CHAPTER 2 PRELIMINARY DESIGN

2 PRELIMINARY DESIGN

2.1 DESIGN CRITERIA

Design criteria applied for the project are presented in this section. The criteria do not have major difference compared to those of latest or on-going projects implemented by HWBC, and also those proposed in the Master Plan.

2.1.1 Service Level

(1) Service Hours

The system, all facilities for raw water intake, treatment and distribution, is to be planned by 24 hours continuous operation basis.

(2) Type of Service

Water is to be supplied through individual house connection to all consumers. All connections (service pipes) shall be equipped with water meters for billing purpose.

Installation of public taps for people is not considered in the project.

(3) Water Quality

Water quality of treated water shall comply to the Vietnamese drinking water standard.

2.1.2 Capacity

(1) Peak Day Factor

The peak day factor, (Daily Maximum) : (Average Daily), which will be applied to size dimensions of facilities of water treatment and raw water intake is to be 1.35 (135%).

(2) Peak Hour Factor

The peak hour factor which will be applied to determine diameters of distribution pipelines is to be 1.40 (140%) of the daily maximum distribution capacity.

(3) Raw Water Intake Capacity

Taking consideration of plant loss in the course of treatment, i.e. filter back-wash water and other miscellaneous use in the treatment plants, raw water intake capacities is set to be 105% of the production capacity. (Plant loss = 5% of treatment capacity)

2.1.3 Water Source Facilities

(1) Water Source

Water source is planned to be deep groundwater, being available in the south area of the Red River.

(2) Deep Wells and Intake Pumps

The groundwater is to be taken through deep wells to be equipped with submersible pumps (one pump to one well). The safe yield of one well is determined at 50 l/sec (180 m3/hr). Assuming 20 hours' operation of pump, 3,600 m3/day of water is available from a single well. Number of standby pump/well is proposed to be 30% of operating pumps.

Operation of a pump is to be done at the control room in the treatment plant with remote operating system, as well as done at the pump station site.

(3) Raw Water Transmission

Raw water taken from deep wells is planned to be transmitted to a treatment plant by way of a pressurelized pipeline. Its material is of ductile cast iron pipe with mortar lining.

(4) Power Supply

Power necessary for raw water intake pumps (submersible pumps) is planned to be of the public electricity.

2.1.4 Treatment Facilities

(1) Treatment

Groundwater in the area contains iron and manganese, concentration of which is higher than the drinking water standard. Accordingly, the groundwater needs treatment.

Treatment process, aim of which is removal of iron and manganese, is to be composed of aeration, sedimentation, filtration and disinfection.

(2) Basic Criteria for Facilities

- Aeration:
  10 m3/m2/h of surface load, at the maximum
- Contact and Sedimentation:
  60 minutes of detention time and 55mm/min of surface load
- Filtration:
  120 m/day of filtration rate

(3) Disinfection

Disinfection is to be done with liquid chlorine, as same as currently used in the existing plants of HWBC. It is fed into a chlorine-mixing chamber to be constructed at a place between filters and reservoirs.

(4) Sludge Treatment

Sludge drained from filter-backwash water and drainage of coagulation/ sedimentation shall be treated in the yard of treatment plant, in prior to disposal, from a viewpoint of environmental protection. The sludge treatment is planned to be processed by the sludge-drying bed system.

Clear water generated through the sludge treatment process is to be returned the aeration towers to save raw water.

(5) Reservoir

Capacity of the distribution reservoir is planned to be 20%-volume, or 4.80 hours' equivalent volume, of the daily maximum production. The reservoir, to be of reinforced concrete, will be constructed on the ground level in the treatment plant yard.

(6) Distribution Pumps

Total capacity for the pump shall meet the peak hour demand.

Power for pumps will be from public electricity. In the case of the electric failure, a generator in the plant will be operated for one distribution pump operation.

(7) Flow Measurement

Water flow shall be measured with flow meters to raw water, distribution water, and clear water returned from sludge treatment system to sedimentation.

2.1.5 Distribution Facilities

(1) Water Pressure

Static pressure in distribution pipes will be 55.0 (5.5 kg/cm2) m at the maximum from an economical viewpoint such as pump power required, volume of leakage in pipelines, strength of pipe materials/ joints, pipe maintenance, etc..

Minimum dynamic pressure is planned to be 20 - 30 m in main distribution pipelines, considering direct supply to 3 - 4 storied buildings.

(2) Diameters of Pipelines

Diameters of distribution pipelines is to be determined based on the peak hour flow. Hydraulic calculation of distribution pipelines will be made by Hazen-William Formula which is widely used among the world. Velocity coefficient (C) in the formula is proposed 110 (C=110).

(3) Pipe Materials

Ductile cast iron pipes with mortar lining (push-on type joint) will be used for diameters of 100 mm or larger. Polyvinyl chloride pipes (PVC pipes or VP) with rubber ring joint type will be used in principle for 75 mm pipes or less. However, in the case of heavy traffic roads or strategical roads, ductile cast iron pipes will be used even in small diameters.

(4) Leakage

Leakage in distribution pipelines is assumed to be 15% of the distribution capacity, considering that the pipelines is to be newly constructed with intact materials and workmanship of pipe installation work will be more improved than old days.

(5) Fire Hydrants

For the purpose of fire-fighting work, fire hydrants will be installed to pipes of 150 mm in diameter or larger and in strategic points at 300 m intervals in principle.

Type of the fire hydrants will be partly underground one.

(6) Stop Valves

For the convenience of pipeline maintenance, stop valves will be installed at strategical points, mainly at branching points. There, stop valves will be installed in principle at downstream sides of pipelines.

(7) House Connections

House connection will be made from network pipes of diameter 200 mm or smaller in principle by way of branch saddles. In the case of Highways or busy roads which have wide width and heavy traffic volume, branched distribution pipelines (100 - 75 mm) will be installed on the both sides of the roads in order to facilitate installation of house connection service pipes.

Pipe material of service pipes will be in principle polyethylene pipes (PE). Diameters of service pipes will be 20 mm for ordinary houses and 40 mm for apartment-type building or the like.

All service pipes shall be equipped with water meters for billing purpose.

2.2 DESIGN CAPACITY

The water demand for this project was forecasted in the preceding section. Design capacity of facilities which shall meet the water demand is decided as given below:

- Intake facilities : Q = 60,000 m3/d (= Daily Maximum Intake capacity)
- Treatment facilities : Q = 60,000 m3/d (= Daily Maximum Production capacity)
- Distribution facilities : Q = 57,000 m3/d (= Daily Maximum Distribution capacity)

(Plant loss : Q = 3,000 m3/d)

The capacity is broken down by the service area into the following:

(m3/d)

Item	Service Area	(A) To Project Area	(B) Supplement to Mai Dich	(C) To New Development Area
Daily Maximum	(1) Intake capacity	60,000		
	(2) Treatment capacity	60,000		
	(3) Plant loss	3,000		
	(4) Distribution capacity	57,000		
	(5) Distribution by area	20,000	20,000	17,000
Average Daily	(6) Distribution by area	14,800	20,000	12,900
	(7) Demand	12,600	20,000	11,000

Note:
(1) = (2)
(3) = (2) x 5%
(4) = (2) - (3)
(6) = (5) / 1.35 (Peak day factor = 135%)
(7) = (6) x (1- 0.15) (Physical loss = 15%)
(In the case of "Supplement to Mai Dich Treatment Plant", 20,000 m3/d is to be distributed constantly with 24 hours basis everyday.)

2.3 ALTERNATIVE PLAN

2.3.1 Location of Facilities

(1) Wellfield

The wells have been arranged on a line which is almost parallel to the Red River dike, keeping the distance more than 700 m (ten times of the proposed well depth) from the dike. Although the arrangement on plural lines is supposed alternatively, as the lowering of drawdown of the wells arranged on the land side and the bad influence to the land side existing wells seem to occur, because of the groundwater flow line from the river to the land as stated in the M/P, the wells were arranged on a single line. Furthermore, the use of the existing roads for construction and maintenance of the proposed wells has been considered as much as possible.

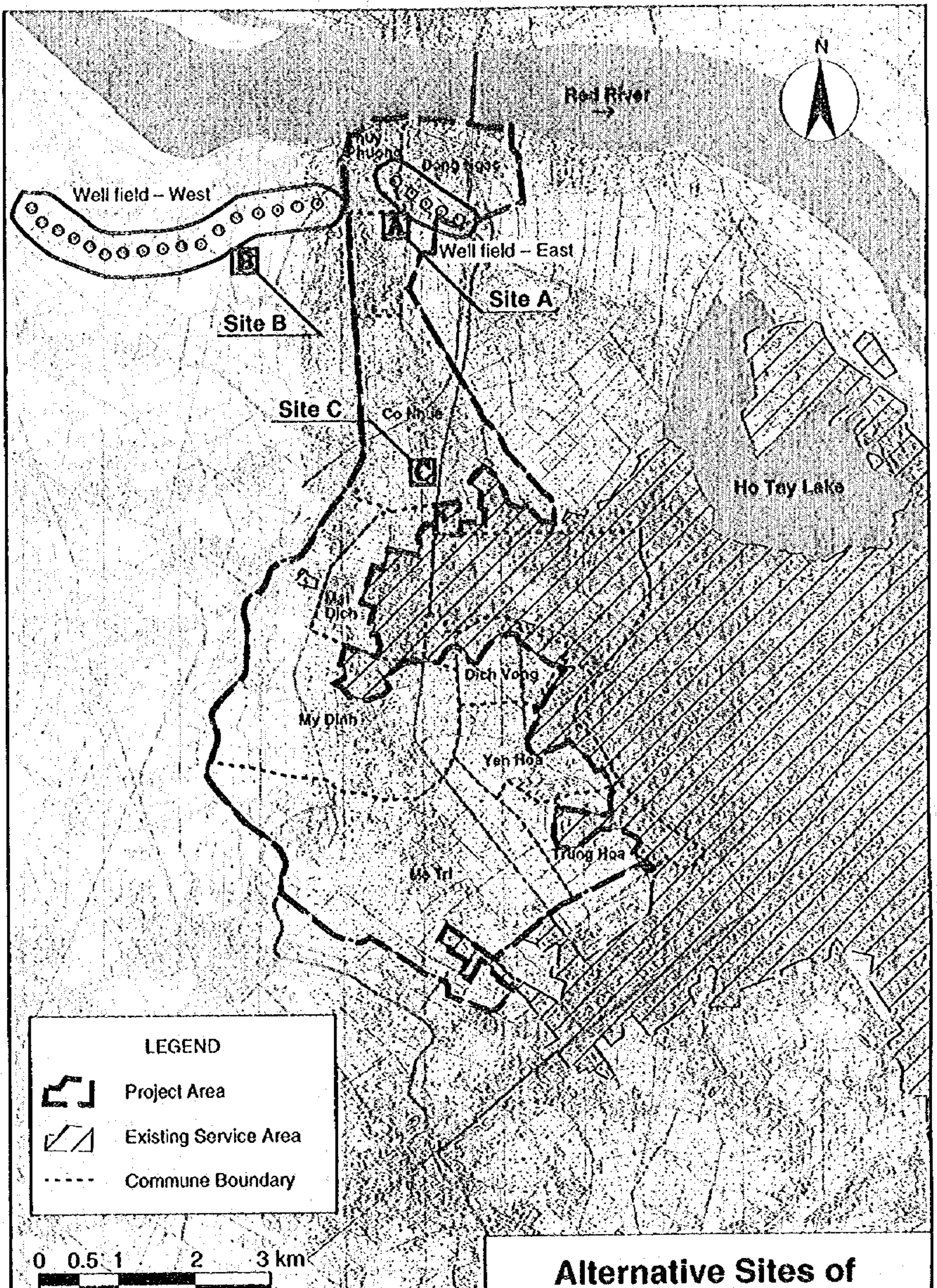
(2) Location of Treatment Plant

For the location of a proposed treatment plant, three sites were taken into consideration: Site A in Xa Dong Ngac, Site B in Xa Lien Mac and Site C in Xa Co Nhue (Please see the drawing of "Alternative Sites of Treatment Plant").

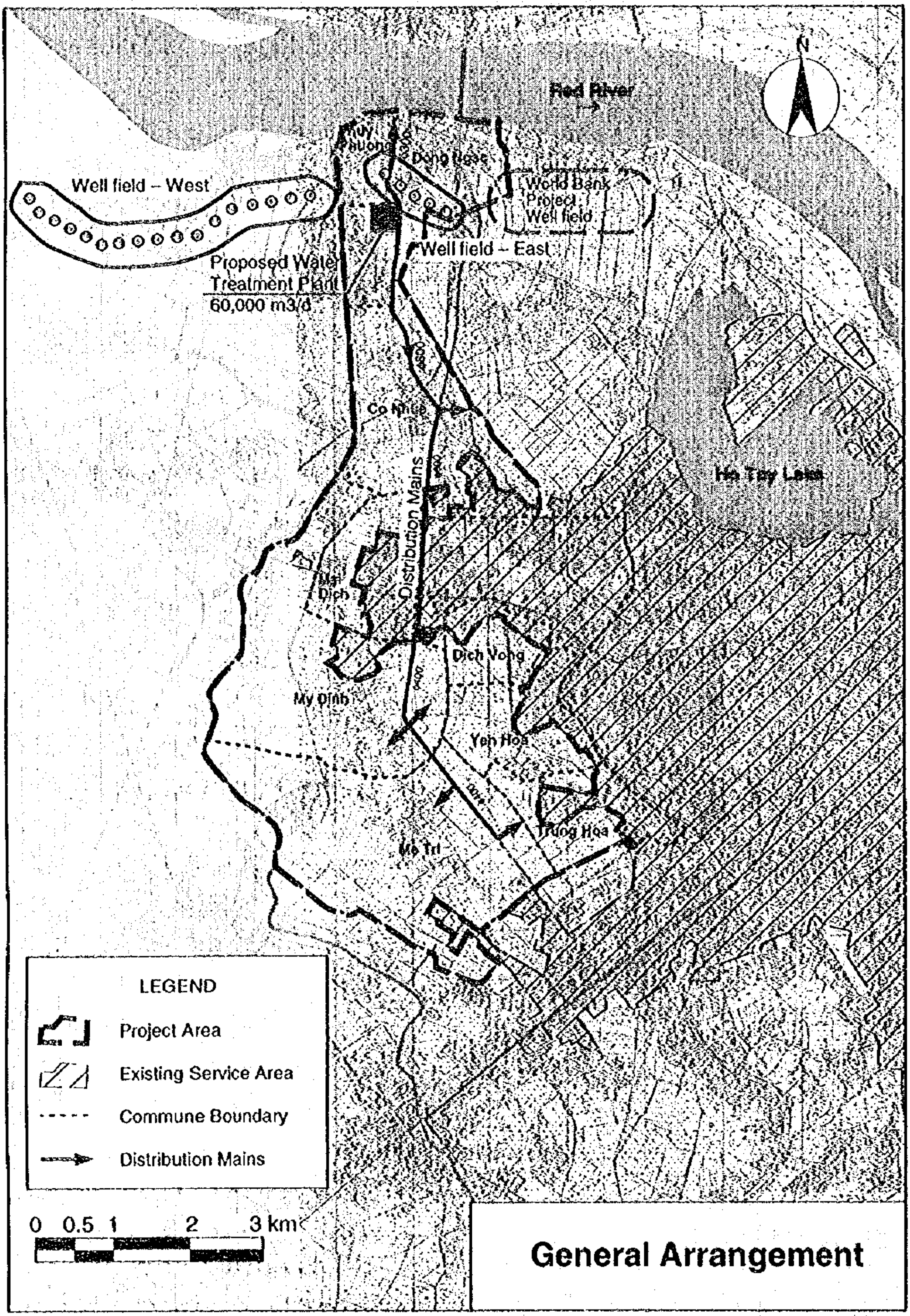
Comparing various elements among them, Site A can be recommended for the location of the proposed treatment plant; and Site C is secondly recommended. (Please refer to the following comparison table).

Site Comparison of Proposed Treatment Plant

Item	Site A	Site B	Site C
(1) Location	In Xa Dong Ngac, East of Nhue River	In Xa Lien Mac, West of Nhue River	In Xa Co Nhue, East of Nhue River
(2) Inside or outside of service area	Inside	Outside	Inside
(3) Present land use	Paddy field	Paddy field	Paddy field
(4) Land cost	Site C (Expensive) > Site A > Site B (Low)		
(5) Distance from service area	Short	Farest	Shortest
(6) Accessibility and transportation from Hanoi downtown	Good	Not convenient	Convenient
(7) Power supply possibility	Possible	Possible	Possible
(8) Raw water transmission cost	C (Expensive) > A > B (Low)		
(9) Water distribution cost	B (Expensive) > A or C (Low)		
(10) Negative impact to environment	Small	Small	Medium
Recommendation for treatment plant site	Prior recommendation	Not recommendable	Secondly recommended



Alternative Sites of Treatment Plant



General Arrangement

2.3.2 Treatment process

(1) Requirement

The raw water does not satisfy the Vietnamese criteria for drinking water quality in substances of iron and manganese. The table below compares between raw water quality and drinking water criteria.

Item	Raw Water Quality	Drinking Water Criteria
Total Iron	Maximum 9.2 mg/l	Maximum 0.3 mg/l
Manganese	Maximum 0.5 mg/l	Maximum 0.1 mg/l

To achieve the criteria, proper treatment process should be employed. The system should be designed in terms both of technical and economical aspects.

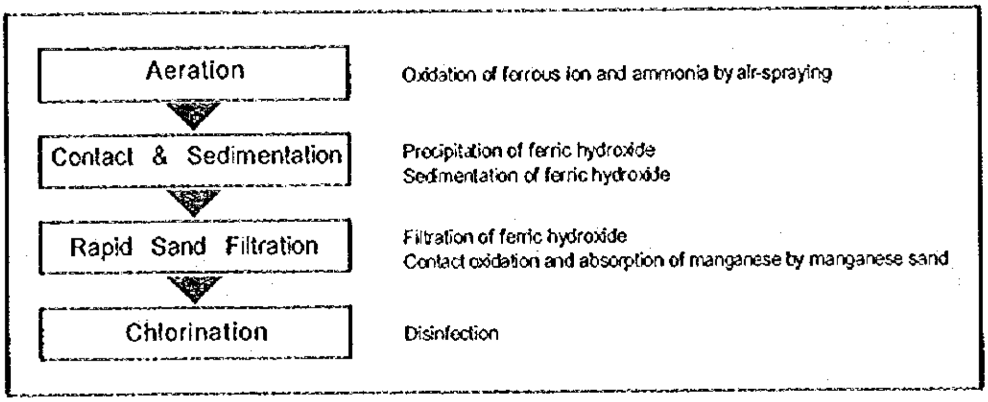
Besides the above process, the ammonia removal should be considered because ammonia consumes chlorine used for disinfection although ammonia concentration of 1.4 mg/l clears 3.0 mg/l of the criteria.

(2) System Alternatives

1) Alternative A : Aeration System

This system has been conventionally taken into operation in Hanoi. The aeration and contact process is able enough to oxidize iron with the contact time of about 30 minutes. The longer retention time would enable a part of ferric hydroxide precipitation to settle in the bottom.

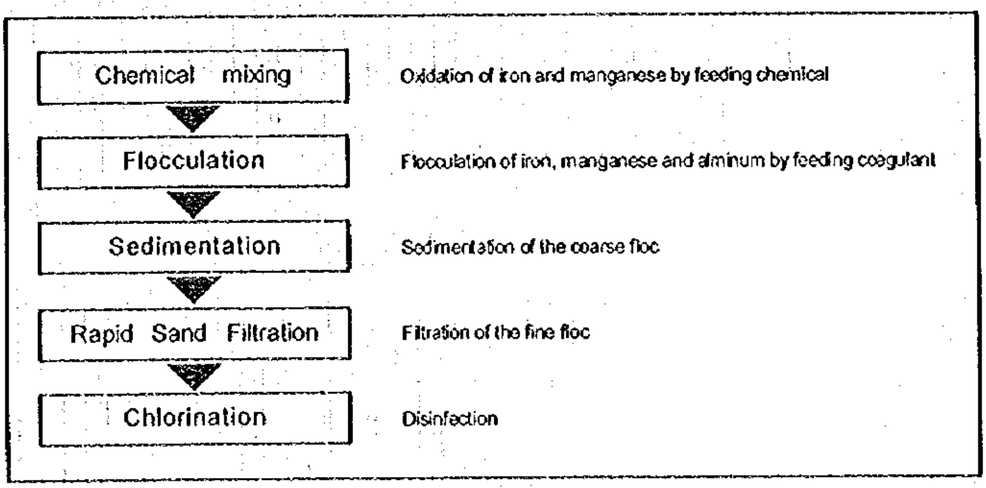
To remove manganese, the contact oxidation and adsorption by manganese sand is designed. In order to keep manganese sand in active, break-point chlorination is required.



2) Alternative B : Chemical Sedimentation System

Oxidation can be achieved by feeding the oxidizing chemical such as chlorine, potassium permanganate, etc. In most cases, the chemical oxidation is followed by the flocculation and sedimentation to settle the floc. This system is applicable to groundwater which requires oxidation for treatment.

Although this would be effective in technical aspects, it should be noted from the economical viewpoint that the construction cost be high and also the chemical cost for operation in general be rather high.



3) Alternative C : Iron Bacteria System

It is known that iron and manganese can be oxidized and absorbed by the biological action of iron bacteria growing in the slow sand filter. The system can not be applied to the high concentration of iron and manganese.

Compared to the rapid sand filtration, about ten times wider land for filtration is required due to its slow filtration rate. In operation, washing and replacement of the clogged sand is regularly required.

Filteration (Oxidation)	Oxidation and removal of iron and manganese by iron bacteria
▼	
Chlorination	Disinfection

4) Alternative Proposed

The above three alternatives are compared on account of the technical and economical advantages. The table below summarizes the comparison.

The aeration system (Alternative A) was decided as the proposed alternative. The treatment system flow sheet is illustrated in Chapter 2.4.4.

	Alternative A Aeration System	Alternative B Chemical Oxidation	Alternative C Iron Bacteria
Easiness of Construction	Easy Common in Hanoi	Difficult	Easy Wider area is required
Removal Efficiency	Good Air-spraying oxidation is very effective	High Oxidizing chemical has high potency	Not applicable to high concentration of Iron
Easiness of Operation	Easy Well experienced in Hanoi	Difficult Control of chemical dosage is difficult	Sand replacement or cleaning is hard
Investment Cost	Nearly equal to the other on-going projects	More expensive due to chemical dosing equipment	The wider land raise cost
Operation and Maintenance Cost	Nearly equal to the other existing plants	Expensive Oxidation agent and Coagulant is expensive	Not so high Chlorine for disinfection Sand replacing cost

(3) Number of Series

To supply water coincident with the water demand, it is necessary to consider the number of series and blocks of the treatment facility. Considering the water demand components in amount, the capacity of one block was decided to be 10,000 m3/d. Three blocks constitutes one series of 30,000 m3/d treatment capacity. Consequently, the maximum operational capacity of 60,000 m3/d is performed from the two series.

The multi-series system is in general more advantageous than the single-series system, because the former system can operate continuously while one series stops in repairing, cleaning or the other maintenance works.

(4) Design Concept

A. Retention period of contact and sedimentation basin

From the result of the study of the retention time; see appendix "Study for the Design of Contact and Sedimentation Tank", the retention period is designed to be 60 minutes.

According to the study, 30 minutes is enough for oxidation and the additional 30 minutes is regarded as the sedimentation period. The sedimentation prior to filtration contributes to the longer operation hours of filters because the load to the filters is or can be reduced.

B. Operation and maintenance cost

The operation and maintenance cost, in particular chemical and electric cost should be minimized without degrading the functions.

C. Emergency electric generator

In preparation against long time electric power cut, the emergency electric generator should be equipped. Considering the water demand of domestic users, it should have a capacity of operating at least one distribution pump and the internal lighting.

D. Sludge treatment system

Considering the water source saving and the environmental aspect, the sludge treatment system is required. After the sludge treatment, overflow water from the sludge thickener is returned to the main treatment system. The drain water from the sludge drying bed is cleaned and discharged to outside.

E. Chlorine neutralization equipment

As the chlorine gas for disinfection is a hazardous material to respiratory organs, chlorine neutralization equipment should be provided so as not to cause a serious accident.

In the chlorination facility, a number of chlorine containers are to be kept. In case of accidental leakage, the chlorine container room will be filled with the chlorine gas, which is heavier than air and is not diffusive.

The neutralization equipment can detect the chlorine leakage and the chlorine gas will be transferred by blower through the air duct to the neutralization tower. The chemical used for neutralization is caustic soda that is reserved in a tank.

2.4 PRELIMINARY DESIGN

2.4.1 Water Source

(1) Hydrogeological conditions and well design

Typical hydrogeological conditions of the wellfield and the proposed well design are shown in the following page. They were estimated and decided referring to the existing wells around the proposed wellfield and in the main wellfields.

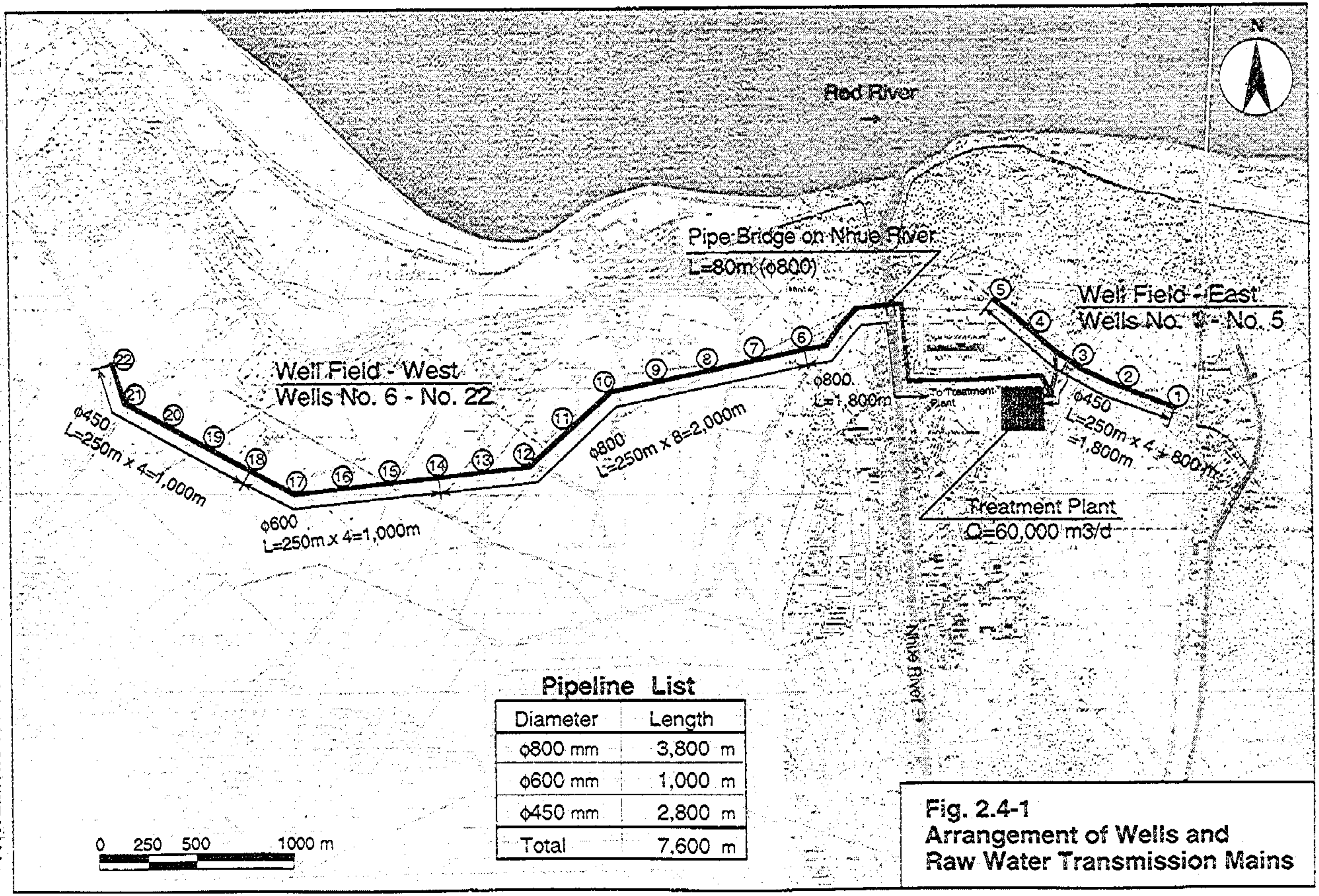
(2) Distance between wells

The distance between the adjacent wells was set 250 m referring to the existing main wellfields in the south Hanoi. If the distance between wells is 250 m, the drawdown at the middle point of the adjacent wells is calculated with the hydrogeological equation.

The calculated drawdown at the middle point of the adjacent wells is 1.18 m.

(3) Required well number

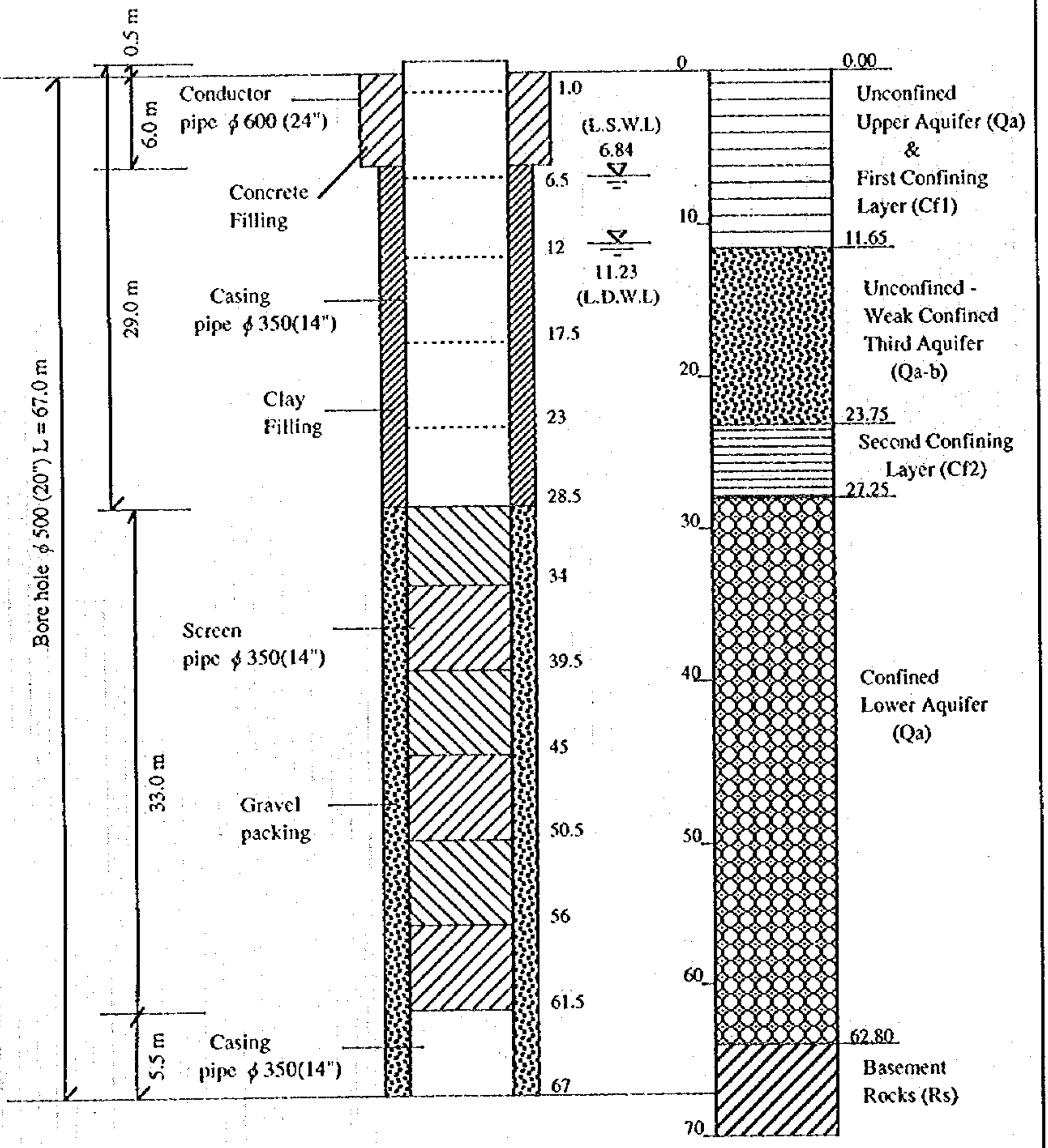
Proposed daily maximum production is 60,000 m3/d. Proposed discharge is 3,600 m3/d/well (50 lit/sec, 20 hrs pumping), and required well number is 22 {(60,000/3,600) x 130 % (including 30 % for standby)}.



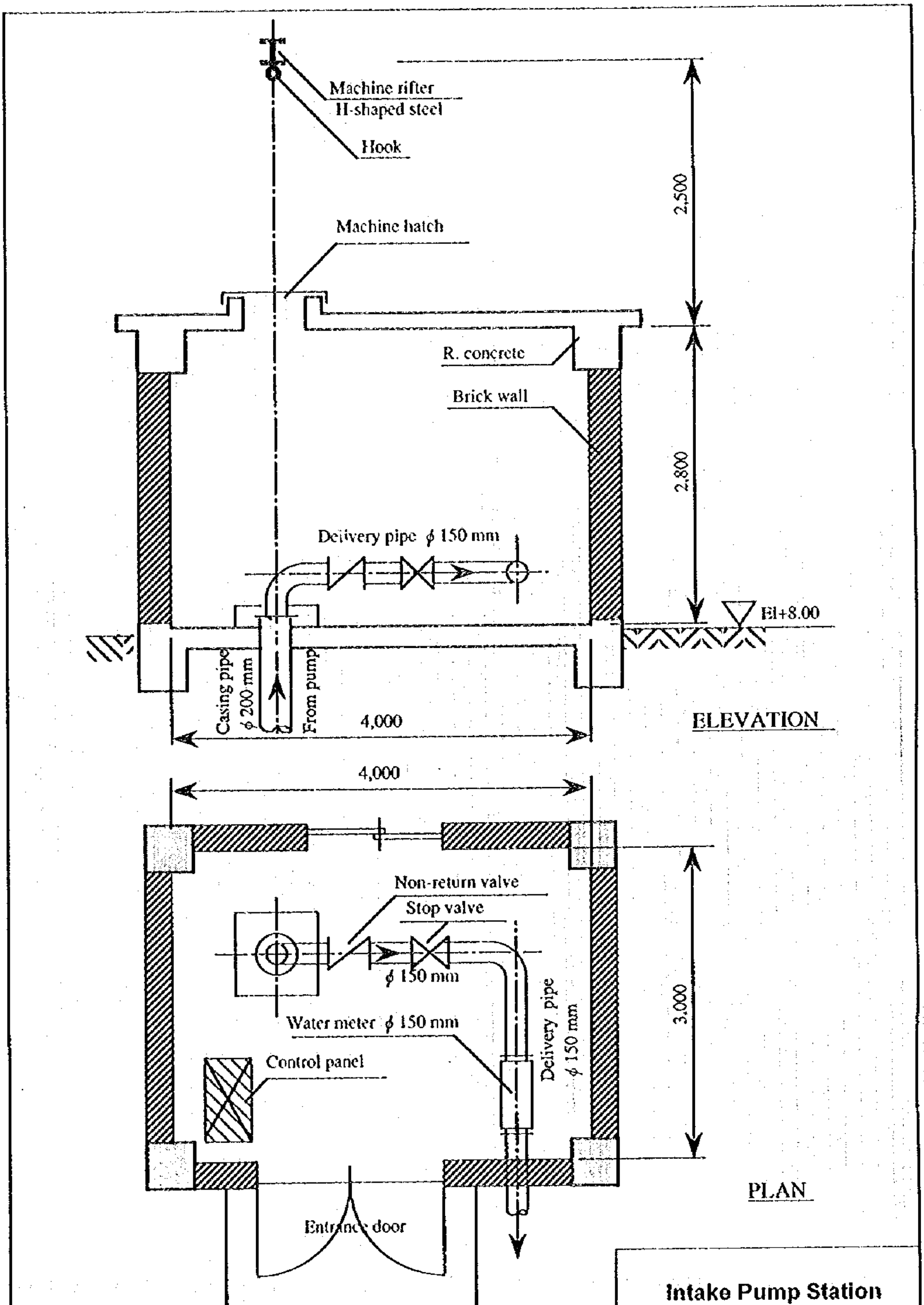
Pipeline List

Diameter	Length
φ800 mm	3,800 m
φ600 mm	1,000 m
φ450 mm	2,800 m
Total	7,600 m

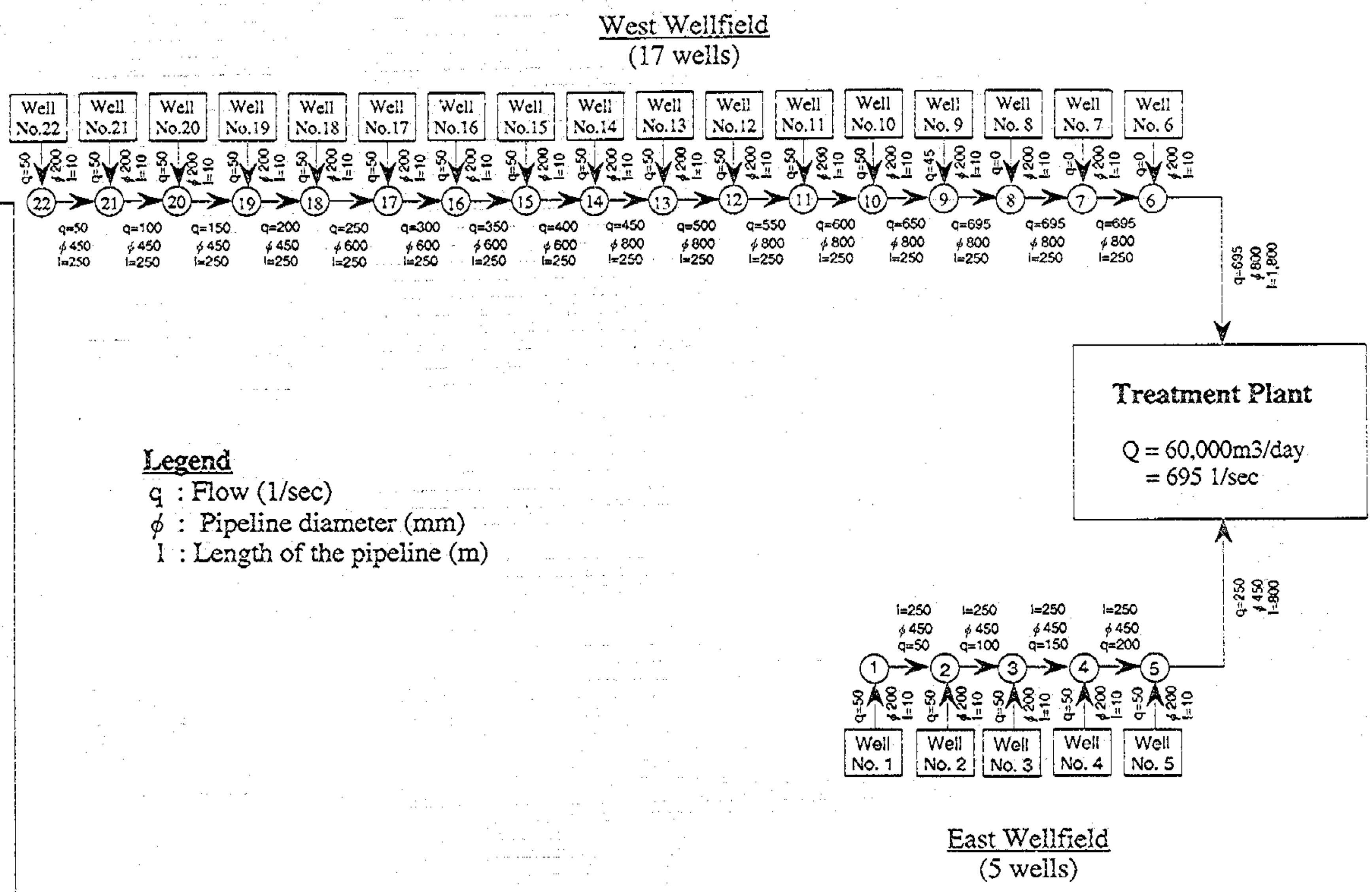
Fig. 2.4-1
Arrangement of Wells and
Raw Water Transmission Mains



Well Design for the Project



Intake Pump Station



Hydraulic Calculation Chart of Raw Water Transmission Pipelines

Hydraulic Calculation of Raw Water Transmission Pipeline
(From groundwater wells to the Treatment Plant)

Pipeline Well-Well	Flow (l/sec)	Dia. (mm)	L (m)	I (1/1000)	V (m/s)	H (m)	T.H. (m)
West							
Well 22 - Well 21	50	450	250	0.34	0.31	0.09	0.09
Well 21 - Well 20	100	450	250	1.23	0.63	0.31	0.39
Well 20 - Well 19	150	450	250	2.61	0.94	0.65	1.04
Well 19 - Well 18	200	450	250	4.44	1.26	1.11	2.15
Well 18 - Well 17	250	600	250	1.65	0.88	0.41	2.57
Well 17 - Well 16	300	600	250	2.31	1.06	0.58	3.15
Well 16 - Well 15	350	600	250	3.08	1.24	0.77	3.92
Well 15 - Well 14	400	600	250	3.94	1.42	0.99	4.90
Well 14 - Well 13	450	800	250	1.21	0.90	0.30	5.20
Well 13 - Well 12	500	800	250	1.47	1.00	0.37	5.57
Well 12 - Well 11	550	800	250	1.75	1.09	0.44	6.01
Well 11 - Well 10	600	800	250	2.06	1.19	0.51	6.52
Well 10 - Well 9	650	800	250	2.38	1.29	0.60	7.12
Well 9 - Well 8	695	800	250	2.70	1.38	0.67	7.79
Well 8 - Well 7	695	800	250	2.70	1.38	0.67	8.47
Well 7 - Well 6	695	800	250	2.70	1.38	0.67	9.14
Well 6 - Plant	695	800	1,800	2.70	1.38	4.86	14.00
East							
Well 1 - Well 2	50	450	250	0.34	0.31	0.09	0.09
Well 2 - Well 3	100	450	250	1.23	0.63	0.31	0.39
Well 3 - Well 4	150	450	250	2.61	0.94	0.65	1.04
Well 4 - Well 5	200	450	250	4.44	1.26	1.11	2.15
Well 5 - Plant	250	450	800	6.71	1.57	5.36	7.52

(Note):

Flow required = Treatment plant capacity = 60,000 m3/day = 695 l/sec
L = Length of the pipeline
I (Hydraulic gradient) = 10.666 x C**(-1.85) x D**(-4.87) x Q**(1.85) (C = 110)
H (Loss of head in the pipeline) = I x (Length)
T.H. = Total loss of head from the farthest well to the treatment plant

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Capacity of Intake Pump (Submersible pump)
(Ground elevation of the plant = +8.00m, Ground elevation of the wellfield = +8.00m)

- Pumping capacity per unit = 50 l/sec = 3.00 m3/min
- Water level of Aeration Tank in the Plant = + 18.00 m
- Dynamic groundwater level in the well = - 4.00 m
- Actual pumping head = (+18.00) - (-4.00) = 22.00 m
- Loss of head in the raw water transmission pipeline = 14.00 m (See above Table)
- Loss of head around the pump = 1.50 m
- Total pumping head = 22.00 + 14.00 + 1.50 = 37.50 m → 38 m
- Motor power required:
  P= { 0.163 x 3.00 x 38.0 / (0.7) } x (1+0.15) = 30.5 kw → 37 kw
- Total power required = 37 kw x 22 pumps = 814 kw
- Maximum operation power = 37 kw x 14 pumps = 518 kw

2.4.2 Water Treatment Plant

(1) Design water capacity

Maximum design water capacity of the treatment plant is 60,000m3/day. The drain water from plant is estimated to be 5% of the total treatment capacity with 3,000m3/day. Therefore, the capacity of the sludge treatment facility is based on the drain water volume. For the saving of the water source, the over-flow water from the thickener is transferred to the aeration tower and, is treated for reuse. Maximum distribution water capacity at outlet of the plant is to be 57,000m3/day.

(2) Outline of the facilities

The raw water is transmitted directly to aeration tower by intake pumps. The raw water inlet-pipe material in the tower is stainless steel due to pH value.

The capacity of the contact with sedimentation tank is considered to have 60 minutes of retention time, because of settling efficiency. Type of the sedimentation is up-flow system. The sludge in the tank is discharged by intermittent operation under the gravity conditions.

The filter media consists of fine sand, manganese sand and supporting gravel.

The capacity of the reservoir tank is to be 20% of maximum design water capacity. The back-wash water for the filter is from the treated water in the reservoir. Distribution water is transmitted by 5 distribution pumps.

Maximum chlorine dosing rate is determined depending on ammonium concentration in the raw water. In the design conditions, ammonia of raw water is estimated to be average 0.4 mg/l (maximum 1.2 mg/l). As ammonia consumes ten times of chlorine in amount, additional chlorine dosage is required for disinfection. For design criteria, average 5 mg/l (maximum 14 mg/l) dosage is designed. The chlorine neutralization equipment is proposed to protect chlorine leakage accident.

The sludge treatment facility consists of sludge reservoir tank, thickener, chemical dosing, over-flow water transfer pump and drying bed. The dry sludge is carried out by trucks for land reclamation.

Electrical power system consists of low and high tension power boards and transformer. Stop or start for the main treatment system can operate at the central control room. However, regulating control for each equipment is operated by manual at local control panel. Operation for the sludge treatment plant is controlled by manual at local control panel. Necessaries indicator, recorder and alarm are indicated on the monitory panel in the central control room.

(3) Equipment

The specifications of the main components are described as below :

Aeration

Structure	Aeration tower, concrete made
	4m height with one intermediate floor
Aeration area	165 m2 x 3 blocks x 2 series
Air-spraying	Perforated spray pipes, Stainless steel

Contact Sedimentation Basin

Criteria	
Contact period	60 minutes
Surface load	55 mm/min
Specifications	
Structure	Up-flow type concrete basin
Volume	420 m3 x 3 basins x 2 series
Sludge removal	Mechanical sludge scraper

Filtration

Criteria	
Filtration rate	120 m/d (Maximum 143 m/d)
Specifications	
Structure	Rapid sand filter, concrete made
Filtration area	42 m2 x 12 beds
Filter media	0.9 - 1.6 mm grain size sand
Filter beds	Sand layer : 1.5 m depth
	Supporting layer : gravel, 150 mm depth
Water collecting system	Nozzle type
	Supporting layer : 20 - 30 mm gravel, 150 mm depth
Backwash system	Air-scouring type
	Backwash pump : double suction centrifugal pump
	45 kW x 2 units (including one standby pump)
	Air scouring blower : roots blower
	59 kW x 2 units (including one standby blower)

Chlorination

Chemical	Liquid chlorine
Dosing equipment	Vacuum-type chlorinators
Dosage	14 mg/l (Maximum)
	5 mg/l (Average)

Distribution Reservoir

Criteria	
Capacity	20 % of the treatment capacity (= 12,000 m3/d)
Specifications	
Structure	Partly underground concrete reservoir
Volume	6,000 m3 x 2 basins

Distribution Pumps

Pump type	Single stage horizontal centrifugal pumps
Number of pumps	7 units (including 2 standby units)
Discharge capacity	10 m3/min, Total head : 58 m
Motor output	140 kW/unit

Sludge Treatment System

Sludge Reservoir Basin	160 m2 x H3.2 m x 2 basins
Sludge Thickener	ϕ14m x 2 basins
Coagulation Chemical	Alum
Dosage	50 mg/l
Sludge Drying Bed	Sun-drying type
	W16m x L32m x H2m x 5 beds

Electrical Equipment

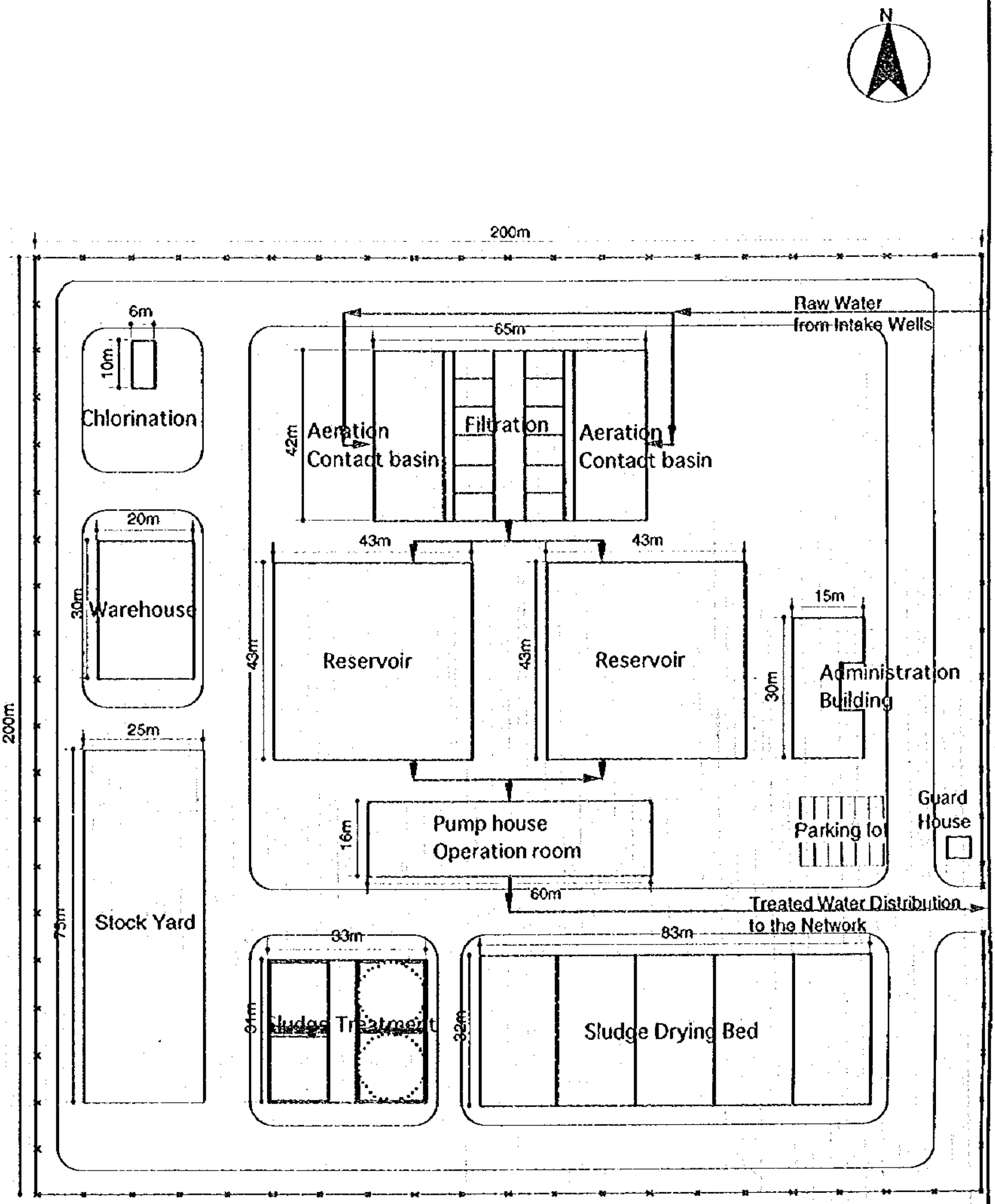
High-voltage power supply	22 kV, 3-phase, 4 wire
Low-voltage power supply	AC 380 V, 3-phase, 4 wire
	AC 220 V, single-phase
Emergency power supply	Engine generator
	Maximum 1,000 kVA x 1 unit
Center control panel with graphic board	
	Intake pumps
	Water treatment facilities
	Distribution pumps
Local panel	Backwash pump and air blower
	Chlorination equipment
	Sludge treatment equipment
	Filter console
	Sludge drying bed

Administration Building

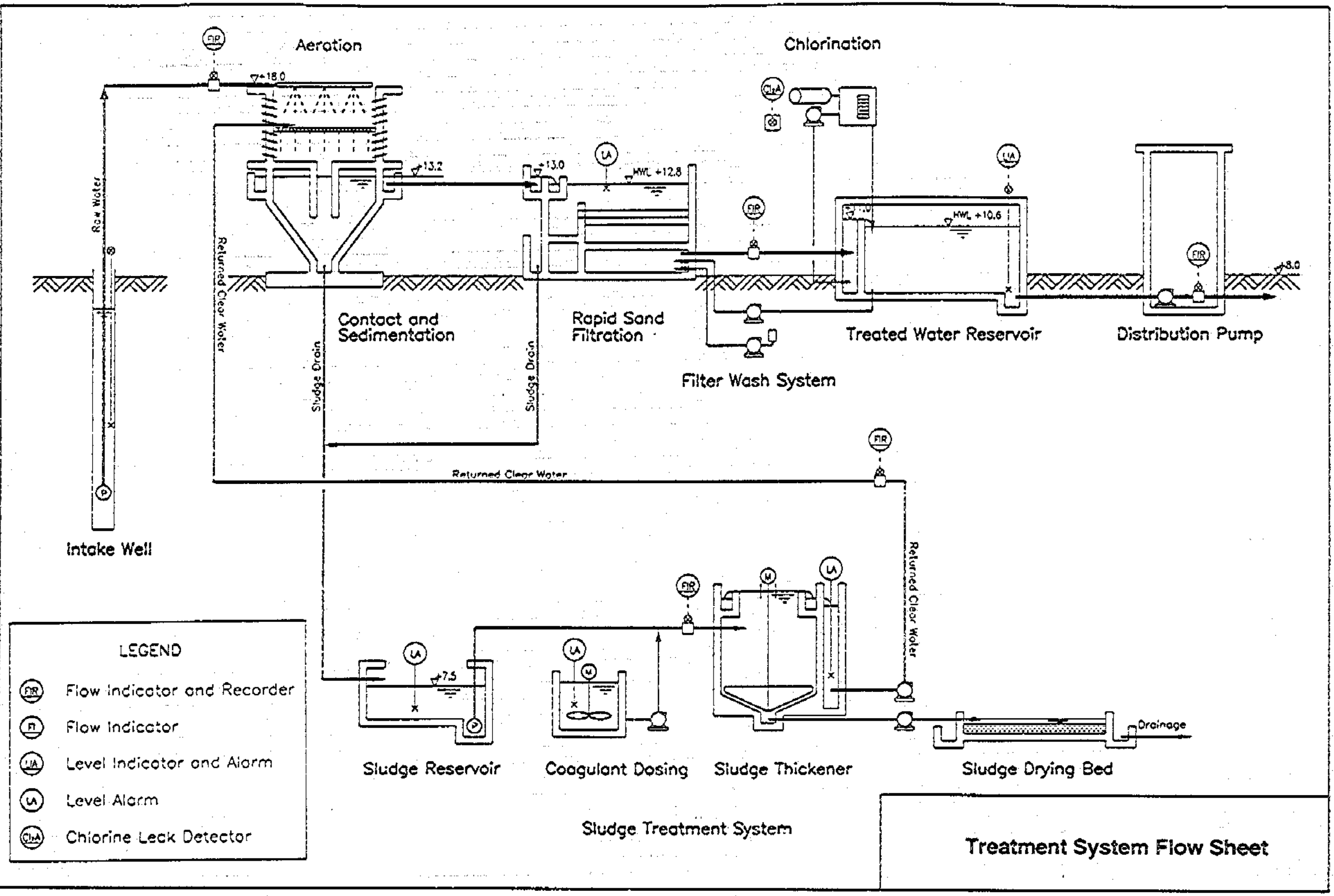
Director's room	1 room	(20 m2)
Officers' room	4 rooms	(160 m2 = 40 m2 x 4)
Staff room	2 rooms	(80 m2 = 40 m2 x 2)
Meeting room	1 room	(80 m2)
Laboratory	1 room	(200 m2)
Storage	4 rooms	(120 m2 = 30 x 4)
Rest room	1 room	(40 m2)
Shower room	1 room	(10 m2)
Toilet	2 places	(20 m2 = 10 m2 x 2)
Entrance hall	1 hall	(40 m2)
Total floor		770 m2

Pump House

Operation room	1 room	(200 m2)
Pump room	1 room	(440 m2)
Electrical room	1 room	(120 m2)
Transformer room	1 room	(60 m2)
Engine Generator room	1 room	(80 m2)
Total floor		900 m2



Tentative Layout Plan of Treatment Plant (Q = 60,000 m3/d)



Treatment System Flow Sheet

2.4.3 Distribution Pipelines

(1) Route of the Distribution Main

The service area is long in the direction of north towards south and the treatment plant is located in the northern part of the service area. There is a wide road of the Ring Road No.3, the northern part of which is already existing and its remaining southern part is to be expanded in the future, in the middle of the service area. Accordingly, the distribution mains (Diameter: 800-400 mm) are planned to be installed on the Ring Road No.3.

(2) Pipe Diameters

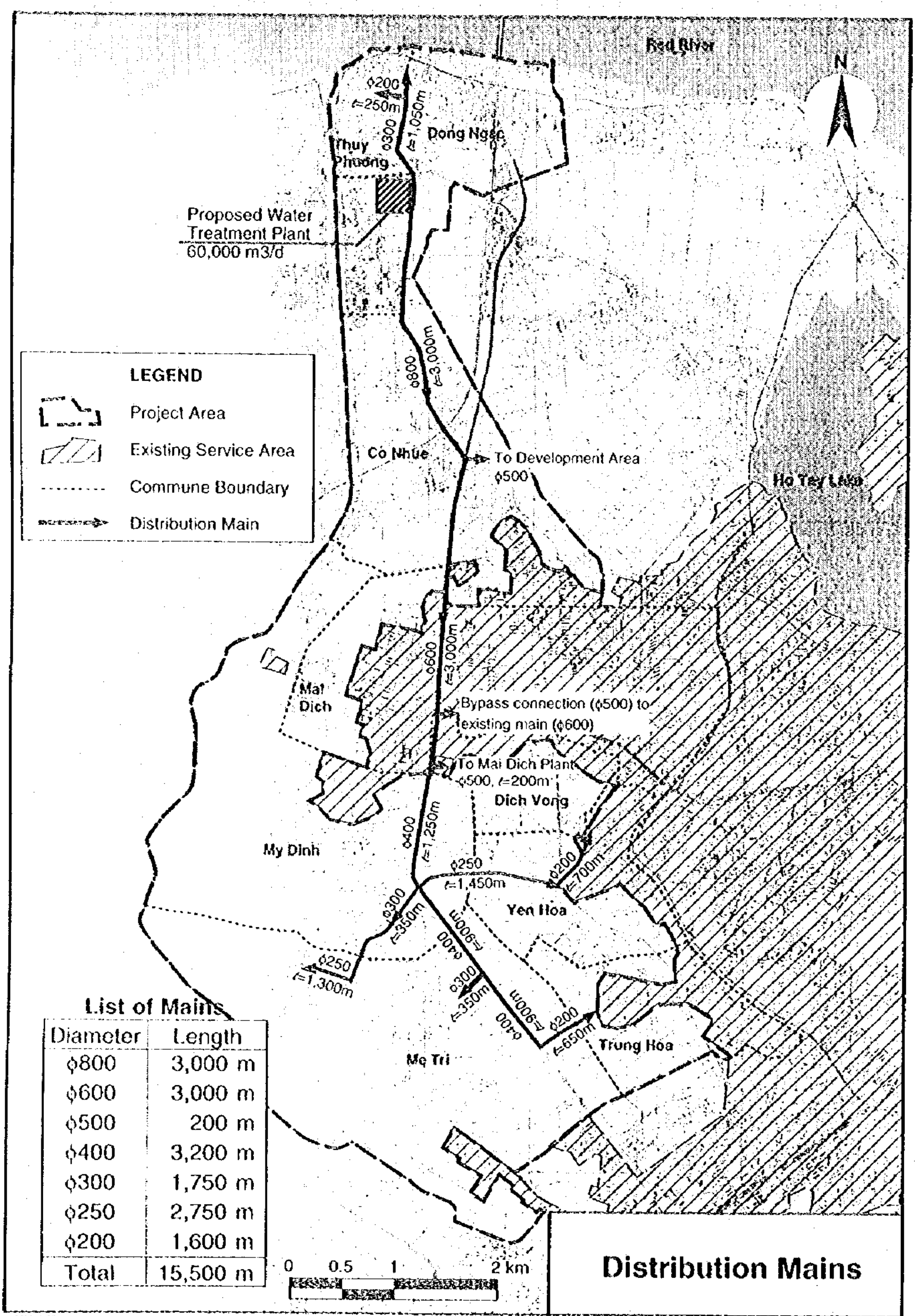
Diameters of the distribution mains were decided based on the Hazen-Williams formula, taking hydraulic gradient and flow velocity in the pipeline into due consideration, as well as residual pressure. The diameters were decided in order to meet the peak hour demand. The maximum diameter was calculated at 800 mm. The minimum diameter was determined to be 400 mm with the consideration of emergency supply to or from other adjacent service areas.

(3) Supply to Communes

Supply to communes (Xa of Dong Ngac, Thuy Phuong, Co Nhue, My Dinh, Me Tri, Dich Vong, Yen Hoa, Trung Hoa and Mai Dich) is planned to be done through distribution networks branched from the distribution mains. The branched pipes range 250-150mm in diameters and the distribution networks consist of 250-50 mm. The branched pipelines will be equipped with water flow meters (one meter to one commune) for the maintenance and operation purpose.

(4) Bulk Water Supply

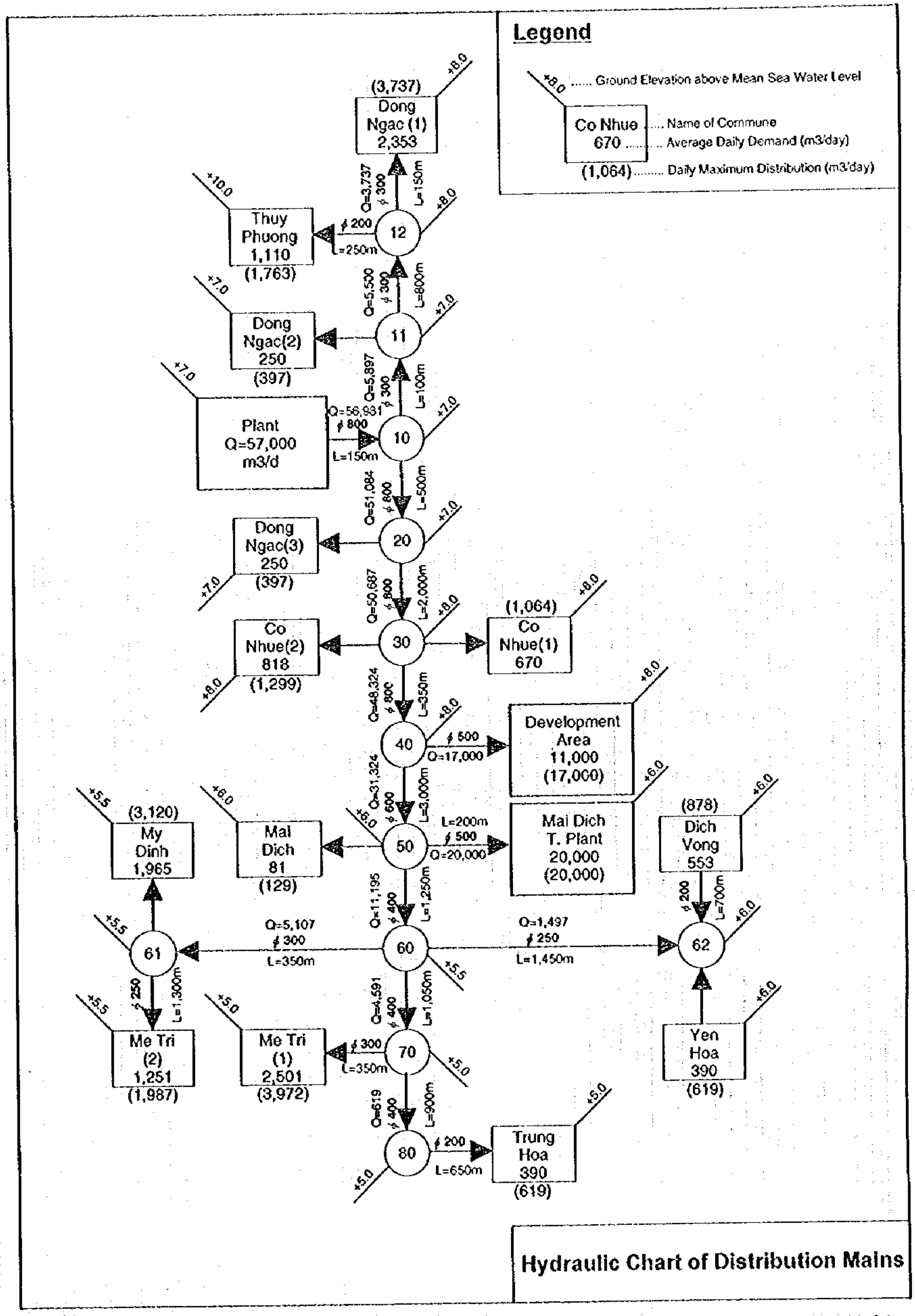
The project aims to supply not only to communes above mentioned, but also to the New Development Area and to Mai Dich Supplement by way of bulk water supply. It was planned that the both would receive treated water from the distribution main (ϕ800 mm) at branched points with branch pipes of ϕ500 mm. On the branch pipes, water flow meters will be installed in order to record the water volume supplied.



List of Mains

Diameter	Length
φ800	3,000 m
φ600	3,000 m
φ500	200 m
φ400	3,200 m
φ300	1,750 m
φ250	2,750 m
φ200	1,600 m
Total	15,500 m

Distribution Mains



Hydraulic Chart of Distribution Mains

Hydraulic Caculation of Distribution Mains

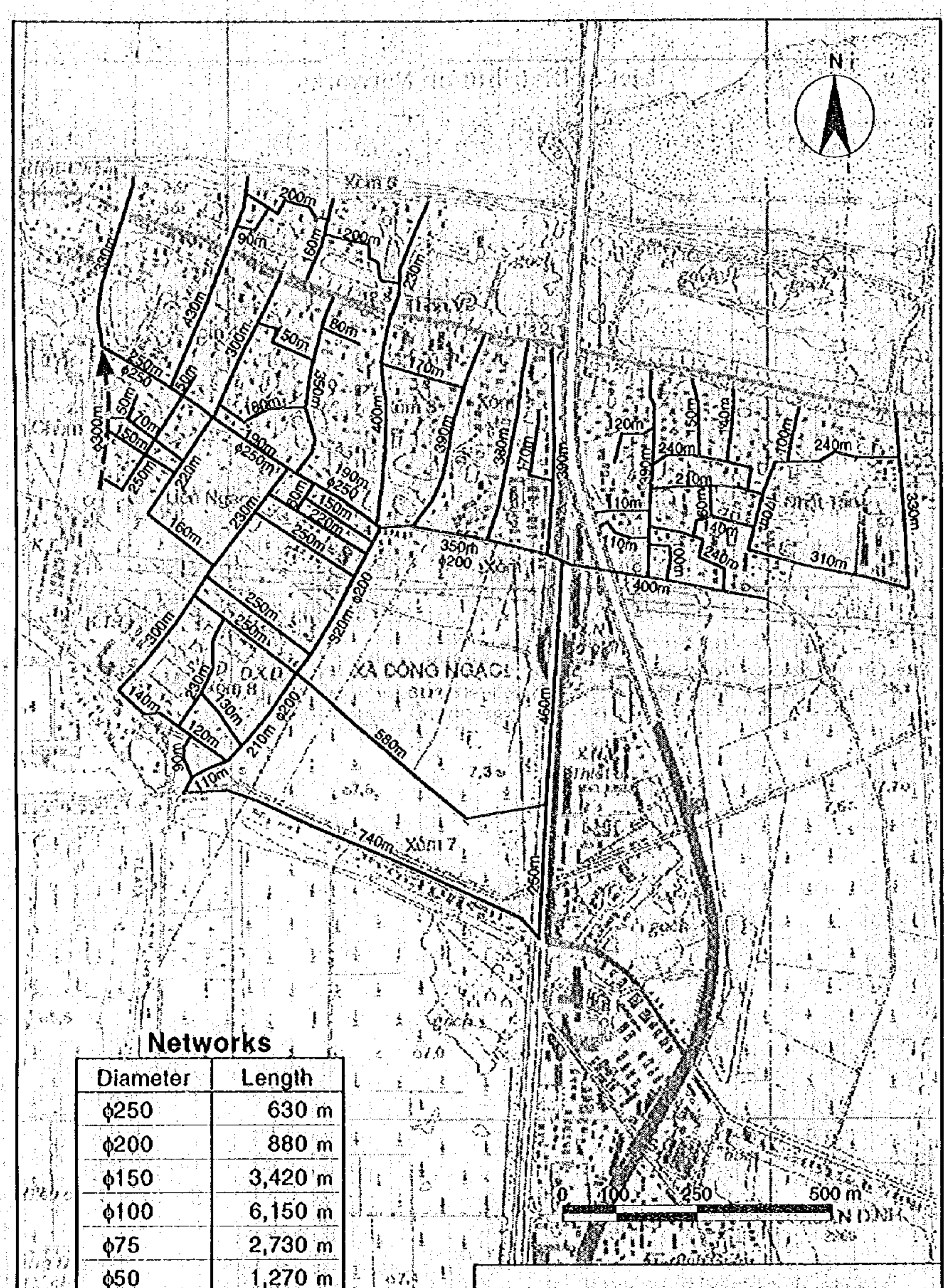
Pipeline			Q	q	f	L	I	V	H	TH	WL	GL	RP
			Maximum Daily Distribution (m3/d)	Hourly Peak Flow (l/sec)	Diameter (mm)	Distance (m)	Hydraulic Gradient (x 1/1,000)	Velocity m/sec	Head Loss m	Total Head Loss m	Dynamic Water Level (+m)	Ground Elevation (+m)	Residual Pressure (m)
		Plant	-	-	-	-	-	-	-	0.00	+ 62.00	+ 8.00	+ 54.00
Plant	-	10	56,981	830.7	800	150	3.75	1.65	0.56	0.56	+ 61.44	+ 7.00	+ 54.44
10	-	20	51,084	735.2	"	500	2.99	1.46	1.5	2.06	+ 59.94	+ 7.00	+ 52.94
20	-	30	50,687	728.7	"	2,000	2.95	1.45	5.89	7.95	+ 54.05	+ 8.00	+ 46.05
30	-	40	48,324	690.4	"	350	2.67	1.37	0.93	8.88	+ 53.12	+ 8.00	+ 45.12
40	-	50	31,324	415.0	600	3,000	4.22	1.47	12.66	21.54	+ 40.46	+ 6.00	+ 4.46
50	-	60	11,195	181.4	400	1,250	6.57	1.44	8.22	29.76	+ 32.24	+ 5.50	+ 26.74
60	-	70	4,591	74.4	400	1,050	1.26	0.59	1.33	31.09	+ 30.91	+ 5.00	+ 25.91
70	-	80	619	10.0	"	900	0.03	0.08	0.03	31.11	+ 30.89	+ 5.00	+ 25.89
Plant	-	10	56,981	830.7	800	150	3.75	1.65	0.56	0.56	+ 61.44	+ 7.00	+ 54.44
10	-	11	5,897	95.6	300	100	8.16	1.35	0.82	1.38	+ 60.62	+ 7.00	+ 53.62
11	-	12	5,500	89.1	"	800	7.16	1.26	5.73	7.11	+ 54.89	+ 8.00	+ 46.89
12	-	Dong Ngac (1)	3,737	60.6	"	150	3.51	0.86	0.13	7.64	+ 54.36	+ 8.00	+ 46.36
12	-	Thuy Phuong	1,763	28.6	200	250	6.31	0.91	1.58	9.83	+ 52.17	+ 10.00	+ 42.17
60	-	61	5,107	82.8	300	350	6.25	1.17	2.19	31.95	+ 30.05	+ 5.50	+ 24.55
61	-	Me Tri (2)	1,987	32.2	250	1,300	2.65	0.66	3.44	34.53	+ 27.47	+ 5.50	+ 21.97
60	-	62	1,497	24.3	250	1,450	1.57	0.50	2.28	33.37	+ 28.63	+ 6.00	+ 22.63
62	-	Dich Vong	878	14.2	200	700	1.73	0.45	1.21	34.58	+ 27.42	+ 6.00	+ 21.42
70	-	Me Tri (1)	3,972	64.4	300	350	3.93	0.91	1.38	32.46	+ 29.54	+ 5.00	+ 24.54
80	-	Trung Hoa	619	10.0	200	650	0.9	0.32	0.59	31.7	+ 30.30	+ 5.00	+ 25.30
50	-	Mai Dich Plant	20,000	231.5	500	200	3.48	1.18	0.70	22.24	+ 39.76	+ 6.00	+ 33.76

(Note)
- Treatment plant production capacity (Maximum Daily) = 60,000 m3/day
- Treatmnet plant distribution capacity (Maximum Daily) = 57,000 m3/day
- Ground elevation of the plant = + 8.00 m (above the mean sea water level)
- Low water level of the distribution reservoir in the plant = +5.50m
- Dynamic water level at the plant = +62.00 m (Pump head = 58m)
- Q: Maximum Daily Distribution
- Hourly peak factor = 140%
- q: Hourly peak flow = (Maximum Daily Distribution) x 140%
  From the plant to Mai Dich Plant (No.50):
  q = (Q - 20,000m3/d) x 140% + 20,000m3/d
  For No.50 - No.80 and others:
  q = Q x 140%
- I (Hydaulic gradient) = 10.666 x C**(-1.85) x D**(-4.87) x q**(1.85) (C=110)
- H (Loss of head in the pipeline) = I x (Distance)
- TH = Total loss of head from the plant

List of Distribution Networks

Network	ϕ250	ϕ200	ϕ150	ϕ100	ϕ75	ϕ50	Total Distance
① Dong Ngac (1)	630 m	880 m	3,420 m	6,150 m	2,730 m	1,270 m	15,080 m
② Thuy Phuong	-	210 m	940 m	1,690 m	750 m	370 m	3,960 m
③ Dong Ngac (2)	-	-	1,360 m	2,660 m	1,180 m	590 m	5,790 m
④ Co nhue	-	2,050 m	3,860 m	6,950 m	3,090 m	1,540 m	17,490 m
⑤ My Dinh	-	570 m	940 m	1,700 m	760 m	380 m	4,350 m
⑥ Me Tri (2)	-	720 m	1,050 m	1,900 m	840 m	420 m	4,930 m
⑦ Me Tri (1)	590 m	740 m	2,260 m	4,070 m	1,810 m	950 m	10,420 m
⑧ Others*	-	-	1,650 m	2,980 m	1,320 m	660 m	6,610 m
Total	1,220 m	5,170 m	15,480 m	28,100 m	12,480 m	6,180 m	68,630 m

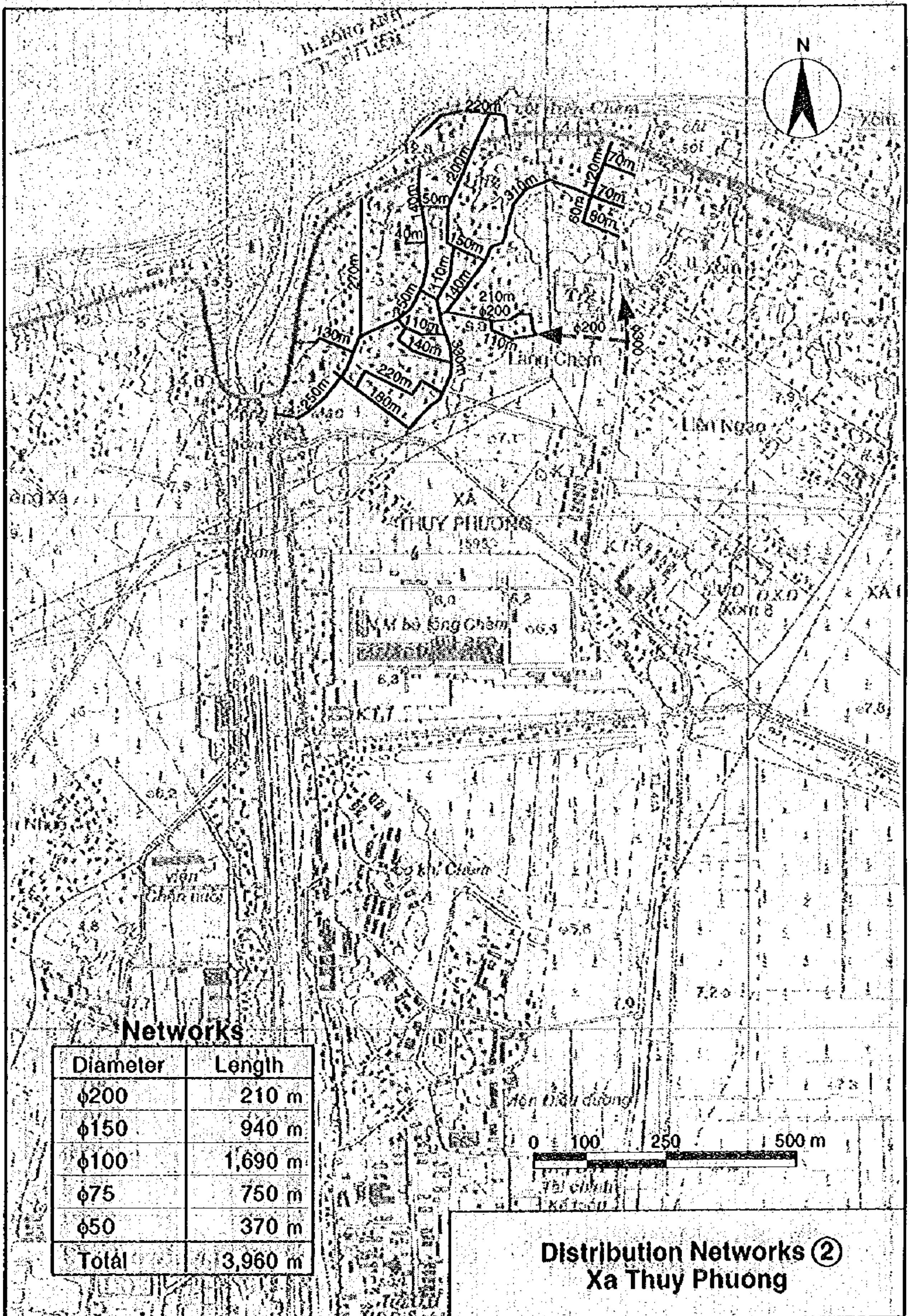
Note : ⑧ Others consists of Dich Vong, Yen Hoa, Trung Hoa and Mai Dich. Most of their existing inhabited areas have existing distribution pipelines. The networks mentioned in the above list are for future residential areas. Therefore, distances of the networks pipelines in the above list were estimated in proportion to population to be served.



Networks

Diameter	Length
φ250	630 m
φ200	880 m
φ150	3,420 m
φ100	6,150 m
φ75	2,730 m
φ50	1,270 m
Total	15,080 m

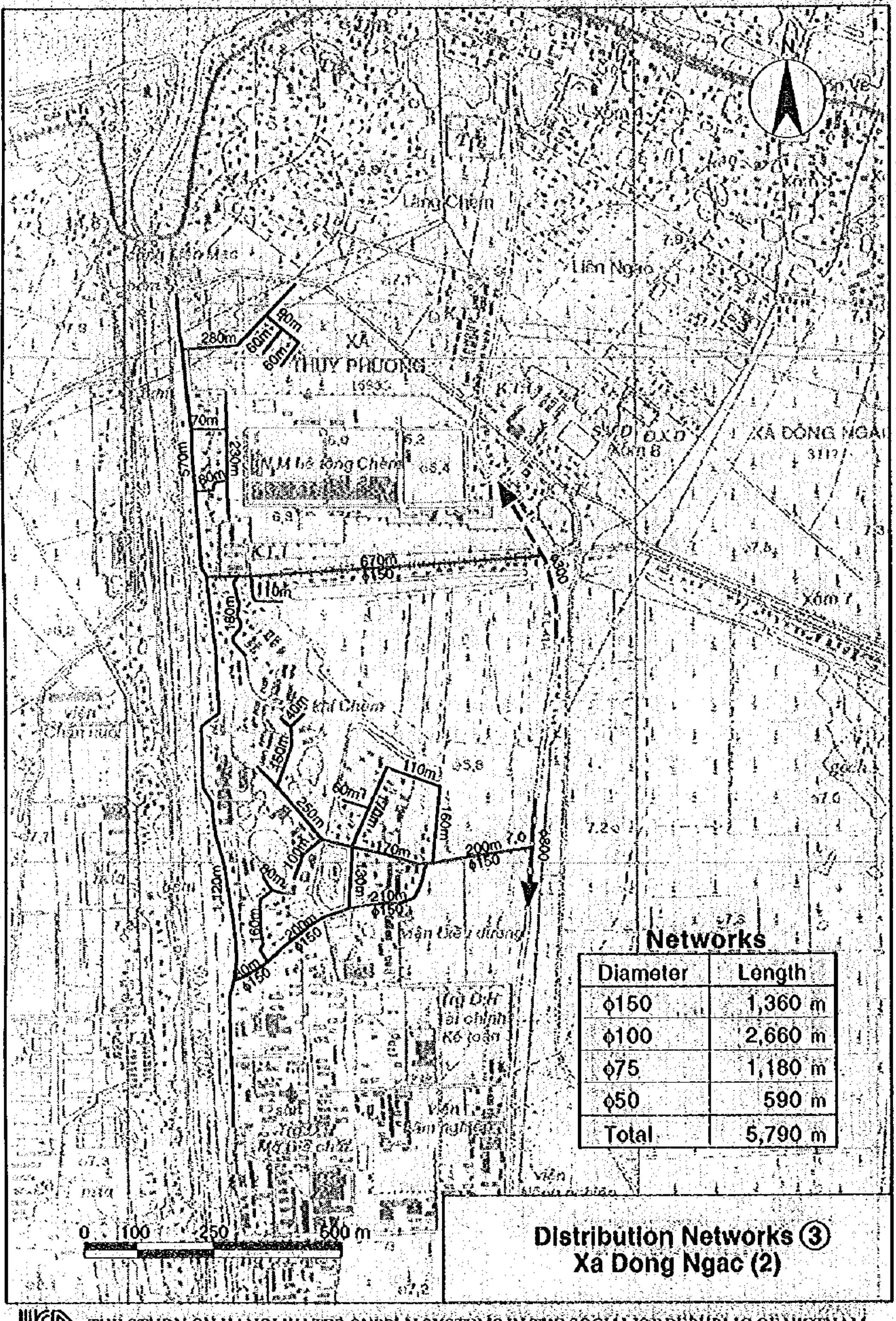
Distribution Networks ①
Xa Dong Ngac (1)



Networks

Diameter	Length
ϕ200	210 m
ϕ150	940 m
ϕ100	1,690 m
ϕ75	750 m
ϕ50	370 m
Total	3,960 m

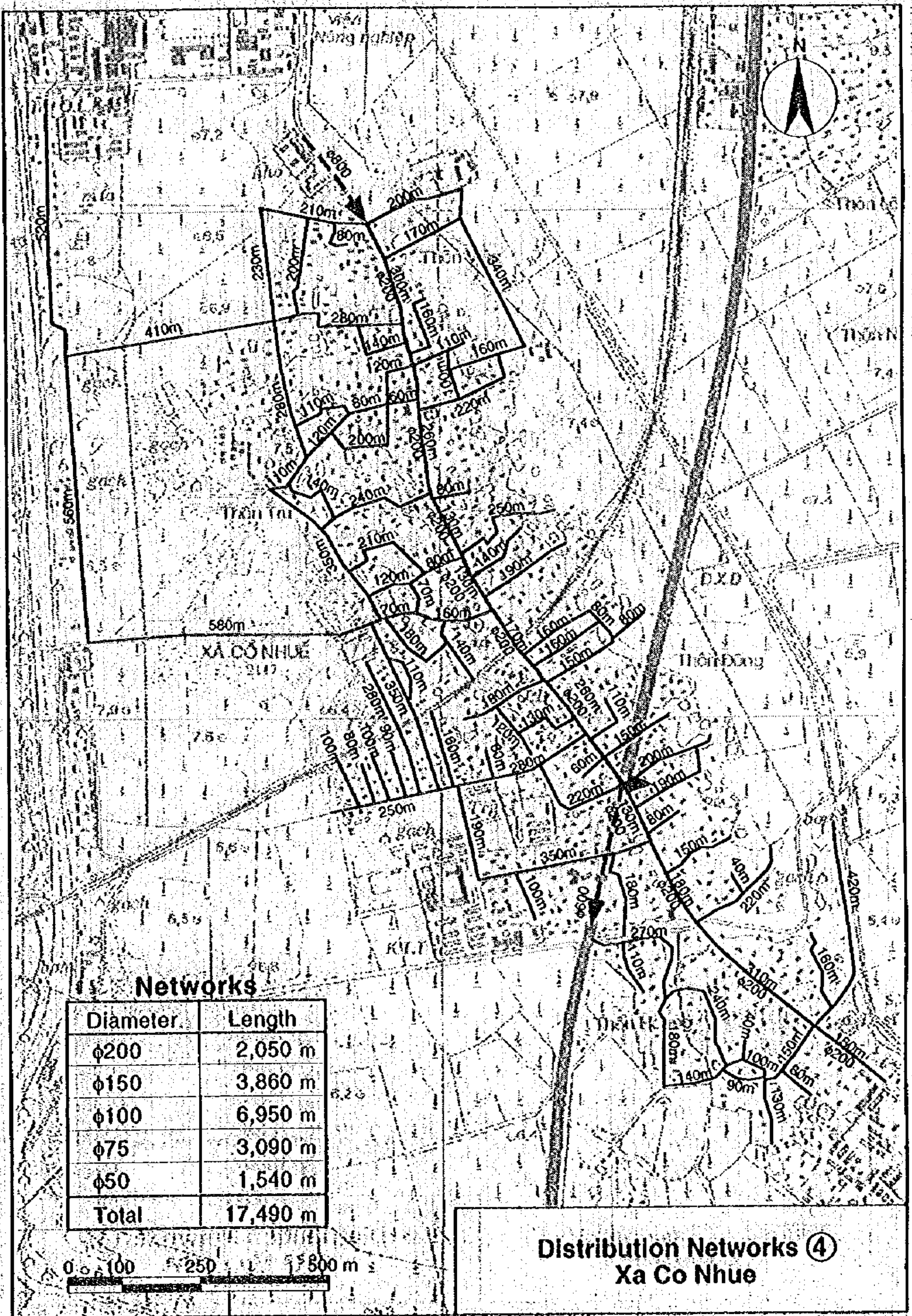
Distribution Networks ②
Xa Thuy Phuong



Networks

Diameter	Length
φ150	1,360 m
φ100	2,660 m
φ75	1,180 m
φ50	590 m
Total	5,790 m

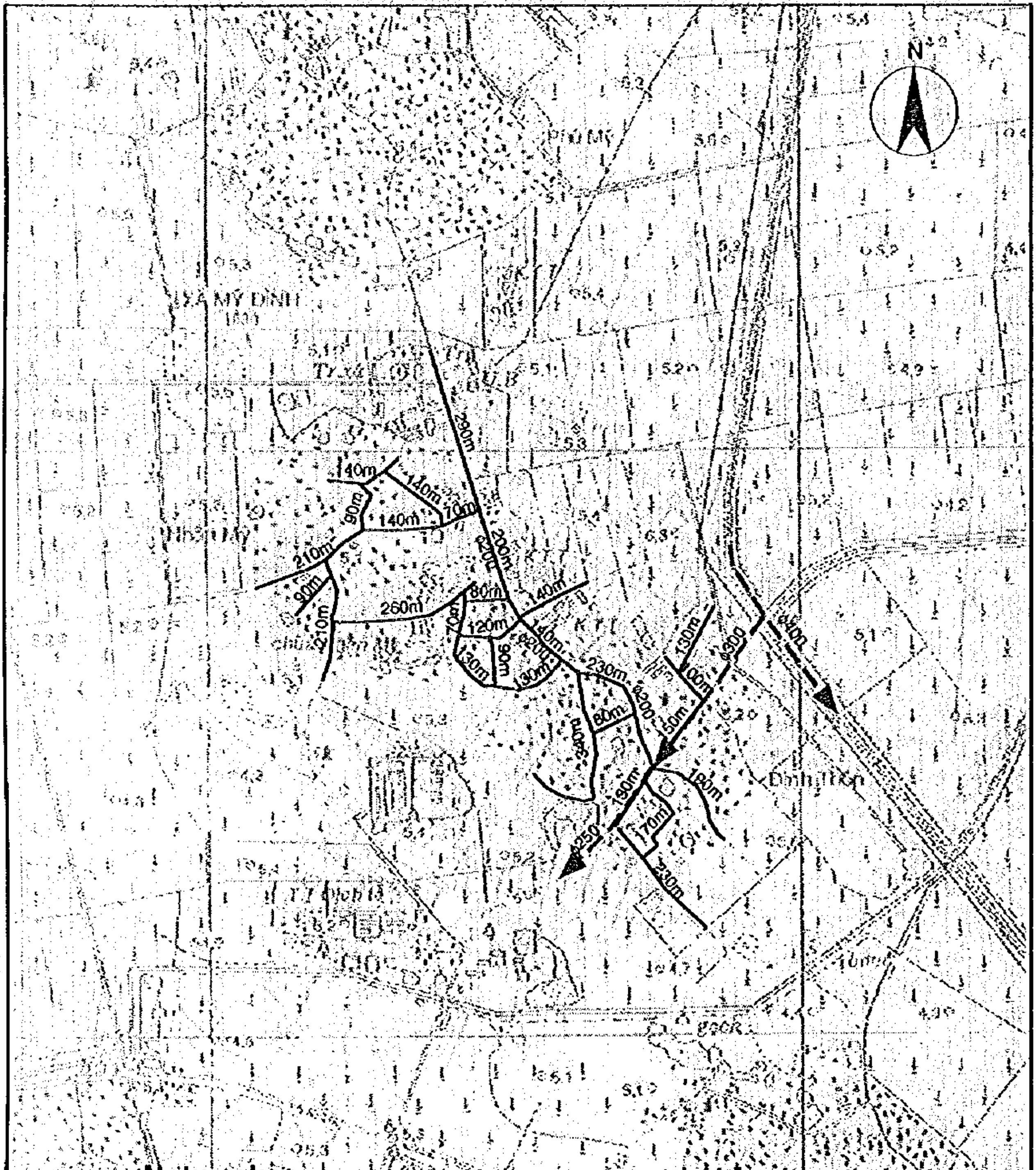
Distribution Networks ③
Xa Dong Ngac (2)



Networks

Diameter	Length
ϕ200	2,050 m
ϕ150	3,860 m
ϕ100	6,950 m
ϕ75	3,090 m
ϕ50	1,540 m
Total	17,490 m

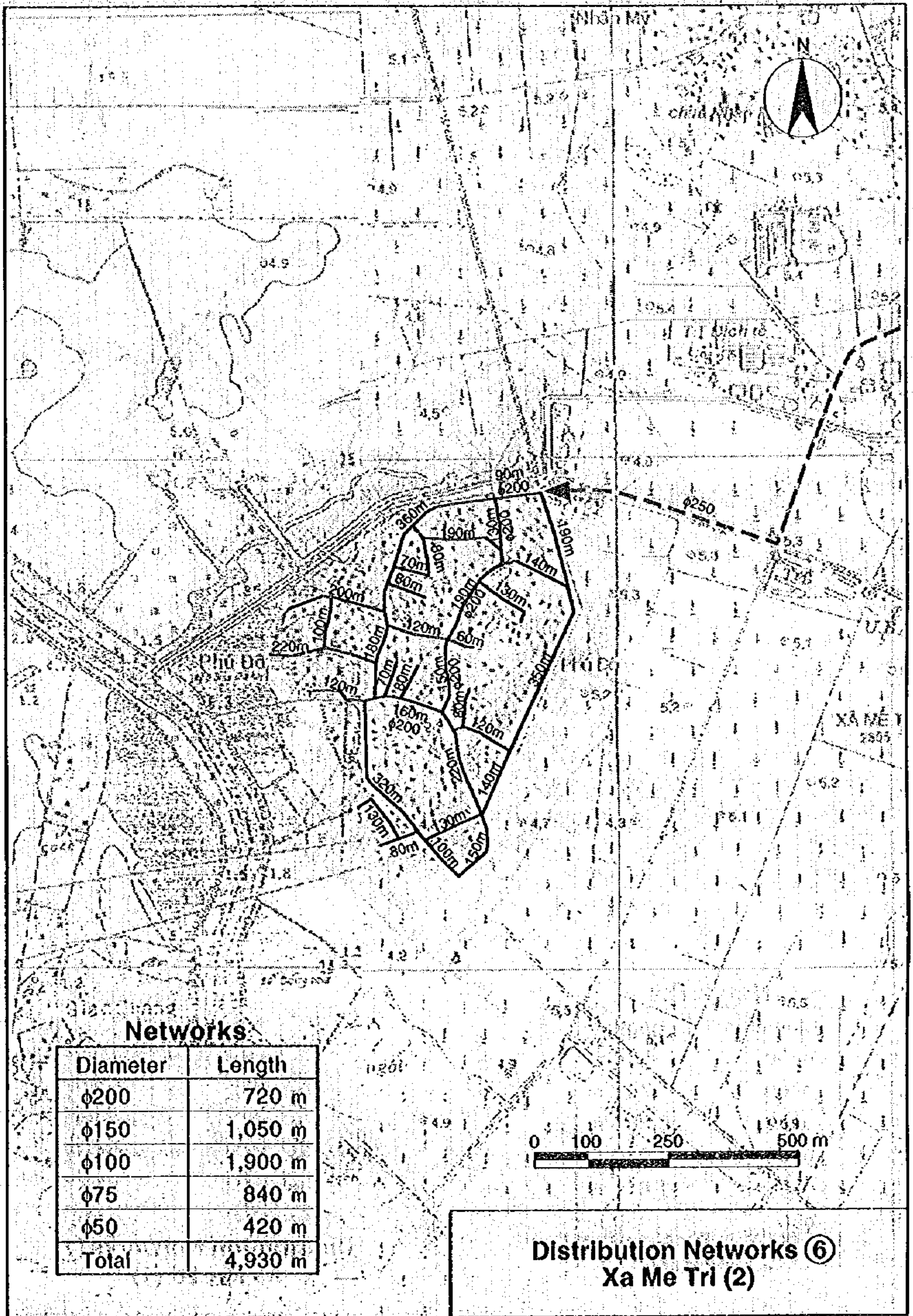
Distribution Networks ④
Xa Co Nhue



Networks

Diameter	Length
φ200	570 m
φ150	940 m
φ100	1,700 m
φ75	760 m
φ50	380 m
Total	4,350 m

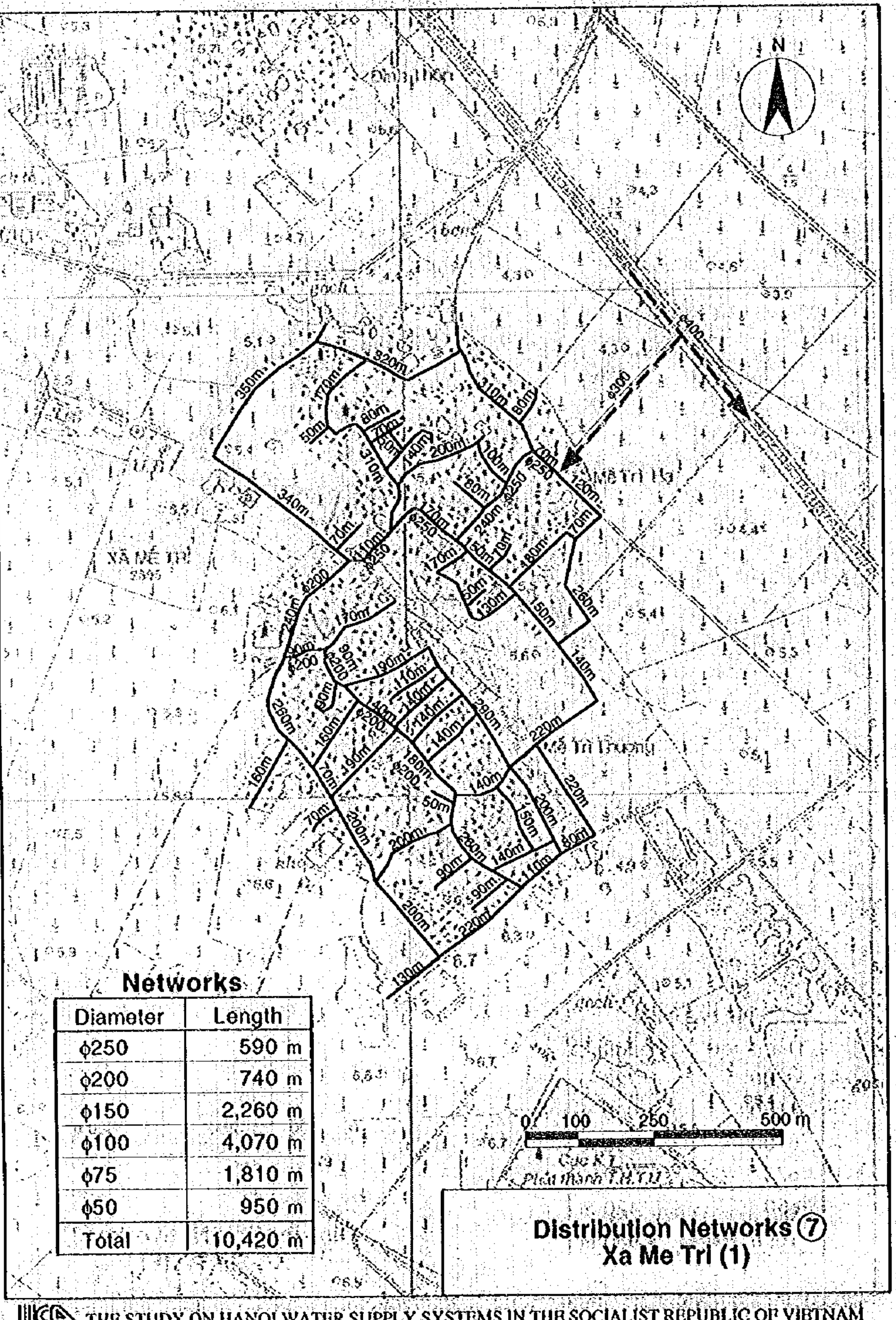
Distribution Networks ⑤
Xa My Dinh



Networks

Diameter	Length
φ200	720 m
φ150	1,050 m
φ100	1,900 m
φ75	840 m
φ50	420 m
Total	4,930 m

Distribution Networks ⑥
Xa Me Tri (2)



Networks

Diameter	Length
φ250	590 m
φ200	740 m
φ150	2,260 m
φ100	4,070 m
φ75	1,810 m
φ50	950 m
Total	10,420 m

Distribution Networks ⑦
Xa Me Tri (1)

2.5 COST ESTIMATION

Project cost consisting of costs for facilities construction, pipelines construction, land use, engineering services and physical contingency was estimated at the year of 1997 price level. (Exchange rate: US$1.00 = VND11,000 (Vietnamese Dong)).

The total project cost estimated is:

489,034 million VND: equivalent to 44.46 million US$,

as given in Table of "Project Cost (Summary)".
For more detail, please refer to Tables of "Water Source and Treatment Plant Construction Cost", "Pipelines Construction Cost (Summary)" and its breakdowns.

Note:

As for financing, price contingency shall be added to the above cost, for future price escalation (inflation). The total financing required will be:

587,548 million VND: equivalent to 53.42 million US$.
(Please refer to Table of " Investment Schedule (Summary)".

Project Cost (Summary)

Component	Quantity	Cost (Mil VND)
(A) Facilitties construction		
1) Treatment plant	60,000 m3/day x 1	112,365
2) Water source	22 well stations	34,190
	Total (A)	146,555
(B) Pipelines construction		
1) Raw water pipelines	L=7,600 m	48,241
2) Distribution mains	L=15,500 m	58,809
3) Distribution networks	L=68,600 m and 16,700 water meters	78,545
	Total (B)	185,595
(C) Land cost	L.S.	78,000
(D) Engineering services		
1) Detail design	L.S.	18,268
2) Construction supervision	L.S.	23,250
	Total (D)	41,518
(E) Base Cost (A+B+C+D)		451,668 (= 41.06 mil US$)
(F) Physical contingency		37,366
(G) Project Cost (E+F)		489,034 (=44.46 mil US$)
(H) Price contingency		98,514
(I) Total financing required (G+H)		587,548 (=53.42 mil US$)

Note:
- Cost: 1997 year price level
- Exchange rate: US$ 1.00 = VND 11,000 (VND: Vietnamese Dong)

Water Source and Treatment Plant Construction Cost

Item	Cost (x1,000VND)		
	Amount	F/C (Foreign component)	L/C (Local component)
(A) Water Source Facilities			
A1) Deep wells (22 sites)	8,140,000		
A2) Well pumps and stations	18,700,000		
A3) Electrical facilities	4,250,000		
A4) Miscellaneous work	3,100,000		
Sub Total (A)	34,190,000	20,514,000	13,676,000
(B) Treatment Plant Facilities			
B1) Aeration, contract and filtration faciliti	46,400,000		
B2) Reservoir tank	8,930,000		
B3) Chlorination system	3,750,000		
B4) Sludge treatment facilities	27,500,000		
B5) Distribution pump station and electrical power supply system	11,900,000		
B6) Administration building	2,950,000		
B7) Land development work	9,255,000		
B8) Others	1,680,000		
Sub Total (B)	112,365,000	67,419,000	44,946,000
(1) Sub Total (A+B)	146,555,000	87,933,000	58,622,000
(2) Detail design cost = 5.5% of (1)	8,060,530	5,239,340	2,821,190
(3) Construction supervision = 7.0% of (1)	10,258,850	6,155,310	4,103,540
(4) Sub Total (1+2+3)	164,874,380	99,327,650	65,546,730
(5) Physical contingency = 10% of (4)	16,487,440	9,932,770	6,554,670
Total (4+5)	181,361,820	109,260,420	72,101,400

Note:
- (2) "Detail design" includes costs of test well construction, groundwater simulation study, soil investigation, topographical survey, tender documentation work.

Pipelines Construction Cost (Summary)

Item	Cost (x1,000VND)		
	Amount	Foreign Component	Local Component
(1) Raw water pipelines	48,241,600	38,082,300	10,159,300
Distribution Mains	58,808,850	48,034,910	10,773,940
Distribution networks	78,544,640	54,449,220	24,095,420
Sub Total (1)	185,595,090	140,566,430	45,028,660
(2) Detail design cost = 5.5% of (1)	10,207,730	6,635,020	3,572,710
(3) Construction supervision = 7.0% of (1)	12,991,660	7,795,000	5,196,660
(4) Sub Total (1+2+3)	208,794,480	154,996,450	53,798,030
(5) Physical contigency = 10% of (4)	20,879,450	15,499,650	5,379,800
Total (4+5)	229,673,930	170,496,100	59,177,830

Note:
- (2) "Detail design" includes costs of toporaphical survey and tender documentation work.

Pipelines Construction Cost (Breakdown (1): Raw Water Pipelines)

Item	Quantity	Cost (1,000VND)				
		Unit Cost	Total Amount	Foreign Component	Local Component
(A) Raw water pipelines					
A1) ϕ 800 DIP	3,800 m	5,111	19,421,800	16,404,600	3,017,200
A2) ϕ 600 "	1,000	3,483	3,483,000	2,850,000	633,000
A3) ϕ 450 "	2,800	2,254	6,311,200	5,040,000	1,271,200
Sub Total (A)	7,600 m		29,216,000	24,294,600	4,921,400
(B) Fitting and valves					
15% of (A)			4,382,400	3,646,200	736,200
(C) Pipe bridge					
L=80m on Nhue River			8,800,000	5,280,000	3,520,000
(D) Extra pipes and work					
20% of (A)			5,843,200	4,861,500	981,700
Total (A+B+C+D)			48,241,600	38,082,300	10,159,300

Pipelines Construction Cost (Breakdown (2): Distribution Mains)

Item	Quantity	Cost (1,000VND)			
		Unit Cost	Total Amount	Foreign Component	Local Component
(A) Distribution Mains					
A1) ϕ 800 DIP	3,000 m	5,111	15,333,000	12,951,000	2,382,000
A2) ϕ 600 "	3,000	3,483	10,449,000	8,550,000	1,899,000
A3) ϕ 500 "	200	2,647	529,400	426,600	102,800
A4) ϕ 400 "	3,200	1,909	6,108,800	4,841,600	1,267,200
A5) ϕ 300 "	1,750	1,363	2,385,250	1,858,500	526,750
A6) ϕ 250 "	2,750	1,087	2,989,250	2,310,000	679,250
A7) ϕ 200 "	1,600	882	1,411,200	1,081,600	329,600
Sub Total (A)	15,500 m		39,205,900	32,019,300	7,186,600
(B) Fittings, valves and fire hydrants 20% of (A)			7,841,180	6,406,240	1,434,940
(C) Extra pipes and extra works such as detour/sheeting 30% of (A)			11,761,770	9,609,370	2,152,400
Total (A+B+C)			58,808,850	48,034,910	10,773,940

Pipelines Construction Cost (Breakdown (3): Distribution Networks)

Item	Quantity	Cost (1,000VND)			
		Unit Cost	Total Amount	Foreign Component	Local Component
(A) Network pipes					
A1) ϕ 250 DIP	1,220 m	1,087	1,326,140	1,024,800	301,340
A2) ϕ 200 "	5,170	882	4,559,940	3,494,920	1,065,020
A3) ϕ 150 "	15,480	696	10,774,080	7,740,000	3,034,080
A4) ϕ 100 "	28,100	533	14,977,300	9,778,800	5,198,500
A5) ϕ 75 "	12,480	435	5,428,800	3,244,800	2,184,000
A6) ϕ 50 PVC	6,180	165	1,019,700	210,120	809,580
Sub Total (A)	68,630 m		38,085,960	25,493,440	12,592,520
(B) Fittings, valves and fire hydrants					
25% of (A)			9,521,490	6,369,880	3,151,610
(C) Extra pipes and extra works					
20% of (A)			7,617,190	5,095,900	2,521,290
(D) House connections with meters					
D1) For domestic	16,200 Nos.	1,100	17,820,000	13,365,000	4,455,000
D2) For non-domestic	500 Nos.	11,000	5,500,000	4,125,000	1,375,000
Sub Total (D)			23,320,000	17,490,000	5,830,000
Total (A+B+C+D)			78,544,640	54,449,220	24,095,420