | SE 23 | - |
| Sep. | SE13 | S 13 | S 17 | SSE29 | V 13 | ESE20 | - | SSE10 | SE 3 | S 17 | SE 4 | SE 12 | SE 3 | - |
| Oct. | - | SE 13 | E 13 | SSE 28 | SE 20 | SE 18 | - | E 10 | SE 6 | E 13 | V 7 | SE 10 | V 3 | - |
| Nov. | N 9 | NNE 12 | SW 5 | NNE40 | NE 20 | NW 15 | - | NW 2 | NW 3 | SW 5 | NNW 6 | V 5 | V 2 | - |
| Dec. | N/NW5 | N 5 | V 5 | V 10 | - | V 10 | - | NW 3 | NW 3 | V 5 | - | - | V 2 | - |

## 6-10 Details of Water Supply Facilities to be Constructed under this Project

| Type of Construction | West | East | Total |
|---|---|---|---|
| 1. Purification plant | One site (28,184 $m^3$/day) | One site (12,038 $m^3$/day) | Two sites (40,222 $m^3$/day) |
| 2. Transmission pipes ø300 - 700 mm DCIP | 2,772.0 m | 750.0 m | 3,552.0 m |
| 3. Overhead tanks 300 - 2,000 $m^3$ | 6 | 2 | 8 |
| 4. Distribution pipes | | | |
| DCIP ø600 mm | 1,990.0 m | - | 1,990.0 m |
| " ø500 mm | 1,540.0 m | - | 1,540.0 m |
| " ø450 mm | - | 1,630.0 m | 1,630.0 m |
| " ø400 mm | 1,140.0 m | 410.0 m | 1,550.0 m |
| " ø350 mm | 950.0 m | 760.0 m | 1,710.0 m |
| " ø300 mm | 2,350.0 m | 1,060.0 m | 3,410.0 m |
| " ø250 mm | 5,190.0 m | 1,890.0 m | 7,080.0 m |
| PVC ø200 mm | 4,490.0 m | 2,930.0 m | 7,420.0 m |
| " ø150 mm | 4,310.0 m | 1,880.0 m | 6,190.0 m |
| " ø100 mm | 11,705.0 m | 6,800.0 m | 18,505.0 m |
| Total | 33,665.0 m | 17,360.0 m | 51,025.0 m |
| 5. Valve room | | | |
| ø600 mm butterfly valve | 6 pints | 0 points | 6 points |
| ø500 mm " | 5 | 0 | 5 |
| ø450 mm " | 0 | 3 | 3 |
| ø400 mm " | 3 | 1 | 4 |
| ø350 mm " | 2 | 0 | 2 |
| ø300 mm " | 13 | 4 | 17 |
| ø250 mm " | 16 | 3 | 19 |
| ø200 mm sluice valve | 29 | 4 | 33 |
| ø150 mm " | 14 | 11 | 25 |
| ø100 " | 73 | 27 | 100 |
| Total | 161 | 53 | 214 |

| Type of Construction | West | East | Total |
|---|---|---|---|
| 6. Blow off valve box | 25 | 12 | 37 |
| 7. Air valve | 4 | 2 | 6 |

## 6-11 Project Cost

(1) Cost to be Borne by the Government of Bangladesh

In implementing this project, the Government of Bangladesh shall also bear a part of the project cost. Some of the costs to be borne by the Government of Bangladesh are the following:

(a) Land acquisition/development cost

(b) Customs duty and other expenses on materials and equipment to be imported from Japan

(c) Maintenance and administration facilities and equipment cost

The breakdown of each cost item is as follows:

(a) Land acquisition/development cost

As with the seven towns, the unit cost rate shall be 300 TK per square meter. The land acquisition/development cost by district is estimated in the table below.

Table 6-11-1 Land Acquisition/Development Cost

| District | Purification Plant | Overhead Tank | Total |
|---|---|---|---|
| West | DPHE's site | (1,000m²x4+500x2)x300=1,500,000 | 1,500,000 |
| East | 10,000m²x300 = 3,000,000 | 1,000x2x300=600,000 | 3,600,000 |
| Total | 3,000,000 | 2,100,000 | 5,100,000 TK |

(b) Customs duty and other expense on materials and equipment to be imported from Japan

Customs duty and other expenses by district are as follows:

| | |
|---|---|
| West District | 103,594.797 TK |
| East District | 45,985,228 TK |
| Total | 149,580,025 TK |

(c) Maintenance and administration facilities and equipment cost

The cost of pump room within the purification plant is included in the construction cost. Office buildings and equipment necessary for maintenance and administration of facilities are stated in Paragraph 8-4. If these are to be constructed anew, their costs would be as follows:

(Facilities)

| | | |
|---|---|---|
| Main administration office buildings : | | |
| 92.9 m² x 2 bldgs. x 3,250 TK/m² | = | 603,850 TK |
| Spare parts storage house : | | |
| 278.7 m² x 1 bldg. x 1,630 | = | 451,494 |
| Purification plant administration office buildings : | | |
| 46.45 x 2 bldgs. x 3,250 | = | 301,925 |
| Sub-total | | 1,357,269 TK |

(Vehicles, etc.)

| | | |
|---|---|---|
| Ordinary jeep : | | |
| one vehicle (West) | | 219,407 TK |
| Small jeep : | | |
| two vehicles (one each for East & West D.) x 106,888 | = | 213,776 |
| Motor cycle : | | |
| Four vehicles (two each for East & West D.) x 14,982.5 | = | 59,930 |
| Sub-total | | 493,113 TK |

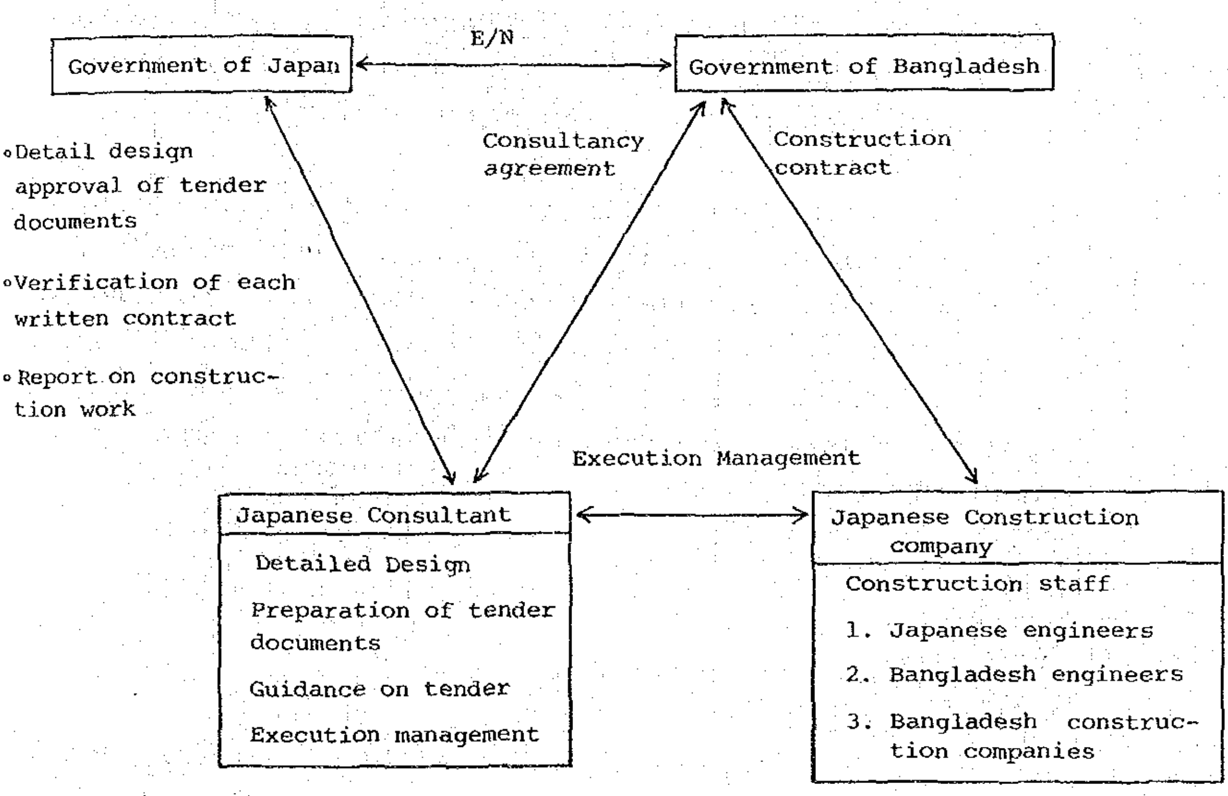
| | |
|---|---|
| (Duties & taxes for importing vehicles, etc.) | 493,113 TK |
| (Duties & taxes for importing water quality testing apparatus) | 228,054 TK |
| Total | 2,571,549 TK |

# CHAPTER 7 IMPLEMENTATION SYSTEM FOR THE PROJECT

## 7-1 Organizations Involved in Implementation of Works

### (1) Overall Relationship

This Project will be implemented by the grants-in-aid of the Japanese Government. The overall relationship among organizations concerned may be illustrated as follows:



(2) Bangladesh Organizations Involved in Implementation of Project

The Department of Public Health Engineering (DPHE), Local Government Division, Ministry of Local Government, Rural Development and Cooperatives of the Government of Bangladesh shall be responsible for the implementation of this project.

The Planning Circle of DPHE shall be the direct window which shall be contacted for various consultations and negotiations with the Central Government in Dhaka.

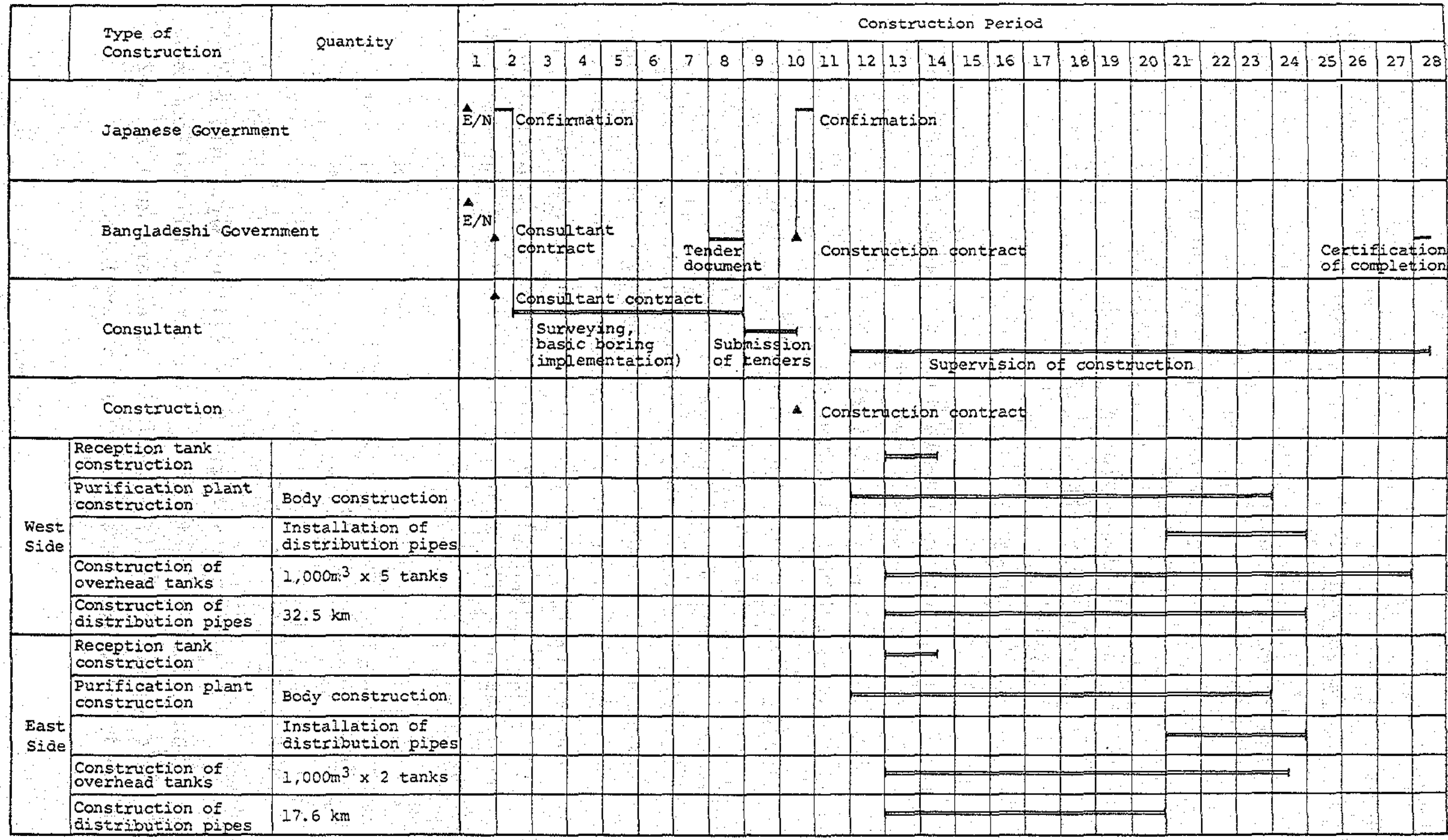
Narayanganj Town already has the DPHE's local office and also the Waterworks Department within Porou-shoava. The DPHE's local office shall serve as the window for field contact during the construction work.

After the completion of construction works, the DPHE will directly control and manage the facilities. To be in association with the Japanese Consultant and Construction firms, the DPHE should assign full-time personnel (senior engineer) to Narayanganj for implementation and management of construction and subsequent operation and maintenance of completed facilities.

## 7-2 Implementation Schedule

The implementation schedule of this project is as shown in Fig. 7-1. Construction requires 17 months, and when detail design and tender activities are included, it takes 28 months.

Fig. 7-1 Implementation Schedule for Narayanganj Water Supply Facilities Construction Plan



## 7-3 Execution Plan

### (1) Execution Method

Facilities to be constructed under this project are:

- Purification plants
- Overhead tanks
- Piping
- Public posts

In executing construction of these facilities,

(a) Conventional method,

(b) Turnkey method, and

(c) Inhouse engineering

may be considered. Each method has advantages and disadvantages, but the inhouse engineering in particular requires some increase in the number of DPHE's staff and also results in increased workload for the consultant. Recently, the inhouse engineering method is sometimes employed when the volume of work is hard to determine, but is seldom employed for construction of facilities such as above. In general, grants-in-aid projects often employ the conventional method. Accordingly, the conventional method will be adopted in this project.

### (2) Execution Plan

#### (i) Purification plants

Excavation and back-filling will all be done manually. Foundation will be direct foundation as a rule, but where foundation pile is necessary such as for filter bed, cast-in-place pile will be employed.

For placing concrete, staging and timbering will be erected.

(ii) Overhead tank construction

Cast-in-place pile is adopted for foundation work of overhead tanks. Excavators will be used for this work and also for digging of wells. For placing concrete, staging and timbering will be erected and concrete will be lifted to a higher position by crane or elevator.

(iii) Piping work

Excavation for laying pipeline will all be done manually. In-back-filling and sand laying works, rammers will be used for tamping.

As PVC pipes of 200 mm (8") or less in caliber are mainly used, all of these will be laid manually.

(3) Construction Period

In view of the meteorological conditions in Bangladesh, it is desirable to execute construction works mainly consisting of civil engineering work during the dry season between November and June. Bangladesh is a low-lying, flat country and the water level of the Sitalakhya River and creeks rises during the rainy season and during the ensuing flood season between July and October, and the groundwater level also rises close to ground level. At such places, it becomes extremely difficult to execute foundations work of structures or to dig ditches for piping.

Meanwhile, in implementing the grants-in-aid program of Japan, various restrictions are imposed on execution of work due to the fiscal year system adopted by the Government of Japan. Accordingly, it is necessary to implement this project with due consideration to full utilization of the dry season (from November to June) as the construction period in Bangladesh.

(4) Timing for Conducting Detailed Design Survey

As stated in the foregoing paragraph, it is desirable that the civil engineering works be executed during the dry season from November to June in view of the climatic conditions in Bangladesh. As with civil engineering work, plane-table surveying (on the planned pipeline routes and proposed sites of various structures), test drilling, foundation survey and so forth for the detailed design are difficult to carry out during the rainy season. Therefore, the timing for various surveys necessary for the detailed design must be adequately studied in conjunction with the timing for executing construction works. The project requires 28 months for implementation after the exchange of notes as shown in Fig. 7-1.

## 7-4 Scope of Works

The scope of work for construction under this project is as follows:

(1) The Scope of Work to Be Borne by the Government of Bangladesh:

(a) Acquisition and development of sites for constructing the water supplying facilities.

(b) Taxes, customs clearance fees and other expenses for importing necessary equipment and materials for the construction work.

(c) Required costs for maintenance and administration facilities and equipment:

Costs for constructing administration offices and storage buildings to store spare parts, etc. and also for purchasing small jeeps and motor cycles, etc. necessary for maintenance and administration in Narayanganj.

(d) Construction of house connections

(2) The Scope of Work to Be Borne by the Government of Japan:

(a) The construction works of the water supplying facilities covered by this project (intake facilities purification plant, pumping equipment, pump house, overhead tank, water conveyance pipe, distributing pipe, ancillary facilities of aqueduct).

(b) Ocean freight and insurance charges on materials and equipment to be imported from Japan.

(c) Of various costs for the maintenance and operation equipment, the cost for purchasing water quality testing apparatus to be equipped in Narayanganj.

(d) Costs of detailed design and execution management.

## 7-5 Detailed Design and Construction Supervision

### (1) Contents of Detailed Design

Contents of detailed design work are as follows:

(a) Topographic Survey and Geological Survey

a) Preparation of planimetric map of pipelines
b) Preparation of planimetric maps of the sites for overhead tanks and purification plants
c) Study of foundation by boring, and
d) Water quality test

(b) Detailed Design

(c) Preparation of Tender Documents

### (2) Contents of Construction Supervision

(a) Guidance and assistance in tender and contracting works

The consultant shall invite and execute tender on construction works on behalf of the Government of Bangladesh as entrusted by it, and shall guide and assist so as to conclude the construction contract as between the Government of Bangladesh and the Contractor as promptly as possible.

(b) Construction supervision activities

Major works of the consultant are the control of (i) work schedule, (ii) quality and (iii) cost. In the grants-in-aid of Japan, the contract is anticipated to be on a conventional (third party) method, basis, and the control functions other than the above three - for example, material management, machinery and equipment management, labor management, safety and health management - will be within the scope of responsibility of the construction contractor.

The construction supervision activities of the consultant will be performed by civil engineer, pipeline engineer and geohydrogist, etc. who will be dispatched to Bangladesh. The civil engineer will be stationed in Bangladesh throughout the construction period.

(c) Interim and final inspection

Final inspection and, if necessary, interim inspection of construction works will be performed by consultant.

## CHAPTER 8 PLAN FOR MAINTENANCE AND ADMINISTRATION

### 8-1 Organization

(1) Existing Organization for Maintenance and Administration

In Narayanganj Town there are water supplying facilities that date back to the days of British and East Pakistani rule, from whence city water had been supplied to the town. At present, maintenance and administration are being handled by the Waterworks Department of Poroushoava (Municipality). The present organization of Narayanganj Poroushoava is shown in Fig. 8-1. The Waterworks Department in this organization chart is directly responsible for the maintenance and administration of the facilities. There are 66 persons working in this Department.

This organization maintains and administers the water supplying facilities installed by the DPHE and installs, maintains and administers pipes with diameters under 100 mm (4 in.). Installation of pipes with diameters of over 100 mm (4 in.), development of water sources and construction of overhead tanks are all taken care of by the DPHE.

The waterworks operating budget is between 14% and 16% of the total budget of the town. The disbursements cover personnel costs, maintenance and administration costs, ect., and these items in the 1982/83 and 1983/1984 budgets are shown below.

| | 1982/1983 | 1983/1984 |
|---|---|---|
| Town's total budget | 27,471,662 TK | 28,202,000 TK |
| Waterworks operating budget | 3,805,000 | 4,540,000 |
| Breakdown into: | | |
| Personnel cost | 632,940 | 480,268* |
| Maintenance & administration cost | 1,447,287 | 1,042,290* |
| Other cost | 1,684,773 | 3,017,442 |

(Note) *: Actual disbursements up to and including May, 1984

The revenue from water rates corresponds to only about 40% of the amount of budget for waterworks, and the costs necessary for operating waterworks are supplemented by other revenue sources than water rates.

The water rates are not collected specifically as such since the water meter is not installed in each household. The Collection Section collects the water rates together with the municipality tax, which is charged at a rate of 7% on the assessed value of the house of the household to which water is supplied and at a rate of 5% on the household to which water is not supplied. From this, it may be inferred that the water rate is the difference between the two, or equivalent to 2% of the assessed value of each house.

The diffusion of house connection at present is about 30% , or 3,205 households out of 10,706 total households.

For reference, the organization chart of Dhaka WASA is presented in Fig. 8-2, and the organization chart of Dhaka Purification Plant which is about the same size as the purification plant proposed under this project is presented in Fig. 8-3. This purification plant in Dhaka employs 39 people.

Fig. 8-1 Present Organizational Chart of Narayanganj Town

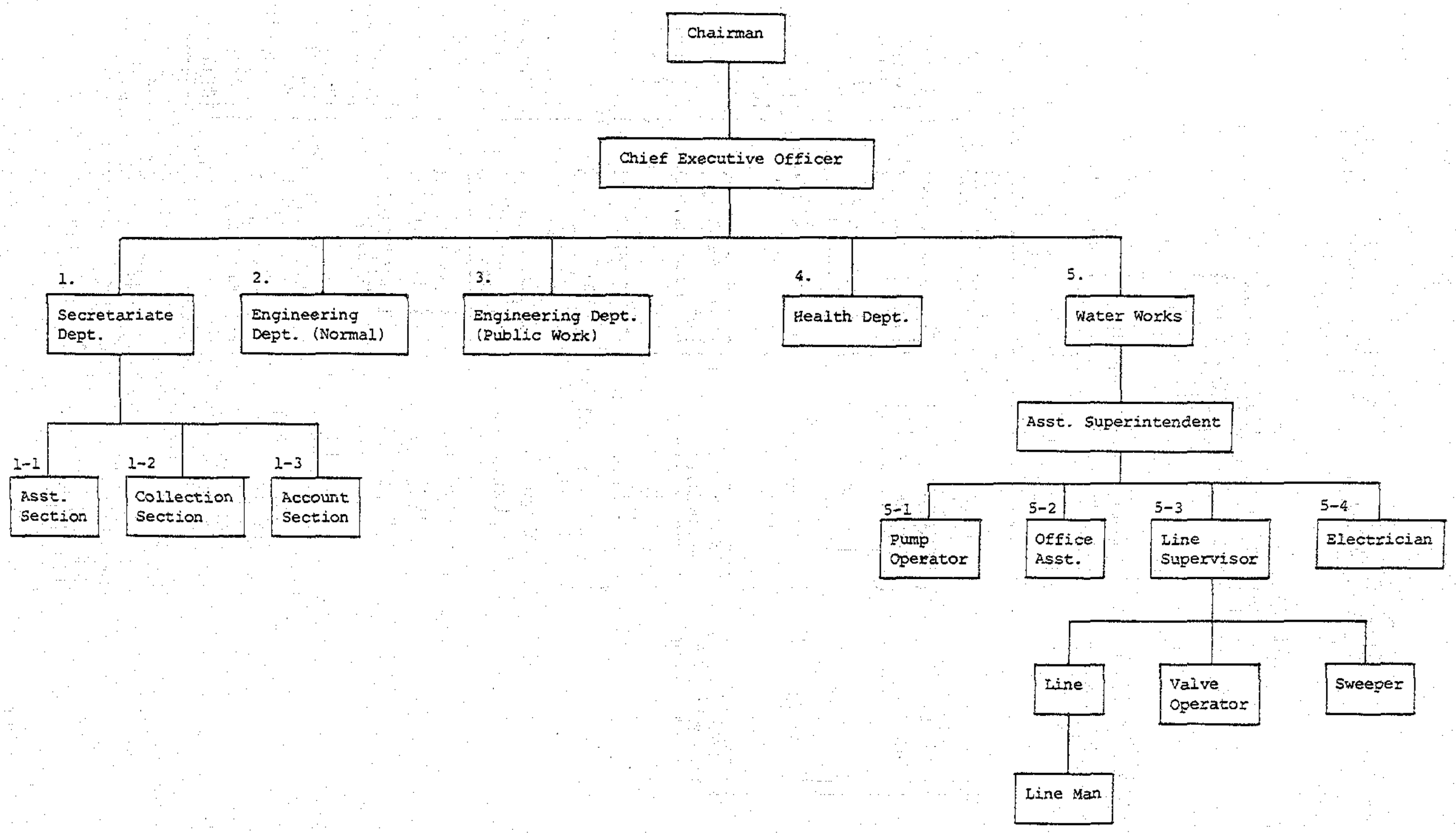


Fig. 8-2 Organization Chart of WASA Dhaka

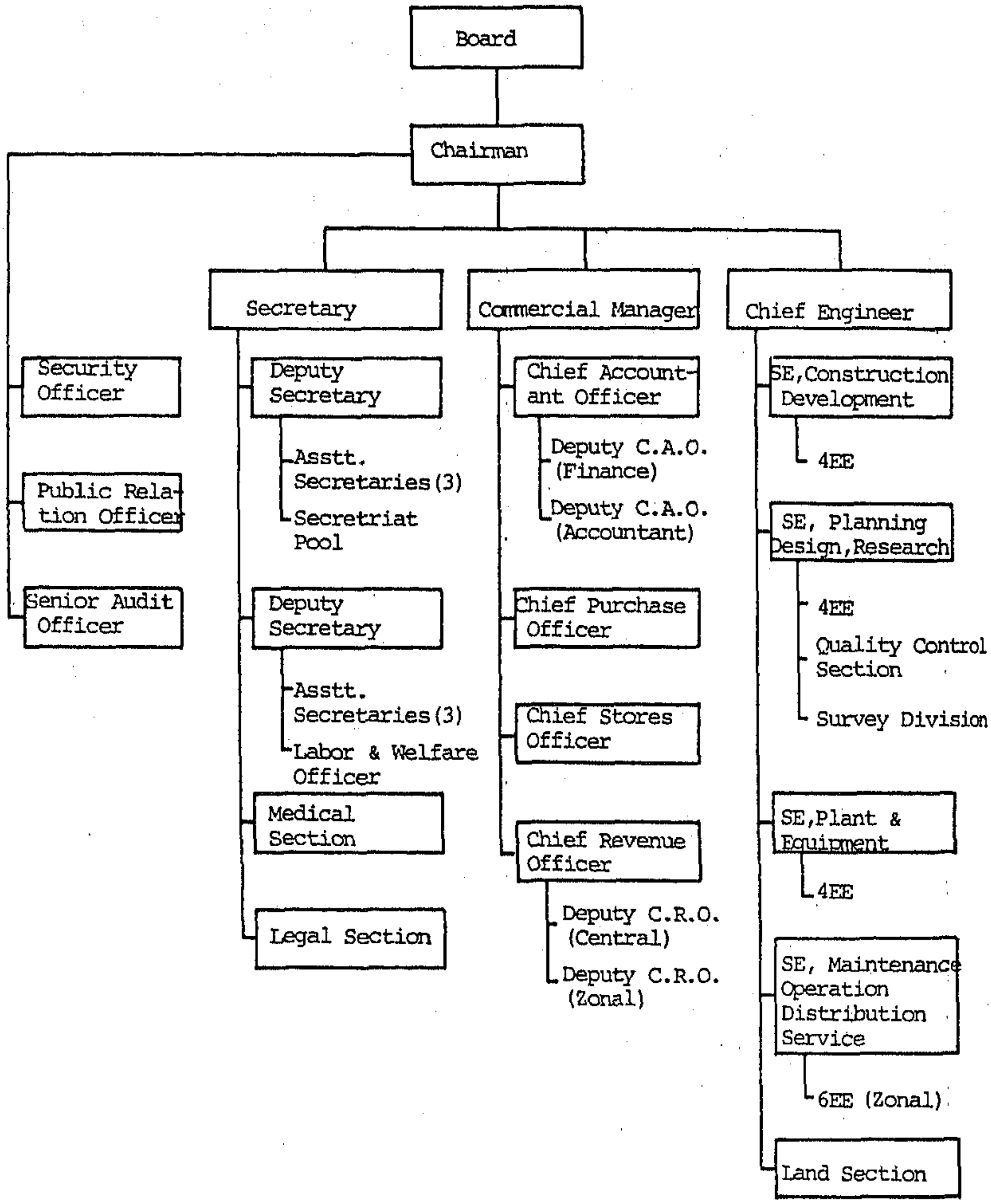
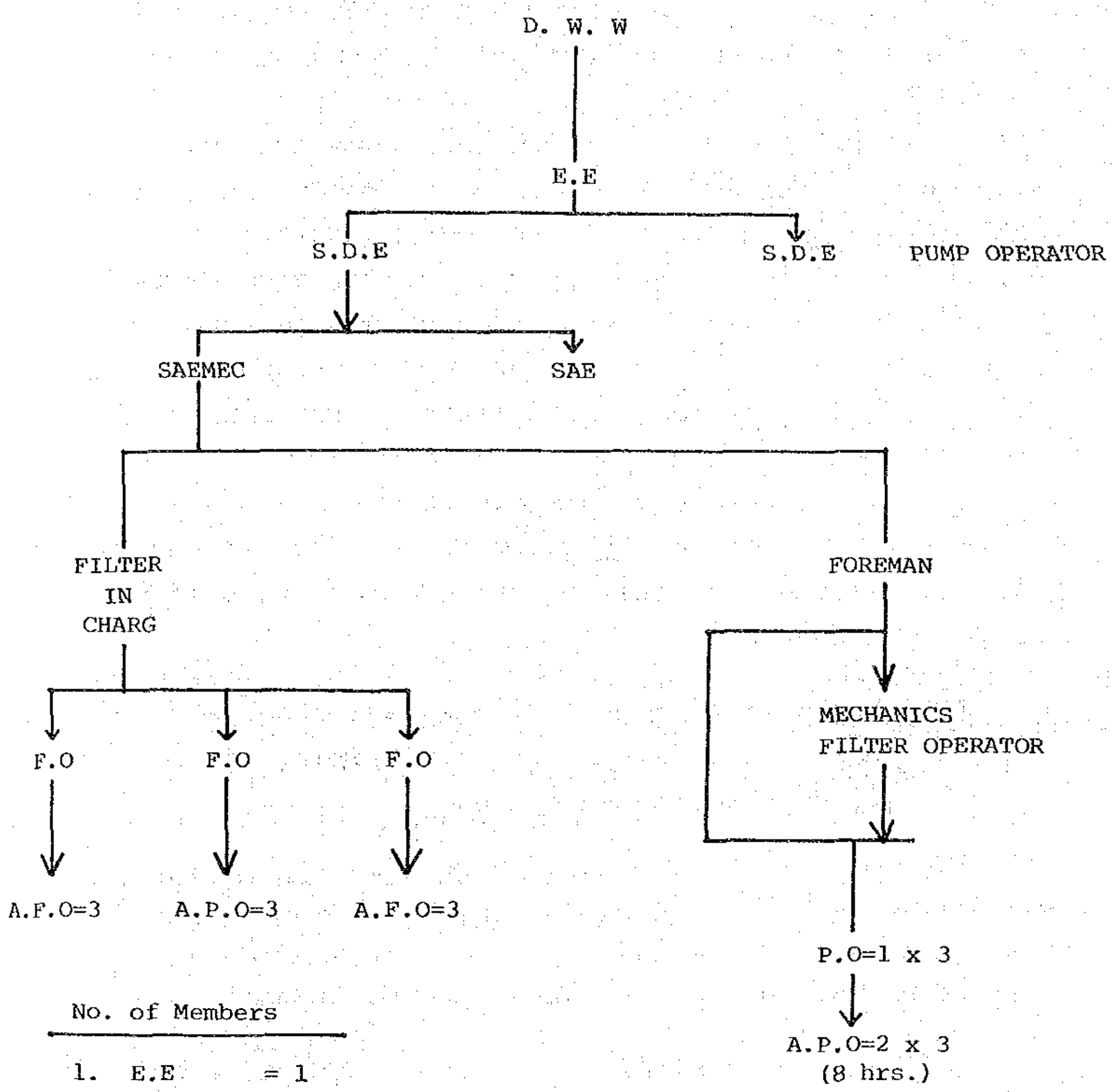


Fig. 8-3 Organizational Chart of Purification
Plant WASA Dhaka




No. of Members

| | | |
|---|---|---|
| 1. | E.E | = 1 |
| 2. | S.D.E | = 1 |
| 3. | S.A.E | = 1 |
| 4. | f/nan | = 1 |
| 5. | f/i | = 1 |
| 6. | F.O | = 3 |
| 7. | A.F.O | = 7 |
| 8. | P.O | = 7 |
| 9. | A.P.O | = 6 |
| 10. | MALI | = 1 |
| 11. | SEWEERER | = 1 |
| 12. | HELPER | = 6 |
| 13. | CLEANER | = 1 |
| 14. | P.L.M | = 2 (PIPELINE MISTRY) |
| | | 39 |

(2) Recommendation on New Organization

At present there are 66 persons employed in the Waterworks Department at Narayanganj Poroushoava.

As the purification plants, overhead tanks, and distribution pipe network will be constructed or improved in both East and West Sides of the Town under the present plan, by which the scale of the water supplying facilities will be expanded, the present organization cannot be considered adequate in terms of both the number and technical competence of its staff to maintain and administer the new facilities.

The water supply organization to be newly established, if it is to supply water in a steady fashion, would have to have at least the following departments to perform the following functions.

(1) A division to publicize waterworks operations and to be responsible for popularizing water supply through house connection

(2) A division to operate the water supplying facilities and provide a stable supply of water

(3) A division to collect water rates

(4) Firm control of the costs of operation and maintenance of installations

(5) Custody of materials

(6) Investigation, planning and design

(7) Construction and repair work

(8) Water quality control

After having consulted the DPHE and referred to the organization of the existing waterworks facilities (WASA's, Dhaka purification plant), we wish to propose a new waterworks organization for Narayanganj shown in Fig. 8-4. The construction maintenance and administration of the new water supplying facilities will be carried out by DPHE.

It is most important to create an appropriate administrative organization on the basis of this proposal with due regard to the prevalent administrative and institutional systems in Bangladesh.

The contents of work assigned to the various divisions of the proposed organization are roughly as follows.

(1) The General Affairs Division (Administration Division), besides overall administration of the whole organization, will design future waterworks plans, will disseminate and publicize the house connections for water supply, concern itself with payment of wages to employees and all monetary disbursements, compile and analyze annual budgets and maintenance and administrative costs, and engage in collection of water rates and other activities.

(2) The Operations Division will be directly responsible for the operation and maintenance of waterworks facilities such as the purification plant, and will guarantee a steady supply of water to the people by operating the pumps and valves of the facilities to supply water. It will also be responsible for the maintenance and administration of structures such as purification plants, wells, overhead tanks, pipelines as well as of equipment such as pumps and valves. On a part time basis,

Fig. 8-4 Proposed Maintenance and Supervision Organization

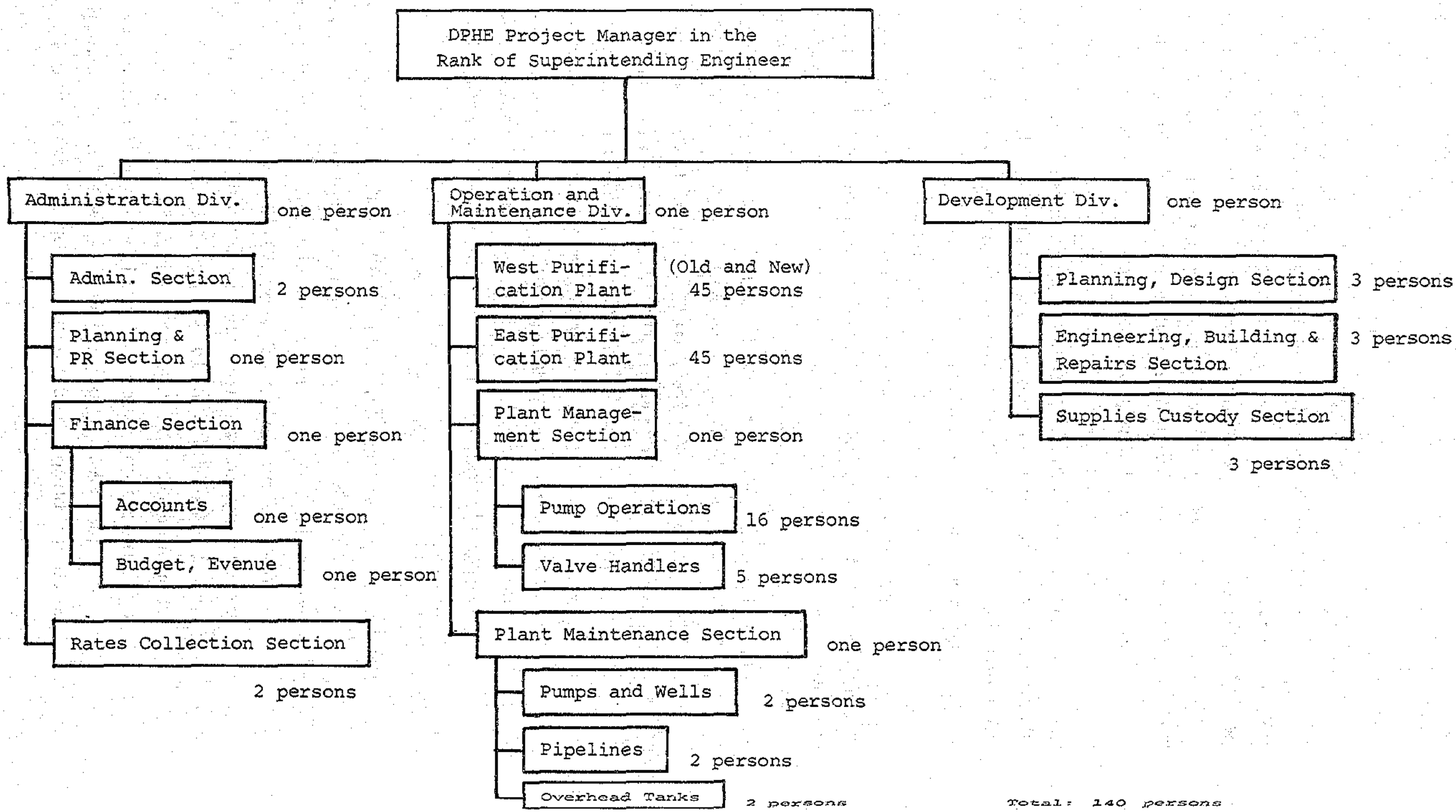
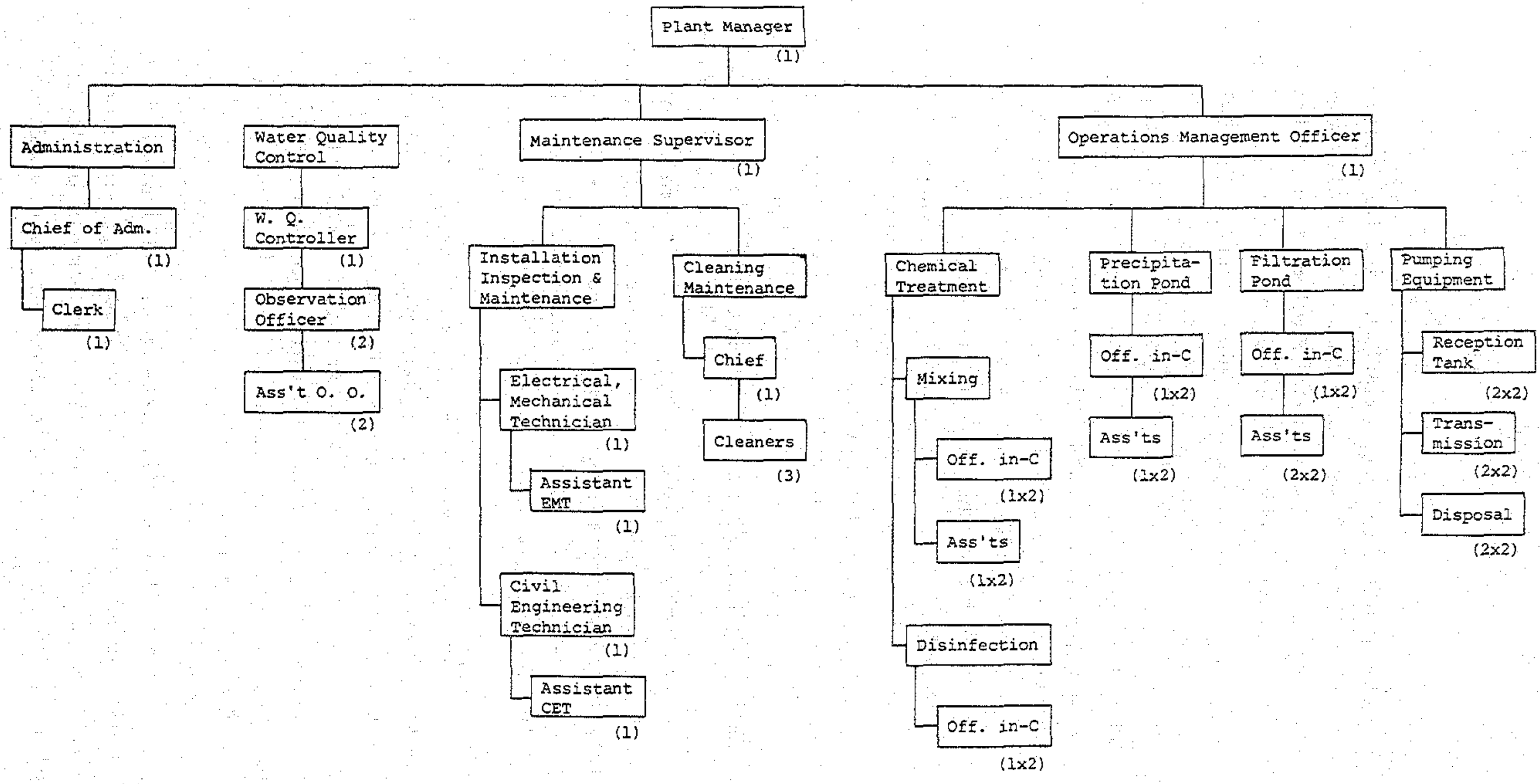


Fig. 8-5 Organizational Chart of Purification Plant




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

the Division will conduct quality control of the water which it supplies. It is also one of its duties to contact the Engineering Section of the Development Division in the event of any anomally in any of the water supplying facilities and to have it take appropriate actions.

(3) The Development Division will engage in the expansion of the water supply facilities which will be planned in the future, plan and design the investigation of new water sources and will supervise the construction involved in these undertakings, as well as the repair work of existing installations and assume custody of materials and machine parts.

## 8-2 Maintenance and Administration Staff

It goes without saying that in order to operate the waterworks installations constructed, it is necessary to consolidate the organization proposed in the foregoing paragraph, but it is also important that the operational staff in the organization is appropriately assigned.

The staff assigned to the task of maintenance and operation should be engineers and personnel with education and experience in their respective areas of competence. However, in Bangladesh today, there are only some 50 cities besides the WASA of Dhaka and Chittagong which have piped water supply systems and most of them have only recently acquired these systems.

Under these circumstances, the number of technicians with experience in water supply system in general is limited. When this and other water supply projects are completed, the shortage of technicians and staff will be aggravated making it difficult to provide appropriate maintenance and operation. Therefore, it is necessary to train technicians and staff for maintenance and operation of water supply installations.

As these installations are planned to be directly administered by DPHE after their completion, it is imperative for DPHE to train the staff and improve the organization. In view of the contents and the levels of the water supplying facilities of this project, the organization and manning for their maintenance and administration would reasonably be as proposed in Figs. 8-4 and 8-5. The required number of staff is 140 persons, which is at a ratio of approximately 1/2,600 to the current population.

The number of staff required for maintenance and operation of water supply projects in Japan which are of the same scale as the present project is at a ratio of one staff member for every 1,000 residents serviced.

At the present time, the ratio of WASA employees engaged in the waterworks at Dhaka and Chittagong to the population serviced is 1/1,250 to 1/1,200.