WATER SUPPLY IN FAST GROWING CITIES

Amsterdam
19-21 September

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Organized by:

AQUATECH'88

CONFERENCE PROGRAMME

"Water Supply in Fast Growing Cities".

MONDAY 19 SEPTEMBER 1988

10.00-12.00 Official Opening Ceremony
12.00-13.00 Aquatech Receptie
13.00-17.00 Visit to the Exhibition Aquatech'88

TUESDAY 20 SEPTEMBER 1988

10.00 Opening by the Conference President Mr. C. van der Veen
10.15 Mr. C. Rietveld, World Bank
10.40 "The Parisian Agglomeration".
Mr. D. Versanne
Compagnie des Eaux de Paris, Paris, France
11.00 Coffee break
11.30 "Water Supply in Bangkok Metropolis".
Mrs. Chuanpit Dhamasiri
Metropolitan Waterworks Authority, Bangkok, Thailand
11.50 "Water Supply in Fast Growing Cities - Metropolitan Lagos".
Mr. S.O. Oyewole
Lagos State Water Corporation, Lagos, Nigeria
12.10 Discussion
12.30 Lunch Break

Session Chairman: Mr. C. Rietveld

14.00 "Five Minutes to Midnight".
Mr. S.P. Unvala
Indian Water Works Association, Bombay, India
14.20 "Water Supply for Metropolitan Manila".
Mr. L.V.Z. Sison
Metropolitan Waterworks and Sewerage System
Quezon City, Manila, Philippines
14.40 Tea Break
15.10 "Water Supply in Fast Growing Cities"
Mr. Y. Sekine
Tokyo Metropolitan Government, Tokyo, Japan
15.50 Discussions
16.00 Visit to Exhibition

WEDNESDAY 21 SEPTEMBER 1988

10.00 Session Chairman: Ir. C. van der Veen
"Peking case"
10.15 "Recent Water Supply Problems and Proposed Solutions in Mexico City".
Mr. H.B. Schlotfeldt and Mr. R.A. Juarez
Universidad Autonoma Metropolitana, Mexico C., Mexico
10.30 "Challenges in Meeting Future Water Needs in Southern California".
Mr. J.F. Wickser
Department of Water and Power, Los Angeles, USA
10.50 Coffee Break
11.10 Panel Discussion
12.00 Closing Address

WATER SUPPLY IN FAST GROWING CITIES THE PARISIAN AGGLOMERATION

PRESENTED BY:

D. VERSANNE
COMPAGNIE DES EAUX DE PARIS

RAI CONGRESS CENTRE, AMSTERDAM

WATER SUPPLY IN FAST GROWING CITIES

THE PARISIAN AGGLOMERATION

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Septembre 1988

CONTENTS

INTRODUCTION

The birth of the water supply system of the Parisian urban area as we know it today, in fact only dates from the middle of the ninetheenth century. The development of means of communication, in particular the railway, the industrial and economic progress of the capital, the growth of Paris by the incorporation of peripheric communities, have obliged those responsible, at the time, for water supplies, to bring important new resources into being.

Thus the Prefet HAUSSMANN and the Engineer BELGRAND, Manager for the water supply and for the sewerage for Paris, appear to us as visionaries since their solutions are still valid a hundred and fifty years later.

The growth of the agglomeration of Paris occures principally up to about the middle of the nineteen seventies. The water supplies from the public network which will alone be discussed here, involve nearly nine millions inhabitants. We, the water distributors, approach the problem of satisfying the demand not only from the point of view of quantity but also those of quality and of security. In fact, the french consumer remains very concerned by the quality of the drinking water delivered to him as also by the guarantee of supply continuity in all circumstances.

This triple concern has therefore governed the formulation of the answers to what the consumers seek and which we shall endeavour to expose.

I. PRESENTATION

All the solutions adopted to satisfy the demand of water of the nine million inhabitants of the region of Paris obviously rely upon the hydrogeological context of the Paris Basin as regards the water resources and on the Administrative Organization of the water supply as regards the water distribution.

I.1. ORIGIN OF WATER RESOURCES

The Parisian agglomeration is located at the heart of the Seine catchment basin. The latter bordered by the outcrops of the primary base which constitutes its bed occures geologically as a succession of outcrops of progressively more and more recent formation as one approaches the center.

The succession of secondary, tertiary and quaternary strata creating an alternance between permeable and impermeable levels, permits the delimitation of the sources and the ground water levels available for exploitation as water resources. Local resources being either small in quantity and of mediocre quality it has been necessary to seek sometimes more than one hundred kilometers away adequate resources of ground water. For the same reason the river Seine is largely called upon as also its two most important affluents, the Marne and the Oise river.

I.2. ADMINISTRATIVE STRUCTURES

According to french legislation, the supply of drinking water is the responsability of the "Commune", that is to say the smallest territorial administrative entity. The agglomeration of Paris includes 335 "communes", many of which have associated together to constitute intercommunal syndicates for the water supply. The most important of these is the "Syndicat des Eaux de l'Ile de France" which regroups together 144 "communes" to the North, East and South of Paris and which supplies four million inhabitants.

Furthemore, nearly all theses "communes" have, in most cases, for over fifty years entrusted the management of their water supply to private companies and essentially to the Compagnie Générale des Eaux and to the Société Lyonnaise des Eaux or to their subsidiaries, as figure 1 below shows.

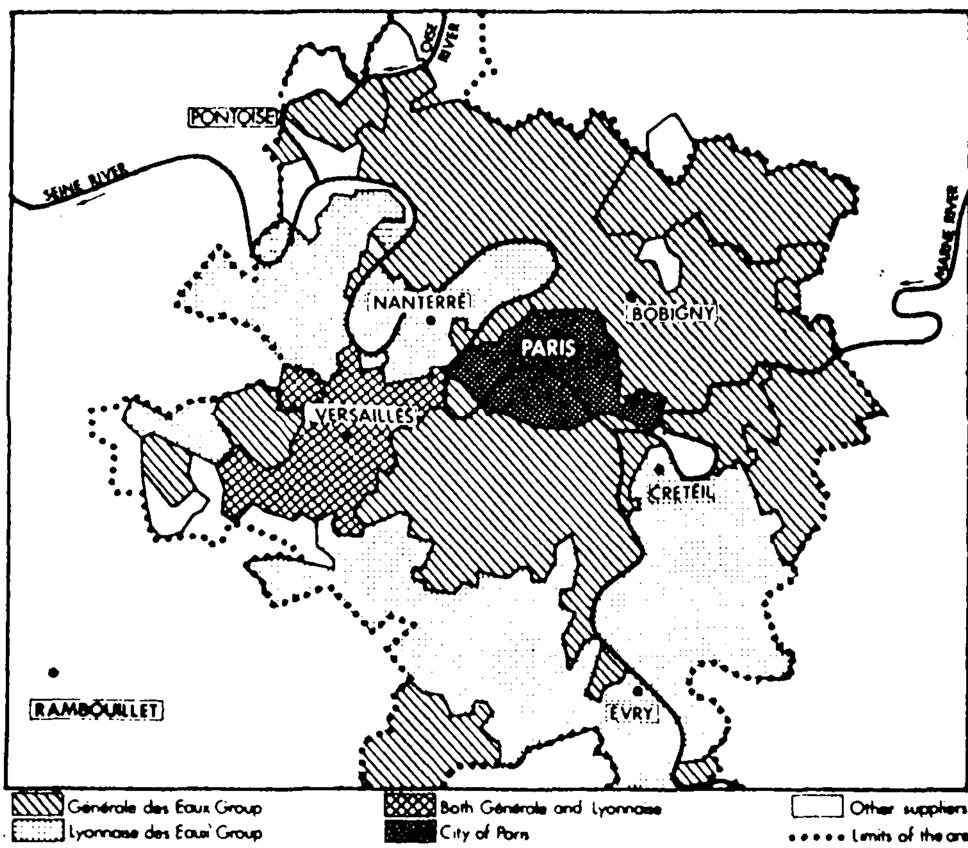


Figure n° 1 : Water services management.

Paris constitutes a special case : since january 1985, the distribution of the right bank of the Seine river was entrusted to the Générale des Eaux and on the left bank to the Lyonnaise des Eaux, and since february 1987 the production of the water is entrusted to a "Société d'Economie Mixte", the SAGEP, (72 % City of Paris, 14 % Générale des Eaux, 14 % Lyonnaise des Eaux).

There has thus resulted a concentration and harmonisation of all the means employed to assure water supply.

Those responsible from the local communities, the water suppliers and the relevant administrations meet in the "Comité Technique de l'Eau d'Ile de France", an instrument for concertation and study with a view to establish and progressively adapt the dispositions on organization of the water supply of the Parisian Region.

For its part, the "Agence Financière de Bassin Seine Normandie" is responsible for implementing the agreed general policy for fighting against the pollution and for protecting water resources by redistributing in the form of loans, advances and subsidies the dues imposed at the same time and on the same bill as the charges for water and sewage.

II. QUANTITATIVE EVOLUTION OF THE DEMAND FOR WATER

Like all the agglomerations of some importance Paris and its suburbs have, since the last world war, seen rapid growth, since the population has grown from six million in 1945 to nearly 8 million in 1975. Today it is around 8 800 000 inhabitants following a slowing down in the rate of increase since 1975.

Thus 16 % of the population of France is concentrated in an area of 2000 km^2 or less than 0.5 % of the national territory. From the point of geographical distribution we have the City of Paris properly speaking of which the resident population is more or less stable or slightly decreasing (25 %), the inner suburbs now relatively saturated (40 %) and the outer suburbs (35 %) with an increasing density clearly concentrated on five new towns created some twenty years ago (15 %), as figure n° 2 on the next page shows.

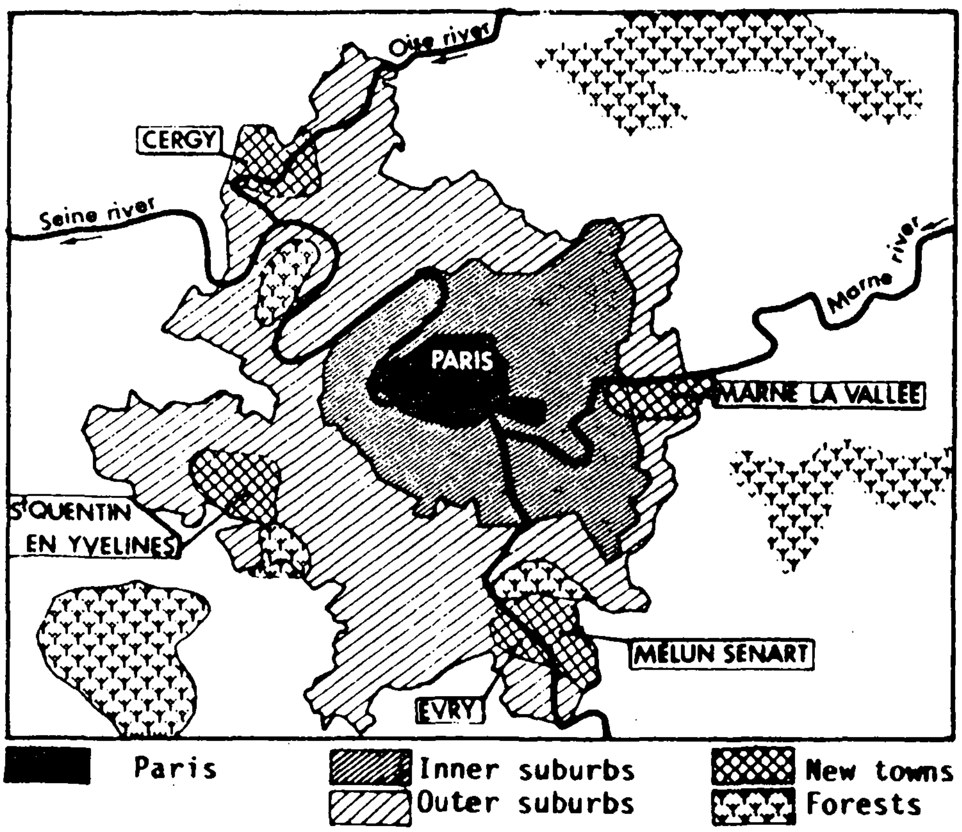


Figure n° 2 : Repartition of the population.

For the next twenty years only a limited progression of the population and of its concomitant tertiary activities is envisaged (urban renovation, densification having reached their limits, industrial emigrations practically finished). For 2005, estimates are around 9 200 000 inhabitants.

As regards the evolution of the need for water it is appropriated to isolate the figures for Paris where we observe quasi-stagnant consumption resulting from the fall in the resident population and the increase in the activities of the tertiary sector.

Nor must it be forgotten that Paris is equipped with a distribution network for non-potable water specifically for the washing out of gutters and streets and the watering of the public gardens and the sewer flushing.

The evolution of the needs for drinking water observed at the source is as follows in million of cubic meters per year :

PRODUCTION OF DRINKING WATER	1970	1980	1986
PARIS Remainder of the agglomeration	305 440	295(1) 490	300 540
TOTAL	745	785	840

(1) Reduction resulting from an active campaign of research and suppression of distribution leaks.

The table of present average unitary needs at source brings out the specific case of Paris.

1986 SITUATION	POPULATION (millions inhabitants)	TOTAL NEEDS (Mm3)	AVERAGE UNITARY NEEDS (l/inhab/d)
PARIS PARIS	2,2 4 (consumers)	300 300	375 205
Remainder of the agglomeration	6,6	540	225
TOTAL	8,8	840	260

For futures years, indicative unitary figures might be of the order of 400 l/d/inhab. for Paris and 250 l/d/inhab. for the remainder of the agglomeration ;
the peak water demand would be respectively 480 l/d/inhab. and 375 l/d/inhab.

Globally, the expected evolution of the water demand is around the following quantities :

- 1995 : 890 Mm3 per year and 3 400 000 m3/d at the peak.
- 2005 : 960 Mm3 per year and 3 700 000 m3/d at the peak.

III. THE MAJOR ORIENTATIONS OF THE ANSWER TO THE EVOLUTION OF THE WATER DEMAND

The current state of the different resources exploited today is set out in table 1, 2, 3a, 3b and 4 below with an indication of the treatment capacity, date of construction and flow sheet.

Figure n° 3 which follows them shows the importance and location of these different resources.

Table 1 : Ground water without treatment.

Ground Water without treatment	Dhuis	Avre	Vanne Voulzie	Loing Lunain	Calcaires de Champigny
Date of construction	1863-65	1891-93	1867-74	1897-1900 1922-24	1987-88
Capacity m3/d	20 000	140 000	250 000	100 000	90 000
Supplied sector	Paris	Paris	Paris	Paris	South of Paris
Lenght of the adduction	135 km	143 km	183 km	94 km	about 20 km

Table 2 : Ground water with treatment.

Ground water with treatment	Croissy Le Pecq	Aubergenville	Villeneuve La Garenne	Louveciennes
Date of construction	1933-1970	1961	1978	1955-1983
Capacity m3/d	112 000	144 000	36 000	120 000
Supplied Sector	West of Paris	West of Paris	West of Paris	West of Paris
Artificial ground water recharge capacity m3/d	150 000	30 000		
Origin	chalk	chalk	sand	chalk
Nitrification	X	X	X	X
Ozonation	X	X	X	X
Sand filtration		X	X	
Activated carbon filtration	X			X
Iron removal		X		X
Catalytic decarbonatation			X	
Final desinfection	X	X	X	X
Other treatment				acidification

Table 3 a : Surface water rapid filtration.

Surface water rapid filtration	Morsang	Viry	Vigneux	Orly	Choisy
Date of construction	1970	1919	1930	1969	1963-86
Capacity m3/d	225 000	120 000	55 000	300 000	800 000
Supplied sector	South of Paris	South of Paris	South of Paris	Paris	South of Paris
Origin	Seine upstream	Seine upstream	Seine upstream	Seine upstream	Seine upstream
Raw water storage				X	
Preozonation					X
Prechloration	X	X	X		
Powder activated carbon	X	X	X	X	X
Flocculation décantation	X	X	X	X	X
Sand filtration	X			X	X
Ozonation	X			X	X
Activated carbon filtration	X	X	X		X
Final desinfection	X	X	X	X	X
Other treatment	neutra-lization	neutra-lization	neutra-lization	-	-

Table 5 b : Surface water rapid filtration

Surface water rapid filtration	Mont Valérien	Neuilly sur Marne	Annet-Sur-Marne Part I & II	Part III & IV	Mery sur Oise
Date of construction	1901-1985	1969-1980	1973		1965-85
Capacity m3/d	130 000	800 000	86 000		270 000
Supplied Sector	West of Paris	East of Paris	East of Paris		North of Paris
Origin	Seine downstream	Marne upstream	Marne upstream		Oise upstream
Raw water storage					X
Preozonation	X			X	X
Prechlorination			X		
Powder activated carbon	X	X			X
Flocculation décantation	X	X	X	X	X
Sand filtration	X	X	X		X
Ozonation	X	X		X	X
Activated carbon filtration	X			X	X
Postozonation			X	X	X
Final desinfection	X	X	X	X	X

Table 4 : Surface water slow filtration

Surface water slow filtration	Ivry	Saint-Maur
Date of construction	1937	1896
Capacity m3/d	175 000	300 000
Supplied sector	Paris	Paris
Origin	Seine upstream	Marne upstream
Rough filtration	x	
Prefiltration	x	x
Slow filtration	x	x
Ozonation	x	
Final desinfection	x	x

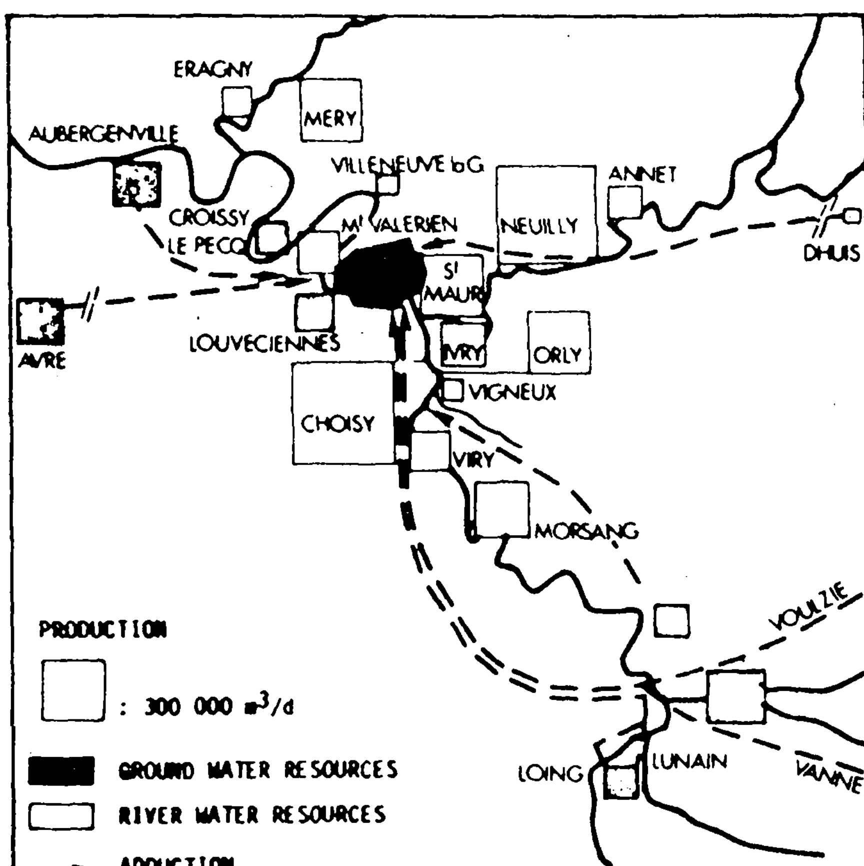


Figure n° 3 : Localisation of different water resources.

A study of these tables and of this figure brings out the orientation which have led to this situation and which are morever again adopted in the basic schema for the supply of drinking water for the Parisian agglomeration. It is important to stress that for more than ten years, having regard to the small growth in consumption, the main efforts of those responsible for water supplies have concentrated particularly upon the improvement and the protection of resources (at the level of the basic river water and at the level of the different stages of the treatment) and upon increased security in the distribution network.

III.1 ACTIONS AT THE LEVEL OF PRODUCTION

a. From the point of view of quantity, three things are obvious :

- The absence of any notable development in the resources from ground water since the end of the XIXth century, in spite of numerous studies being conducted (end of XIXth century : adduction of the waters of Lake Genova to Paris ; before the second world war : adduction of the waters of the Loire Valley to Paris ; twenty years ago : adduction of 300 000 m3/d from Montereau on the Seine river to Paris).

- The important diversification of the origin of the resources which constitutates a factor of security :

  . 45 % ground water (of which 2/3 from long distance adductions).

  . 55 % surface water (11 plants located on three independant water courses).

- Good security quantitatively of present need, the cumulation of existing capacity (3 270 000 m3/d) being adequate even to satisfy future demand, except for peak periods and exceptional drought.

The development of resources at present being conducted (extension of the adduction of the Champigny limestone) or whose envisaged for the future (adduction of the river of the Eure 100 000 m3/d) involve almost exclusively the increase in security of the water supply.

b. From the point of view of quality, we observe :

- The generalisation of the process of clarification of the river water by rapid filtration with the exception of two City of Paris plants (Ivry and Saint-Maur), although for Ivry the automatisation of the operations and extension of the treatment stages (ozonation and filtration on granular activated carbon) are foreseen in the near future.

- The introduction in the treatment plants of special stages after the clarification allowing simultaneously to satisfy confortably the potability standard fixed by the European Economic Community for drinking water and to tolerate any transient degradation in the raw water (e.g. accidental pollution) whilst still guaranteering the potability of the water delivered.

Thus the combination of the biological filtration on granular activated carbon and ozonation after clarification allows an effective fight against the micropollutants and a considerable improvement in the organoleptic qualities of the water supplied to the consumers.

c. As regards the security of the supply of drinking water, important efforts have been made notably in the following ways :

- Construction of reservoirs-dams in the upper reaches of the river (Seine, Marne, Oise) permitting both to control the flood water and to increase the low water debit of the water courses.

- Installation of raw water storage basins upstream from the treatment plants (Mery-Sur-Oise, Orly) permitting an improvement of the raw water quality and the continuated fonctionning of the plant during the passage of a polluted flux in the river.

- Construction of the more recent plants upstream from the agglomeration (Annet-Sur-Marne, Morsang-Sur-Seine) and a project from the transfert upstream of the water catchment point for the older plants.

- Establishment of potential pollution inventories and concertation with industrialists with the support of the public authorities, in particular to reduce their waste and to establish warning procedures in case of an incident.

- Installation of warning station on the river upstream from to plant in which raw water is automatically and continually analysed, the results being teletransmitted to the plant.

- Establishment at the regional level of warning procedures including the creation in case of necessity of a crisis commission mustering the different involved parties and in particular the administration and the water distributors.

- The development of the installation of electricity generating units to mitigate any failing in the electricity supply.

III.2. ACTIONS AT THE LEVEL OF DISTRIBUTION

The distribution is itself the object of specific mesures to take into account the increasing demands as regards quality and permanence in the supply of water :

- The development of interconnexions permitting important transfers of water from one production unit to another, either within the same distribution zone (as for example the double liaison between Choisy-Le-Roi on the Seine and Neuilly-Sur-Marne, or the liaison between Morsang-Sur-Seine and Aubergenville-Sur-Seine), or between neighbouring distributors (the City of Paris, for example, has ten interconnexions which can operate in both direction with the Lyonnaise des Eaux and with the Generale des Eaux).

- The development of distribution reservoirs, the capacity is around 2 200 000 m3 or nearly one day average consumption. Particular attention is given to the annual cleaning of these and in some cases the purification of the air which penetrates into them.

- The continous control of the evolution of the quality of the water in the course of its distribution, and in certain cases complementary treatment (chloration) in order to eliminate any development of germs.

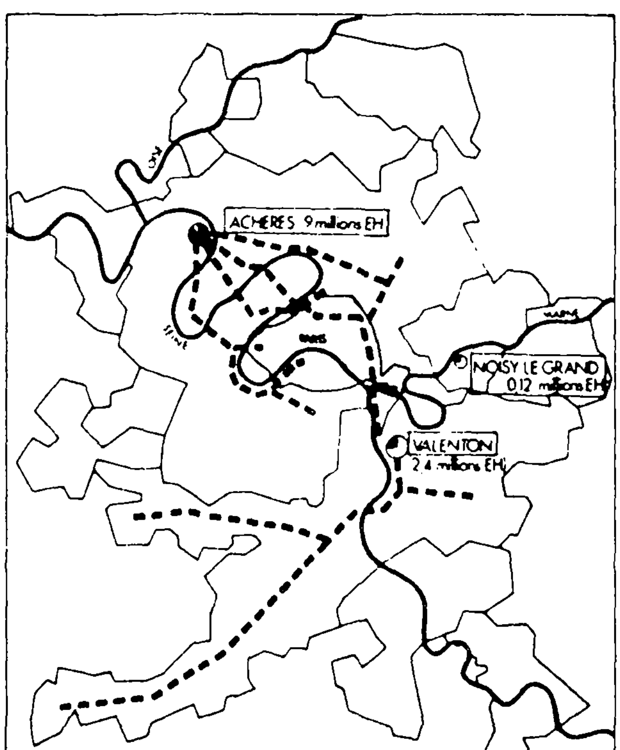
- The protection of the network against any backflow of water from the consumers connexion, and relying upon a sanitary regulation imposing disconnectors in case of important potential pollution.

- The organizing of an intensive policy of renewal of the distribution networks coupled in certain cases with their reinforcement (such was one of the objectives of the City of Paris when the distribution system was privatised in 1985).

III.3. THE SEWERAGE OF THE PARISIAN AGGLOMERATION

The collection, transport and treatment of waste water are the indispensable corollary of supplying water. If the collection, properly speaking, and part of the transportation are effected at the level of each "commune" (or at the level of a group of "communes"), the "Syndicat Interdepartemental d'Assainissement de l'Agglomeration Parisienne" is the responsible for the primary transport and the sewage treatment means for almost all the agglomeration, except for a few local sewage treatment plants such as this for the western region of Versailles.

The figure 4 shows that most of the effluents are transported by mains to the sewage treatment plant at Achères (capacity 9 million equivalent inhabitants) the principe of the treatment of effuents at Achères goes back more than a century and was the idea of the engineer BELGRAND, the father of the first long distance adduction of ground water for Paris.



The effluent from the eastern suburbs (including those of the new towns of Marne-La-Vallée are processed in the station at Noisy-Le-Grand of which the first part was built in 1976. Those of the southern suburbs (including the new towns Evry and Melun-Sénart) are purified at Valenton (a station opened in 1987).

These three sewage treatment plants will be doted with additionnal hydraulic capacity but also, and above all, with the addition of water processing equipments (elimination of nitrogene and phosphates for example) and of sludge treatment units.

In the same way, an important effort is being made regarding the collection and evacuation of rain water, and the treatment of the first flush of storm water, and the development of separate sewerage system and the automatisation of the management of these networks.

CONCLUSION

These rapid outlines does not permit an exhaustive approach to all the actions adopted and the studies made to satisfy the exacting demands of the public service of drinking water in the Parisian agglomeration. In spite of an apparent harmonisation, the constraints are many and varied but an attempt has been made to set out the governing factors behind past and future policy.

The last of these constraints is clearly economic. The bulk of the necessary investment is reflected in the price of water, at a time when it appears normal to pay the just price for a service given. Yet taking into account the importance of these investments, the price to the consumers is very reasonable since it is on average around 7,50 F/m3 in Paris it is only 6 F/m3 (i.e. a little less than one ECU), in which the water supply represents only 50 %.

The final action of the water distributors but not the least is to inform the consumer. This policy of communication is fully operative in the Parisian agglomeration. In addition to the traditionnal printed information, such modern means as films and audiovisual methods in the board sense of the term constitute a useful aid. But these indispensable exchanges and public relations campaigns are certainly not unique to Paris.

The distribution of water has become a hightly technical craft. To foresee, to built, to manage, are no longer enough. It must be well done and above all be known to be well done. We cannot only say to consumers "Turn the tap, we have done the rest", but we have also to explain them what we have done for giving them satisfaction.

WATERSUPPLY IN BANGKOK METROPOLIS

PRESENTED BY:

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WATER SUPPLY

IN

BANGKOK METROPOLIS

BY

CHUANPIT DHAMASIRI

ASSISTANT GOVERNOR FOR PLANNING & DEVELOPMENT

METROPOLITAN WATERWORKS AUTHORITY

BANGKOK, THAILAND

CONTENTS

WATER SUPPLY IN BANGKOK METROPOLIS

1. GEOGRAPHICAL DATA

Topography

The Bangkok Metropolitan Area and its vicinity, located in the Lower Central Chao Phraya Plain along the Chao Phraya River basin about 50 river km. upstream from the Gulf of Thailand, form a flat low lying deltaic plain, with average elevation ranging from 1.0 to 1.5 meters above the mean sea level, with maximum elevation of about 2.0 meters.

The great plain of the Chao Phraya comprises approximately 35 percent of country's total area and about 40 percent of its population. The delta area is extremely flat, extensively irrigated, and very rich agriculturally. It is surrounded by low rugged mountains which are an extension of the Himalaya range. The Bangkok Metropolis has a total area of 3,080 km^2

The lower Central Chao Phraya Plain is covered by thick alluvial and toritorial sediments. The top most thick clay, called " Bangkok Clay " , is about 20 to 30 meters thick covering the whole area. Bangkok Clay is considered to be one of the important factors in considering land subsidence occurring in the Bangkok Area. In the Bangkok area, the clay has high corrosiveness to ferrous metal according to the soil corrosivity survey.

Climate

The Chao Phraya River Basin is located in the tropical monsoon region which has distinct dry and rainy seasons. The rainy season is brought by the southwest monsoon coming from the Indian Ocean during the period from April to October. The monsoon is laden with high moisture content and provides high values of precipitation and humidity.

During the rainy season, tropical cyclones often occur in the South Pacific Ocean and move into the basin, especially in September and October. Due to the tropical cyclonic disturbances , the widespread precipitation of longer duration can happpen in the basin.

The dry season continues from November until March during which a dry and cold air mass is brought by the northwest monsoon from the China Mainland. Consequently , the dry season provides low values of precipitation and humidity.

Rainfall

The arrival rainfall in the basin varies from 1,000 mm. in the western area to 1,400 mm. in the northeastern area. About 85 percent of the annual rainfall occurs during the rainy season. During a tropical cyclone, one day precipitation sometimes exceeds 100 mm.

Temperature

The temperature is regularly high through out the year. In summer the temperature range is between 33-38 degree celcius, April is normally the hotest month of the year. The average temperature in the dry season (winter) is between 10-20 degree celcius. The average temperature different in a day is 12 degree celcius.

Relative Humidity

Evaporation in the basin is normally at its highest in April and lowest in August to September. Since Bangkok Metropolis is located near the Gulf of Thailand where the moist air mass come from, therefore the relative humidity of Bangkok Metropolitan area is relatively high throughtout the year.

2. POPULATION

The population census of Thailand has been conducted at 10 years since 1960, and it showed the population of 26.258 million in 1960, 34.393 million in 1970 and 44.825 million in 1980. The average annual rate of population growth for both periods of 1960-1970 and 1970-1980 was 2.74 % and 2.68 % respectively. The population in 1985 amounted to 51.795 million according to the report of the National Statistical Office, and the growth rate was estimated at 2.93 % per annum during the five years from 1980 to 1985.

In the population by region, it is noticed that the population of Bangkok made a remarkable growth, i.e., it rose from 2.136 million in 1960 to 3.077 million in 1970 at the growth rate of 3.72 % per annum, and further to 5.153 million in 1980 at the rate of 4.32 % per annum. Such a great growth in population was due mainly to the increased migration from rural areas and the high birth rate. However, this growth rate has declined gradually in the 1980's due to the decreased migration. According to the government report, the population of Bangkok in 1986 amounted to 5.47 million and the growth rate indicated 2.69 % per annum during the period 1980 - 1985. Total population in Bangkok Metropolis in 1987 is 7.3 million.

The population density in 1985 was estimated at 101 persons per square kilometer on the average in the whole country and Bangkok had the population density of nearly 3,500 persons per square kilometer in the same year. Following Bangkok the two (2) provinces of Nonthaburi and Samut - Prakan had a comparatively high population density, i.e., 775 and 744 persons per square kilometer, respectively.

3. HOUSEHOLD INCOME

A Socio-Economic Survey of the whole Kingdom was conducted in 1981 by the National Statistical Office. According to the survey results, the average annual household income was indicated at 40,536 baht for the whole Kingdom for the said year. Among households by region, those in the Bangkok Metropolitan Area had the highest average annual income of 71,664 baht per household.

4. WATERWORKS AUTHORITY FOR BANGKOK METROPOLIS

The water supply activity for bangkok was firstly extablished in 1909 by his Royal Command of King Rama V with His Majesty's objective to offer hygenic water to Bangkok people for being free from epidemics possibly by occurred by consuming natural water from rivers and canals which is unqualified for domestic purposes.

The construction of the first Bangkok water supply system was completed during the reign of King Rama VI in 1914. The first water treatment plant of 28,000 CMD capicity, the raw water intake from the Chao Phraya River and the raw water canal still serve as the main structure of the present system.

In 1967 the Government enacted " The Metropolitan Waterworks Authority (MWA) " by combining the water supply systems of Bangkok and nearby cities to act as a public utility state enterprise under the Ministry of Interior, to perform responsibility in providing water supply services to the people living in the responsible area. The management of the MWA is under the "Governor" while the supervision and policies are directed by the "Board of Directors" appointed by the Cabinet

5. WATER SUPPLY SYSTEM

MWA provides system water for both the core area of Bangkok Metropolis which is called "Central System" and another seven individual systems outside the central system called "Separate Systems" , each of which covers its own limited area by way of groundwater supply. The areas served by the seven separate systems are totalled to approximately 5 % of the central system.

At present, the MWA serves approximately 770,000 customers, all metered. The total population served is approximately 5.3 million which is about 70 % of the total population in the Bangkok Metrolopis . The total area served is approximately 550 sq km, or about 18 % of the total responsible area. The average daily supply is approximately 2.45 million cubic meters (CMD).

Besides the MWA, there is no other public water supply system for the remaining 2.2 million people of the Bangkok Metropolis. These people, including commercial and industrial entities outside the present service area, have to rely on their own water supply facilities through all available sources. These sources are not only the groundwater, but also surface water and even rain water.

6. THE EXPANSION PROJECTS

In 1970, the Master Plan for Water Supply and Distribution was established. The 1970 Master Plan presented the recommendations on the future system improvement, in step-wise plans, to satisfy the water demand up to the year 2000. Instead of expanding the existing treatment plants, the Master Plan recommended the new setup of water production, transmission and distribution facilities for the improvement of water supply in the central system. The new setup consisted of a new water treatment plant with provisions for future expansion, a series of water distribution pump stations and reservoirs at various localities in the demand center, and a water transmission tunnel connecting the new treatment plant and those pump stations.

MWA started the first project of Master Plan in the year 1974 and has carried out the projects as follows:

(1) Project 1 (Phase I of Stage I) - Bang Khen water treatment plant was constructed and the project was completed in the late 1979, providing for facilities with a capacity of 800,000 CMD at the cost of approximately 230 million US dollars. The service area was expended from 215 to 280 km²

(2) Project 2 (Phase II of Stage I) - An additional of 400,000 CMD in order to avoid water shortage up to year 1980 was continued.

At the year 1985 another 2 clarifiers was constructed at Bang Khen to increase the plant capacity another 400,000 CMD. The production part was finished by the year 1985. The total project cost is about 323 million US dollars, and the area served is expected to be 430 km²

(3) Project 3 (Phase IA of Stage II) - The total supply will be increased by another 500,000 CMD (400,000 CMD from Bang Khen and 100,000 CMD from Sam-Sen plant) and the area served at the end of project will be 580 km² The project is expected to finish by this year (1988) at the cost of 265 million US dollars.

(4) Project 3/1 (Phase I B of Stage II) - The Bang Khen plant will have the additional of 400,000 CMD while the area served will be 630 km² The project will be started in 1988 with the estimated cost of 68 million US dollars.

7. TECHNICAL PROBLEMS

Though the expansion projects have been continuously processed, but the supply is still behind the demand. The present situation is

	Total	Served	% Served
Responsible area (km^2)	3080	550	18
Population (million)	7.5	5.3	70

The long-drawn out water shortage bring in the following problems :

(1) Salt water intrusion into ground water aquifer

Ground water has been used both by the MWA and privates as source of supply. Ground water quality in most area was quite good and it can be freely used till the salt water intrusion was observed around 20 years ago.

(2) Land Subsidence Crisis

Land subsidence was observed late after the first problem. In 1982 the critical area No. 1 was reported to have the rate of subsidence more than 10 cm. per year. The Groundwater Act was passed out in year 1977 to limit the use of groundwater. In these last few years the rate of land subsidence was decreased by half.

(3) Tunnel and Pipe Breakage

Due to unequal subsidence of land and settlement of Bangkok Clay (top soil) , unexpected breakage of main tunnel which bring treated water from Bang Khen Plant to central area was found after start using for a year

(1980). The pipe breakage was found all over caused the leakage in system as high as 30 - 35 percent of water produced.

(4) Direct pumping from service pipe

In low pressure area some customer who has no space to install the sump will pump the water directly from service pipe. The suction from pump will bring in the polluted water through the breakage of pipe and contaminate the tap water.

8. FINANCIAL PROBLEMS

MWA had no profit since establishment up to year 1985 due to controlled water tariff by the Government and high percentage of unaccounted - for water. In 1984 the Government allowed MWA to increase the tariff gradually to cover all deficits. The unaccounted - for water was reduced from 73 percent in 1967 to less than 45 percent since 1983, therefore , the profits start showing out in 1985.

In the situation of losses for many years, MWA had to depend on lending money for all capital investment. First loan for Project 1 was from world Bank (IBRD) and Asian Development Bank (ADB) and the following loans was from OECF (Japan) and ADB. At present the total foreign debt is 477 million US dollars, about 68.3 % are in Yen. The strength of Yen credit in these past few years effects so much with MWA financial. Loss on foreign exchange rate increase from 1.7 million baht (0.07 million $ US) in 1984 to 420 million baht (16.84 million $ US) in 1987. It is expected that there will be no profit in year 1990 if the rate of exchange situation still continue like this.

9. CONCLUSION

While the population served is being increased from 70 % at present to reach 75 % level in 1989 from project 3, the long-term plans for Project 3/1 (1988- 1991 for 400,000 CMD production increase) and other projects are already projected in the revised Master Plan. In case that the MWA's financial capability enables the future projects to be accomplished as planned, the population served in 1995 will be 7.13 million people or 80 % of total population 8.86 million at that time.

Even the gap of non-served population is narrowing during the next 10 year period, the MWA still cannot enjoy this projection. Interpretation otherwise illustrates that the non-served population is decreased from 2.2 million at present to about 1.9 million in year 2000. While the goal of the Master Plan Programs has to be maintained, an accelerated plan to increase the water production for the non-served population from the Master Plan has to be investigated concurrently. Technical assistance for feasibility study of such and follow-up action for financing the accelerated program of water production increase are being sought by the present MWA's management.

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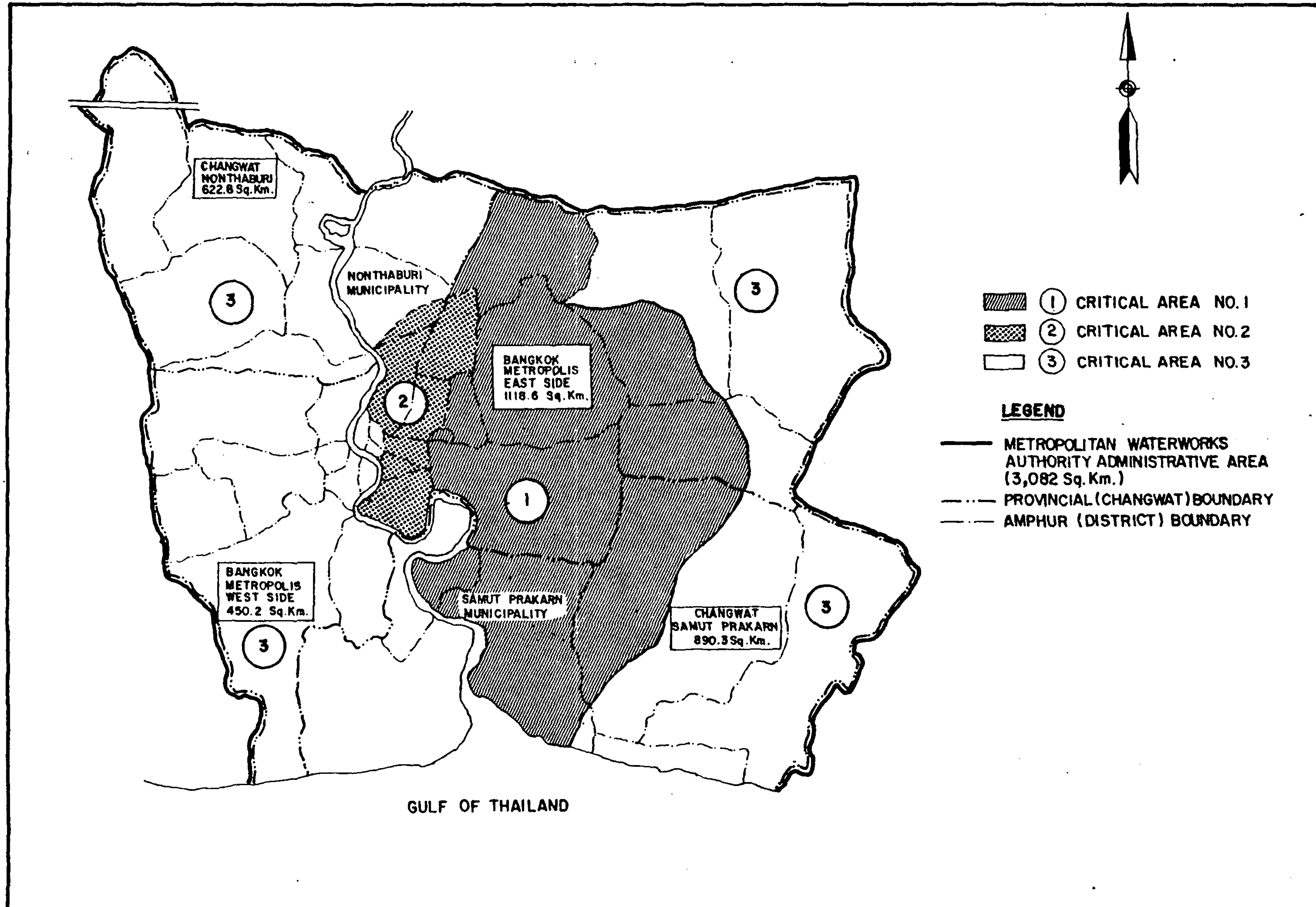
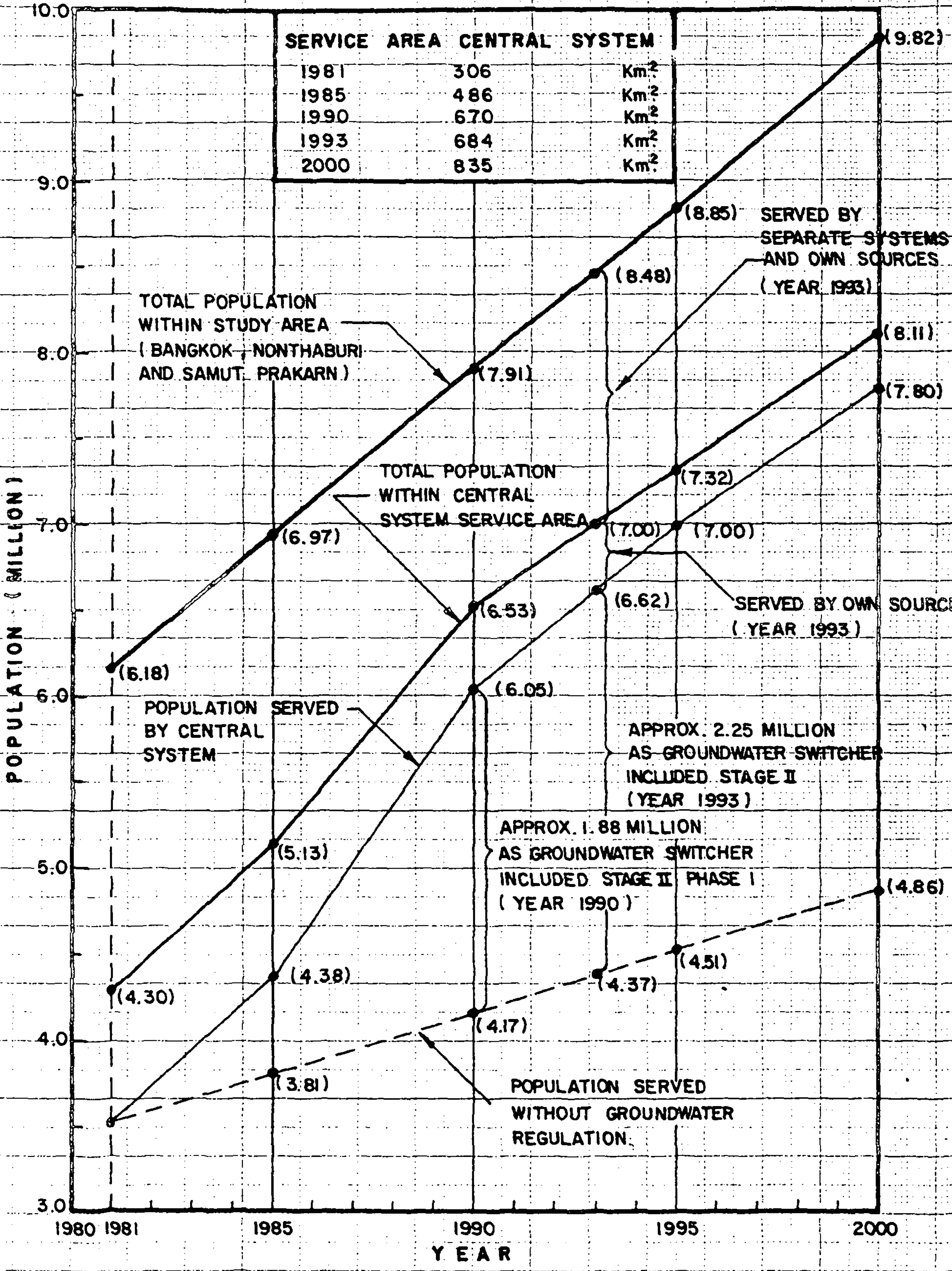


MAP SHOWING CRITICAL AREA OF LAND SUBSIDENCE IN BANGKOK METROPOLIS



PROJECTED POPULATION SERVED (CENTRAL SYSTEM)

Statement of Income

For the Fiscal Years Ended September 30, 1980 to 1989

mil.Baht

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	← audited							→	← estimated	→
Revenues										
Operating Revenues	618.4	877.9	1,202.3	1,393.0	1,717.9	2,742.6	3,391.0	3,625.8	3,829.8	4,275.9
Gov't Supported Sales	424.0	-	263.8	210.0	-	340.0	-	-	-	-
Non Operating Income	42.8	37.3	58.2	58.0	60.0	69.6	153.6	85.2	87.5	25.0
Total Revenues	1085.2	915.2	1,524.3	1,661.0	1,777.9	3,152.2	3,544.6	3,711.0	3,917.3	4,300.9
Expenses										
Operating Expenses	822.0	980.0	986.3	1,074.4	1,156.9	1,281.0	1,352.4	1,395.3	1,489.4	1,773.3
Depreciation and Amortization	203.4	283.2	310.4	332.3	406.0	428.0	548.2	631.6	720.4	894.1
Interest and Commitment Charges	312.1	404.1	540.1	453.9	448.0	652.7	666.5	664.7	710.5	837.9
Non - Operating Expenses	21.8	13.7	26.1	14.3	15.3	18.6	22.6	34.2	30.8	4.5
Loss on Foreign Exchange rate	-	-	-	-	1.7	407.7	317.4	421.2	440.7	450.0
Total Expenes	1,359.3	1,681.0	1,862.9	1,874.9	2,027.9	2,788.0	2,907.1	3,147.0	3,391.8	3,959.8
Net Income (loss)	(274.1)	(765.8)	(338.6)	(213.9)	(250.0)	364.2	637.5	564.0	525.5	341.1

WATER SUPPLY IN FAST GROWING CITIES - METROPOLITAN LAGOS -

S.O. OYEWOLE
LAGOS STATE WATER CORPORATION

RAI CONGRESS CENTRE, AMSTERDAM

"WATER SUPPLY IN FAST GROWING CITIES"

- METROPOLITAN LAGOS"

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TABLE OF CONTENTS

1.0 GENERAL DATA ON GEOGRAPHICAL SITUATION, INHABITANTS AND ECONOMY

1.1 HISTORICAL BACKGROUND

Lagos derived its name from the Portuguese for that area of the Metropolis located south-east of the mainland called Eko. It was ceded to the British in August 1861. The main occupations at that time were fishing and trading. At the turn of the century, a more organized expanded settlement began to spring up with the original settlers, and new immigrants moving towards the mainland.

1.2 However, during the second half of this century and specifically immediately after independence, factors such as better job opportunities, and higher wages resulting from establishment of more industries, improved inter-city transportation facilities amongst others, influenced the town's growth both spatially and in population. This growth pattern became even more prominent with the advent of the oil boom era. Job places were available in abundance attracting unprecedented migration from Lagos environs and from the hinterland by immigrants who abandoned their agricultural occupations in favour of employment in the Metropolis.

1.3 AREA AND POPULATION — 1

Lagos State area which is 357,700 Hectares contains 60,839 Hectares (17 per cent) of Lagoons and Waterways. The State which is divided into eight (8) Local Governments for administrative convenience, is one of the twenty-one State of the Federation. In land-area, the size of Lagos is comparatively 0.4 per cent of Nigeria. Lagos is the smallest, but most densely populated State in Nigeria. Metropolitan Lagos, with a population estimated at over 6 million, accounts for approximately 90% of the State's population. This was as a result of both immigration and a high natural growth rate (about 9% per annum in the 1950 - 1980 period). The population is expected to continue to grow at an estimated 4.5% per annum to reach 12.1 million by the year 2000. The Metropolitan area occupies only 37 per cent of the land area of Lagos State.

1.4 GEOGRAPHICAL BACKGROUND — 1

Lagos Metropolis presently serves as the Headquarters of both Federal and

Lagos State Governments. It is located on the south-western corner of the country, bordered by the Atlantic Coastline or the Bight of Benin to the south. The Lagos Lagoon is to the east, and latitude 6°30' approximately traverses the settlement area. It is situated on an area characterized by creeks, Lagoons and tributaries of major rivers - Ogun and Owo - with large catchment areas which present difficulty in drainage due to high water table and near flat marshy terrain. The water area and marshland represent about 40% of the total area of the Metropolis. Geologically poor areas which are predominantly mangrove or rain forest types of vegetation, and cover about 60 per cent of the State limiting the land available for agricultural development.

1.5 CLIMATE — [1]

Lagos experiences two major seasons namely the wet and dry seasons. The wet season which peaks in June, occurs during the months of March through to November, inclusive, with a break in between called the August break. Annual rainfall in Lagos averages 1800mm with over 80% occurring during this season. The dry season commences from late November through to early March with the dust storm season (harmattan) occurring in December through to January. The season is often hot particularly outside the harmattan period, with occasional isolated showers. Temperatures change from as low as 18°C at night during the mid-harmattan period to as high as 33° just before the rains. The relative humidity is in the order of 70 - 100 per cent in the morning depending on the season and decreases with the increase of the day temperature.

1.6 GEOLOGY AND SOIL

The geological survey maps reveal two prominent formations in the Lagos Metropolis. These are:- (a) the Recent Coastal Deposits, which lie over; (b) the Coastal Plains Sands. The Recent Coastal Deposits occur along the estuaries of the larger rivers and lagoon areas and consists of soft alluvial deposits and sediments of organic materials usually found in the mangrove and rain forest belts. They are located within the southern marshland of Lagos Metropolis. The Coastal Plains

Sands date to the Oligocene - Pheistocene geological ages and are predominantly located on the northern part of the Lagos Metropolis. They consist partly of deep weathered medium and fine grained sands and silts. Due to the consolidation factor and rain water infiltration potentials, reasonable ground water storage is assured and thus is provided in the aquifer from which most of the underground water source schemes draw.

1.7 THE ECONOMY — 1

Lagos was predominantly a trading centre, dating back to the Portuguese era. With its two modern port complexes, the majority of all national import and export trades are handled within the Metropolis. Lagos State generates an important share of the income in the Nigerian economy. Until 1967, the share of Lagos in Nigerian foreign trade remained at about 70 per cent. After that it rose sharply to 90 per cent during and just after the civil water. In terms of value of foreign trade, Lagos, with 80 per cent of the total value of imports, is still the largest Nigerian Port. Due in large part to the petroleum boom, its share in the total volume of exports has fallen in recent years. In terms of contribution to production, Lagos accounts for nearly 50 per cent of the total value added by the manufacturing sector in the country. Manufacturing employment is somewhat less concentrated in Lagos due to the relative capital intensity of its production structure. Over 40 per cent of Nigeria's skilled manpower is also concentrated in Metropolitan Lagos. Lagos economy is divided into nine activity groups. They are Agriculture, Forestry and Fishing, Mining and Quarrying, Manufacturing and Crafts, Utilities, Building and Construction, Distribution, Transport and Communication, Public Administration and other services. Lagos, the largest city, the main port and industrial centre of Nigeria accounts for over a fifth of total production in terms of value added.

2.0 SPECIFIC DATA ON WATER SUPPLY

2.1 WATER RESOURCES

Drinking water supplies in Lagos State are drawn from both surface and underground sources. There are three principal surface sources, the Iju and the Ogun Rivers, which serve the needs of the majority of the population; and the Owo River. Presently about 204,570m^3 per day of raw water are drawn from the Ogun and the Iju at Iju Waterworks and about 18,180m^3 per day from the Owo at Ishasi Waterworks. The Oyan River Dam completed in 1983, and operated by the Ogun-Oshun River Basin Development Authority (OORBDA) ensures reliable yields of an additional 636,440m^3/day for Lagos State Water Corporation into the next century. Further impoundment under construction in the upper catchment area will increase considerably the safe yield of the Ogun River making it possible to continue its use to supply most of the anticipated future water supply needs of the metropolis. The potential for groundwater is limited - maximum reliable yield in the Lagos area was assessed in 1977 at 477,330m^3 per day of which industry was estimated to be abstracting about 363,680m^3 per day and the rest for domestic consumption through the Mini Waterworks. More up-to-date information is being gathered to enable Lagos State Water Corporation control groundwater use. An agreement has been signed between LSWC and the OORBDA for the additional abstraction up to 954,500m^3/day. Table 2.1.1 shows the water sources and production capabilities till the year 2000.

TABLE 2.1.1

PRESENT AND PROPOSED SOURCEWORKS DEVELOPMENT FOR METROPOLITAN LAGOS (1988 - 2000)

S/No.	SOURCES	A. PRESENT (m^3/day)	B. STAGE I EXPANSION(1990) (m^3/day)	C. ULTIMATE STAGE YEAR 2000 (m^3/day)
(i)	Iju	204,500	204,500	204,500
(ii)	Isasi	18,200	18,200	159,000
(iii)	7 Metropolitan Mini Waterworks	81,800	81,800	NIL (EXCLUDED)
(iv)	Adiyan	-	318,200	954,500
	TOTAL SOURCE CAPACITY	304,500	622,700	1,318,000

2.2 WATER TREATMENT AND QUALITY

During heavy rainstorms, the catchment areas which are not ordinarily eroded by runoffs and flood plains not usually occupied by surface streams, contribute large amounts of silt to flood flows. Both mineral and organic particles are picked up by erosion together with solid bacteria and other organisms. Also natural and synthetic fertilizers are taken along with biocide residue, although the binding power of soils is remarkably strong. The resultant effects on the raw water quality are high colour and turbidity values measured during this period. Annual averages of some of the parameters monitored in the last ten years are shown in the tables below for both the dry and wet seasons:-

TABLE 2.2.1

OGUN RAW WATER - DRY SEASON

PARAMETERS	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Colour Hazen Unit	200	100	180	80	100	160	110	95	144	250	147
Turbidity F.T.U.	62	40	20	15	20	31	30	22	25	69	39
p^H	6.8	6.8	6.9	6.9	6.9	6.8	6.9	7.0	7.0	7.3	7.3
Total Hardness as $CaCo_3$ mg/1	35.8	134	30	38	36	40.6	33.5	33.5	29.5	33.9	33
Iron (Fe) mg/1	0.5	0.3	0.3	0.3	0.5	1.61	0.2	0.52	0.96	0.7	0.6

TABLE 2.2.2 - WET SEASON

PARAMETERS	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Colour Hazen Unit	700	680	450	360	260	210	150	195	245	567	504
Turbidity F.T.U.	240	120	65	110	140	50	30	40	12	157	136
p^H	6.8	6.6	6.9	6.5	6.95	7.0	7.45	7.1	7.1	7.0	7.1
Total Hardness as $CaCo_3$ mg/1	28.64	25	25	35	35.5	35	39.5	36	41	28.9	44
Iron (Fe) mg/1	0.2	0.1	0.2	1.0	0.63	ND	1.25	0.8	0.8	1.12	0.6

Consequently, higher dosages of coagulants are required for effective treatment. Also, there is an increase in the quantity of chlorine employed as disinfectant.

2.3 In the dry season, there is generally a reduction in the quantities and cost of the various chemicals used for water treatment. This is due to the improved quality of the raw water. The major problem confronting the surface-source waterworks is the back-flow of saline water from the Lagoon to the Ogun river, giving rise to high values of salinity. This problem is taken care of through the additional releases of water from the OORBDA from the Oyan Dam, which is situated upstream of the Ogun River. During this season, there is an annual occurence of increase in the phytoplankton in the river course, which gives rise to the use of copper sulphate as algicide, in order to overcome the algal bloom. The raw water quality at the Waterworks with groundwater sources are remarkably different from the quality of the surface water. Both the physical and chemical parameters measured are generally of lower concentration due to the fact that the water is not susceptible to intrusion and pollution. The raw water source at Ishasi Waterworks is of a peculiar nature. There is a high concentration of organic matter in the water due to vegetation. During the rainy season, the raw water colour rises to such levels as 1,160 Hazen Units. Additional coagulant-aid in the form of polyelectrolytes are added prior to the conventional treatment to reduce the cost of treatment. As expected, the water quality improves during the dry season.

2.4 Annual consumptions of types of chemicals used at some of the Waterworks are shown below.

WATERWORKS	ALUMINIUM SULPHATE (MT)	HYDRATED LIME(MT)	LIQUID CHLORINE (MT)	SODA ASH(MT)	H.T.H (MT)	POLY ELECT. (MT)	CALCIUM CARBONATE(MT)
Iju	5,400	1,200	100	-	10	-	-
Ishasi	900	630	20	300	3	3	-
Isolo	-	-	-	-	12	-	50
Apapa	36	-	5	300	-	-	-

The effects of the leachates on the shallow wells in residential areas which are not served by pipe-borne water have started to be of great concerns to the Water Corporation. Effort are being made to evaluate the full extent of the effect and how to arrest this.

2.5 The distribution network has undergone considerable expansion in the last five years with 43.8 kilometers of tertiary mains, laid in 1984, 120.1km in 1985, 52.3km in 1986 and 21.8km in 1987. The effect is that water connections have also risen from 586 in 1984, 1312 in 1985, 2271 in 1986 and 3240 in 1987. During the same period, a total of 9,781 mains and service bursts were repaired within the network, with 2307 meters installed between 1985 and 1987.

3.0 PROBLEMS ENCOUNTERED DURING PAST PERIOD OF RAPID GROWTH

3.1 PLANNING AND ORGANISATION

LSWC was established in 1985 as a parastatal organisation to develop and manage water supply facilities in Lagos State. It is being re-organised according to the four functional areas of Engineering, Operations, Finance and Administration, each headed by an Assistant General Manager. New Divisional and Zonal arrangements are being set up to enable LSWC to be more responsive to the needs of its customers on a localised basis, particularly, while the distribution system is being expanded and the new billing and collection systems are being installed. To complement its efforts, the Corporation would utilise various form of Technical Assistance in selected key-areas, principally training, project management, accounting, billing and collection and data processing.

3.2 Until recently, in early 1988, when some degree of autonomy was approved for LSWC, its autonomy was severely limited due to the insistence on the use of Civil Service regulations and renumerations. LSWC is now undergoing rapid institutional development in consonance with its rate of evolution during this continuous period of rapid growth. Some of the problems impairing the excercise of the autonomy include LSWC's partial dependence on State subventions for recurrent expenditures and complete dependence for capital expenditures. This is mainly due to lack of effective recovery mechanisms and adequate tariffs. By and large, LSWC still suffers from overmanning, especially in the lower levels; lack of manpower development and training capabilities; inadequate accounting, billing and collection systems; high unaccounted-for water; insufficient funds for spare parts to carry out efficient operations and maintenance of its facilities.

3.3 TRAINING

Presently, LSWC employs 1,658 staff, of which about 80 have university or technical qualifications and training. The bulk of these have been with the Corporation for many years and have come up through the Lagos State civil service. In anticipation of the substantially increased workload and the need to broaden the experience and skills profile of its staffing, LSWC is presently recruiting qualified staff to reinforce the middle management positions and to cope with activities in relatively weak areas of training, accounting, billing and collection and data processing. LSWC provides 2% of its annual personnel budget to recurrent costs of training. It is envisaged that institutional development will be reinforced by technical assistance to be provided through a twinning arrangement with a foreign water utility.

3.4 FINANCE

The accounting processes still follow the basic receipts and payment system operated by government. Improvements in financial operations are expected with the introduction of the accrual accounting system based on commercial principles in 1988. With a rapidly expanding expenditures budget, internally generated revenues accounted for about 35% in 1985, 39.4% in 1987 of its operating expenses. The Corporation pursues a two-tier target of:-

(i) gradual disengagement from recurrent subvention, between now till December 1991, developing capabilities to meet its cash operating expenses, 100% in 1991; and (ii) generation of revenues adequate to meet not only its cash operating expenses, but also its debt service obligations on all external loans by 1996. The specific financial targets have been agreed to, by all the external borrowers, the State Government and the Water Corporation. The major problems encountered in revenue generation centre around setting up of the appropriate cost-recovery mechanisms as discussed under the new organisational set up. Enumeration and identification excercise of all consumers is being embarked upon to arrive at a more realistic base for revenue generation. Only the industrial and commercial consumers are now being billed directly. Domestic revenues are received as bulk-charges from the eight Local Governments which really do not reflect true revenue expectations.

3.5 TARIFFS

The approved 1986 average tariff level was 0.45k per cubic metre. The structure has provided a reasonable relationship between different classes of consumers. It also provided for direct charges for the first time for water sold at public standposts for which a vendor licencing arrangement was envisaged. New tariff levels have been approved for 1988, which allowed for an increase of 270% over the 1986 average tariff level, serving as a good base on which LSWC can operate its direct billing system. It is estimated that there are about 92,000 consumer connections in the State (1988), of which about 82,000 are domestic connections.

3.6 DISTRIBUTION

The general problems of the distribution system are mainly inadequacy of supply and low distribution pressures. In respect of the former, an expansion project which is supposed to double the present production capacity is about to be started. Part of the project objectives is the improvement of access to water supply and the pressures. Presently, the consumers have to install underground tanks to save some water overnight for day use. This is supposed to be overcome when the project is completed. The first cast-iron trunkmain, 700mm in diameter, was laid in 1911 while the second one, 600mm, diameter, was laid in 1943. Both pipes have their carrying capacities and hydraulic efficiencies greatly reduced due to encrustation; also giving rise to low pressures within the distribution network. Both pipes are now undergoing renovation, and will be internal finished with cement-mortar linings.

3.7 CONSUMER AND PUBLIC RELATIONS

Presently, LSWC does not have direct relationship with most of its customers i.e. the domestic, since it receives bulk payments from the eight local governments through deductions from the tenement rates. With the establishment of Divisional and Zonal offices, the operations of LSWC, be it, commercial or distribution are decentralised and will be much closer to be responsive to the needs of its customers. The computer in each zone would serve as a terminal to the main at Ijora. Every consumer would have a file and every zone will have a customer-relation officer. The LSWC has started publicising its activities in the electronic and print media. The scope of the publicity campaign will be greatly improved with the commencement of the Lagos Water Supply Expansion Project.

4.0 PROGNOSIS OF FUTURE DEVELOPMENT

4.1 Presently, the total water production capacity in Metropolitan Lagos from all sources is 304,500m^3/day. This is grossly inadequate compared with the present water demand which is estimated at 853,520 cubic metres per day in 1988. Engineering studies put projected demand at about 1,400,000m^3/day in the year 2000, reference table 2.1.1. To meet this demand, the following water supply projects were earmarked for implementation:- (a) Adiyan Waterworks with a total capacity of 960,000m^3/day to be implemented in 3 stages, each stage with a capacity of 320,000m^3/day; and (b) the improvement of Ishasi Waterworks to a capacity of 159,000 cubic metres per day. The studies recognised the sources of raw water supply for the Adiyan Waterworks as the Ogun River with the intake station contiguous to the present one for Iju Waterworks; with the two dams upstream to serve as the reservoirs that would release all the raw water for the Adiyan Waterworks. The Owo River would serve as the raw water source for the Ishasi Waterworks. To complement the Waterworks, the studies recognised the necessity to lay a total of 350 kilometres of Primary Trunkmains consisting of large diameter pipes ranging in sizes between 800mm and 2400mm diameters to transmit the water produced. It was found necessary to lay a total of 560 kilometres of Secondary Trunkmains consisting of pipes with diameter ranging in sizes between 300mm and 800mm which will further transmit the water to localised areas. The studies also recognised the need for 3000 kilometres of tertiary mains of pipe-sizes below

300mm to distribute and supply water directly to the consumers, at the various levels of service as shown in tables 4.1.1 and 4.1.2.-2

4.2 A multi-national co-financing arrangement is envisaged on this project as follows:- World Bank - US $173.2 million; European Investment Bank (E.I.B) - US $47.7 million; and Coface - US $137.5 million. The following grants have been received, namely: (i) Canadian Internation Development Agency (CIDA) - Cdn $4.67 million, for the Detailed design of the Secondary and Tertiary Distribution network, which has just commenced; and (ii) United Nations Development Programme (UNDP) - US $0.55 million for the Organisation and Management Study of the Lagos State Water Corporation which was completed in 1986.

4.3 This project would make potable water accessible to about 80% (or 6 million) of the citizens of Lagos Metropolis at levels of service comparable with most big cities of the World. However, the total financing arrangement is to come under the umbrella of the World Bank. The World Bank financing would focus on the provision of the Secondary and Tertiary mains, the rehabilitation components of the project package, Institutional Development of LSWC and Technical Assistance, to ensure optimal access of water supply to the people, maximisation of revenues, cost recovery and debt servicing. The project has been planned on an eight-year cycle.

TABLE 4.1.1

CATEGORIES OF POPULATION DENSITIES

	1985 c/ha	1990 c/ha	1995 c/ha	2000 c/ha	2005 c/ha
R 1	50	50	100	100	100
R 2	200	200	300	300	300
R 3	400	400	500	500	500
R 4	750	750	750	750	750
R 5	-	-	1,000	1,000	1,000

TABLE 4. 1. 2

LEVELS OF WATER SUPPLY SERVICE

LAND-USE CATEGORY / YEAR	CONSUMER TYPE			
	R 1	R 2	R 3	R 4
1 9 8 5	100% house connection with 225 1/c/d	100% house connection with 110 1/c/d	100% house connection with 70 1/c/d	70% standpipes with 20 1/c/d. 30% house connection with 50 1/c/d
1 9 9 0	100% house connection with 225 1/c/d	100% house connection with 110 1/c/d	100% house connection with 70 1/c/d	70% standpipes with 20 1/c/d. 30% house connection with 50 1/c/d
1 9 9 5	100% house connection with 225 1/c/d	100% house connection with 110 1/c/d	100% house connection with 70 1/c/d	50% standpipes with 20 1/c/d. 50% house connection with 50 1/c/d.
2 0 0 0	100% house connection with 225 1/c/d	100% house connection with 110 1/c/d	100% house connection with 70 1/c/d	30% standpipes with 25 1/c/d. 70% house connection with 70 1/c/d
2 0 0 5	100% house connection with 225 1/c/d	100% house connection with 110 1/c/d	100% house connection with 70 1/c/d	30% standpipes with 25 1/c/d. 70% house connection with 70 1/c/d
	Low Density upper income one or two family houses, farden, all facilities.	Lower medium density,middle income, good construction, sometimes small gardens, government housing estates, piped water.	higher medium income, large variety of houses, several families living in one house, poorer building material.	high density, low income, inadequate facilities, partly slum like areas, public fountains or piped water shared by several housing units.

ACKNOWLEDGEMENT

My acknowledgement gò to the Departmental Heads in the Lagos State Water Corporation and also to my Secretary - Mr. M. A. Aka for the support provided during the preparation of this paper.

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FIVE MINUTES TO MIDNIGHT

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FIVE MINUTES TO MIDNIGHT

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CONTENTS | PAGE

FIVE MINUTES TO MIDNIGHT

by
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Three successive droughts, resulting in long-term damage to India's economy, have brought into focus the urgent need for planned action to manage water resources effectively at national level; and to focus attention of powers-that-be to almost chaotic conditions in towns and cities of India; where millions of displaced persons from agricultural rural areas have migrated and come to stay.

BOMBAY'S PATHETIC SITUATION

Droughts come in the wake of failure of rains. 90 Districts out of 396 districts of India covering 16% of the total area have progressively come under the shadow of drought due to merciless deforestation.[1] In the most industrialized State of India i.e. Maharashtra - whose capital city is BOMBAY - droughts are a chronic feature of the agricultural scene. The brunt of exodus from parched agricultural areas is taken by BOMBAY; where the population is now estimated to stand at approximately 10.20 million. Just two years back, the estimated mid-year population of the City stood at approximately 9.86 million.[3] Bombay has a total land mass of only 438 sq. kms.[4] and has a population today equal to that of either of the countries such as Lebanon, Belgium, Bulgaria, Greece, or Ecuador, which have a land mass of 10,400, 30,513, 110,912, 131,944, 10,400 and 283,561 sq. kms respectively.[2] Population density of Bombay is 23,300 persons to a sq. km.

The total water supplied during the year ending 31st March 1986 was 770150 ML which meant a daily average of 2110 ML.[3] (ML = Million Litres). Of the 9.86 million people, approximately 50% reside in slums or near-about slum conditions. Bombay has gone on record to accommodate the largest slum in Asia. Bombay has 1680 slum pockets with over 627000 huts of bamboo and cloth or plastic.[5] The rough distribution of total quantity of water brought to the City shows the following pattern:[3]-

	%	Quantity in MLD (Million Litres/Day)
Domestic metered	37.46	790
Domestic unmetered	22.96	485
Industrial metered	9.24	190
Commercial metered	3.69	80
Government viz Railways & Port Authorities	8.04	170
En-route supply i.e. supply to areas outside Bombay	3.76	82
Transmission and Distribution Losses	14.85	313
	100.00	2110

The tabulation shows that the purely domestic consumption appears to be 1275 MLD for a population of 9.86 million in 1986 i.e. 129 litres per day per capita, against the national planned average target of 200 litres per day per capita. In comparison New Delhi, the Capital of India is supplied water @ over 220 litres per day per capita. Bombay is the commercial capital of India, contributing 32% of Indian Government revenue; accounting for 25% of India's industry and 10% of nation's industrial jobs[4] but appears to be grossly neglected by the State and

Central Governments. The average of 129 litres per day per capita of 1986, may have apparently come down to 125 litres per day per capita today. Due to phenomenal growth of Bombay from 1950 upto the present date, the water supply is not only intermittent but unequitable.

Only 4% receive water for more than 8 hours.
33% receive water for more than 4 hours.
42% receive water for just 3 hours.
21% receive water for less than 3 hours.

In the last category the minimum period as recorded by consumers is very often ONLY ONE HOUR.

Besides the supply being unequitable, the pressures at which water is made available at plinth level of the buildings vary from locality to locality depending of course on the consumers' location. Tail-ends of distribution systems are worst off and the 21% group mentioned afore are mostly belonging to tail-end situations. There are 9 wards in the City, 8 wards in Western Suburbs and 5 wards in Eastern Suburbs. The unequitable quantity and poor pressures result in short supply complaints from each of the wards. In the year 1985-86 (as per last published report)[3], there were 13206 short supply complaints from the 9 wards of City proper, 8919 such complaints from 8 wards of Western Suburbs and 4669 complaints from 5 wards of Eastern Suburbs. The maximum for any ward was 3132 in the B Ward which is the most congested ward and is the oldest part of Bombay. The adjoining old portions of the city viz C and D Wards recorded 3016 and 2798 complaints in 1985-86. Minimum number of complaints was 276 during that year and these were from S Ward - a new and comparatively sparsely populated ward. The total complaints during the year were 26794; the maximum being 2484 for the whole city in April 1985 and the minimum being 1966 for the whole city in December 1985. April and May are the hottest months of the year just before the outbreak of rains in June for any year; when the lake levels are very low. Complaints in May are about 10% less than in April, because in May there is a mini-exodus from the City, as schools and colleges have their summer vacation and people leave the Metropolis to go to their native towns or hill stations. Considering the magnitude of inadequate water supply the number of short supply complaints show a daily total city average of only 73; which means only little over 3 complaints per ward per day. People have realized that water supply situation at best could be only what they get and unless their normal rationed supply of 3 to 4 hours is not drastically reduced for any unforseen reason, they do not complain.

HEALTH ASPECTS

When one thinks of intermittent supply, restricted to few hours in the day or night at poor pressures one may get apprehensive about the quality of water. During 1985-86, only 323 cases of complaints of contaminated water were recorded; maximum being once again from B Ward and next worst being C Ward the figures being 91 and 64 respectively. 307 contamination cases were in the City Wards, 12 in Western Suburbs and 4 in Eastern Suburbs; S Ward recording NIL.[3]

When such complaints are received, it is normal to expect ingress of sewage from surcharged sewers in congested areas of the city viz, A, B, C, D and E Wards; and steps taken to rectify the situation include flushing through hydrants and superchlorination using portable chlorination plants. At this juncture it has to be mentioned that the entire Water Supply of the Metropolis is filtered and chlorinated at 5 different stations and normally it is considered safe to drink water in Bombay. Paradoxically all major 5-STAR Hotels of Bombay are located in A Ward from where 34 contamination complaints were received in 1985-86 i.e. 11% of the City's complaints. However, each Hotel has its supplementary treatment system consisting of full filtration and chlorination. For instance, an internationally famous group of Hotel Complex has a 14 MLD Rapid Sand Gravity Filter Plant in the second basement below the ground floor, and the filter sand is capped with activated carbon. Filtration is followed by chlorination which makes the water as much pathogenically safe as possible.

Reverting to the quality aspects of the water supply of Bombay in general; in each of the Wards of the City and Suburbs, there are four groups of sampling points from which water is sampled for bacteriological and chemical examination. Sampling points are on the service mains and samples are collected by mobile squads of trained personnel. During 1985-86 total routine samples taken for bacteriological analysis were 6597 i.e. approximately 22 samples per day (working days being 300 per year); i.e. one sample per day per Ward. 92.08% of these samples were totally free from coliform bacteria.[3] There are 11 service reservoirs; whose waters were kept under surveillance throughout the year, and 9645 samples were collected; i.e. approximately 3 samples per day per reservoir. Out of these samples, 93.05% were free from coliform bacteria. Special samples were collected in connection with 323 complaints of contamination, during prophylectic measures and after, and this number stood at 4386 for 1985-86[3] i.e. approximately 13 samples per complaint showing protracted nature of surveillance. The above figures of sampling exclude almost continuous monitoring of water quality at the 5 Treatment Stations. Quality of water being thus kept under strict and continuous surveillance, the problem of QUANTITY of water looms large.

WATER LOSSES : The water supply system of Bombay suffers loss of usable water due to (a) evaporation from the surfaces of impounded reservoirs which are sources of water; (b) non-recycling of washed waste from 3 Filter Plant Stations (c) pipe bursts (d) leakage and wastage (e) fire fighting operations (f) wanton wastage.

EVAPORATION[3]

NAMES OF LAKE	MODAK SAGAR (VAITARNA)	TANSA	VEHAR	TULSI
WATER SPREAD AT FSL (SQ. KMS)	8.55	19.11	7.28	1.35
DISTANCE FROM BOMBAY (KMS)	119	106	24	35
TOTAL AVERAGE RAINFALL (mms)	2700	2640	2440	2750
LOSS OF WATER - EVAPORATION IN 7 DRY MONTHS (ML) (1985-86)	6145	14283	5180	862
AVERAGE DAILY LOSS (IN 7 DRY MONTHS PERIOD) (ML)	29	67	24	4
QUANTITY OF SUPPLY PER DAY FROM THE LAKE (ML)	1058*	418	76	18
TOTAL DAILY LOSS AS % OF DAILY SUPPLY PER LAKE	2.74	16.02	31.57	22.22

* This includes daily receipt and discharge of about 500 MLD, of water from Upper VAITARNA Lake which is in upper reaches of the river upstream of VAITARNA Lake. Total average loss due to evaporation per day from 4 lakes is 124 ML. Total water supply per day

(excluding Upper Vaitarna daily discharge into Vaitarna Lake) is 1070 ML. Hence percentage loss due to evaporation is 11.59%. Attempts have been made to control evaporation by use of cetyl alcohol, way back in late 50's and early 60's. However, not much success was recorded in view of very strong winds prevailing resulting in creation of waves on the lake's surface and breaking of the cetyl alcohol film. International experience of other Water Works authorities would be very helpful to Bombay.

WASHED WASTE

As in the year of the report 1985-86 and even today, washed waste from filters and clarifiers desludge systems at 3 Treatment Plant Stations is not treated and recirculated. Total Water supply arriving at Filter Plants today is approximately 2682 MLD more than 2110 MLD reported in the earlier part of this paper, because of pumping additional quantity from BHATSA River. Total loss due to discharge of washed waste water in unconserved manner is 14.09 (9.08 + 2.73 + 2.28) MLD today but may grow to 32.09 MLD by the year 2000, as by that time 1362 MLD of water may come to be treated at Panjrapur.

By 1994 the quantity would definitely be about 23 MLD and steps should be initiated to treat and recycle this washed waste. This subject is already assigned to consultants for study.

TREATMENT WORKS LOCATION	BHANDUP	PANJRAPUR	POGAON	VEHAR	TULSI
SOURCE OF WATER	VAITARNA & TANSA LAKES & BHATSA RIVER (PUMPED)	BHATSA RIVER (PUMPED)	ULHAS RIVER (PUMPED)	VEHAR LAKE	TULSI LAKE
QUANTITY TREATED (MLD)	2043	454	91	76	18
% WASTE	2	2	3	3	3
QUANTITY COMING OUT AS WASTE (MLD)	80.86	9.08	2.73	2.28	0.54
DISCHARGING LOCATION	IN VEHAR LAKE W/O TREATMENT	IN BHATSA RIVER D/S	LAND DRAINAGE	IN MITHI RIVER	IN VEHAR LAKE W/O TREATMENT
COMMENTS	WATER CONSERVED	THIS QUANTITY WILL INCREASE TO 27 MLD BY THE YEAR 2000	-	THIS IS AN ANNUAL RIVULET	IN SUMMER IT DRIES UP BEFORE REACHING VEHAR LAKE

PIPE BURSTS : Within the City limits of Bombay, there are 1137 KM of pipelines of different materials of construction, namely mild steel and cast iron, some of which are nearly 100 years old. During 1985-86, bursts attended to on pipelines upto 1200 mm diameter were 39 in number.[3] The smallest size pipe attended was 80 mm diameter. Of the 39 bursts, 33 occurred in City Wards, 4 occurred in Western Suburban Wards and only 1 occurred in Eastern Suburban Wards. These occurrences are a true reflection of the age of the pipelines in 3 major divisions of the City. However, quantity of water as could have been probably lost is not known. Considering the age of the pipelines, statistically ONE BURST for over 29 KM of pipelines either reflects on the good quality of material of construction of the pipelines or highlights the poor pressures prevailing in the distribution system.

LEAKAGE & WASTAGE : By continuous monitoring done on distribution pipelines within the Municipal Limits, it is deduced that approximately 15% of water supply is lost due to leakages. Considering that approximately half the total length of 1137 KM of pipelines is more than 30 years old, and at least a quarter of total length is over 60 years old, 15% leakage is a very modest figure. In a comparatively recent situation, a new distribution system of another city in India has recorded continuous leakage of over 22%, since last 5 years.

For purposes of control over various facets of maintenance of water supply, the City is divided into 79 water distribution zones, and these zones are further divided into 552 LEAK DETECTION ZONES.[3] Each Leak Detection Zone is made of 250 to 300 consumer connections. Sounding of mains is done by electronic instruments. In 1985-86, for entire length of 1137 KM, total number of leaks detected and attended to was 2227 of which 271 were above ground. This work is coupled naturally with sampling of water, and as a preliminary precautionary measure, where contamination is suspected, tail-end or nearest hydrants are opened to flush the pipeline. In 1985-86 the total number of hydrant opening and pipeline flushing operations was 1796.

FIRE FIGHTING OPERATIONS

In 1985-86, there were 61 calls for the fire brigade in the City limits i.e. Wards A, B, C, D, E, F, G; 33 calls from Western Suburbs i.e. Wards H, K, P, R; and 17 calls from Eastern Suburbs i.e. Wards L, M, N, S, T.[3] The quantity of water lost in quenching fires is however not available. These losses cannot either be estimated nor can be economised with, during fire fighting operations.

WANTON WASTAGE

Against the above listed sources and reasons for depletion of usable water, measures taken to avoid such losses based on strict vigilance against wastage of water by the consumer are difficult to practice and achieve. In all strata of society whether the water supply is through meters or not — universal metering is not yet adopted in Bombay as a time-bound programme — whether the consumer is in a rich locality or a slum, whether the consumer is educated or illiterate; wastage of water is a common scourge. Because of intermittent supply, because of difficult supply hours, people keep their taps ALWAYS open, so first flush of water is wasted as the receiving bucket is not under the tap; and the previous day's left-over water, almost 2 to 3 buckets for a family of 4 is put down the drain as it is "stale" water. Water is stored in every household in 2 sets of recepticles; one the plastic drum of 60 litres capacity where general purpose water is stored and the other, baked earthen pot or brass tank or stainless steel receptacle of 2 litres capacity where water for drinking is stored. The left-over water from both the receptacles is drained to waste every time when the fresh supply of water is received the next day. The Water Supply authorities could if empowered conduct a survey of water so wasted and this may reveal a loss of precious 15% of water, as per private survey done in 1986, in 8 buildings of a middle class locality, all situated on one road in H Ward. This is good, potable, paid-for water going down the drain. On the same road, there are some buildings which are given the facility of pumping water to the overhead tanks during supply hours. In two buildings out of eight, the pumping is done beyond supply hours, resulting in the supply main on the road being sucked dry, and the overhead tanks on buildings overflowing for 30 to 40 minutes each day. The Municipal Authorities have to take very long and complicated steps to take any drastic measure; though the authorities could and should insist on level-switches being mounted on such pumping units so that the pump would be switched-off once the overhead tank is full.

To get more water than that receivable from stand pipes installed by the Municipality in poor and slum localities, tampering of pipelines, creation of artificial leakages, thefts of controlling devices are a daily feature. The Municipal Authorities have to paddle a soft approach as they are left with no options. They either keep on repairing such damages at speeds which are not commensurate with the speed of wanton destruction or face street battles between groups of people over a bucket of water.
So PRECARIOUS IS THE SITUATION.

PRECARIOUS SCENARIO

In Bombay, Water Supply scenario is near-black — almost "FIVE MINUTES TO MIDNIGHT" situation. Inspite of such a predicament, there is no concerted effort to stop the daily influx of approximately 300 people from outside Bombay. They come as fugitives from politically disturbed areas, or economically stressed areas or agricultural parched lands, or just for the sake of entrepreneurship, or for seeking employment.

At economically poor localities and in slums, water is supplied through stand pipes and following figures give an indication of growth of such economically handicapped population in the city in one year.

	CITY WARDS	WESTERN SUBURBS	EASTERN SUBURBS	TOTAL
Number of existing[3] stand-pipes as on 1.4.1985	585	10734	10149	21468
New Stand-pipes[3] given during the year	252	1102	1324	2678
Number of stand-pipes removed during the year	10	65	6	81
Number of stand-pipes as on 1.4.1986	827	11771	11467	24068
Percentage increase in one year	41.36	9.66	12.98	12.09

This makes one infer that population which arrives in the City at 2 Terminal stations of Western Railway and Central Railway and at State Road Transport Terminus do not leave the City to go and stay in the Suburban areas; and the finite quantity of water continuous to be supplied to the evergrowing population. This is the reason why the 21% group reported earlier to receive water for less than 3 hours is located in the main City Wards and not in the suburbs.

For economically better-off localities, the increase in number of metered connections could be an indicator how same quantity of water is made to go round more people.

	CITY	WESTERN SUBURBS	EASTERN SUBURBS	TOTAL
Number of Metered[3] connections as on 1.4.1985	25396	52471	27087	104954
Number of Meters[3] fixed on NEW connections and number of un-metered connections metered during the year	1101	3427	1911	6439
Total number of[3] metered connections as on 1.4.1986	26497	55898	28998	111393
Percentage increase in one year	4.33	6.53	7.05	6.13

Increase in metered connections in either of the Suburban areas is more than one-and-half times that in the City indicating residential building activity in the Suburbs, giving inference of growth of economically comfortable people in those areas. This is because there is no space left within the City Wards for construction of new housing colonies. The City Wards have still got many consumers whose connections are unmetered and who pay water charges linked with rateable value of property and hence do not pay for actual consumption of water. It is debatable whether metering of such areas in any case is worthwhile when water supply is less than 2 to 3 hours per day.

The aforegone amply highlights the situation of FINITE Quantity of WATER to be distributed or rather to be DOLED OUT to ever increasing population.

SOLUTIONS

The options and solutions available to the Municipal Corporation of Greater Bombay are such as are to be motivated and put into effect by the State Government and the Central Government. Some simplistic solutions which are more easily said than done, are useless and the one most commonly talked-of is to STOP — God alone knows how — the daily influx of people into Bombay. The way to achieve this is to smite at the cause of this influx i.e. to make Bombay less attractive to outsiders, to remove it as it were from the position of ELDORADO of India. Bombay has little over 1% of the nation's population but over 11% of the nation's automobiles.[4] There are hard decisions to be taken by the State and Central Governments. If the measures as required are not taken, Bombay is expected to have a population of over 14 million by 2001 A.D.

The Central Government could shift the Headquarters of two major Railway Systems of the country viz. Western Railway and Central Railway from Bombay to more logistically situated cities like Baroda in Gujarat State and Nagpur in same Maharashtra State respectively. This move is expected to decongest the City by about 250,000 people. The State Government could stop development activity by halting conversion of green and marshy lands in Bombay into building zones. These areas work to almost 20% of the built-up area of Bombay.

The State Government should proceed with considerable speed to build and provide all infrastructural facilities in satelite towns around and near Bombay. Beginning has been made in this direction by building a township called NEW BOMBAY on the mainland of India, approximately 3 hours drive from South Bombay i.e. about 60 kms. away. There are other 2 to 3 such townships in the making. Such towns could be built to plan shifting of population of about 2,000,000, part of whom are already residing in NEW BOMBAY. This should be done and could be achievable in the next 10 years. Seats of certain Ministries of State Government of Maharashtra could then be shifted to areas such as New Bombay and other satellite townships within the next 5 years. Certain Government Departments have been already shifted to NEW BOMBAY. The Bombay Metropolitan Regional Development Authority has been created for the purpose of decongesting the present Bombay City commercially and industrially. A 12 year plan drawn-up by the Kerkar Committee (1981), mentioned expenditure of Rs. 42 Billion for housing alone of over 2 million people, in satellite towns near Bombay.[5] At todays' price index the figure could work out to Rs. 71.40 Billion (taking annual inflation rate of 10 per cent into account).

The effect of measures such as listed above could reduce the commercial and economical attractions of the City which can then be expected to reduce the daily influx of population by 2000 to about 50 or so. The population figures to be achieved in 2000 may then be as shown hereunder :

Population as on today including those who come to work in Bombay from 8.00 hrs. to 18.00 hrs. (Such floating population using water supply/sewerage systems add-up to approximately 2,00,000)	10 200 000
Reduction in population by 1990 if 2 Railway Terminals are shifted	250 000
	9 950 000
Increase in population by 1990 due to daily influx @ 300 persons per day	2 160 000
	12 110 000
Mass planned migration to Satellite towns to be completed by 1998	2 000 000
	10 110 000

C/O	10 110 000
Increase in population by 1998 due to daily influx at progressively reduced rate :	
In 1991 at 300 per day	108 000
In 1992 at 250 per day	90 000
In 1993 at 200 per day	60 000
In 1994 at 150 per day	54 000
In 1995, 1996 at 100 per day	60 000
In 1997, 1998 at 50 per day	30 000
	10 512 000
Further migration by shifting of industries, shifting of port activities, shifting of major markets like those dealing with steel, cement, fertilizer etc. to areas near Bombay on the mainland of India	300 000
	10 212 000
Increase in population in 1999 and 2000 @ 50 per day	36 000
	10 248 000

	C/O 10 248 000
Increase in population due to births @ 1 per 100 for 12 years at population level of 10 million*	1 200 000
	11 448 000

*The national annual average percent increase in population is 2.0.[6] However in Bombay City with all its problems of survival and higher level of education, the trend is to have only 1 child or 2 children; and the trend is more towards 1 child.

The steps mentioned afore coupled with moratorium on building licenses, commercial establishment licenses and industrial licenses by the Municipal Corporation of Bombay for a 5 year period would lead to almost ZERO GROWTH and the daily floating population could be expected to diminish by about 1,000,000, resulting in water consuming population at 10.5 million.

To improve the quality of life of citizens of Bombay the Municipal Corporation of Bombay should simultaneously take steps to conserve controllable wastage of water and undertake schemes for augmentation of water supply. Wastage that could be controlled by the Municipal Corporation is saving of water by treatment of washed waste from Treatment Plants and recycling. This could provide 30 MLD of water for Bombay citizens by the year 2000. Municipal Corporation should undertake COMMUNITY EDUCATION PROGRAMMES to prevent wanton wastage of water by the users. This may save water to the extent of 10% of supply to 50% of the population. At today's rate of supply of water @ 125 litres per capita per day for 4, 000,000 people, it could mean saving of 50 MLD. Today there is no Community Education or Community Participation programme practised by the Bombay Municipal Corporation either directly or even with the assistance of technical organisations like the Indian Water Works Association and other social organisations like the Bombay Chamber of Commerce, Maharashtra Women's Council, Tata Institute of Social Sciences etc. This cannot be achieved in a year, but has to be a 5 to 7 years concerted effort and it is sure to yield results, but only IF the population is controlled and water supply situation can be eased by undertaking augmentation measures.

Augmentation measures planned as on today include :-

440 MLD Water Augmentation Scheme by creating an impoundage between existing impoundages viz Modak Sagar (Vaitarna) and Upper Vaitarna. This scheme is scheduled to be completed by 1998.

454 MLD* Water Augmentation Scheme by pumping and treating additional 454 MLD water from Bhatsa River. This scheme is scheduled to be completed by 1995.

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894 MLD

136 MLD Desalination Plant in Eastern Suburbs This scheme is not yet declared as planned. Estimates of Feasibility Study for such a project are proposed to be compiled shortly based on quotations received from Consultants.

1030 MLD

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* Part supply is being pumped even today to a limited extent.

CONCLUSION

By the year 2000 Bombay Municipal Corporation could be in a position to supply 3140 MLD to 10.5 million people. The distribution of water in the year 2000 could be reasonably predicted to be as under :-

	Percent IN (2000 AD)	(Today's Figures) MLD	MLD IN 2000 AD	Approx. Percent Increase
Transmission & Distribution Losses	15	(313)	470	33
Enroute Supply i.e. supply to areas outside Bombay	3.82	(82)	120	46
Railways & Port Authorities	6.36	(170)	200	18
Commercial metered	3.18	(80)	100	25
Industrial metered	6.68	(190)	210	10
Domestic: Metered & Unmetered	64.96	(1275)	2040	67
	100.00	(2110)	3140	

Consumption of water for domestic use could be 194 litres per day per capita. However, 2040 MLD could be increased to 2040 + 30 + 50 = 2120 MLD, say 2100 MLD, if we have recycling of washed waste from Treatment Plants and saving of water by community participation programmes. Distribution of 2100 MLD of water to 10.5 million citizens working and residing in Bombay in the year 2000 would mean per capita daily average of 200 litres. Only then will life be worth living in Bombay as WATER IS ESSENTIAL FOR LIFE. Drastic measures as suggested, public awareness and political will are required to move away from today's frightening situation of "FIVE MINUTES TO MIDNIGHT".

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BUTCHER ISLAND
MIDDLE GROUND
OYSTER ROCK
CROSS ISLAND
R
P
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WATER SUPPLY FOR METROPOLITAN MANILA

PRESENTED BY:

L.V.Z. SISON
METROPOLITAN WATERWORKS AND SEWERAGE SYSTEM

RAI CONGRESS CENTRE, AMSTERDAM

WATER SUPPLY FOR METROPOLITAN MANILA

LUIS V.Z. SISON (banker)
Administrator

METROPOLITAN WATERWORKS AND SEWERAGE SYSTEM
Quezon City, Philippines

I bring you greetings from the Philippines and 55 million Filipinos, which have just restored democracy in their country in February 1986.

The Philippines shares the global concern to provide adequate safe drinking water to all peoples of the world. The world's mission is its mission. Even the pain from failure experienced by other countries is its own, too. Although our efforts have persisted through decades, we have not sufficiently met the water needs of our growing populace. The mission becomes now more compelling within the context of our political and social structure that had just enjoyed a transformation from repression to freedom.

As our own President Corazon Aquino said, and I quote, "Our country is free again, and in the process, prouder than it has ever been in its history. But while the epic chapter has closed, the long and more difficult story remains to be written and told." That story is about the efforts of the Filipinos to liberate themselves from poverty. And one of our endeavors is to provide our people with their basic needs, like water. The institution that I represent, the Metropolitan Waterworks and Sewerage System

(MWSS), is directly involved and totally committed to provide adequate potable water supply to our country's fastest growing area - Metropolitan Manila.

The MWSS - Premier Water Agency

The MWSS is the premier water agency in the Philippines, with a history of more than 106 years of service. Its mission is to provide clean drinking water to 8.27 million people in its service area at affordable costs. Water harnessed by the MWSS from the Angat, Ipo and La Mesa dams is treated and transformed into one of the cleanest and sweetest in the world, surpassing international health standards. The System also provides waste water disposal services.

The Manila Water System actually began as the Carriedo Waterworks System built in 1882 from the proceeds of the donation of a Spanish philanthropist, Don Francisco Carriedo Y Peredo. Through the years, this water system, considered one of the first properly designed water supply systems in Asia, underwent considerable changes and improvements to meet the demands of the evolving cultures, needs and economy.

Today the system is known as MWSS. It serves five cities and 23 municipalities in Metropolitan Manila and two neighboring provinces, with a service area of about 148,750 hectares and a population of eight million. Metro Manila is the center of government, culture, and business in the Philippines.

Metro Manila is one of the fastest growing metropolises in Asia in terms of population. Being the center of culture, trade and industry, it will continue to experience an urgent need for potable piped water supply.

Water Sources, Treatment and Distribution

The present sources of raw water are the Angat River, Ipo River, and the Novaliches (La Mesa) Reservoir. This supply is augmented by water drawn from deepwells.

The Angat River, the main source of supply, is located 40 kilometers from Manila. Water from Angat River collected by the Ipo Dam enters two tunnels bored through mountains and travels a distance of 6.4 kilometers to Bicti; thence through four aqueducts each about 16 kilometers long. (see Figure 1)

The first three aqueducts discharge water to the Novaliches Reservoir where it is temporarily stored before it travels again a distance of 6.8 kilometers to the Balara Water Treatment Plant, which has a rated capacity of 1,600 million liters per day (MLD).

The fourth aqueduct releases water directly to the La Mesa Treatment Plant with a total capacity of 1,500 MLD, considered the largest and most modern in Asia and the fourth largest in the world.

The water purification plants at Balara and at La Mesa render the water safe to drink through the following process: screening, mixing, flocculation, sedimentation, filtration and chlorination.

As a further safeguard, tap water samples are taken daily from different stations and are examined physically, chemically, and bacteriologically by the MWSS laboratory, the laboratories of the Manila Health Department and the Department of Health. The results have consistently surpassed the required standard specifications of potability set by the World Health Organization.

With the water already purified and ready for household use, it travels from the treatment plants to the distribution system.

The distribution system consists of about 3,000 kilometers of pipes ranging from 50 millimeters to 3 meters in size.

Problems Encountered

The fast growth of Metro Manila, in terms both of population and commerce, has generated a problem in water supply. The difficulties encountered by the MWSS in its effort to cope with this ever rising need are grouped into three major areas:

1) Infrastructure (water sources and facilities) - Metro Manila's population as a whole is increasing at an average compounded growth rate of 2.4 percent annually. At the rate water demand is increasing, the total water supply including the incremental increase from the ongoing expansion program of MWSS is designed to meet the growing demand only up to 1990. Total potential average daily yield of the existing water system is 2,500 MLD. However, because of limitations in distribution capacities, actual

withdrawal average is only 2,290 MLD.

The treated water flows into the central distribution system which stretches about 1,550 kilometers. However, majority of the water mains are inadequate in size. Pressures throughout large parts of the system during the day are inadequate. Service pipes are of galvanized iron and a large portion is badly deteriorated. Leakage is accordingly very high. Non-revenue water is relatively large due to illegal users, leakages and other causes. As of mid 1988, our unbilled water stood at 59 percent of the total water produced.

Based on the volume of water supply and the volume of consumer demand, the MWSS provides water to 7.06 million people which is 85 percent of the total population in the service area of 8.27 million.

Also, because urban expansion had been very rapid in recent years, the number of housing subdivisions has increased significantly. These were not even identifiable nor included as input data during the planning phase of the distribution system. Since 1984, when the MWSS began to interconnect the water distribution systems to subdivisions, there have been 429 requests from subdivisions for such services. Of this number, 169 or 40 percent have been denied due to the very low water availability and low water pressures prevailing in the MWSS lines. This is primarily attributed to the relatively higher elevations of some subdivisions or simply the lack of water supply.

Because of the physical limitations of the water system, most of these subdivisions rely on ground water for their water service. However, ground water is already grossly overpumped and is now between 50 and 150 meters below sea level, resulting in salt water intrusion in the metropolis.

2) Finance - Faced with the reality of the water situation, the MWSS had to look for alternative water supply sources, construct new facilities, improve the existing one, and extend its services throughout its area.

In 1987, we completed the Manila Water Supply Project II which increased the supply distribution capacity of MWSS from about 1,350 to 2,500 MLD. This cost MWSS P2.4 Billion and US$ 186 Million. Our main problem now is the huge debt servicing brought about by the appreciation of the foreign currencies. The servicing for calendar year 1987 totalled 61 percent of our total revenues. Because the funds are not sufficient to pay our obligations and run our agency, we had to borrow from our National Treasury.

The present charter rate of return (net of income tax payments) is at 10.4 percent while the maximum allowable rate of return is 12 percent. Water is becoming a political commodity, hence an increase in tariff is usually resisted by politicians. The last tariff increase we made was in April 1986.

3. Organization - Because MWSS consumers had increased to 553,000, responding immediately to their needs became a problem. Because of this the MWSS decentralized its operations to bring its services closer to the people.

Recently, the MWSS was reorganized resulting in the creation of five service sectors and further subdivided into 18 branches located strategically within the service area. (see Figure 2)

Last year we introduced a productivity incentive scheme patterned after the Scanlon Plan, and conducted a top management training seminar for quality public service. These resulted amazingly in a marked improvement in organizational performance. Our total collection in 1987 jumped by 20 percent from the previous year. This meant a 95.96 percent collection efficiency, better by eight percent than 1986.

Looking Ahead: Prognosis

Table I shows the estimated population and the corresponding water demand beyond the year 2000.

TABLE I

YEAR	POPULATION	WATER DEMAND (MLD)
2000	14,800,000	6,632
2020	18,030,000	9,845
2040	20,170,000	11,663

This situation stresses the need to develop a large source of water supply.

Studies conducted showed that Kaliwa River in Tanay, Rizal was found to be a viable next source of water supply for Manila. Known as the Manila Water Supply Project III (MWSP III), the development of the Kaliwa River basin will provide an additional 1900 MLD of water supply to the MWSS system. However, due to the discovery of a new source of water at cheaper costs, the scheduled implementation of MWSP III has been deferred.

We refer to the Angat Water Supply Optimization Project, which is designed to bring additional water to the MWSS at half the time and half the cost of MWSP III. When completed in 1992, it will increase our water supply capacity by 1,300 MLD. This will enable us to supply an additional 360,000 water service connections for about three million more people. This project will cost about P6.7 Billion, financed by the Philippine Government and a consortium of Filipino banks led by the Philippine National Bank (PNB) and Union Bank for the local funding cost of P4.6 Billion and the Asian Development Bank (ADB)/ World Bank (WB) for the foreign funding of US $100 Million.

To supplement MWSS efforts to reduce non-revenue water, we launched the first Manila Water Supply Rehabilitation Project (MWSRP I) in 1984 to repair and replace old pipes as a measure to reduce non-revenue water in 56 pre-selected zones. The project is financed from an ADB foreign loan amounting to US$ 39.3 Million and from local counterpart funds of P540 Million.

Recently, we started implementing the second phase of the rehabilitation project - MWSRP II -

to improve water supply services in 52 zones and seven subdivisions. This covers about 10,000 hectares. About 1.5 million consumers will directly benefit from the project while another 3.2 million will indirectly benefit from increased system pressure and volume of water available. The Development Bank of the Philippines (DBP) and the Philippine Government shall finance the local funding needs of P900 Million while the ADB will finance the foreign funding needs of US$ 25 Million.

There are some positive factors that augur well for the realization of the MWSS program. There are:

1. Half of borrowed funds have shifted to Filipino banks, thus reducing the huge cost of foreign debt servicing/repayment.

2. The new moral tone in the conduct of public servants stimulates the restoration of the public's confidence and trust in the government, in general, and in the MWSS, in particular, and facilities the renewal of mutual support and cooperation between the MWSS and its customers.

#

SYNOPSIS OF WATER SUPPLY FOR METROPOLITAN MANILA

The Metropolitan Waterworks and Sewerage System (MWSS), a century-old premier water agency in the Philippines, is directly involved and totally committed to provide clean drinking water to 8.27 million people in 5 cities and 23 municipalities in Metropolitan Manila (Metro Manila), and its environs with an area of 148,750 hectares. It now processes and delivers 2,400 megaliters per day (MLD).

Metro Manila is the Philippines' center of culture, trade and industry, with a population that grows at the compounded rate of 2.4 percent annually.

The present MWSS administrator, Luis V.Z. Sison, one of the Philippines top investment bankers was appointed Administrator of the MWSS on March 6, 1987 by President Corazon C. Aquino. He is also a civil engineer, having practiced his profession successfully for 10 years before becoming a banker for 21 years.

The present sources of raw water of MWSS are the Angat River, Ipo River and the Novaliches Reservoir. This supply is augmented by water drawn from deepwells. From the Angat River, the main source, water travels through two tunnels and four aqueducts. Three aqueducts discharge water to the Balara Water Treatment Plant (1,600

MLD capacity) for processing, while the fourth aqueduct releases water to the La Mesa Water Treatment Plant (1,500 MLD capacity) the largest in one place in Asia, also for purification purposes. The processed water travels from the treatment plants to the distribution system consisting of 3,000 kilometers of pipes ranging from 50 millimeters to three meters in size.

The fast growth of Metro Manila has generated problems in water supply, namely; 1) Infrastructure, 2) Finance and 3) Organization.

Infrastructure problems concern the limited capacities of the distribution system arising from the inadequate size of water mains, low water pressure and badly deteriorated service pipes in many areas.

Corollary to this condition is the increase in non-revenue water to 65 percent in March 1987 which at mid-1988 was brought down to 59 percent.

The main financial problem is the huge debt servicing of foreign currency loans principally from the Asian Development Bank (ADB) and the World Bank (WB) in the construction of the Manila Water Supply Project II. Because of the appreciation of the foreign currencies, the servicing for 1987 totalled 61 percent of MWSS gross total revenues.

On the matter of organization, because MWSS registered services had increased to 553,000, responding immediately to their needs became a problem. To solve this problem, the MWSS decentralized its operations to bring its services closer to the people, resulting in the creation of 5 service sectors, further subdivided into 18 branches located strategically within the service area.

In 1992, the MWSS plans to increase its water supply by 1,300 MLD through its Angat Water Supply Optimization Project to serve an additional three million people. To supplement this effort, it has launched two major rehabilitation projects to reduce non-revenue water and to improve water supply services in a total of 108 zones and 27 subdivisions.

One positive factor that aids the MWSS to achieve its program is its shift to Filipino banks for partial financing which reduced the huge cost of foreign debt servicing. MWSS will acquire foreign loans only for the foreign components of MWSS projects.

#

METROPOLITAN WATERWORKS AND SEWERAGE SYSTEM

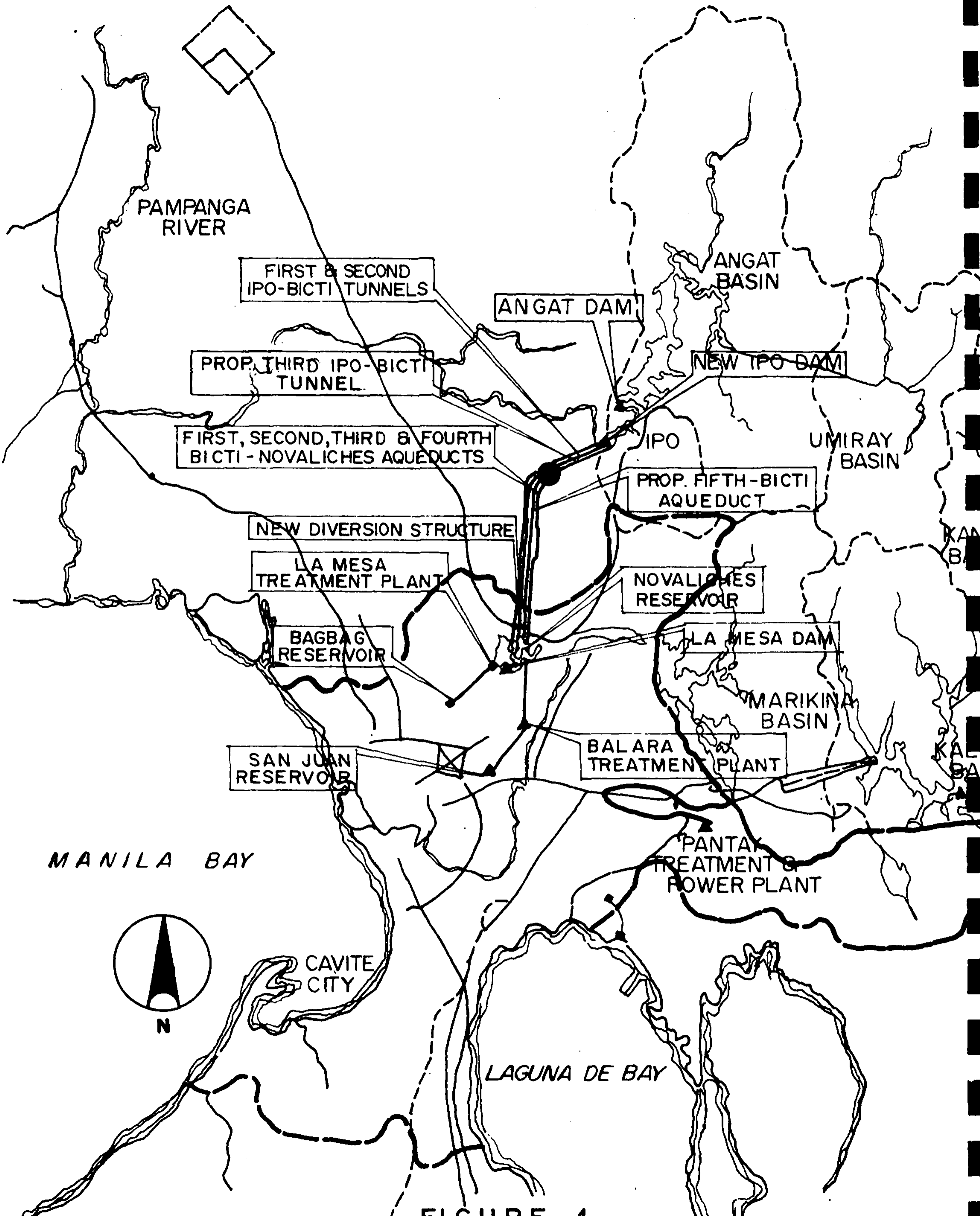

FIGURE 1
SCALE : 1 : 40,000 M.

WATER SUPPIY SOURCF OF MFTRO MANII A

„Het is vijf minuten voor middernacht", riep deze week de directeur van de Indiase Vereniging van Waterleidingbedrijven op een congres tijdens de Aquatech in Amsterdam over de drinkwatervoorziening in snel groeiende steden. Alle verbeteringen in de drinkwatervoorziening in de Derde Wereld dreigen te worden overspoeld door de explosieve bevolkingsgroei.

In veel steden in India ontbreekt het aan goed drinkwater.

Explosieve bevolk drinkwatervoorzie

GOED drinkwater staat aan de basis van een gezonde samenleving. Pas toen duidelijk was geworden dat schoon drinkwater een heleboel ziekten voorkwam en de levering ervan werd gerealiseerd, verdwenen de epidemieën, zoals de pest, die in de vorige eeuwen de steden hebben geteisterd.

De grote steden in de Derde Wereld worstelen echter nog steeds met de drinkwatervoorziening. De oorzaak hiervan is veelal de explosieve groei van de bevolking.

Volgens S. Unvala van de waterleidingmaatschappij in Bombay en directeur van de Indiase Vereniging van Waterleidingbedrijven, is het wat betreft de levering van drinkwater „Vijf minuten voor middernacht." Hij slaakte deze noodkreet dinsdag tijdens een congres over de watervoorziening in snel groeiende steden. Die bijeenkomst werd gehouden tijdens de beurzen Aquatech'88 en Enviro 88 in de RAI te Amsterdam.

De drinkwatervoorziening in de Derde Wereld heeft de afgelopen tien jaar veel aandacht gekregen. De Verenigde Naties riep de jaren '80 uit tot waterdecennium. Aan het eind ervan moet elke wereldburger beschikken over schoon en veilig drinkwater.

Dat deze ambitieuze doelstelling bij lange na niet wordt gehaald, blijkt uit de voordrachten tijdens het congres over de drinkwatervoorziening in snelgroeiende steden. Vertegenwoordigers uit onder andere Manila, Mexico City, Lagos, Bangkok en Bombay voerden er het woord. De steden hebben weliswaar een drinkwatervoorziening op poten gezet, maar doordat de bevolking explosief groeit en de vraag naar schoon water toeneemt, slagen de steden er niet in overal goed drinkwater te distribueren.

Neem als voorbeeld Bombay. In 1950 woonden in de stad aan de Arabische Zee in het westen van India drie miljoen mensen. In 1987 telde de stad ruim tien miljoen inwoners. Dit aantal zal bij ongewijzigd beleid in 2000 zijn gegroeid tot ruim veertien miljoen. De bevolkingsaanwas in de hoofdstad van Mexico is nog sensationeler. In 1950 woonden er drie miljoen mensen in Mexico City, nu is dat zeventien miljoen en tegen de eeuwwisseling zullen dat er 25 miljoen zijn. Ook in steden als Lagos (Nigeria), Manila (Filippijnen) en Bangkok (Thailand) groeit de bevolking explosief.

Het somberste verhaal tijdens de conferentie kwam uit Bombay. Maar de problemen in de andere steden in de Derde Wereld zijn niet veel anders. De vertegenwoordiger van Bombay, de drinkwaterdeskundige S. Unvala, hield tijdens het congres een emotioneel pleidooi de bevolkingsgroei van de stad te stoppen. Alleen dan kan er in de toekomst voldoende schoon drinkwater worden geleverd.

Dagelijks trekken gemiddeld driehonderd mensen naar de stad in de hoop een betere toekomst te vinden. Van de tien miljoen inwoners woont de helft in sloppenwijken. Bombay heeft de meeste sloppenwijken van Azië. De stad telt 1680 van dergelijke wijken, waar ruim 627 duizend hutten staan. De hoofdstad van de deelstaat Maharashtra is aantrekkelijk voor bewoners van het platteland. Bombay is economisch gezien de belangrijkste stad van India. Een kwart van de Indiase industrie staat in Bombay. De stad levert tien procent van de werkgelegenheid.

De stad mag aantrekkelijk lijken, de watervoorziening is echter niet goed, zegt Unvala. Slechts 110 duizend woningen zijn met een meter aangesloten op het waterleidingnet. Daarnaast zijn veel huizen niet via een meter aangesloten. De meeste mensen, vooral in de krottenwijken, moeten zich behelpen met een kraan of een pomp in de buurt.

Het grootste probleem is dat er op de meeste plaatsen maar een paar uur per dag water uit de kranen stroomt. Slechts vier procent van de mensen heeft meer dan acht uur per dag water. Bijna een kwart van de mensen beschikt minder dan drie uur over drinkwater. Vaak betekent dit dat de kraan maar één uur water kan leveren. Vooral de aansluitingen die op het eind van de leidingen zitten, leveren maar korte tijd water.

Door de onregelmatige aanvoer van drinkwater staan de buizen meestal niet onder druk. Dit heeft grote gevolgen voor de kwaliteit van het drinkwater. Als een buis lekt, kan regenwater of nog erger rioolwater in de waterleidingbuizen binnendringen. In de meer ontwikkelde steden staan de buizen altijd onder druk. Bij een lek stroomt het drinkwater dan uit de buizen in de bodem. Vervuild water kan onmogelijk het waterleidingnet besmetten.

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Explosieve bevolkingsg drinkwatervoorziening

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In Bombay kan dat wel. Unvala ver- telt dat er in 1986 ruim 350 gevallen van drinkwaterbesmetting zijn gecon- stateerd. In bijna alle gevallen is riool- water uit de overbelaste en lekke riole- ring in de waterleidingen gekomen. Het waterleidingbedrijf probeert de proble- men met verplaatsbare chloreringsin- stallaties onder controle te houden. Het water van Bombay komt uit meren op dertig tot honderd kilometer afstand en wordt gefilterd en gechloreerd. „Nor- maal is het drinkwater in Bombay vei- lig", zegt Unvala.

De vijfsterren-hotels in Bombay ver- trouwen de situatie echter niet. Elk groot luxe hotel heeft een eigen aanvul- lende zuivering. Een hotel van een gro- te keten heeft een zandfilter en een koolstoffilter in de kelder geïnstalleerd die jaarlijks veertien miljoen liter water zuiveren. Voordat de gasten van het water kunnen drinken, wordt het nog

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Foto Hans Spruyt

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Eigen onderzoek van de gemeente Bombay bevestigt de zorgelijke situatie. Ruim negentig procent van de drinkwatermonsters die de gemeente neemt, is vrij van coli-bacteriën. Die organismen

Straatgevechten om een emmer water

zijn een maat voor de vervuiling met rioolwater. In een westerse stad als Amsterdam is verontreiniging van drinkwater met coli-bacteriën praktisch uitgesloten.

De mogelijkheid genoeg drinkwater te leveren is echter een grotere zorg dan de kwaliteit ervan, zegt Unvala.

Het Bombayse drinkwaterbedrijf levert gemiddeld bijna 130 liter water per persoon per dag. Het streven van de Indiase overheid is 200 liter water per dag per inwoner te leveren. Ter vergelijking: Een Nederlander gebruikt 148 liter drinkwater per dag. In sommige Westerse steden loopt het gebruik op tot 400 liter per dag.

Unvala noemt de verdamping van water uit de voorraadbassins als eerste probleem dat de levering van voldoende water in de weg staat. In Bombay is de jaarlijkse neerslag erg groot. Er valt bijna vier keer zo veel regen als in Nederland, maar de neerslag is niet gelijkelijk over het jaar verdeeld. Gedurende de zeven maanden is het er droog en verdampt er veel water uit de meren.

Al het water dat verdampt kan niet worden gebruikt als drinkwater. Unvala heeft berekend dat er in de droge tijd tot elf procent water verdampt. Pogingen de verdamping te beperken door het wateroppervlak te bedekken met een dunne laag alcohol zijn mislukt, omdat het meestal te hard waait. De wind slaat het laagje kapot.

Veel meer water wordt verspild als gevolg van het slechte buizenstelsel. Het waterleidingbedrijf kan wel 130 liter per dag per inwoner in de buizen pompen, maar een fiks deel daarvan bereikt de consument niet. In Bombay ligt ruim duizend kilometer hoofdbuis in de grond, waarvan een deel honderd jaar oud is. Regelmatig, in 1986 was dat 39 keer, barsten de buizen open. Dit is overigens niet extreem hoog.

Ernstiger is het gewone lekken. Unvala schat dat zeker vijftien procent van het water in Bombay weglekt. Uit een onderzoek in een andere stad blijkt dat daar maar liefst bijna een kwart van het water weglekt. Dit lekken kan twee redenen hebben. Of het water lekt bij buizen en aansluitingen weg of inwoners verspillen het water moedwillig.

Als gevolg van de onregelmatige aanvoer van water laten de inwoners de kraan altijd open staan. Ze weten niet precies wanneer de leiding onder druk staat. Als er dan water komt, kunnen ze daar onmiddellijk van profiteren. Onder de kraan staan dan jerrycans en emmers. Als die vol zijn en de bewoners letten niet op, stroomt het water weg. „Hiertegen is moeilijk op te treden", zegt Unvala.

Veel gezinnen verzamelen dagelijks water in een tank van een liter of zestig. Ze gebruiken het water gedurende de tijden dat er geen water is. Als de kraan de volgende dag weer water levert, wordt het water van de vorige dag weggegooid en worden de tanks gevuld met vers water. Een onderzoek in een Bombayse wijk becijfert dit verlies op zo'n vijftien procent.

In de slums daarentegen is het saboteren van de buizen aan de orde van de dag. Veelal maken bewoners buizen moedwillig lek om water te kunnen tappen. Dit vergroot tevens de kans op besmetting. De gemeente treedt niet hard op tegen deze overtredingen, zegt Unvala, domweg omdat er geen alternatief is. Het beleid is de schade zo snel mogelijk te herstellen. Ook dat is niet altijd gemakkelijk. De mensen van de reparatiedienst hebben te maken met straatgevechten met groepen mensen om een emmer water: „Zo nijpend is de situatie."

Als oplossing draagt de Indiase drinkwaterdeskundige aan dat de bevolkingsgroei van de stad moet stoppen. „Bombay moet minder aantrekkelijk worden voor mensen buiten de stad. Het beeld dat Bombay het Eldorado is van India moet worden weggenomen." Unvala realiseert zich dat dit gemakkelijker is gezegd dan gedaan. Hij adviseert de twee hoofdkantoren van de spoorwegmaatschappijen te verplaatsen naar andere steden in de deelstaat Maharashtra. Hierdoor zou het inwonertal van Bombay met een kwart miljoen dalen.

In de omgeving van Bombay moeten nieuwe steden komen. Zestig kilometer buiten de stad wordt de wijk Nieuw Bombay gebouwd. Daar en in drie andere nieuwe voorsteden moeten twee miljoen mensen worden gehuisvest. De regering van de deelstaat stimuleert de ontwikkeling van de nieuwe voorsteden door kantoren van de ministeries te verplaatsen naar de nieuwe steden.

„Daarnaast wil Unvala het lekken en verspillen van drinkwater terugdringen. Hij voorspelt dan dat de gemeente elke bewoner ongeveer tweehonderd liter per dag kan leveren. „Alleen dan is het leven in Bombay de moeite waard, omdat water essentieel is voor het leven. De voorgestelde drastische maatregelen zijn nodig om het huidige schrikbeeld van vijf minuten voor middernacht te doen verbleken."

MARC VAN DEN BROEK

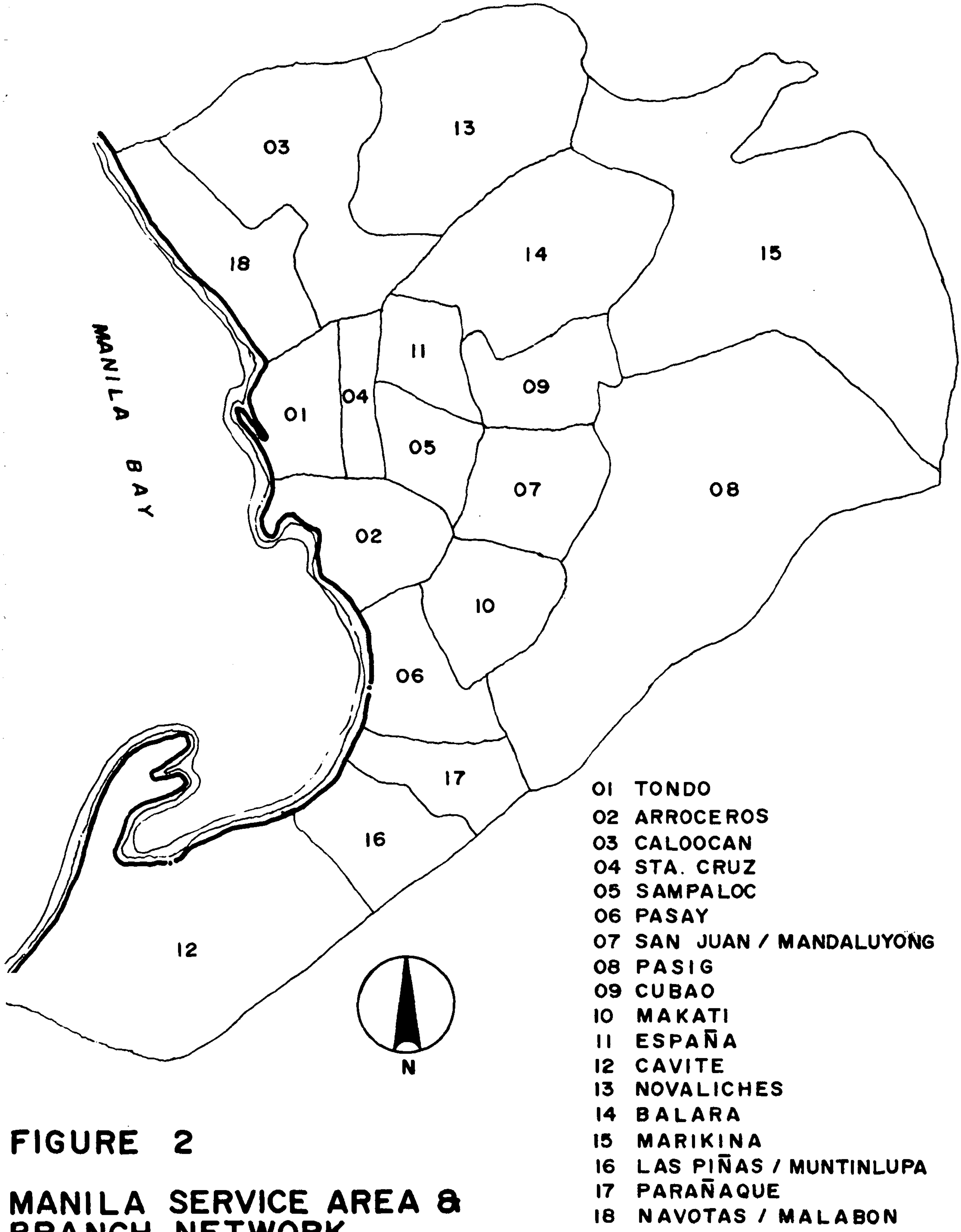


FIGURE 2

MANILA SERVICE AREA & BRANCH NETWORK
METRO MANILA AND ENVIRONS

WATER SUPPLY IN FAST GROWING CITIES ** TOKYO JAPAN **

PRESENTED BY:

Y. SEKINE
TOKYO METROPOLITAN GOVERNMENT

RAI CONGRESS CENTRE, AMSTERDAM

"WATER SUPPLY IN FAST GROWING CITIES"

** TOKYO JAPAN **

By Yuji Sekine

Director of Planning Section

Water Supply Operation Center

Bureau of Waterworks

Tokyo Metropolitan Government

7-1, Hongo 2-Chome, Bunkyo-Ku, Tokyo 113 Japan

Contents

"Water Supply in Fast Growing Cities"

1. Introduction

The growth of Tokyo as a large city has started since the period of Ieyasu Tokugawa, the first Shogun in the Edo era. He sat up his castle in Edo, now called Tokyo, in 1590. As this castle town developed, it became necessary for people living in Edo to depend on the Tama River as a new water resource. Around that time Tamagawa Canal and some other ones were built and approximately 60 percent of Edo's one million population were supplied with water from these canals.

After the Meiji Restoration in 1868, Edo was renamed Tokyo and became the capital of Japan. Japan took off from the feudal period and started as a modern state. Soon after that some sanitary problems on the drinking water such as spreading of cholera occurred. In order to solve these problems, plans were made for the development of a modern waterworks system. In 1892, the construction work of the Yodobashi Purification Plant started and Tokyo's first modern waterworks system began to operate in 1898. This system was followed by further expansion plan and it was completed in 1911.

Before World War II lots of Waterworks Expansion Projects were planned but almost all of them could not be realized because of the war. After the war these projects were resumed and completed.

The demand for water in Tokyo increased rapidly as the Japanese economy grew. Especially during the 1960s and the early 1970s, it increased remarkably because rapid economic growth accompanied by the concentration of industry and population to the Metropolitan area. To cope with the rapid increase of water demand, the 1st, 2nd and 3rd Tone River Waterworks Expansion Project (W.E.P.) were carried out, which intended to increase the capacity of facilities to 3.6 million cubic meters per day. After that the 4th Tone River

W.E.P. which included construction of Misato Purification Plant, was accomplished, and now the capacity of facilities has grown to 6,630 thousand cubic meters per day.

2. Outline of Tokyo

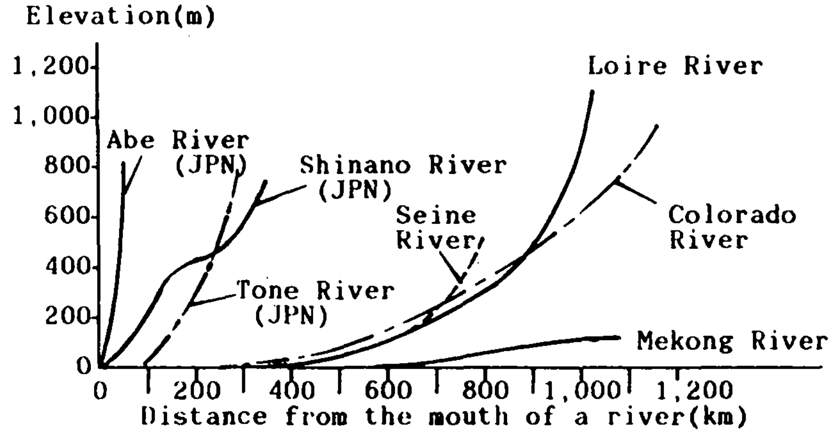
2.1 Characteristics of Tokyo's topography

Japan, situated in the East Asia and in the Asia Monsoon region, is a long and narrow island country.

The annual rainfall reaches 1,800 millimeters, twice as much as world's average. However, in Japan, more than 120 million people live in a small area, 378,000km², so precipitation per capita rather small. Moreover mountainous topography, which makes gradient steep, causes the rain water to run down through rivers rapidly. As a result, in spite of much rainfall, it is not always blessed with abundant water in Japan.

Tokyo is located at North Latitude 36° in the south of the Kanto plain, the broadest plain in Japan. It is a large city with an area of 2,164 square killometers on the delta area opening upon the Tokyo Bay.

Fig.1. River Gradient of the World



2.2 Population and economy of Tokyo

The population movement in Tokyo is characterized by a remarkable difference between the daytime population and the nighttime population, especially in the center of Tokyo.

Tokyo has been developing as a political and cultural center and also a big consumer area since the Edo era. This tendency has grown stronger after the Meiji period. After World War Ⅱ, Tokyo's economy recovered from the damage of the war rapidly and has been progressing by technological innovation, especially in the 1960s and the 1970s. In the 1970s the economy of Japan suffered a big imbalance between supply and demand from the 1st Oil Crisis in 1973 and the 2nd one in 1979. However the economy of Tokyo did not suffer the impact so much from the oil cricis because the service and financial industries had been developing and the energy consumption had been decreasing in the manufacturing sectors. Meanwhile, the Knowledge-intensive industries such as an information industry with high-technology have already developed in Tokyo and they have contributed to the progress of the economic activities of Tokyo.

This tendency has lasted and Tokyo is moving to a higher internationalized city and an information-intensive society. Nowadays the economy of Tokyo isl expected to grow in a higher rate.

Fig.2. Change in Population of Tokyo

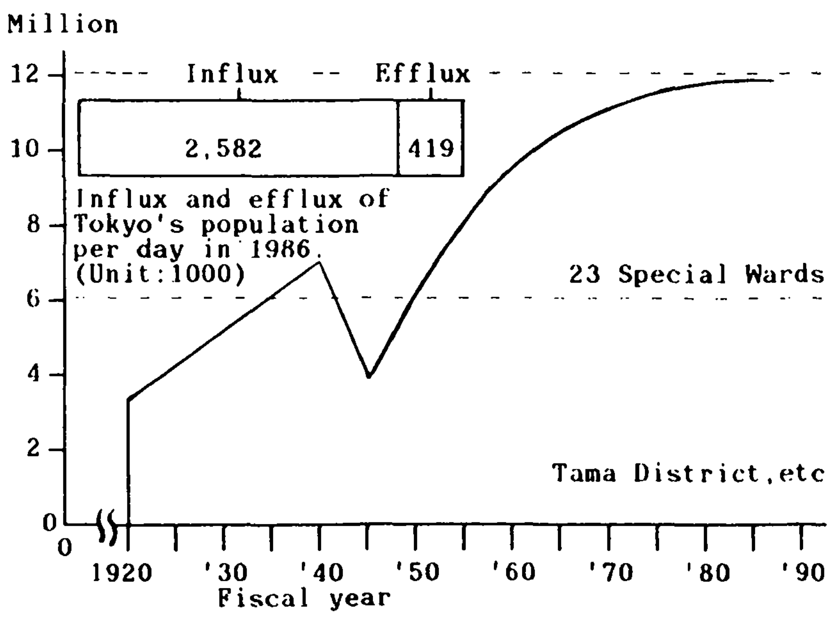
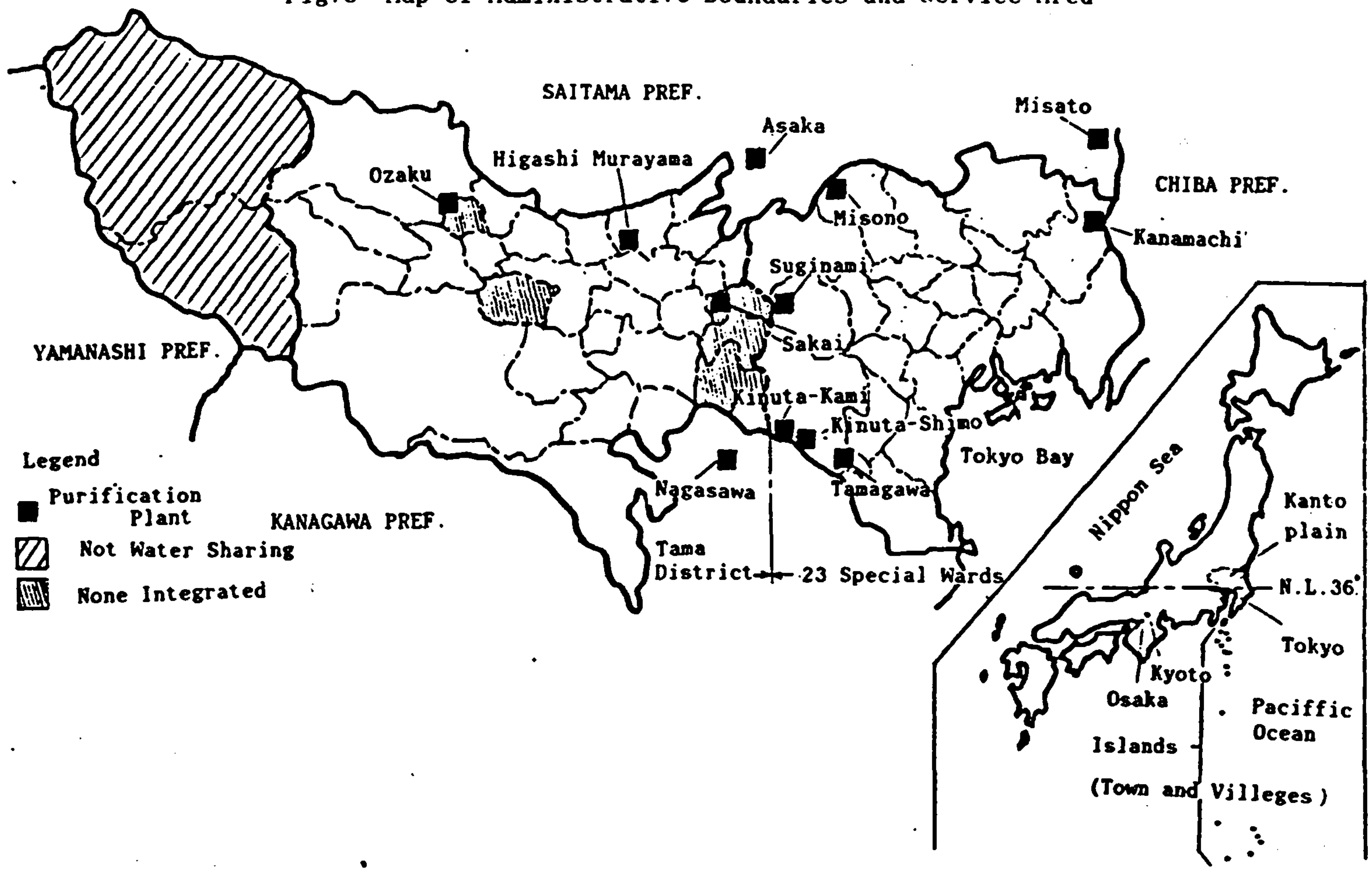


Fig.3 Map of Administrative Boundaries and Service Area



3. Change in Tokyo's waterworks

As the water demand in Tokyo has increased rapidly through the Meiji, Taisho and Showa period, the waterworks of Tokyo had been fighting with the construction work to expand facilities. Meanwhile the capacity of facilities reached 6,630,000m^3/day at present. It is about 40 times as large as the begining of the Tokyo waterworks. On the other hand, the water-served population has increased from 83 thousand people to 11 million. Especially the water demand rapidly increased during the 1960s in accordance with the high economic growth, which caused the huge imbalance between the water demand and the capacity of facilities. Thus the waterworks of Tokyo was compeled to expand the capacity of facilities. The shortage of water supply often occurred in those days. Especially in 1964, the year of Tokyo Olympic Games, the metropolis experienced a sérious drought called the "Tokyo Desert". After that the growth of water demand became gradual and it has leveled off for this decade.

Now the capacity of facilities exceeds the actual water demand after the completion of the Misato Purification Plant in 1986.

The statistical table of the Tokyo Metropolitan Waterworks in fiscal 1986 is as follows;

Table 1. The Tokyo's Waterworks System

(1) Basic Items

Inception of waterworks system	
Approval for establishment	July 5, 1890
Commencement of service	Dec.1, 1898
Service area (km^2)	1,124.65
Capacity of faciilities(m^3/d)	6,629,500
Volume of water resources (m^3/d)	5,970,000
Population served	11,045,023
Length of mains (km)	19,869
Number of customers	4,551,731
Number of meters installed	4,247,350
Employees (Apr.1, 1987)	6,482

(2) Water Supply Volume (m^3)

Total annual supply	1,711,986,000
Average daily supply	4,598,000
Maximum daily supply (Sept. 4)	6,011,000
23 special wards	4,632,000
Tama district	1,379,000

(3) Financial Analysis

Total revenue (million yen)	304,905
Water supply revenue (million yen)	263,659
Unit selling price (yen)	192.59
Unit product price (yen)	206.53
Business revenue per employee (1,000 yen)	50,319
Total cost (million yen)	288,531

(4) Cost Structure (million yen)

Wages and salaries	50,837	17.6 %
Interest payments	56,600	18.6
Depreciation	37,639	13.1
Power	9,446	3.3
Chemicals	2,013	0.7
Others	131,996	45.7
Total	288,531	100.00

Table 2. Analysis of Supplied Water

(Unit:1,000m³)

Fiscal year / Item	1983		1986	
	Volume	%	Volume	%
Total supply	1,758,110	100.0	1,711,986	100.0
Effective use	1,416,557	80.6	1,457,258	85.1
Paid	1,353,567	77.0	1,402,817	81.9
*Water rates	1,323,470	75.3	1,369,004	79.9
*Wholesale	29,910	1.7	33,695	2.0
*Others	186	0.0	118	0.0
Unpaid	62, 90	3.6	54,441	3.2
*Unmetered	57,439	3.3	50,617	3.0
*Self-use	4,874	0.3	3,181	0.2
*Others	677	0.0	643	0.0
Not effective	341,553	19.4	254,729	14.9
Leakage	258,616	14.7	226,496	13.2
Rate deduction	5,623	0.3	4,145	0.3
Miscellaneous	77,314	4.4	24,137	1.4

4. Water demand and water resources

4.1 Water demand now and in future

The water demand of Tokyo has yearly increased. Since 1960, especially during the high economic growth period, it has explosively risen by 300 thousand cubic meters per day every year due to the excessive concentration of population and industries into the metropolitan area.

However, since the 1st Oil Cricis in 1973 the water demand remained on a level or increased slightly as a result of the advent of a low-economic growth and the measures to reduce the water demand. Reffering to the future water demand, it is estimated that the daily demand will swell to 6.7 million cubic meters in 1995 because of the progressive urbanization in the Tama district, the trend toward nuclear family life styles and the increase of large buildings.

4.2 Development of water resources

The Ogochi Storage Dam was the last dam which could be developed in the Tokyo metropolitan area. After the completion of the Ogochi Dam, the development of water resources relied exclucively on the Tone River system and now two-thirds of the water resources depend on the Tone River.

At present, Tokyo holds 5.97 million cubic meters per day of water resources. However, as some of facilities are still not completed, there are some uncertain water rights in the resources. So once a drought occurs, Tokyo's water resources are reduced preceding to other waterworks by the Ministry of Construction. Thus, in Tokyo it is difficult to cope with drought. As a result the development of water resources is urgent and that on the Tone River and the Ara River system is implemented by the Ministry of Construction and the Water Resources Development Public Corporation.

However, the construction of dams and other water resource facilities has a grave impact on the daily life of people living in the catchment areas concerned. Considerable periods are required to solve the issues involved, and substantial delays have been experienced in the implementation of the plans.

4.3 Water resource facilities

Tokyo's water resource facilities are divided into two systems; the Tama River system and the Tone River one. The facilities on former system are directly managed by the Tokyo Metropolitan Waterworks Bureau. On the other hand, those on latter one are done by the Ministry of Construction and the Water Resources Development Public Corporation.

There are several facilities in the Tama River system; the Ogochi Storage Dam known as the largest dam in Japan among the exclusive storage dams for water supply, the riverhead forest covering an area of 22 thousand hectares, which are lied in the upstream of the Tama River and stretching from the Tokyo Metropolitan areas into Yamanashi Prefecture, and the three reservoirs, namely the Murayama-Kami Reservoir completed in 1924, the Murayama-Shimo Reservoir completed in 1927 and the Yamaguchi Reservoir completed in 1934. The storage capacity of these facilities totals 219.75 million cubic meters. The almost all facilities of water resources in the Tone River system are located in Gunma Prefecture and all of them are the multi-purpose storage dams.

5. Waterworks facilities

5.1 Purification facilities

The Bureau operates 11 purification plants. The newest one is the Misato Purification Plant which began to treat water in June 1985. Until then, the capacity of purification facilities was always under the water demand becsuse the increase of water demand was too rapid to cope with timely. Meanwhile, the Tamagawa Purification Plant (its capacity is 152,500 m^3/day) suspended water supply in 1970 due to deterioration of raw water quality. Generally speaking, quality of raw water taken into purification plants from the downstream of rivers has been deteriorating, because most of the upstream area is not covered with sewage system. It is an urgent problem to solve the deterioration of raw water quality, which causes the composition of Trihalomethan or offensive ordor water. To remove such pollution, much chemicals such as activated carbon are infused, and it costs a great deal. The Bureau carries out reserch activities of new technology in water purification treatment such as an experiment on the higher order processing using bio-activated carbon.

Table.3 Purification Plants of Tokyo

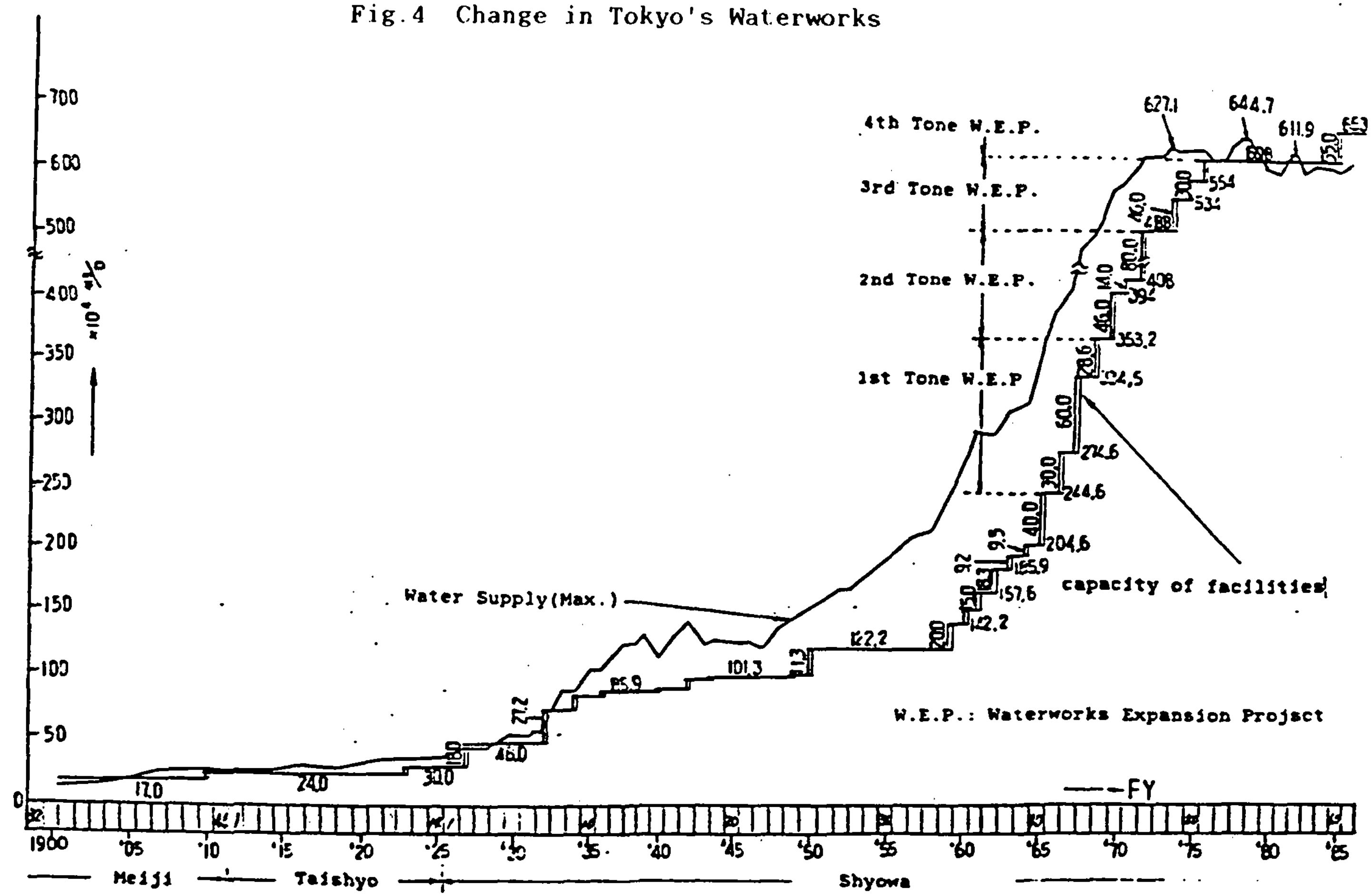
(As of Apr.1, 1988)

River system	Name	Capacity (m^3/day)	Contribution %		Treatment method
			Plant	System	
Tone River	Kanamachi	1,820,000	27.5	79.2	Rapid Sand Filtration (R.S.F.)
	Misato	550,000	8.3		
	Asaka	1,700,000	25.6		R.S.F.
	Misono	300,000	4.5		
	Higashi-	880,000	19.1		
Tama River	Murayama	385,000		17.6	
	Ozaku	280,000	4.2		
	Sakai	315,000	4.8		Slow Sand Filtration (S.S.F.)
	Kinuta-kami	114,500	1.7		
	Kinuta shimo	70,000	1.1		
	Tamagawa	(152,500)	-		S.S.F. R.S.F.
Sagami River	Nagasawa	200,000	3.0	3.0	R.S.F.
Ground water	Suginami	15,000	0.2	0.2	S.S.F.
Total		6,629,500	100.0	100.0	

5.2 Distribution facilities

There are 21 major pumping stations with distribution reservoirs, those capacity amounts to 1,255,900 cubic meters. Distribution pipes are essential to supply water in the service area. About 19,869 killometers of mains and submains (inside diameter is 50－2,700mm) are laid throughout the Tokyo area.

Fig.4 Change in Tokyo's Waterworks



6. Water rates

The water rate system of the Bureau was changed in February 1967 from that of classification by users to that of classification by diameter in order to construct the fare and reasonable system. While cumulative rate system was adopted to suppress water consumption.

Water rates can be paid both through bank account and through direct payment at a bank or a service station, and now they are in the proportion of approximately 2 to 1.

The Bureau introduced a computerized on line system in order to improve customers service and progress the efficient management in December 1986. By means of this system it became possible to respond quickly to inquiry and application from customers.

7. Financial administration

Administration of waterworks is ruled by the Local Public Enterprise Law enforced in October 1952, which regulates that a public enterprise must be run on a self supporting basis from an economical viewpoint while it must contribute to public welfare. In spite of this basis, the water rates revisions are sometimes postponed under the policy of maintaining cheap public utility charges. Taking an example of the water rate revision in Septmber 1975, the Bureau had to raise water rate by 259 percent to recover the deficit caused by the past political consideration.

The Bureau had been forced to undertake successive major expansion in its activities to keep pace with the excessive concentration of population into Tokyo area due to the high economic growth in the 1960s and other factors.

Since latter two thirds of the 1970s, the Japanese economy has got into the so called stabilized growth period and the increase of water demand has been moderate. So the expansion projects are arriving at their goals.

In the 1980s, this tendency has become more and more conspicuous. The waterworks of Tokyo seemed to change from the period of expansion into that of improvement. The charge has been forced the Bureau to enhance the maintenance of stable water supply and the improvement of services to the public.

In the long-term future, however, the management situation is likely to become extremely harsh due to such factors as the difficulty to secure new water resources, the deterioration of water quality in rivers and reservoirs and the escalation of maintenance costs of aged facilities.

8. Future directions

The waterworks of Tokyo has become one of the largest system in the world. It has been forced to lay the first priority to satisfy water demands because of its rapid growth. However, there are a lot of problems to be overcome in future. Followings are such problems;

(1) to ensure the uncertain water resources and promote development of new water resources coping with slow but successive increase of water demand.

(2) to promote measures to restrict water consumption, and prevent leakage, etc.

(3) to expand and improve facilities.

(4) to strengthen management system on water quality control coping with deteriorating.

(5) to make plans for long-term stability of financial foundation.

(6) to improve services.

(7) to systematize a general information network of the Bureau's administration.

(8) to renew the organization coping with the rapid innovation of technology and the rapid change of social environment.

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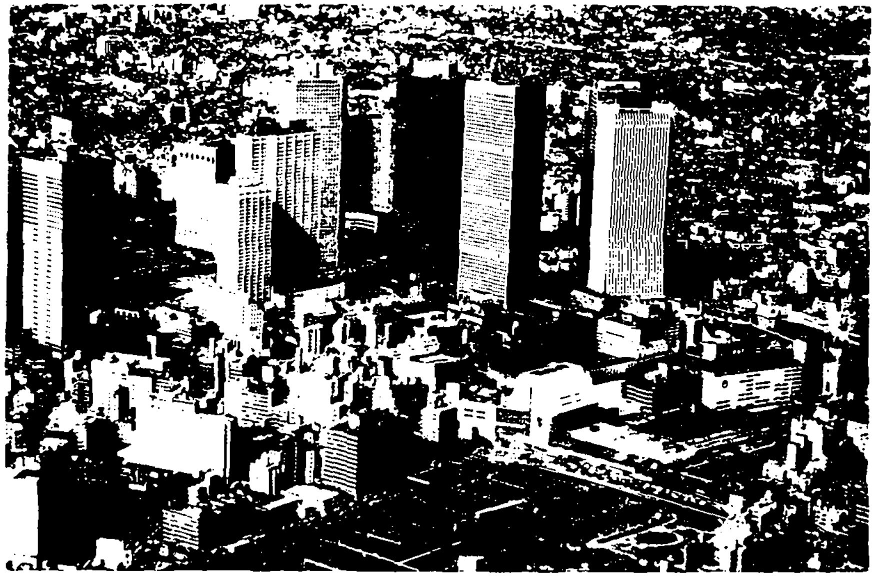
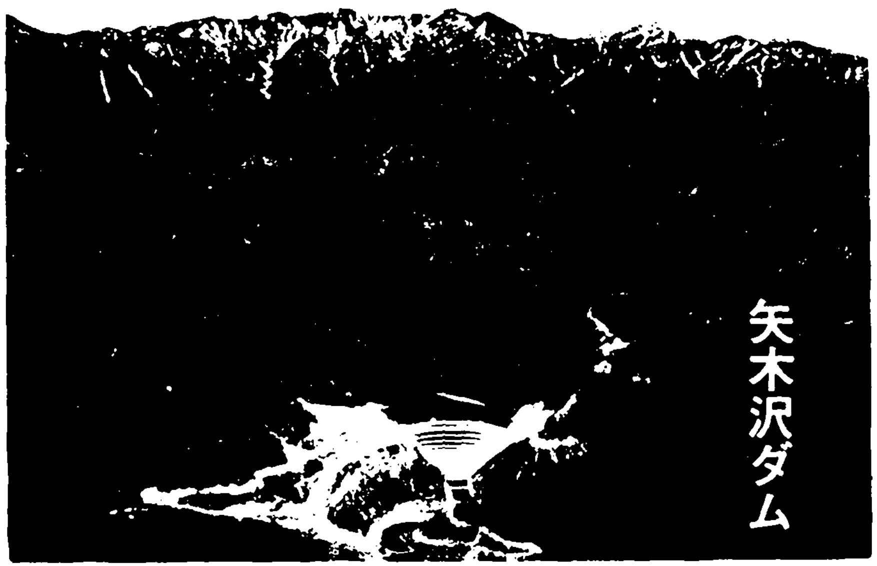
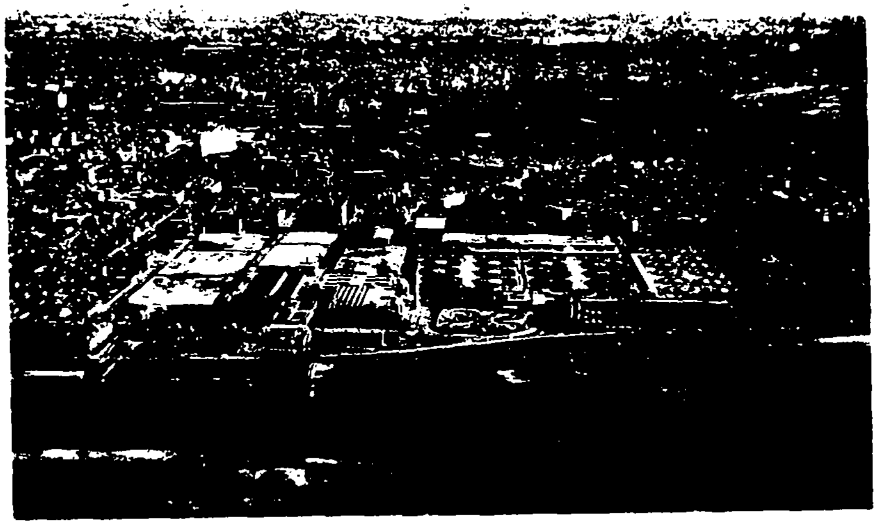


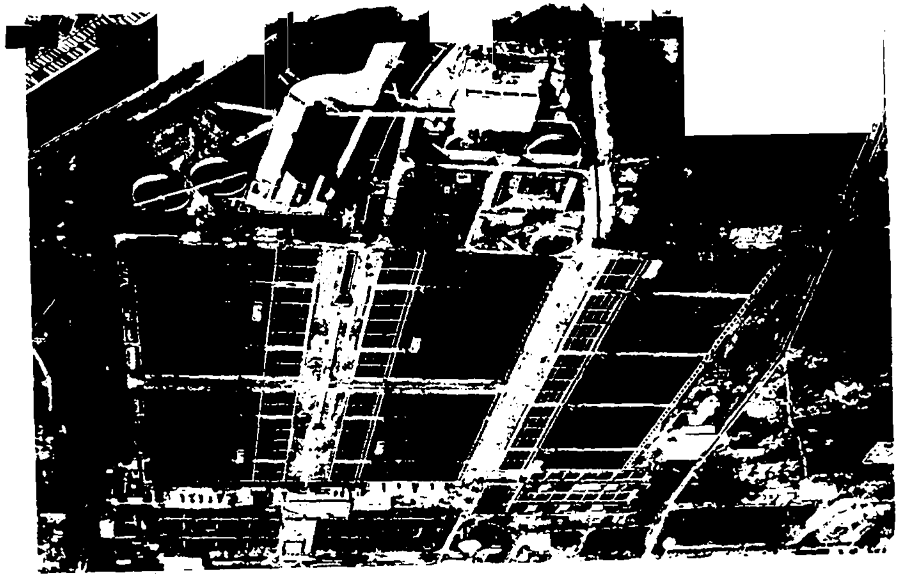
1 *Skyscrapers on Site of Old Yodobashi Purification Plant*



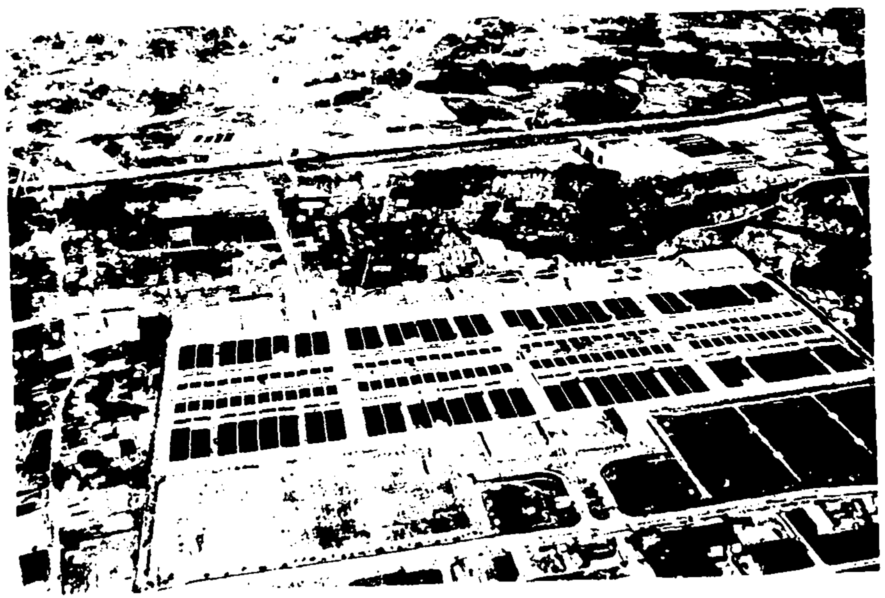
3 *Tone Diversion Weir*



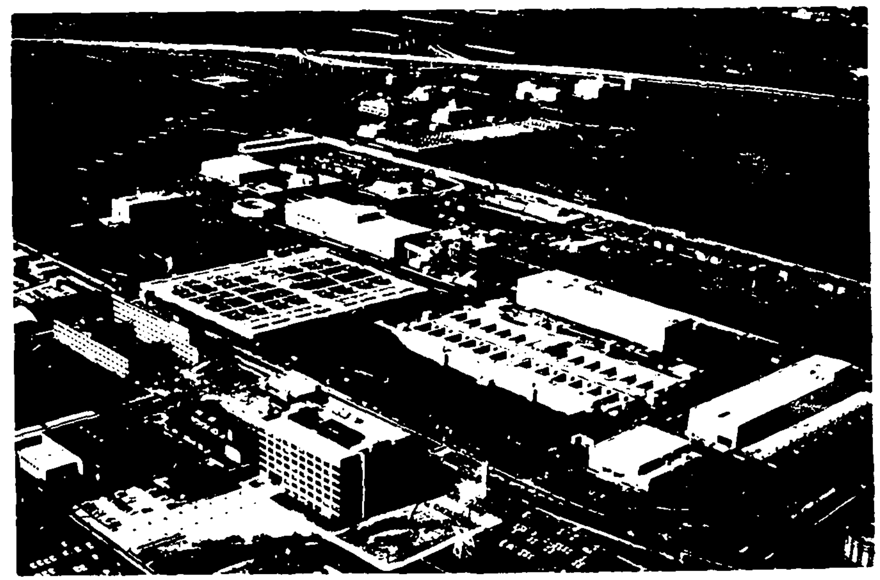
7 *Kanamachi Purification Plant*



9 *Higashi Murayama Purification Plant*



8 *Asaka Purification Plant*



10 *Misato Purification Plant*

RECENT WATER SUPPLY PROBLEMS AND PROPOSED SOLUTIONS IN MEXICO CITY

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Abstract

This paper depicts an overall view of current water supply problems in Mexico City. First the increasing water supply needs are analyzed. Then the overwhelming population growth is studied as the main factor that hinders the adequate performance of the water supply system, leading to a chronic potable water deficit. Later the curtailment of the population growth tendency in first place and water reuse in second place are proposed as solutions to this problem . Finally a set of conclusions and recommendations is included.

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CONTENTS:

General description of the Valley of Mexico basin

The Valle de México (Valley of Mexico) basin is situated between the $19^{o}03'53''$ and $20^{o}11'09''$ latitudes north and between the $98^{o}11'53''$ and $99^{o}30'24''$ longitudes west of Greenwich meridian. It is located at the southern boundary of the central plains and comprises an area of $9600\ km^2$.

The basin is closed, and its boundaries are with the basins of the Amajac and Tula-San Juan rivers to the north, the Tecolutla river basin to the northwest, the high Amacuzac and high Balsas rivers basins to the south and southeast and the Lerma river basin to the west.

The climate is humid temperate with a mean annual temperature, that ranges from $12^{o}C$ to $15^{o}C$, a maximum mean annual temperature, that ranges from $25^{o}C$ to $30^{o}C$ and a minimum mean annual temperature that ranges from -4^{o} C to 6^{o} C.

The annual mean rainfall varies from 600 mm in the north and northwest parts of the valley to 850 mm in the southwest and south-southeast of the valley. The annual mean rainfall is 700 mm, which amounts to 6720 X 10 exp(6) m^3 annually. The rain season spans from may to october and comprises from 80 % to 90 % of total rainfall.

The Valle de México basin has been subdivided in eleven subbasins that yield the following mean annual volumes of surface waters (Table # 1).

Table # 1

Zone	Subbasin	Area km^2	Mean rainfall mm (1979)	Annual Volume $10^3 m^3$
I	Xochimilco	522	806	1212
II	Churubusco	234	927	32853
III	Cd. México	725	864	140793
IV	Cuautitlán	972	900	116215
V	Pachuca	2087	608	514
VI	Teotihuácan	930	593	4609
VII	Texcoco	1146	652	36802
VIII	Chalco	1124	744	19408
IX	Apán	637	727	13321
X	Tochac	690	726	22619
XI	Tecocomulco	533	679	11746
	TOTAL	9600	704	400591

The annual mean rainfall volume per year yields a mean discharge of 213 m^3/s, whose balance is in table # 2.

Table # 2 [1]

	Q (m^3/s)
Annual mean rainfall volume :	213
Evapotranspiration :	171
Aquifer recharge :	23
Streamflow :	19

From the last figure, 3 m^3/s are drawn for agriculture and 16 m^3/s are drained through the storm drainage system[2].

Water supply requirements for Mexico City

The southwestern part of the basin is occupied by the Federal District ("Distrito Federal"), which includes the nation's capital, Mexico City, and surrounding cities,now connected to the metropolitan area,which has extended even to the neighbouring federal states of Mexico ("Estado de México") and of Hidalgo with big joint settlements. Nowadays the Valley of Mexico uses 60 m^3/s for water supply . From this figure, Mexico City draws 40 m^3/s for water supply , distributed as follows: (table # 3)

Table # 3

Usage	Number of users	Flow m^3/s	% of flow
domestic	1 900 000 dwellings	22	69
industrial	30 000 factories	5	16
services	60 000 firms	4	12
commerce	120 000 firms	1	3
TOTAL	2 110 000 users	32	100
unaccounted usages (leaks and garden sprinkling):		8	
		40	

Population growth trends

The population of Mexico City has grown steadily fast due to the intense centralization of the majority of the political and economic functions of the country,as well as a spreading unemployment in the province and a yearly birth rate of 31/1000 in 1970. The migration of unemployed peasants from the countryside to Mexico City was estimated in

1000 dwellers per day in 1979 and nowadays an estimation has been made of 900 000 newcomers per year, which amounts to nearly 2500 new inhabitants per day [3]. Table # 4 shows a census of the population of Mexico City.

Table # 4

Year	Population Distrito Federal (D.F.)	Metropolitan area (AMVM)
1895	476 413	
1900	541 516	
1910	720 753	
1921	906 063	
1930	1 229 576	
1940	1 757 530	
1950	3 050 442	
1953	3 480 000	
1960	4 870 876	5 186 000
1970	6 874 165	8 797 000
1980	8 831 079	14 500 000

The actual population growth trend of AMVM is shown in figure # 1. These actual data are compared with the Gompertz or logistic curve which is often used for the long term forecasting of large population centers. This curve is S-shaped and has a zero lower asymptote and a K upper asymptote. This K value can be considered as a limiting growth value.

The simplest form of the Gompertz curve is [4]

Yc = K / (1 + 10 EXP(a + bX))

where Yc = ordinate of the curve

X = time period in years

K, a, b = constants

The constants are evaluated as follows :

$K = (2Y_0Y_1Y_2 + Y_1{**}2 \ (Y_0+Y_2))/(Y_0Y_2-Y_1{**}2)$

$a = \log (K - Y_0) / Y_0$

$b = (1/n) \log (Y_0 (K - Y_1) / (Y_1(K - Y_0))$

where Y_0, Y_1, Y_2 are actual population values associated with the corresponding years X_0, X_1 and X_2, which are equidistant from each other in succession and chosen so that the X_0 value will be near or at the beginning of the population record, X_1 will be near or at the middle and X_2 will be near or at the end . n is equal to the number of years from X_0 to X_1, or from X_1 to X_2. The origin on the X-axis is at the year indicated by X_0. Table # 5 shows the set of values chosen from table # 4, in order to fit the logistic curve to the actual data.

Table # 5

i	X(i)	Y(i)
0	1900	541 516
1	1940	1 757 530
2	1980	14 500 000

The fitted logistic curve is as follows:

Yc = 15,549,236 / (1 + 10 EXP (1.4427034 - 0.0136997X))

(The fitted curve will be shown at the presentation of this paper .)

A comparison between actual and forecast data shows that there is a divergence of the two curves from 1940 on and this event coincides with the thunderous industrialization process that occurred in Mexico around 1950 and which entails the increasing migration of peasants - looking for a better way of life - from the country to the city. Table # 6 shows the excess population in AMVM from 1950 on , estimated according to the Gompertz model.

Table # 6

year	excess population	% excess
1950	738 029	32
1960	2 181 679	73
1970	4 953 850	129
1980	9 673 915	200

The population growth trend has become clearly exponential . An exponential curve of the form y = ab exp(x) was fitted to the actual data by means of the least square criterion and the result was [5] :

Y =5.2480746 x 10 exp (-28) e (0.0399261 X)

where Y = population for a given year X

X = year of interest

The correlation coefficient was computed as $r = 0.99$.

The population density was estimated as 17 000 000 / 890 mi^2 = 19 000 inhabitants/ mi^2 in 1984 [6].

Current water supply system and storm-drainage system

The water supply for the AMVM is performed by two government agencies , namely: a) Comisión de Aguas del Valle de México (CAVM), a branch of Secretaría de Agricultura y Recursos Hidráulicos (SARH) and b) Departamento del Distrito Federal (DDF) .

Table # 7 shows the current water supply and sources for 1988 .

Table # 7 [7]

Source	Volume Q(m^3/s)
groundwater drawn from wells in VM	44
surface water supply from VM	1
groundwater from Lerma system	7
surface water from Cutzamala system	12
(VM) = Valle de México	64

From this grand total , CAVM supplies 28 m^3 as follows : over 300 operating wells through 15 aqueducts plus Madin reservoir = 16 m^3/s;Cutzamala system = 12 m^3/s .

Water quality is achieved through 8 main treatment plants for chlorination and rechlorination of groundwater , 4 main treatment plants for chemical treatment , 2 of them utilize an ozonization tertiary treatment and 235 small treatment plants scattered throughout the city for groundwater from wells in batch process , 227 utilize sodium hypochlorite and 8 utilize Cl_2 gas.

The storm-drainage system is a combined system that drains both rainfall and wastewater (50 m^3 / s in 1984) .

At first this system was composed of open channels or natural rivers , but most of them have been converted to underground tunnels and new tunnels have been built to drain the increasing flow.

Deficits in the water balance

There is a chronic deficit of water supply as shown in table # 8.

Table # 8

year	deficit m^3/s
1982	1.4
1984	5.0

In 1984 it was estimated that over 2 million of the city's people did not have running water in their homes [8].

Proposed solutions to water shortage

The CAVM has implemented a long range plan for transporting water from neighbouring basins:

Table # 9

Basin	Q m^3/s	Basin	Q m^3/s
Cutzamala	19	Oriental-Libres	7
Temascaltepec	5	Amacuzac	14.2
Tecolutla	14.7	Tula-Taxhimay	2.8
			62.7

The objectives of this plan are as follows:

a) To reduce and to substitute the groundwater drawn from the Valley of Mexico,so that the permanent sinking of the subsoil will be impeded.Subsidence is due to the high compressibility of under laying clay sediments of volcanic origin [6]. This sinking has been estimated as 10 m for the last 20 years in 1982 , which amounts to 20 cm/year. The aftermath has been the disruption of the storm-drainage system in some areas,so it was necessary, to build pumping stations , in order to make the wastewater flow against gravity because the slopes of the conduits were rendered negative by the subsidence . The groundwater drawn from the subsoil amounts to 44 m^3/s (Table # 7) and the subsoil recharge is only 23 m^3/s (Table # 2), so there is a 91 % overdraw of the aquifers.

b) To meet the increasing demand for water supply for the AMVM. The projected population by year 2000 has been estimated as 26 million inhabitants [5].

c) To apportion water for other much smaller communities that surround the AMVM.

Another solution implemented by the DDF is the reuse of water . Table # 10 shows a list of mayor wastewater treatment plants, whose water is reused for public parks sprinkling and for cooling water for the Jorge Luke thermoelectric plant in the case of the Lecheria plant [9] .

Table # 10

Plant	operated by	installed capacity (l/s)	utilized capacity (l/s)	%	initial date
Cerro de la Estrella	DDF	2000	1800	90	1971
Xochimilco	DDF	1250	00	0	1959
others	DDF	1450	1134	70	/
		4700	2934	64	

Conclusions and recommendations

A severe shortage of potable water is imminent for Mexico City. Although CAVM has implemented a new program for transportation of water[2], the cost is prohibitive : a capital cost of from 40 000 million pesos to 60 000 million pesos per m^3/s (17 million US dollars to 26 million US dollars to this date) . The authors propose the following :

a) To curtail the explosive population growth trend for AMVM by means of short and long term policies,capable to increase the quality of living and working conditions in other parts of the country and at the same time to reduce the economic attractiveness of the capital . Furthermore, any effort available should be done to modify current extreme centralization in policies decision making in order to distribute the administration of federal budget and investment all over the country.

Otherwise the only effective solution would be the creation of a new capital in a more appropriate location.

b) To implement widespread reuse of water, actually still very much limited . The optimum percent recycle from the viewpoint of cost has been estimated as 60 % [10] .

c) To minimize leakings from the supply system. It has been estimated, that 20 % of the total inflow is lost due to leaking.

d) To implement practices for saving water. DDF is projecting to exchange the majority of domestic hydraulic installations for newer ones, that save up to 40 % of water consumption. At the same time local authorities are conducting a permanent publicity campaign, inviting the population to optimize water use and consumption. The authors feel, that the results achieved so far are not yet satisfactory and should be increased.

e) Wastewater injection into local aquifers at selected sites within the basin should be further investigated, in order to improve aquifer recharge, which has decreased constantly because of the growth of urbanized area.

Only a set of intelligent and well coordinated political and technical measures, enforced as soon as possible, can assure future water supply for Mexico City and avoid major shortage, that could be the origin of an impending social crisis in the country's center.

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CHALLENGES IN MEETING FUTURE WATER NEEDS IN SOUTHERN CALIFORNIA

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CHALLENGES IN MEETING FUTURE WATER NEEDS IN SOUTHERN CALIFORNIA

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ABSTRACT

Southern California is one of the fastest growing regions on the North American continent. As an international leader in commerce and manufacturing, the region's economy rivals that of many nations. The area is also dependent on imported water supplies for over half its needs. With a rapidly increasing population and the corresponding need for additional water resources, Southern California faces unprecedented challenges in the near future. Because the dependability of established sources of water is also being threatened, water agencies are pursuing traditional as well as innovative approaches to ensure adequate water supplies for now and for the future. In addition to seeking greater amounts of water from Northern California, urban water agencies are investigating transfers of water used historically for agricultural purposes. These activities are pursued along with increased conservation, reclamation, and groundwater management programs.

SOUTHERN CALIFORNIA AREA

The six-county area of Southern California, as shown in Figure 1, consists of 38,220 square miles (98,952 km^2), while major population areas along the coast account for less than one-seventh of this total area. The region's climate varies greatly from the coastal to the inland areas. Daily maximum summer temperatures of 70 degrees Fahrenheit (^oF) (21.1^oC) along the coast increase to 110^oF (43.3^oC) in the inland areas. Annual rainfall, only 13 inches (33 cm) near the coast, decreases to 7 inches (18 cm) or less in the inland areas.

As a result of the urban sprawl, agricultural acreage and associated water use have been declining. Agricultural water use will decline from approximately 28 percent of total water needs to 18 percent by the year 2010.

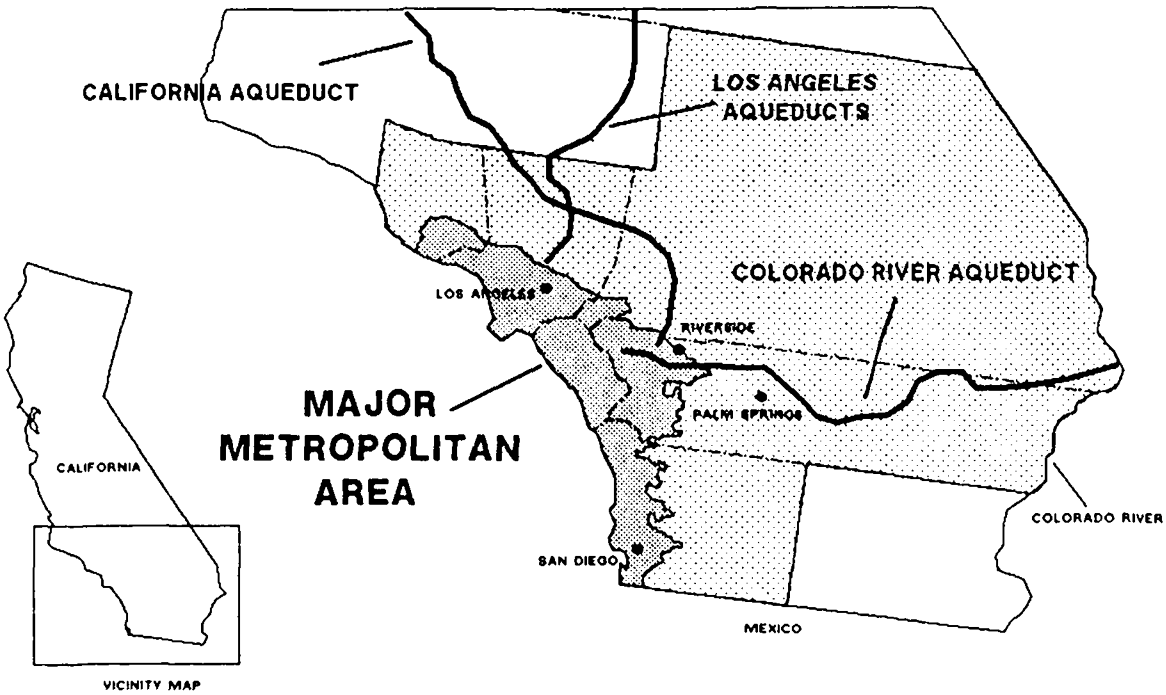


FIGURE 1: SOUTHERN CALIFORNIA AREA

Urban demand for water will increase by 42 percent between the present time and 2010. Figure 2 tabulates the existing and projected dependable water supplies for Southern California and compares these supplies with historical and projected water demands. While ample supplies exist at present, shortage of water supplies are forecasted for the near future. In addition, threats to portions of existing dependable supplies are causing increased concern among Southern California water purveyors.

Total population of the six-county Southern California area is 15.7 million, with approximately 90 percent of the people residing in the coastal metropolitan areas.

FIGURE 2: COMPARISON OF EXISTING DEPENDABLE WATER SUPPLIES WITH DEMANDS FOR SOUTHERN CALIFORNIA

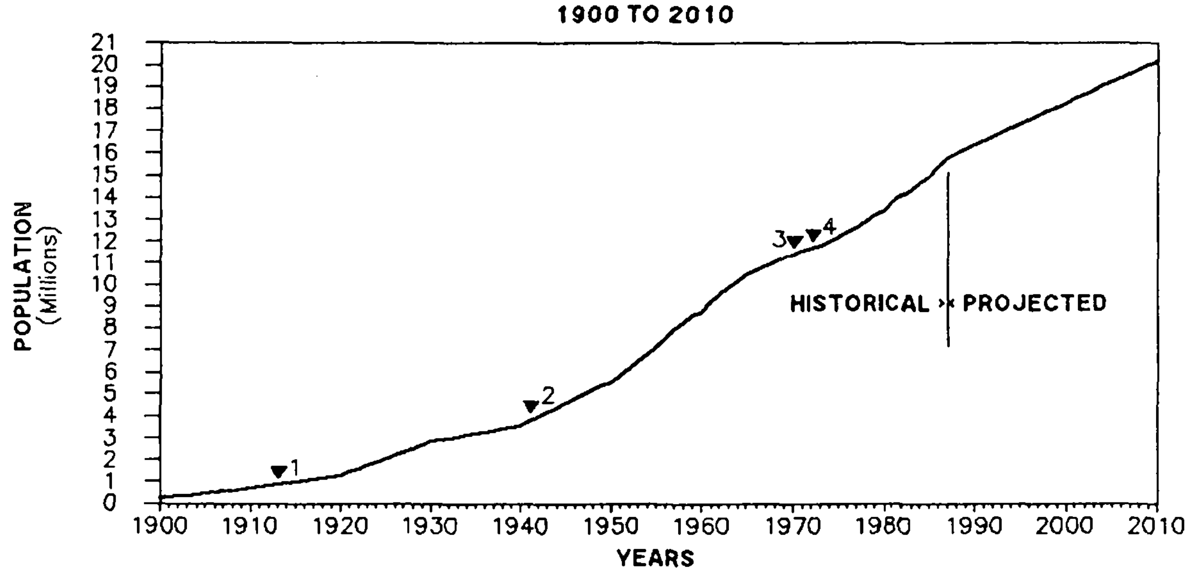
MILLION ACRE-FT ($x 10^9 m^3$)

	YEAR			
	1980	1990	2000	2010
EXISTING WATER SUPPLIES				
Local Surface and Groundwater	2.19 (2.70)	2.19 (2.70)	2.19 (2.70)	2.19 (2.70)
Wastewater Reuse	0.14 (0.17)	0.16 (0.20)	0.16 (0.20)	0.17 (0.21)
Imported				
Los Angeles Aqueducts	0.42 (0.52)	0.42 (0.52)	0.42 (0.52)	0.42 (0.52)
Colorado River	1.73 (2.13)	0.80 (0.99)	0.80 (0.99)	0.80 (0.99)
State Water Project	1.30 (1.60)	1.28 (1.58)	1.34 (1.65)	1.35 (1.67)
Total Water Supplies	5.78 (7.13)	4.85 (5.99)	4.91 (6.06)	4.43 (6.09)
HISTORICAL AND PROJECTED WATER DEMANDS	4.45 (5.50)	5.13 (6.34)	5.76 (7.11)	6.33 (7.82)
SURPLUS (OR SHORTAGES) IN SUPPLIES	1.33 (1.64)	(0.28 [0.35])	(0.85 [1.05])	(1.40 [1.73])

Figure 3 illustrates the historical and projected population growth of Southern California. A population of over 20 million people is estimated for 2010. The population graph includes indicators of completion dates of major aqueducts importing water supplies to the region. These major aqueduct systems were instrumental to the continued growth of Southern California.

FIGURE 3: TOTAL HISTORICAL AND PROJECTED POPULATION SOUTHERN CALIFORNIA

1900 TO 2010



▼1 1913 FIRST LOS ANGELES AQUEDUCT COMPLETED

▼2 1941 COLORADO RIVER AQUEDUCT COMPLETED

▼3 1970 SECOND LOS ANGELES AQUEDUCT COMPLETED

▼4 1972 CALIFORNIA AQUEDUCT COMPLETED

LOCAL GROUNDWATER

Groundwater basin replenishment occurs primarily from local precipitation, runoff from the area's coastal mountains, and the artificial recharge of imported water supplies. Availability of adequate local groundwater resources is directly related to rainfall. In semi-arid Southern California, flow in local rivers can be nonexistent except during storm periods. Most of this freshwater runoff is diverted to underground basins to be pumped out later. Most groundwater basins are strictly managed and controlled to prevent overdraft. Local groundwater is higher in Total Dissolved Solids (TDS) than imported water, with average TDS values ranging from 300 to 600 milligrams per liter (mg/l).

In recent years, the use of groundwater resources in Southern California has been severely restricted due to the discovery of trace amounts of organic chemicals in the underground basins. Past improper chemical disposal practices have allowed groundwater basins to become contaminated. In the San Fernando Valley of Los Angeles, these constituents consist primarily of industrial solvents used extensively since the early 1940's in aircraft and other manufacturing industries.

In order to utilize the maximum amount of groundwater possible, activities have focused on pumping from less contaminated areas of the basins and blending water with other local and imported supplies.

Southern California utilities have also begun the monumental task of cleaning up the contaminated basins. Working in conjunction with the United States Environmental Protection Agency, local water agencies are conducting research and implementing cleanup projects incorporating technologies such as ozone and hydrogen peroxide, aeration, and granular activated carbon filtration.

RECLAIMED WATER

Water reclamation has had limited use in Southern California. In the region, approximately 50 wastewater reclamation plants are treating and distributing reclaimed wastewater. The largest use for reclaimed wastewater is for groundwater recharge, currently the recipient of two-thirds of local reclamation. This use is subject to stringent controls by public health agencies, and health concerns have hindered reclaimed wastewater expansion.

In Southern California, the great distances between open greenbelt areas, which are the potential recipients of reclaimed wastewater, have also contributed to its slow growth. However, where customers can be identified, reclaimed wastewater is successfully implemented.

IMPORTED WATER SUPPLIES

In Southern California, local water supplies provide approximately 45 percent of the region's current water needs. This, however, is not the case for the major urban cities. Los Angeles, the largest city in California with a population of 3.3 million persons, relies on imported supplies for 85 percent of its total water needs. The state's second largest city, San Diego, near the Mexico border, imports 80 percent of its water supply. The majority of the imported supply is delivered to the region by the Metropolitan Water District of Southern California, a wholesaler of water supplies consisting of 27 local cities and municipal water districts.

LOS ANGELES AQUEDUCTS

The City of Los Angeles began experiencing a serious water supply problem in the early 1900's when a prolonged drought period was coupled with a large influx of new residents. The

City discovered the Owens River, located in Owens Valley, 240 miles (386 km) north of Los Angeles and on the east side of the Sierra Nevada mountains of California.

The City acquired approximately 250,000 acres (100,000 hectares) of Owens Valley land to secure water rights. In 1913, after six years of construction, the 233-mile-long (375 km) Los Angeles Aqueduct was completed (Figure 4). The Los Angeles Aqueduct captures Owens River water, which originates from snowmelt in the eastern Sierra Nevada, and also transports water pumped from the Owens Valley groundwater basin.

In 1940, the aqueduct was extended 105 miles (169 km) further north to tap the waters of the Mono Basin which historically flowed into saline Mono Lake. In 1970, the Second Los Angeles Aqueduct, which parallels the original aqueduct, was constructed, further increasing its yield.

The Los Angeles Aqueducts supply Los Angeles with approximately 70 percent of its requirements; however, this supply is reduced in years with low snowfall in the Sierra Nevada. Being a high quality water source from a well-protected watershed, TDS levels in the Los Angeles Aqueduct system average approximately 180 mg/l.

All Los Angeles Aqueduct supply receives treatment at the City's new filtration plant. The facility uses ozone as the primary disinfectant and has high-rate filters to remove suspended particles, keeping trihalomethane levels well within acceptable limits.

The continuing ability of the Los Angeles Aqueducts to deliver their historical average supply is threatened by litigation to reduce Mono Basin diversions and Owens Valley groundwater pumping.

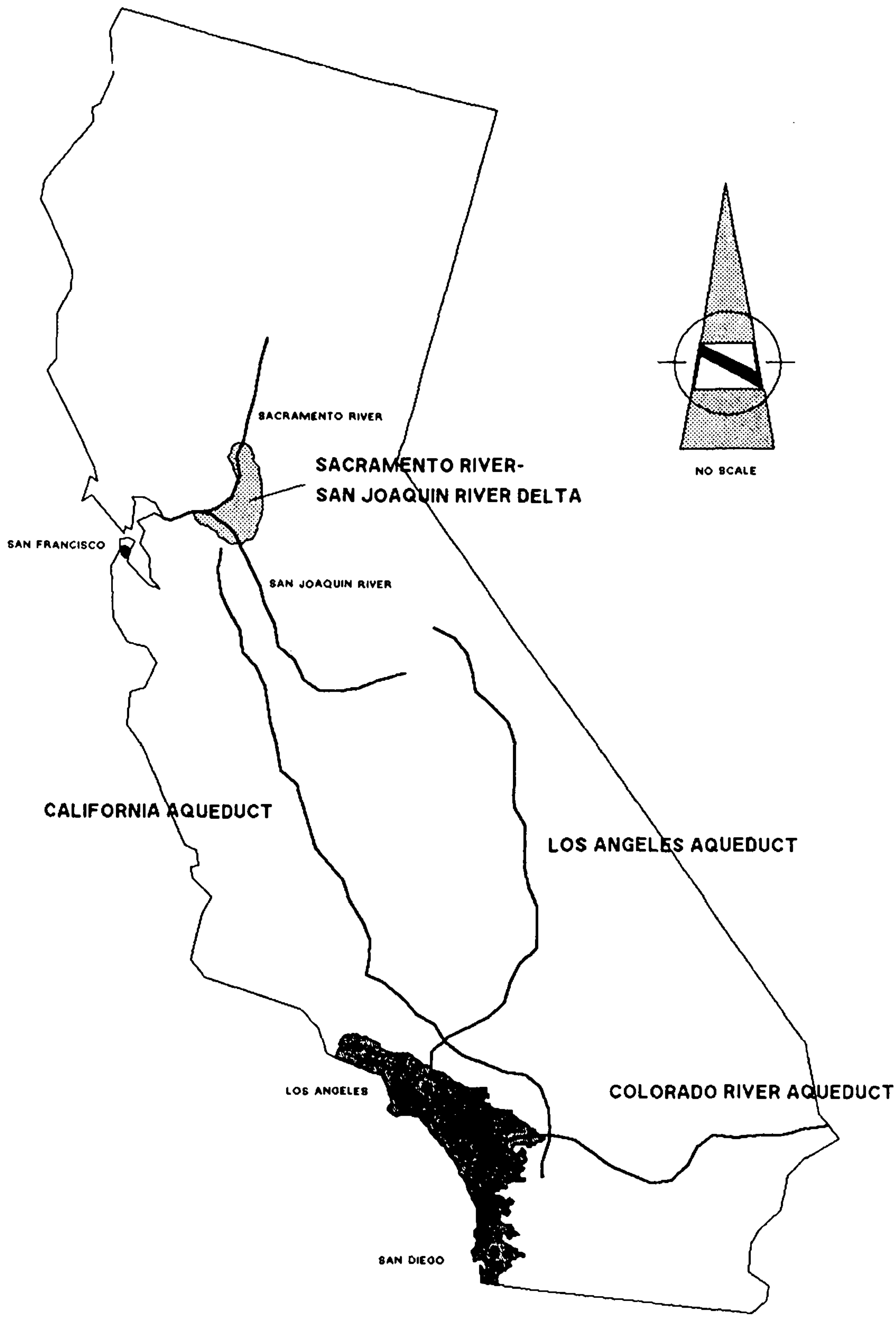


FIGURE 4: MAJOR AQUEDUCTS SERVING SOUTHERN CALIFORNIA

COLORADO RIVER AQUEDUCT

In response to increased water demands in the 1920's, a number of Southern California communities joined together to form the Metropolitan Water District of Southern California and finance construction of the Colorado River Aqueduct. The 300-mile (483 km) aqueduct was completed in 1941, allowing Southern California's growth to continue. Colorado River water has average TDS values of approximately 645 mg/l and is filtered and treated if not used for agriculture or groundwater recharge.

Beginning in 1985, Southern California's share of Colorado River water allocations for urban areas was cut in half so the State of Arizona could augment its supply.

To utilize Colorado River water as efficiently as possible and increase dependable supplies, programs being planned include increased banking of water in underground basins for later use and increased conservation by agricultural users.

STATE AQUEDUCT WATER

The California State Water Project was conceived in the 1950's to supply California's vast agricultural Central Valley and Southern California with sufficient water supplies. The initial facilities were constructed in the early 1970's, supplying water from the Sacramento River and San Joaquin River Delta in northern California. The major component of the State Water Project, the 444-mile (714 km) California Aqueduct, delivers drinking water to more than 16 million people and irrigation water to about 1 million acres (404,700 ha). With regard to water quality, TDS values average approximately 280 mg/l, and all domestic supplies are filtered and treated.

However, since the construction of the original facilities, no additional capacity has been added to the system, leaving its capacity at only one-half of what was originally planned. While water needs statewide, and particularly those in Southern California, have been increasing, the debate over exporting additional supplies from the north continues. Over 75 percent of all water in California is located in the northern half of the state, and over half of the state's water flows through the Delta. Northern Californians, fearful of the loss of adequate water supplies to protect the ecologically sensitive Delta area and supply northern cities, are reluctant to agree to any proposals for increased water deliveries through the California Aqueduct. Southern Californians, aware of the vast quantities of water discharged through the Delta, believe that additional water can be diverted south without adversely affecting the Delta environment. Increased supplies from the Delta area are vital to Southern California's future.

MANAGEMENT OF RESOURCES

Programs to achieve maximum use of limited water supplies are essential to Southern California's continued growth. In the past, Southern California relied on new aqueduct supplies to sustain continued growth, and ample water supplies were available. With no new sources of water supply available to import, and reluctance on Northern Californians to agree to increased water from the Delta area, Southern California must attempt to maximize the use of water supplies already available.

CONSERVATION

In water-dry Southern California, water conservation is heavily promoted to stretch existing limited resources to their maximum use. Many water agencies have instituted comprehensive conservation programs to educate local residents to use water efficiently. Also, programs for business and industry have been developed to demonstrate effective methods for achieving lower water use.

The statewide drought of 1976-77 led to increased awareness of water resources. Low-flush toilets, which use no more than 3-1/2 gallons (13 liters) per flush, and low-flow shower heads in new construction and equipment replacement are now required by state law. Widespread use of local media is utilized to educate and inform Southern California residents of water supply sources and problems.

WATER MARKETING

Transfers of water from agricultural use to urban water use, called "water marketing," is an increasingly popular concept among thirsty regions of the western United States. Although institutionally complex, these reallocations of supplies are important to Southern California's water future.

Many agencies in the region are negotiating with agricultural land holders to obtain water rights. Under several proposals, farmers would be compensated for growing low-water-use crops. The water saved would then be conveyed in existing aqueduct systems to Southern California.

Increased use of agricultural water supplies for municipal use will cause changes in California. Statewide agriculture currently consumes 85 percent of California's water supplies. The state is one of the world's largest agricultural producers, and agriculture is important to California's economy. As farmland decreases so water supplies can be consumed by growing cities, portions of California's historical agricultural abundance will be curtailed.

GROUNDWATER CONJUNCTIVE USE

Conjunctive use is the practice of effectively utilizing underground water basins to store surplus imported supplies for use in dry years. The expansion of existing programs is an important feature of Southern California's future water supply planning.

Los Angeles has had success with the cooperative management program to utilize water stored in the Owens Valley groundwater basin. During years with heavy Sierra Nevada snowfall, the higher runoff can be used to artificially recharge the groundwater basin. In dry years, this stored groundwater can be pumped to the Los Angeles Aqueduct for export to Los Angeles.

CONCLUSION

Complex water supply issues face Southern California. Without new sources of water, the region will find itself with severe shortages by the turn of the century. The most important challenge is completion of the State Water Project to export additional supplies from Northern California. Reallocation of existing agricultural water supplies must increase and growing urban areas will have to pay higher prices for these resources. Increased conservation, wastewater reclamation, and groundwater management programs will continue to be emphasized.

Southern California's location on the Pacific Rim, an area which contains about one-half of the world's population, will ensure the continuation of rapid population and economic growth. Water suppliers are faced with unprecedented challenges to provide adequate water supplies to accommodate that growth. Cooperation among government, local agencies, and competing water users is mandatory if solutions to existing water supply challenges are to be found, enabling Southern California to enter the twenty-first century with adequate, dependable and affordable water supplies.

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THE DEVELOPMENT OF BEIJING WATERWORKS

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THE DEVELOPMENT OF BEIJING WATERWORKS

BEIJING MUNICIPAL WATERWORKS COMPANY P. R. CHINA

1.General Introduction

Beijing Municipal Waterworks Company, which has a history of over 78 years, is a large enterprise bearing the important mission of supplying water to the state capital.

Up to the end of Qing dynasty, Beijing had to rely on local shallow wells for her water supply. In 1908, under the influence of the prevailing tendency of promoting the early industries, the Department of Agriculture, Industry and Commerce of the Qing government established the Capital Waterworks Co.ltd. The Company was run as a commercial establishment under the supervision of the government. Its only surface water treatment plant was then located in a small town named Sunhe and the distribution pumping station was outside of the old city. The plant began to be put into operation in 1910. The daily capacity was only 3300m^3. In 1942, groundwater came to be used instead of surface water. Before 1949, Beijing Waterworks, as an enterprise, developed very slowly. As to the most of the residents, runing water was still not easily available. Till 1949, Beijing Waterworks had only its Dongzhimen water plant and some boosting wells in operation. The daily capacity then was 50,000m^3. The population served was about 600,000. The total length of pipeline was only 364km, and the supplying area was limited only to the downtown area of the city,and water supply pervation in the city proper was 29.5%. The remaining percentage of residents had to rely mainly on the handpump wells and water from local shallow wells transported by water carts.

In 1949, the founding of the People's Republic of China brought forth a new era to Beijing Waterworks enterprise. Along with the city's construction carried out during the 39 years, Beijing Waterworks has gained tremendous development. Extension construction has been carried out to the Company's No.1 Water Plant, followed by the completion of No.2 to No.9 Plant and Tiancunshan Water

Plant.The daily capacity in city proper goes up to 1,720,000m^3 The population served is 4,700,000. The supplying area is 418km^2. The distribution network is a gridiron system. The total length is 4600km. There is a seperated water plant in the city for industry use with capacity of 170,000m^3/day .In the four suburban districts, independent water plants and supply systems are provided by the Company.

In Beijing, many large industries and other organizations have their own water supply system. Along with carrying out the policy of reform and open to the outside world, it is expected that there will be a large number of housing, service facilities and large public buildings constructed in Beijing from now on, so there will be a great increment in city's water consumption correspondingly.

2. Water Resources and Water Treatment.

Beijing is located in the northwest of Huabei plain of China . It is semi-arid region with temperate, continental and monsoon climate. It is cold and dry in winter, but hot in summer. The average annual rainfall for many years is about 600mm, mainly concentrates in july and August. Ground water resources in Beijing are mainly distributed at upper and middle reach of alluvial fans of five main rivers, which are Yongding, Chaobai,Beiyun, Jiyun and daqing river. Among them,the alluvial fans of Yongding River and Chaobai River are much richer in groundwater resources. The surface water resources are consisted of local water and entered water from neighbouring area. The total amount of surface water and groundwater resources for industry,aguriculture and domestic use in about 4,000,000,000m^3/year. Along with the development of social economy,industry and city construction, water consumption is being increase year by year,but the water from neighbouring area has decreased gradually, the existing water resources can't meet great demands of city development.The shortage of water resources will be the severe problem and confined factor for Beijing city in long time.

In Beijing, groundwater has been pumped for long time. The groundwater quality is good and can meet the state sanitory standard for drinking water just after disinfection.But overpumpage and short supplication have dropped down the ground water level for 7~ 25 meters in city proper and suburban area. The max. dropping reaches 32 meters. It forms the "funnel" of ground water level gradually in the area of 1,000km^2 . The total hardness of groundwater has increased. For this reason, in 1985 we completed the construction of the first large surface water treatment plant--Tiancunshang Water Treatment Plant with capacity of 170,000m^3/d. It takes water from Miyun Reservoir in summer and Guanting Reservoir in winter. Water is transmitted through a open channel named Beijing-Miyun channel from Miyun Reservoir by gravity and then through pipe line to deliver to Tiancunshan Plant.Miyun Reservoir is non-polluted reservoir with good water guality, but the water guality of Guanting Reservior is worse. Therefore in Tiancunshan, apart from conventional treatment process-floculation, clarification and sand filtration, we use ozonation and granular activated carbon filtration to ensure the reduction of colur, taste and order of water. It gurarantees the every parameter of finished water to meet the drinking water standard.

In order to meet increased demands of water in Past two years, we constructed No.9 Water Treatment Plant. It intakes water from Miyun Reservoir with capacity of 1,000,000m^3/d. This project was divided into two phases.Each phase is 500,000m^3/d. In August of 1988 ,we partly completed the first phase of this project. It eases the situation of water shortage in this summer. In this project, apart from conventional treatment process, we also adopt granular carbon filter to reduce the turbidity of finished water to 0.5 JTU, the colour is under 5 PCU. The threshold order number is under 3. All parameters can meet drinking water standard. In this project, we import many advanced instruments and equipments from abroad.Now we begin the second phase of the project. It is expected to be completed in the end of 1992 . At that time, the situation of domestic and industry water supply in Beijing will be improved.

3. Management and Operation

In the city proper of Beijing, the general layout of the water plants is in the arrangement of dissipation, symmetry and radial-inward, with gridiron distribution network.The company's central control room directs the operation of all distribution pumps and boosting wells. It adopts micro-computer system to monitor the pressure of the distribution network, process data and print out reports. It ensures the pressure of the network of the whole city in equilibrium. The control room of the respective water plants controls the operation of intake and distribution pumps, according to the order of the control room. It also controls the operation of the treatment facilities.

The Company adopts a three-stage examination system for controlling water quality, That is --Company's Centrol Laboratory performs randam sampling examinations and overall checks for raw and treated water and water in distribution network. The laboratory of respective water plant examines 35 parameters according national standard and also checks the water quality between the treatment processes.The operators of water plant examine colour, taste,order and residual chlorine of finished water. The Company's Centrol Laboratory is equipped with advanced water analysis instruments and equipments.The scope of work which includes physical, chemical,bacteriological,biological and other examinations, far exceeds the requirements specified by the national drinking water standard.

Subsiding to the Waterworks Company, there are Water Meter factory, Waterworks Engineering Co., Water Eqip. repairing & mfg. factory,planning and design Dept,Scientific Research Dept. and other divisions. They are responsible respectively for the management and maintanence of water plants and distribution network,researching new technique of water supply,building new water plant and pipelines etc. For tens of years, under the leadship of the Beijing Municipal government and Beijing Municipal Public Utility Bureau,the water supply capacity of the Company increases constantly.We build new water plants invosted by the government. We have kept the low water price. Because of using more and more surface water and long distance water transmission delivering water, the cost of water production rises gradually, causing financial defect of the Company.Through the Beijing Municipal Government gives financial compensation to the Company, this situation is very unfavourable for the development of water supply in Beijing. The Company is now discussing with the Beijing Municipal Government to find the way to solve this problem.

4. Facing the Challenge of Water Shortage

Facing the serious shortage of water resources, what we are doing is rational cultivatation, multiple utilization, active protection and scientific management of water resources. In strategy, we should have to transport water from southeasten of China to north, such as Yangze River to Tianjing and Beijing. However this project needs huge investment. It is impossible to realize in the near futher .In the coming days,the Company has to lay equal stress on both exploration of new water resources and conservation of the existing ones . We are now active to build the second phase of No.9 Water Plant, and the construction of no.10 Water Plant is under consideration. In 1981,the Beijing Municipal Government organized the Beijing Municipal Water Conservation Office which works side by side with Beijing Water-works. The Office makes great efforts to mobilize the whole city to save water. The Office distributes the posters and brochures, makes movies and TV programms and conducts propaganda through news media such as radio station and newspaper for water conservation. Even in schools there are special classes arranged for students to know the importance of water conservation from childhood. The Office also makes great effort for the increasing of industrial water reuse rate , carrying out progressive water charge and pre-planned water consumption for the large industries , installation of domestic water meters and abolishing ot the fixed-rate payment system for dwellers of city housings, the promotion of water saving techniques, as well as the researching, manufactuering and popularizing of water saving equipments and devices, the minimization of water loss rate, promoting domestic waste-water reuse techniques and awarding the advanced orgnizations of water conservation. All of these efforts is highly effective in past years, although the city construction is growing and people's living condition is developing rapidly, due to the great increment of water saving, the amount of water sold increased slowly, the tense situation of demand has been eased moderately.

Beijing Municipal Waterworks Co. sincerely wishes to extend wide and close contact with our colleagues abroad, and at the same time to widen the scope of technical exchange incessantly, so that valuable experiences can be learnt from one another, and the development of the city water supply work can be promoted by joint effort.

September. 1988.

Water supply in fast growing cities (isn 5751, A'dam 19-21 sept. '88

WATER SUPPLY AND SANITATION

IN FAST GROWING CITIES

by

Carlo Rietveld

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1. The first fact that needs to be confronted in a discussion of urban water supply and sanitation is that the demand for these services will continue to grow dramatically in the years ahead. This growth in demand is a product of two forces:

(a) the rapid growth in population and in particular the urban population that is taking place everywhere (Fig. 1); and

(b) The need to provide coverage for those currently unserved, as well as to improve currently inadequate, insufficient service in many cities of the world.

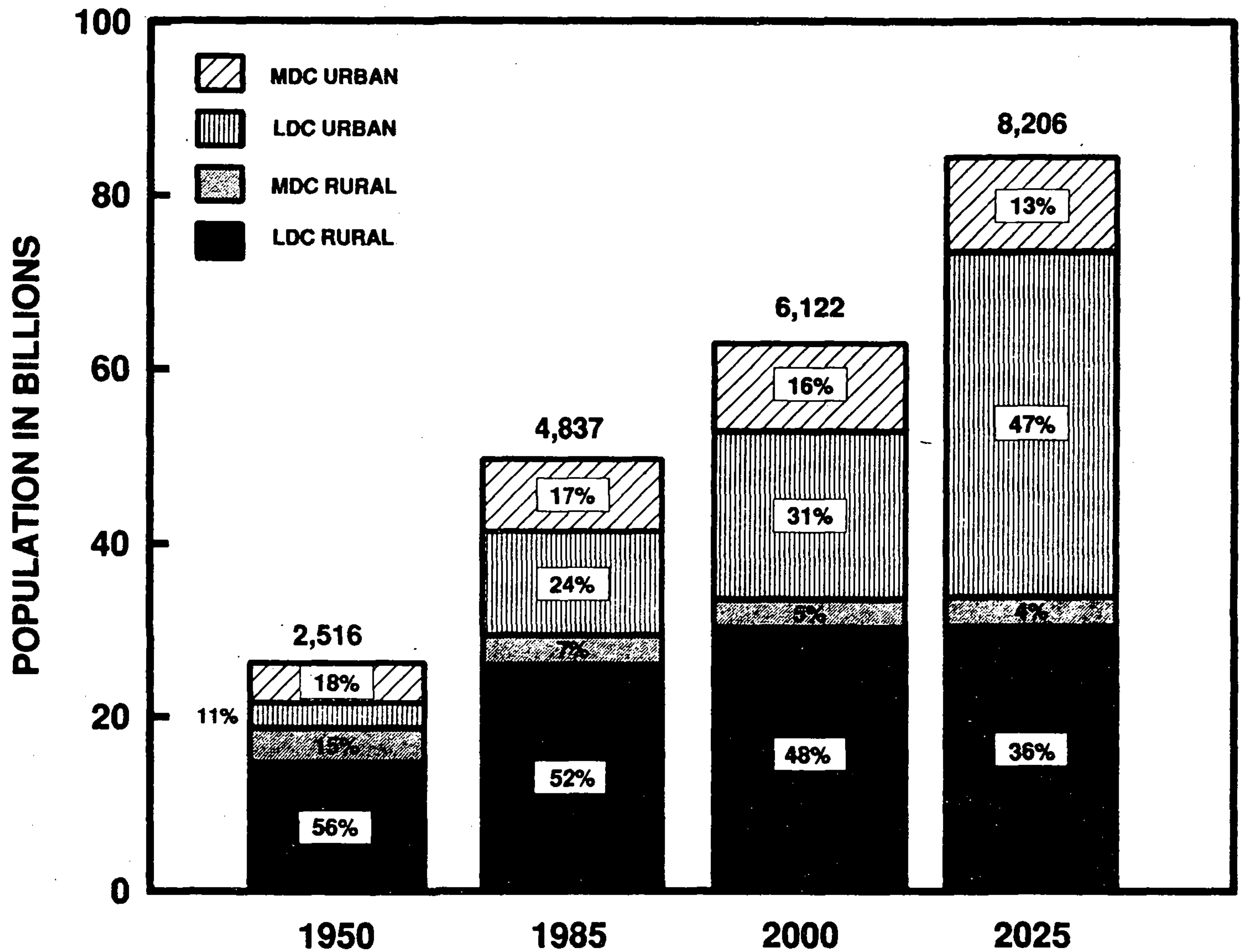
Trends in Urbanization

2. Aside from the growth of world population itself, urbanization is the dominant demographic trend of the late twentieth century Worldwide. The number of people living in cities increased from 600 million in 1950 to over 2 billion in 1986. In developing countries during the same period, urban population is estimated to have quadrupled, growing from about 300 million to 1.2 billion. If this growth continues unabated, more than half of humanity will reside in urban areas shortly after the turn of the century.

3. This urban population explosion is a new phenomenon in history. Historically, world population has been overwhelming rural, with the number and size of urban settlements increasing slowly and sporadically. As recently as 1900 less than 14% of the world's people lived in cities.

4. The first known cities evolved 5,000 years ago on the Nile, Tigris, and Euphrates rivers when traditionally nomadic peoples began to cultivate crops. Food surpluses resulting from successive agricultural advances, such as the harnessing of draft animals and the development of irrigation, enabled farmers to support nascent villages and towns.

WORLD POPULATION
1950-2025



SOURCE: UN - "WORLD DEMOGRAPHIC ESTIMATES AND PROJECTIONS", 1988

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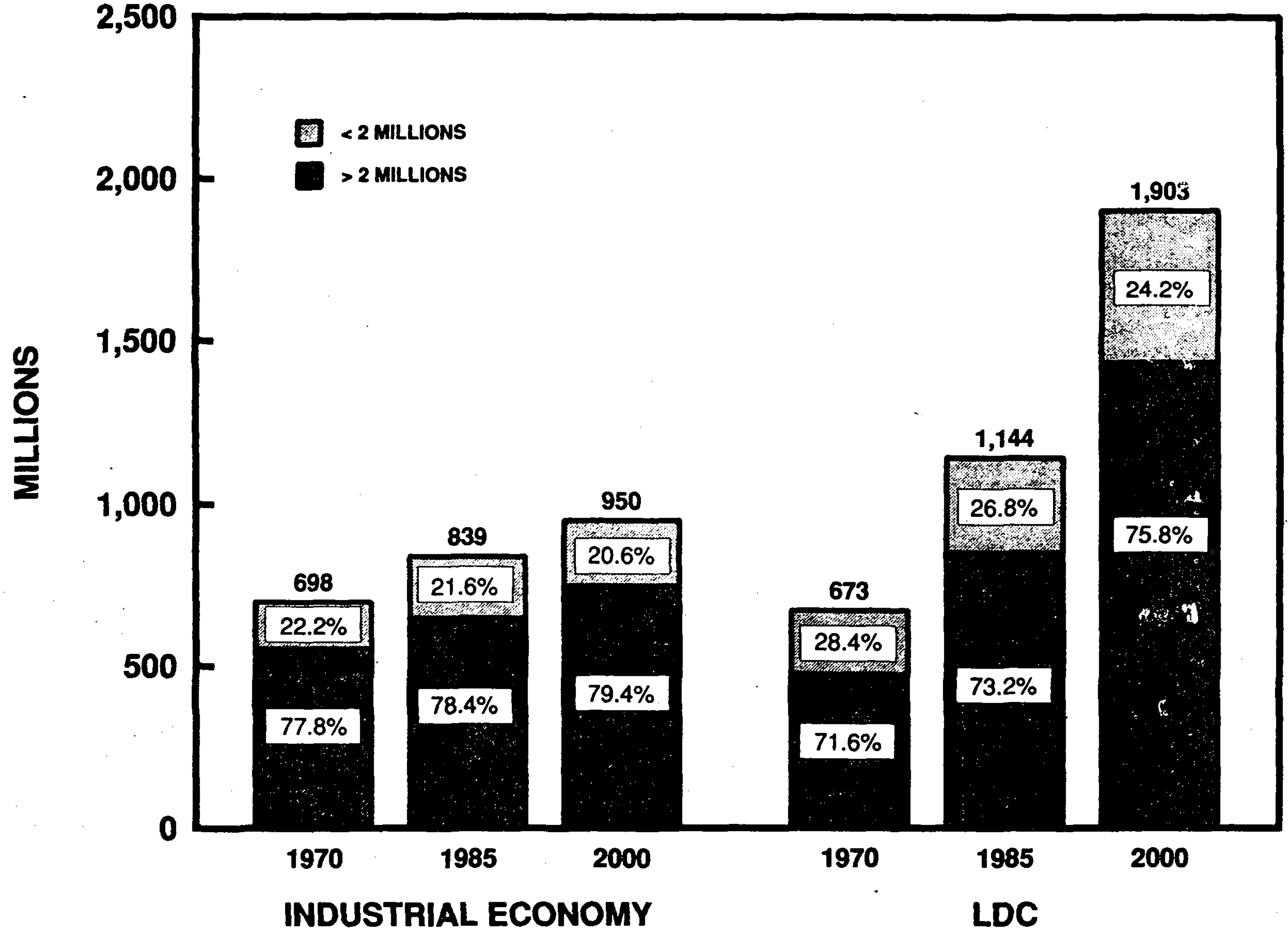
Figure 1

5. Diversification of trade and the production of a wider array of goods encouraged the continued development of human settlements. Pre-industrial cities, such as second-century Rome and Chang'an (Xian), imperial capital of the Chinese T'an dynasty, arose on nearly every continent. Advances in science and the arts seem to have depended on the dynamics of a "human implosion" as the population density of ancient cities speeded the exchange of ideas and innovations. Urban historian Lewis Mumford has noted that the maturation of cities in Greece, for example, culminated in a "collective life more highly energized, more heightened in its capacity for esthetic expression and rational evaluation" than ever before.

6. Technological change and the availability of vast energy supplies dovetailed in the nineteenth century to foster the development of large, modern cities. In 1800, on the eve of the Industrial Revolution, for example, about one-fourth of the British lived in cities; by 1900, two-thirds of the population was urban. Coal, replacing firewood as the dominant energy source in Europe, fueled this urban growth. It was later supplanted by oil, which has supported the massive urbanization of the late twentieth century, providing cheap fuel for transportation and the consolidation of industrial processes.

7. Urbanization has accelerated in recent decades as a consequence of three demographic factors: migration from rural areas, natural increase (the excess of births over deaths), and reclassification of rapidly developing rural areas to cities. Migration is most important in the early stages of urbanization, as in Africa today, while natural increase now dominates city growth in parts of Asia and throughout Latin America. At the current growth rate of 2.5 percent yearly - half again as fast as world population - the number of people living in cities throughout the world will double in the next 28 years. Nearly nine-tenths of this expansion will occur in the Third World, where the annual urban growth rate is 3.5 percent - more than triple that of the industrial world (Fig. 2.) While the high urban population growth rates of recent decades have been slowing down, there is no reason to expect that the general trend of urban growth will be reversed.

WORLD URBAN POPULATION IN URBAN CENTERS OF



SOURCE: UN - WORLD POPULATION PROSPECTS, 1986

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Figure 2

Trends by Geographic Region

8. The following table shows the trends in urbanization by geographic region:

Table 1: Urban Share of Total Population, 1950 and 1986 with Projections to 2000

Region	1950	1986	2000
		(percent)	
North America	64	74	78
Europe	56	73	79
Soviet Union	39	71	74
East Asia	43	70	79
Latin America	41	65	77
Oceania	61	65	73
China	12	32	40
Africa	15	30	42
South Asia	15	24	35
World	29	43	48

Sources: Population Reference Bureau, Washington, D.C.

As this table shows, urbanization is proceeding rapidly in all parts of the world (see also Tables 1 and 2).

9. In Africa, the least urbanized continent, urban population is growing 5 percent yearly as millions of Africans fleeing environmental degradation and rural poverty migrate to cities. Today 175 million Africans live in cities - 30 percent of the continent's total. If current projections materialize, this number will reach 368 million in 2000, a tenfold increase since 1950. The highest growth rates have occurred in Sub-Saharan Africa where many cities grew more than seven-fold from 1950 to 1980. Examples are Nairobi, Dar es Salaam, Abidjan, Lusaka, Lagos, and Kinshasha.

10. During the same period, numerous cities in Asia have tripled or quadrupled their populations, for example Baghdad, Bombay, Dhaka, Jakarta, and Seoul. Latin America, with 65 percent of its people in urban areas, is the site of some of the world's largest cities: Mexico City and Sao Paulo contain 18 million and 14 million people, respectively. By the turn of the

WORLD URBAN AND RURAL POPULATION

1950 - 2025

	1950	1960	1970	1980	1985	1990	2000	2010	2020	2025
World Population (000)	2515652	3018878	3693221	4449567	4836645	5246209	6121813	6989128	7822193	8206765
Urban Population (000)	734096	1031866	1370444	1763990	1982536	2233762	2853017	3622413	4487977	4931628
Urban Population (%)	29.2	34.2	37.1	39.6	41	42.6	46.6	51.8	57.4	60.1
Rural Population (000)	1781556	1987511	2322777	2685578	2854109	3012447	3268796	3366715	3334216	3274137
Rural Population (%)	70.8	65.8	62.9	60.4	59	57.4	53.4	48.2	42.6	39.9
MDC Population (000)	831857	944909	1047392	1136668	1173811	1209777	1276647	1331199	1376686	1396476
Urban Population (000)	447315	571414	697839	798148	838815	877126	949893	1011324	1063394	1086537
Urban Population (%)	53.8	60.5	66.6	70.2	71.5	72.5	74.4	76	77.2	77.8
Rural Population (000)	384542	373495	349553	338520	334995	332651	326754	319874	313291	309939
Rural Population (%)	46.2	39.5	33.4	29.8	28.5	27.5	25.6	24	22.8	22.2
LDC Population (000)	1683796	2073969	2645829	3312899	3662835	4036432	4845166	5657929	6445508	6809289
Urban Population (000)	286782	459953	672605	965842	1143721	1356636	1903123	2611088	3424583	3845090
Urban Population (%)	17	22.2	25.4	29.2	31.2	33.6	39.3	46.2	53.1	56.5
Rural Population (000)	1397014	1614016	1973224	2347057	2519114	2679796	2942043	3046841	3020925	2964198
Rural Population (%)	83	77.8	74.6	70.8	68.8	66.4	60.7	53.8	46.9	43.5

Notes: MDC = More Developed Countries
LDC = Less Developed Countries

Source: UN - "World Demographic Estimates and Projections - 1950-2025", 1988

Table 1

LESS DEVELOPED COUNTRIES
1950 - 2025
(by UN regional groupings)

REGIONS/COUNTRIES	1950	1960	1970	1980	1985	1990	2000	2010	2020	2025
Africa Population (000)	224361	280051	360751	479456	554928	645282	871817	1157528	1467821	1616515
Urban Population (000)	35295	52598	81237	129300	164702	210756	340756	529209	767285	895992
Urban Population (%)	15.7	18.8	22.5	27	29.7	32.7	39	45.7	52.3	55.4
Rural Population (000)	189066	227453	279514	350157	390226	434526	531060	628319	700535	720523
Rural Population (%)	84.3	81.2	77.5	73	70.3	67.3	61	54.3	47.7	44.6
Latin America Population (000)	164810	216754	283407	361378	404806	451072	546395	641978	735008	778662
Urban Population (000)	67544	106731	162570	236119	279110	324857	419432	514346	609283	655152
Urban Population (%)	41	49.2	57.4	65.3	69	72	76.7	80.1	83	84.1
Rural Population (000)	97266	110024	120837	125253	125696	126216	126963	127632	125726	123510
Rural Population (%)	59	50.8	42.6	34.7	31	28	23.3	19.9	17	15.9
Asia Population (000)*	737344	916577	1167038	1470950	1637951	1809969	2163374	2494367	2795920	2927908
Urban Population (000)	122783	175389	261541	395886	480197	578913	826981	1134812	1474489	1645348
Urban Population (%)	16.7	19.1	22.4	26.9	29.3	32	38.2	45.5	52.7	56.2
Rural Population (000)	614561	741188	905497	1075063	1157755	1231055	1336393	1359555	1321433	1282561
Rural Population (%)	83.3	80.9	77.6	73.1	70.7	68	61.8	54.5	47.3	43.8
China Population (000)	554760	657492	830675	996134	1059521	1123815	1255895	1354942	1436320	1475159
Urban Population (000)	60969	124892	166555	203457	218405	240538	313703	429528	569191	643642
Urban Population (%)	11	19	20.1	20.4	20.6	21.4	25	31.7	39.6	43.6
Rural Population (000)	493791	532600	664120	792677	841115	883277	942192	925414	867128	831516
Rural Population (%)	89	81	79.9	79.6	79.4	78.6	75	68.3	60.4	56.4
Oceania Population (000)**	2520	3095	3958	4986	5628	6295	7685	9115	10438	11045
Urban Population (000)	190	343	701	1079	1306	1571	2251	3194	4335	4957
Urban Population (%)	7.5	11.1	17.7	21.6	23.2	25	29.3	35	41.5	44.9
Rural Population (000)	2330	2752	3256	3907	4323	4723	5434	5921	6103	6087
Rural Population (%)	92.5	88.9	82.3	78.4	76.8	75	70.7	65	58.5	55.1
Europe Population (000)***	150270	164559	177412	191834	197623	203099	214078	223110	230002	233140
Urban Population (000)	60024	74934	92541	111342	119546	127375	142836	156461	167614	172630
Urban Population (%)	39.9	45.5	52.2	58	60.5	62.7	66.7	70.1	72.[illegible]	74
Rural Population (000)	90246	89624	84872	80492	78077	75724	71242	66650	62390	60508
Rural Population (%)	60.1	54.5	47.8	42	39.5	37.3	33.3	29.9	27.1	26

NOTES: * Excludes Japan and China
** Excludes Australia and New Zealand
*** Excludes European industrialized countries

Source: UN - "World Demographic Estimates and Projections - 1950-2025", 1988

Table 2

century, over three-fourths of Latin America's 563 million people are expected to inhabit cities. These high urban growth rates have been accompanied by a rapid expansion of peri-urban slum areas populated by low-income families living in dilapidated housing on small plots of land to which they often have no legal title.

11. Cities of more than 5 million can now be found on every continent. Urban projections for the year 2000 indicate that three out of the five cities with populations of 15 million or more will be in the Third World - namely, Mexico City, Sao Paulo, and Calcutta. Asia will contain 15 of the world's 35 largest cities. In Africa, only Cairo is now in the 5 million category, but by the end of the century, the continent is projected to have at least eight such centers (see Figures 3, 4, and 5 and Table 3).

12. These recent urbanization trends in the Third World are unparalleled historically. Between 1800 and 1910, Greater London's population grew almost seven-fold, from 1.1 million to 7.3 million, an increase now achieved within a generation in many Third World cities. Similarly, Paris took more than a century to expand from 547,000 to about 3 million, a growth matched by some Third World cities just since World War II. Moreover, the population bases to which today's high urban growth rates are adding are often dramatically larger than those in the past.

Implications for Water and Sanitation

13. The trends described above provide the setting within which future demand for urban water and sanitation services - as well as the problems of satisfying the service demand - need to be discussed. The demand includes three components:

(a) The unsatisfied needs of urban populations who are presently unserved or have access to sub-standard facilities which do not meet even minimum standards of health and convenience;

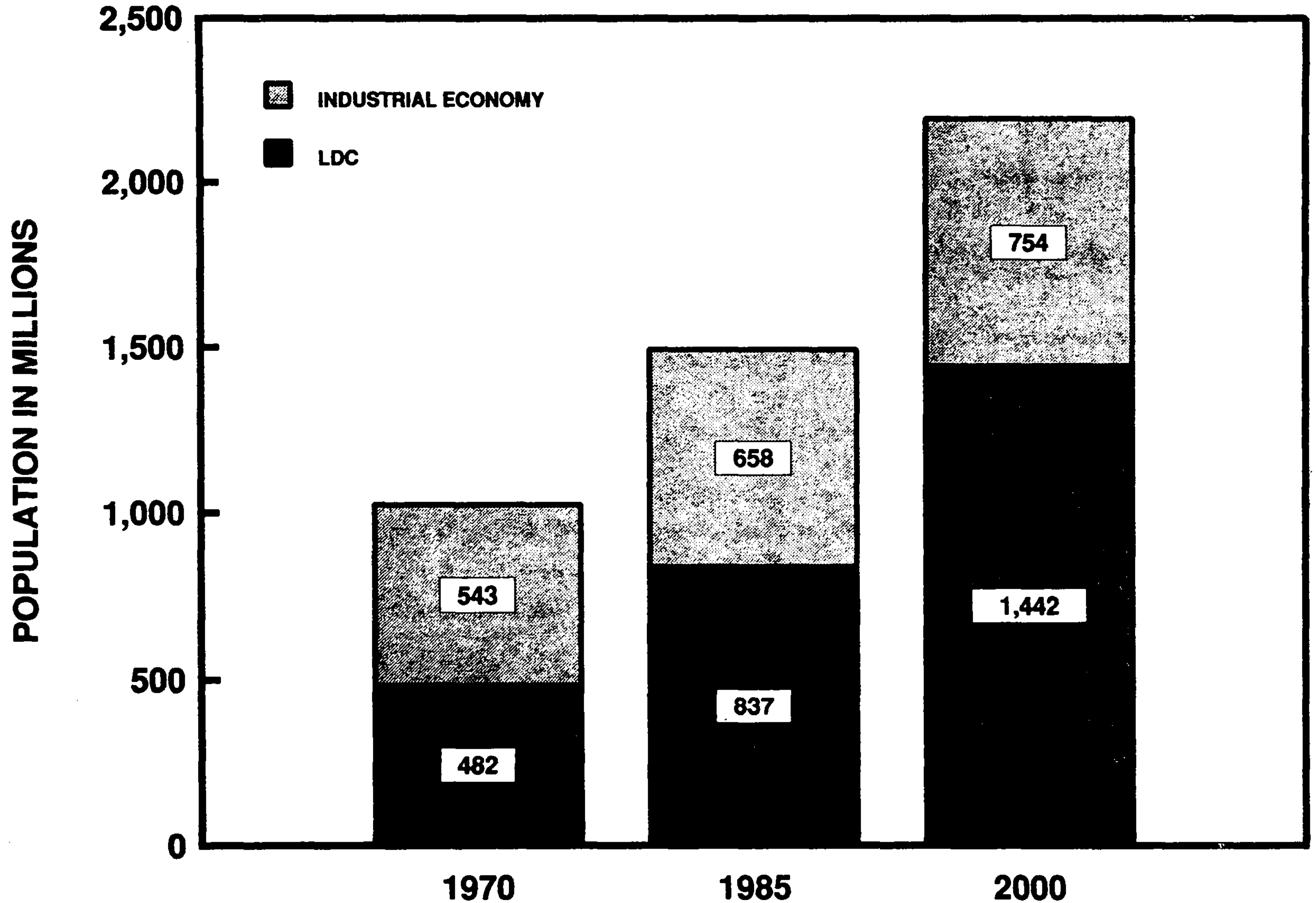
(b) future needs arising from the urban growth trends reviewed above; and

(c) the requirements for sustaining services through maintenance, rehabilitation and eventual replacement of systems.

14. The problems, obviously, are most acute in developing regions of the world where the great bulk of the world's population resides and the following remarks pertain primarily to developing countries.

15. Data on present service coverage are not very complete or reliable but the best statistics available indicate that in 1985 approximately 66% of urban populations were covered by

WORLD URBAN POPULATION
(IN CITIES WITH UNDER 2 MILLION BY 1985)



SOURCE: UN - WORLD POPULATION PROSPECTS, 1986

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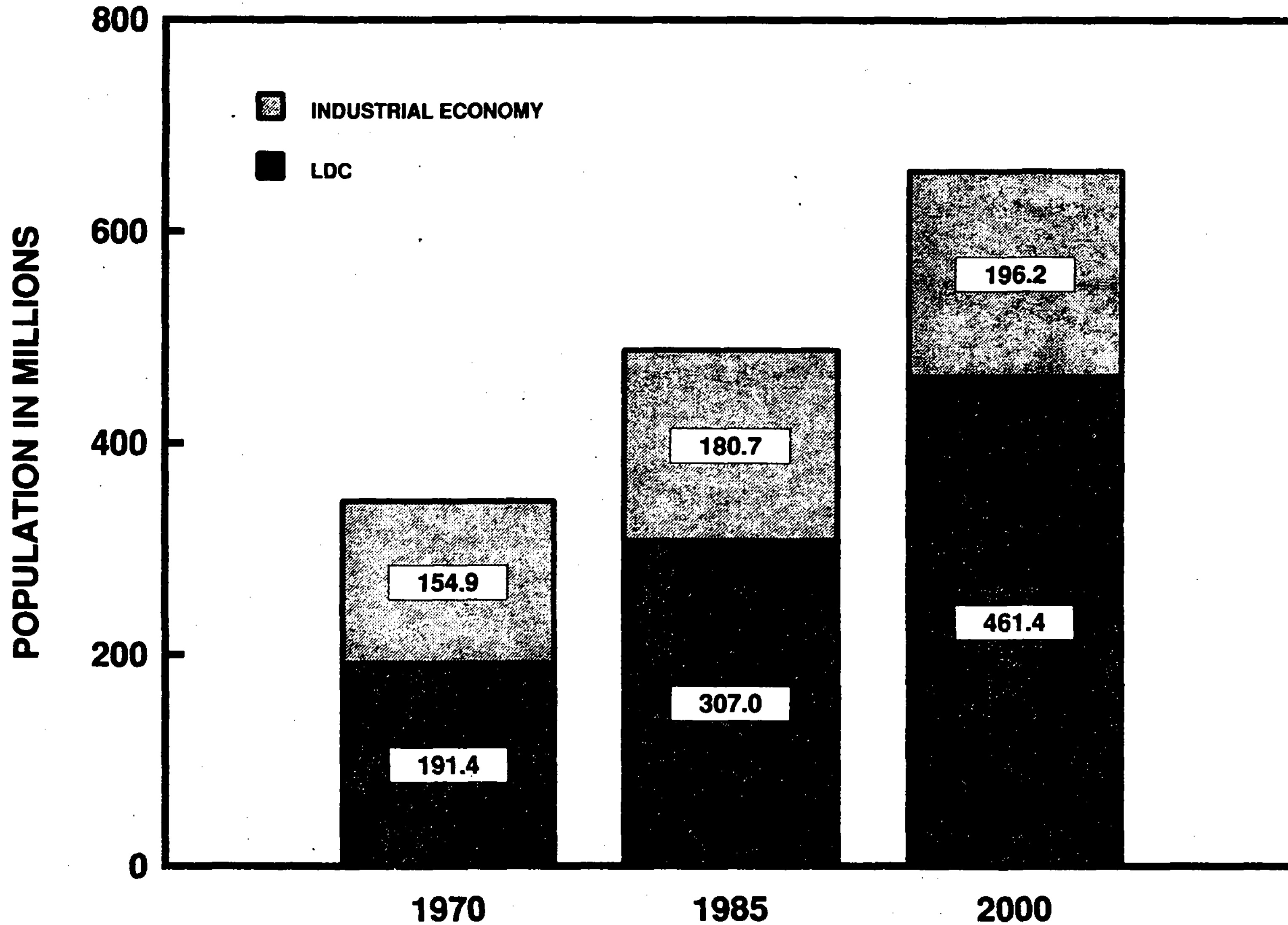
Figure 3

WORLD URBAN POPULATION
(IN CITIES WITH OVER 2 MILLION BY 1985)



SOURCE: UN - WORLD POPULATION PROSPECTS, 1986

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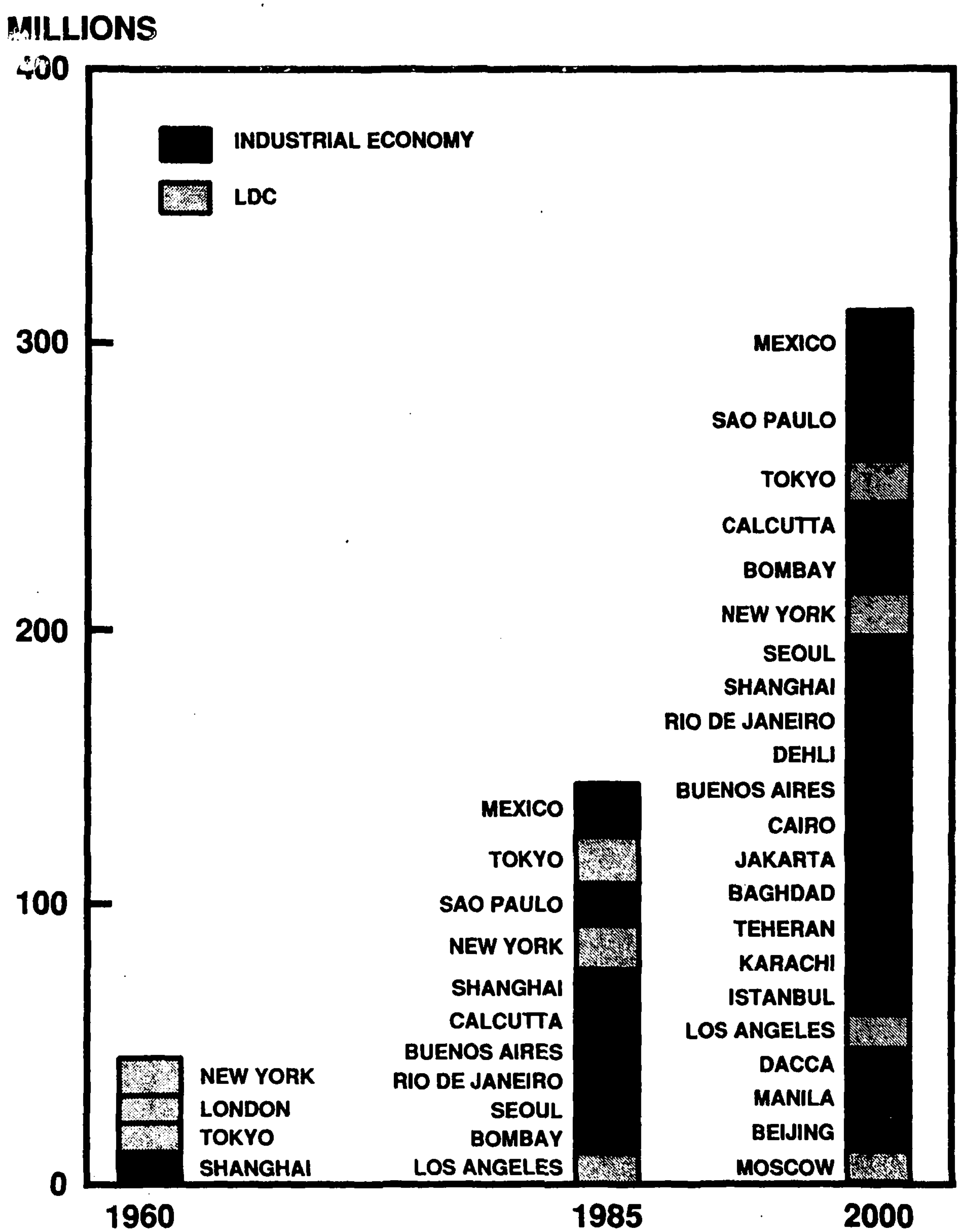
Figure 4

URBAN CENTERS (OVER 10 MILLION PEOPLE)



SOURCE: UN COMPENDIUM OF HUMAN SETTLEMENTS STATISTICS, 1983

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POPULATION AND NUMBER OF CITIES IN A PARTICULAR SIZE CLASS, MAJOR AREAS, 1975-2000

(Population in thousands)

Size class (thousands)	1975	1980	1990	2000
World				
Urban population	1 560 859	1 806 808	2 422 292	3 208 027
4 000+	241 809	311 462	465 112	742 323
Number of cities	30	38	52	86
2 000-3 999	133 344	154 711	242 957	279 835
Number of cities	48	58	86	105
1 000-1 999	150 236	186 838	275 583	344 519
Number of cities	107	139	204	248
500-999	160 330	176 552	222 687	
Number of cities	227	255	327	
250-499	152 099	172 302		
Number of cities	441	497		
More developed regions				
Urban population	767 301	834 400	969 225	1 092 469
4 000+	121 235	141 610	170 610	207 272
Number of cities	13	16	19	25
2 000-3 999	72 486	72 658	99 006	96 451
Number of cities	26	27	36	36
1 000-1 999	77 432	99 370	118 906	131 119
Number of cities	56	74	89	94
500-999	79 918	79 763	98 330	
Number of cities	110	116	149	
250-499	81 871	89 710		
Number of cities	238	259		
Less developed regions				
Urban population	793 558	792 408	1 453 067	2 115 558
4 000+	120 574	169 852	294 502	535 051
Number of cities	17	22	33	61
2 000-3 999	60 858	82 053	143 951	183 384
Number of cities	22	31	50	69
1 000-1 999	72 804	87 468	156 677	213 400
Number of cities	51	65	115	154
500-999	80 412	96 789	124 357	
Number of cities	117	139	178	
250-499	70 228	82 592		
Number of cities	203	238		
A. *Africa*				
Urban population	103 032	132 951	219 202	345 757
4 000+	6 415	7 464	19 703	67 982
Number of cities	1	1	3	11
2 000-3 999	4 522	10 522	32 808	45 953
Number of cities	2	4	12	17
1 000-1 999	12 193	18 499	30 852	40 685
Number of cities	9	14	22	29
500-999	13 802	17 747	22 538	
Number of cities	21	26	32	
250-499	14 051	15 300		
Number of cities	41	44		
B. *Latin America*				
Urban population	198 366	240 592	343 304	466 234
4 000+	44 837	59 485	102 998	165 323
Number of cities	5	6	10	17
2 000-3 999	16 276	26 643	34 033	22 226
Number of cities	6	10	11	8
1 000-1 999	16 476	15 173	27 136	44 609
Number of cities	11	11	21	32
500-999	15 431	17 574	26 024	
Number of cities	22	25	38	
250-499	13 794	20 508		
Number of cities	41	61		

Source: UN - "Patterns of Urban and Rural Population Growth", 1980 adequate water services and about 35% by adequate sanitation services. The World Bank estimates that taking account of existing world economic conditions and population trends, it is likely that these percentages will rise, in the case of water coverage, to only about 68% in 1990 and 75% by the year 2000; and in the case of urban sanitation, to about 38% in 1990, and 50% by 2000 (Figures 6 and 7, and Table 4).

16. Achievement of even these small percentage gains will require the solution of a number of very formidable problems. These can be classified under four main headings:

(a) Investment requirements;

(b) Technology selection;

(c) Sectoral and Institutional Issues; and

(d) Political will of governments.

<u>Investment Requirements</u>

17. The investments needed to expand service by the percentages cited above between 1985 and 1990 are quite large. The Bank puts the figure at $22 billion for urban water supply services, or $120 for each additional person covered. For urban sewerage/sanitation the estimated cost is $19 billion or $150 per person. The total cost is $41 billion in 1985 dollars, assuming that simplified technologies will be used wherever possible. This means that the yearly investments should increase by over 50% for urban water and over 75% for sanitation (Fig. 8 and Table 4). If only conventional means were used, the costs would be considerably higher.

18. To meet the coverage targets for the period 1991 - 2000 shown in Figures 6 and 7, capital costs would be on the order of $200 billion in 1985 dollars, again assuming extensive use of low-cost technologies. The figures would be higher if allowance were made for expanded industrial and commercial uses of water. The annual investment required to reach these targets would be equal to 5% of total domestic investment in the low-income and lower-middle-income countries in 1985. Currently, the share of total domestic investment in the sector is estimated to be nearer to 2% than 5%. World Bank lending for the 1991 - 2000 period, at $900 million annually, is likely to finance less than 6% of the total required. Thus, unless the sector moves toward becoming a net revenue producer, sectoral investments are likely to fall short of the above targets. This will only be possible if a number of inter-related sectoral issues are addressed.

19. Unfortunately, the prospects for mobilizing the needed investments are far from bright given prevailing and projected economic conditions in most developing countries. Overall economic growth is generally slow, real per capita income is flat

POPULATION SERVED BY WATER SUPPLY

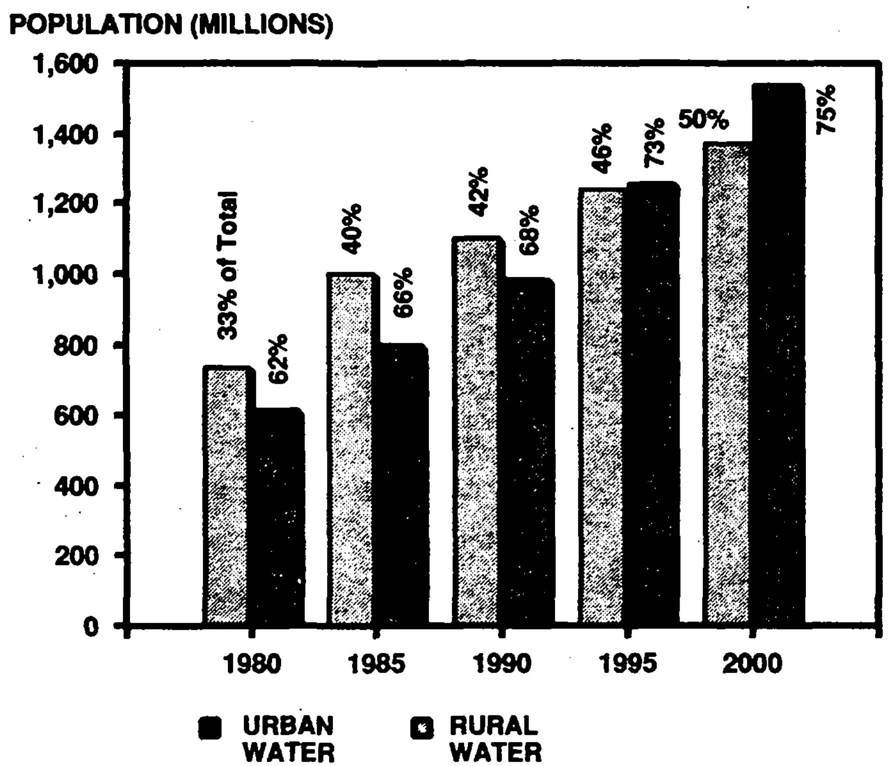

Figure 6

POPULATION SERVED BY SANITATION SERVICES

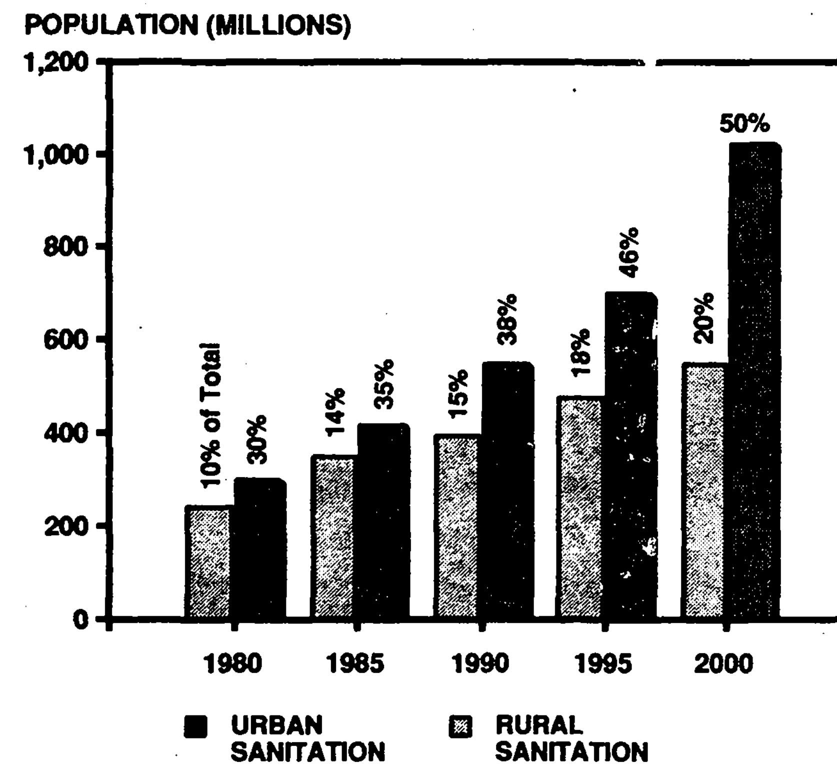

Figure 7

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Table 4

Water Supply and Sanitation Annual Sector Review FY88
Water Supply and Sanitation Services and Investment Requirements
Developing Countries 1/

	1980 Number (10^6)	1980 %	1985 Number (10^6)	1985 %	Annual Growth % 1985-1990	1990 Number	1990 %	Annual Growth % 1990-2000	2000 Number	2000 %
Population										
Urban	990	29	1200	31	(3.8%)	1446	36	(3.5%)	2050	43
Rural	2380	71	2500	69	(0.9%)	2614	64	(0.5%)	2750	57
TOTAL	3370	100	3700	100	(2.0%)	4060	100	(1.75%)	4800	100
Served										
Urban										
Water Supply	614	62	800	66		983	68		1538	75
Sanitation	300	30	420	35		550	38		1025	50
Rural										
Water Supply	735	33	1000	40		1100	42		1375	50
Sanitation	238	10	350	14		392	15		550	20

	Incremental Population to be Served: 1985 - 1990 Pop. 10^6	US$ 1985 Cost/person	Total Cost in 10^6 (1985 US$)	Incremental Population to be Served 1991-2000 Pop. 10^6	Cost/ Person	Total Cost in 10^6 (1985 US$)
Urban						
Water Supply	183	120	21960	555	120	66600
Sanitation	130	150	19500	475	150	71250
Sub-total			41460			137850
Rural						
Water Supply	100	40	4000	275	40	11000
Sanitation	42	20	840	158	20	3160
Sub-total			4840			14160

Urban/year : $8.3 Billion
Rural/year : 1.0 Billion

Bank Investment in WSS/year 1986-1990 in lending at $900 million would finance about 10% of expected investments

Urban/year : $13.8 Billion
Rural/year : 1.4 Billion

Bank investments in WSS/year 1991-2000 in lending at $900 million/year would finance only about 6% of expected investments.

1/ Sources of information: the International Drinking Water Supply and Sanitation Decade - 1985 and 1987 - WHO World Development Report 1988 - World Bank World Resources 1987 - IIED and World Resource Institute Progress in the attainment of the goals of the IDWSSD - Report of the Secretary General 1985 Internal documents of the World Bank.

INVESTMENT REQUIREMENTS TO SERVE ADDITIONAL POPULATION

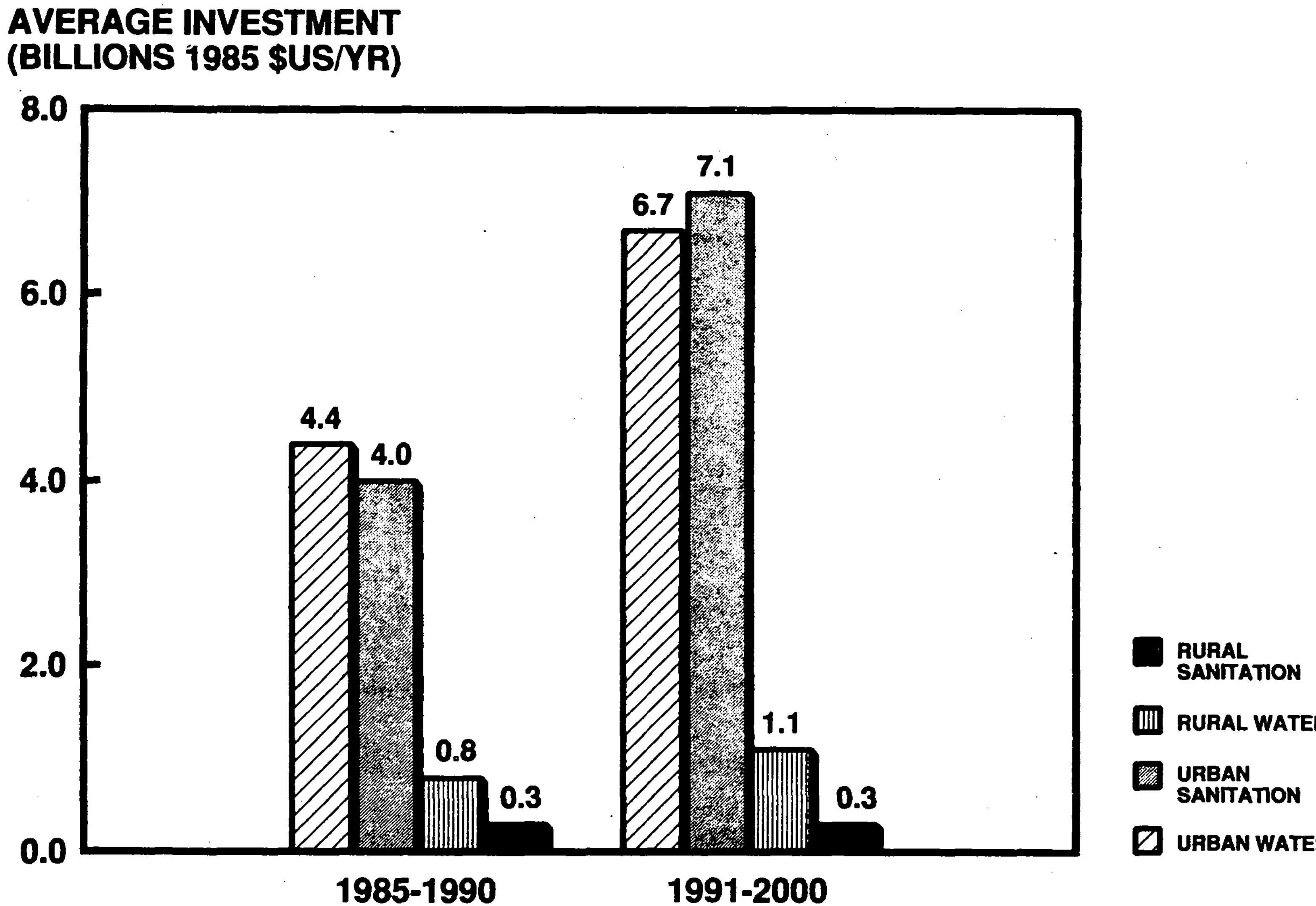

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Figure 8

or declining, except for most countries of the Pacific basin, and overall investments are shrinking, -- including both the share of the gross domestic product available for investment and the share allocated to social investment. Adjustment efforts have focused on the tradable goods sector and public expenditures control. Inflation in many countries is high and nominal and real interest rates volatile. Lowered incomes reduce consumers' ability to pay, while shrinking investment decreases the ability to supply services. The same situation affects international trade and export earnings, reducing the ability of countries to service additional borrowing to make up for lower domestic investment.

20. Macro-economic problems are most acute in Sub-Saharan Africa and in heavily indebted countries in Africa (Cote d'Ivoire and Nigeria) and elsewhere. The degree of macro-economic stringency, however, is substantially different in different regions. Annual growth rates in GDP per capita were strongly positive from 1980 to 1987 in Asia (4.7) and slightly positive in the Middle East (0.8). Annual growth rates in GDP per capita in Latin America were negative (-1.2) and seriously negative in Sub-Saharan Africa (-3.4). In these circumstances, most countries have not been able to keep up with the water and sanitation service requirements of their expanding populations, much less reduce the enormous service deficiencies of the past.

Technology Selection

21. As mentioned, the above investment estimates assume extensive use of low-cost technologies for the extension of water and sanitation coverage. Given the magnitude of the amounts involved it is clearly necessary to reduce capital costs as much as possible. Apart from consideration of cost, it would also be extremely difficult now to try to equip old, heavily congested and over-built urban areas in Africa and Asia with modern water-borne sewerage systems, for example. Technology selection is, accordingly, a major factor in coping with the demand for water and sanitation services.

22. In the case of water supply, this means maximum possible reliance on handpumps, community stand-pipes, measured-volume yard-taps, roof catchment systems and similar low-cost technologies, particularly in peri-urban and low-income urban areas where residents are not able to pay service charges for conventional piped-water systems. Over the past eight years, under the auspices of the International Drinking Water Supply and

Sanitation Decade, considerable progress has been made in improving the quality and lowering the cost of the technologies just referred to, as well as in promoting their local manufacture.

23. In the sanitation sector, considerable research has been devoted to the development of low-cost on-site facilities, notably Ventilated Improved Pit (VIP) latrines, and Pour-flush toilets of various types suited to the needs of rural and peri-urban areas, Little attention, however, has been paid to the need for lower cost intermediate technologies suited to the income-levels and service preferences of the urban middle class, perhaps the fastest growing portion of the urban population in many developing countries. Substantial progress has been made in industrialized countries in developing such technologies for smaller communities, including small-bore and shallow sewers; simplified sewer systems; condominial systems, etc. These technologies are largely unknown and therefore un-applied in developing countries, except for a few of the more advanced countries, e.g., in Latin America. There is an urgent need here for technology transfer to less developed countries and an organized effort to promote their use in fast-growing urban centers around the world.

<u>Sectoral and Institutional Issues</u>

24. In addition to investment generation and technology, a number of other issues need to be tackled to cope with the steadily rising demand for urban and water sanitation services. These include:

(a) How to use the sector's existing assets more effectively;

(b) How to expand the asset base more efficiently;

(c) How to improve organization and management; and

(d) How to get the needed financial resources for the efficient operation and maintenance of facilities.

25. Resolution of these issues will require, among other things, improved management, operation and maintenance of systems already in place; better matching of the size and level of service of new projects to the ability of the beneficiaries to pay; more accurate estimates of demand for service; use of greater variety of technical options based on what communities can afford; and generation of a larger share of financial resources for the systems within the communities they serve through user charges. Appropriate rate structures and more efficient cost recovery mechanisms need to be developed.

26. Financing issues require special attention since the contribution of borrowing countries to sectoral financing and the

necessary mechanisms to ensure continuity and sufficiency of financing to water supply and sanitation service institutions are problematic in the current circumstances. The ultimate financing base in the sector consists of the charges made to the users of the services. The financial stability of supply institutions depends upon their ability to generate sufficient cash flows to operate and maintain their facilities and to service financial obligations owed to others. In the current macroeconomic context of many borrowing countries, it is unrealistic to expect increasing or, even, stable flows of funds from other municipal or national tax revenues. At the same time, sectoral investment is usually heavily front-end loaded; i.e., the funds for capital improvement are needed well before the services they will provide can be delivered, and borrowing will be necessary. Thus the sector has a strong need for the development of well-functioning capital markets as well as for improvements in their own charging systems and related financial operations.

27. In addition to the technical choices and their financing, it is increasingly important in several regions and many countries to improve the management of water resources. While there is no global water resource shortage, the resources are not distributed evenly or proportionally to desired use and there are some severe regional and local shortages. In many cases, the availability of usable water is reduced by pollution of both surface and groundwater sources. In most places water is wasted or mismanaged. Studies in a number of countries show that mis-use and wastage can be significantly reduced by levying higher water charges. This situation presents a classical coordination problem among public and private service institutions and the multiple users they serve --national ministries and local service institutions, urban and rural residents, groups needing water for irrigation and for drinking water, those using water and those concerned with the environment. The lack of coordination in water resource management is reflected in the lack of application of market pricing principles. Additionally, pricing policies for water use which exist are often highly inconsistent and not necessarily related to either demand or to supply costs.

28. Another question that arises is to what extent the traditional sector institutions that have been established to develop and manage conventional piped-water and water-borne sewerage systems are the appropriate organizational structures to deal with lower-cost non-conventional technologies. Formal urban institutions often have little financial incentive to extend services to the poor, or facilitate community-based methods of extending service. In addition, conventional systems customarily have two components viz. a public property component (water mains, sewer pipes); and a private service component (house pipes and taps, private plumbing) accessible only to the house-holder. The traditional institutional organizations and mechanisms established for the provision and management of the public service component of conventional systems are not necessarily

equipped to provide the low-cost on-site facilities which may be needed to meet the service requirements of lower-income users.

<u>Political Will of Governments</u>

29. In the last analysis, provision of adequate water and sanitation services in the fast-growing urban centers of the world will depend in large measure on the priority which governments assign to the sector in their own budget allocations, as well as on the steps they take to involve the private sector, including urban residents themselves, in the development effort, since public investment on the scale needed will not be available. One of the achievements of the IDWSSD has been to draw world attention to the importance of safe drinking water and adequate sanitation, resulting in higher priority being given to this neglected sector in the development of many governments' development plans. This applies, however, more to the water sector than to sanitation, for which there is no effective "lobby" at this time. It is essential that world attention continue to be focussed on urban water and sanitation needs because if urban population growth continues to outstrip available services, serious environmental and health problems are the likely outcome.

CONFERENCE ON

'WATER SUPPLY IN FAST GROWING CITIES'

AMSTERDAM, 19 - 21 SEPTEMBER 1988

LIST OF PARTICIPANTS IN ALPHABETICAL ORDER PER COUNTRY,

AS PER 15 SEPTEMBER 1988

INTERNATIONAL CONGRESS CENTRE RAI

AMSTERDAM, THE NETHERLANDS

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