2.6 Water Supply System in Metropolitan Lima

2.6.1 Outline

The history of Lima's water supply began in the 16th century, when it was a Spanish colony and water for drinking was obtained from wells. The modern system dates from 1955 when the "Atarjea" Water Treatment Plant and the water supply network was constructed.

The water treatment capacity is 5.0 m^3/sec (432,000 m^3/day) and is made up of 4 upward flow sludge blanket type clarifiers and 36 rapid sand filters.

In the decade from 1960 to 1970, expansion works increased the treatment capacity first to 2.5 m^3/sec and then to 10 m^3/sec or 864,000 m^3/day. Presently, the first stage of the Atarjea Plant No. 2 is completed (5.0 m^3/sec) with a treatment capacity of 15 m^3/sec but the system installed in 1955 is so old that it only has a capacity of 90%.

In addition to water from the Atarjea, which source is the Rimac River, there are 326 wells in Metropolitan Lima (263 in operation and the rest in maintenance or on reserve).

The majority of the wells have a depth of 100 - 150 meters and the total capacity obtained to date (1989) is 7.15 - 7.50 m^3/sec (610,000 - 648,000 m^3/day), a quantity approximately equivalent to 40% of SEDAPAL's total water supply capacity. Installation of the distribution pipes is proceeding at a fast pace and has now new reached a total length of 6,100 km (1989).

TABLE 2-29 and FIGURE 2-8 shows the statistics on water service coverage of SEDAPAL. Data prior and up to 1988 are actual values while those for 1989 onward are projections.

TABLE 2-29 STATISTICS ON SERVED POPULATION BY SEDAPAL

(unit: 1,000 persons)

YEAR	TOTAL POP.	SERVED POP.	RATIO (%)	UNSERVED POP.	RATIO (%)
1950	990	740	75	250	25
1955	1220	960	79	260	21
1960	1800	1165	65	635	35
1965	2200	1350	61	850	39
1970	2820	1787	63	1033	37
1975	3730	2677	72	1053	28
1980	4707	3207	68	1500	32
1985	5508	3922	71	1586	29
1986	5736	4239	74	1497	26
1987	5964	4555	76	1409	24
1988	6236	4785	77	1451	23
1989	6461	4997	77	1464	23
1990	6693	5244	78	1449	22
1991	6930	5540	80	1390	20
1992	7173	5758	80	1415	20
1995	7938	6487	82	1451	18
2000	9330	7702	83	1628	18

Source : SEDAPAL

Note : Data before 1987 are estimated by SEDAPAL.
Data from 1988 are planned by SEDAPAL

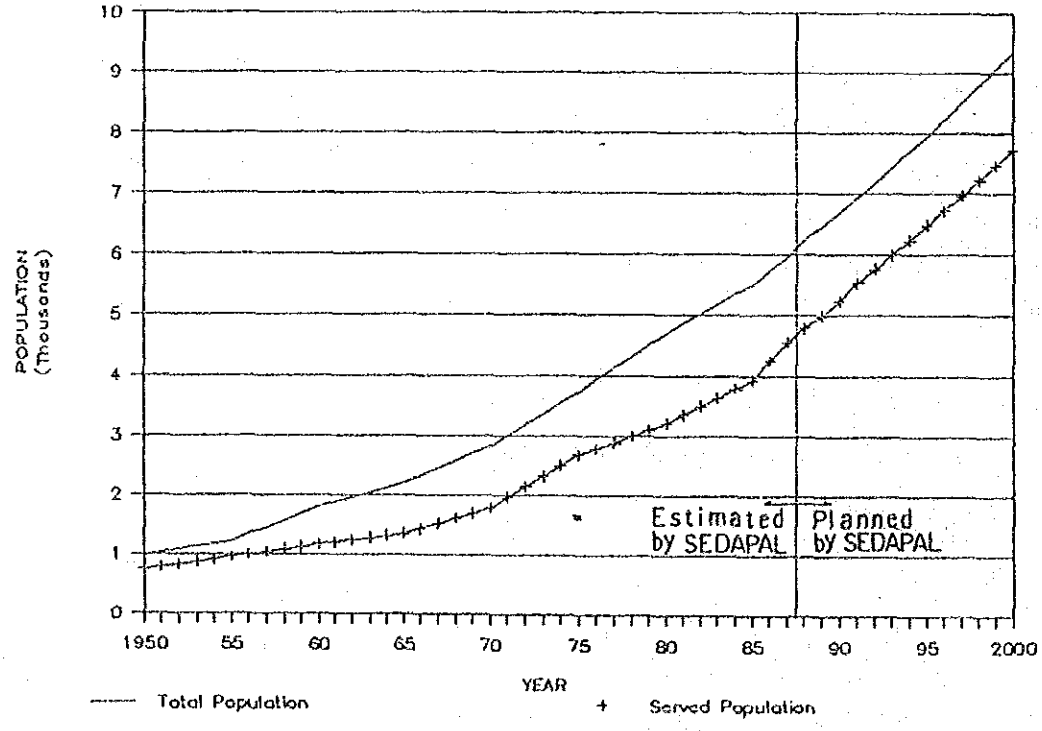


FIGURE 2-8 TRANSITION OF SERVED POPULATION

Zones that are not served by SEDAPAL, like Ancon, Santa Rosa, Cieneguilla, Chaclacayo, Lurigancho, Chosica, Punta Hermosa, Punta Negra, San Bartolo, Santa Maria, Pucusana and Ventanilla, with a population of about 197,000 (approximate daily consumption of 46,600 m^3) are served by entities quite independent from SEDAPAL which are administered by the municipalities.

The zones which are serviced by SEDAPAL are the central parts of Lima. After 1955 and until recently, service ratio has decreased steadily because of migration and concentration to the capital, as well as the natural increase in population. However, during these latter years fruits of the efforts exerted by SEDAPAL have started to be realized and today the water service coverage has gone up to more than 75%.

TABLE 2-30 shows the present status of the type of users.

TABLE 2-30 STATUS OF WATER SUPPLY SYSTEM

Type	Number of Connections	Percentage (%)
House Connections	547,538	89.6
(Community)	(5,522)	
Independent Individuals	23,727	3.9
Commercial	30,624	5.0
Industrial	5,041	0.8
Public Entities	4,203	0.7
Total	611,133	100.0

Source: SEDAPAL, 6/1/89

FIGURE 2-9 shows the main water supply pipeline network of SEDAPAL. FIGURE 2-10 also shows the location of operating wells within the Surco Drainage Area.

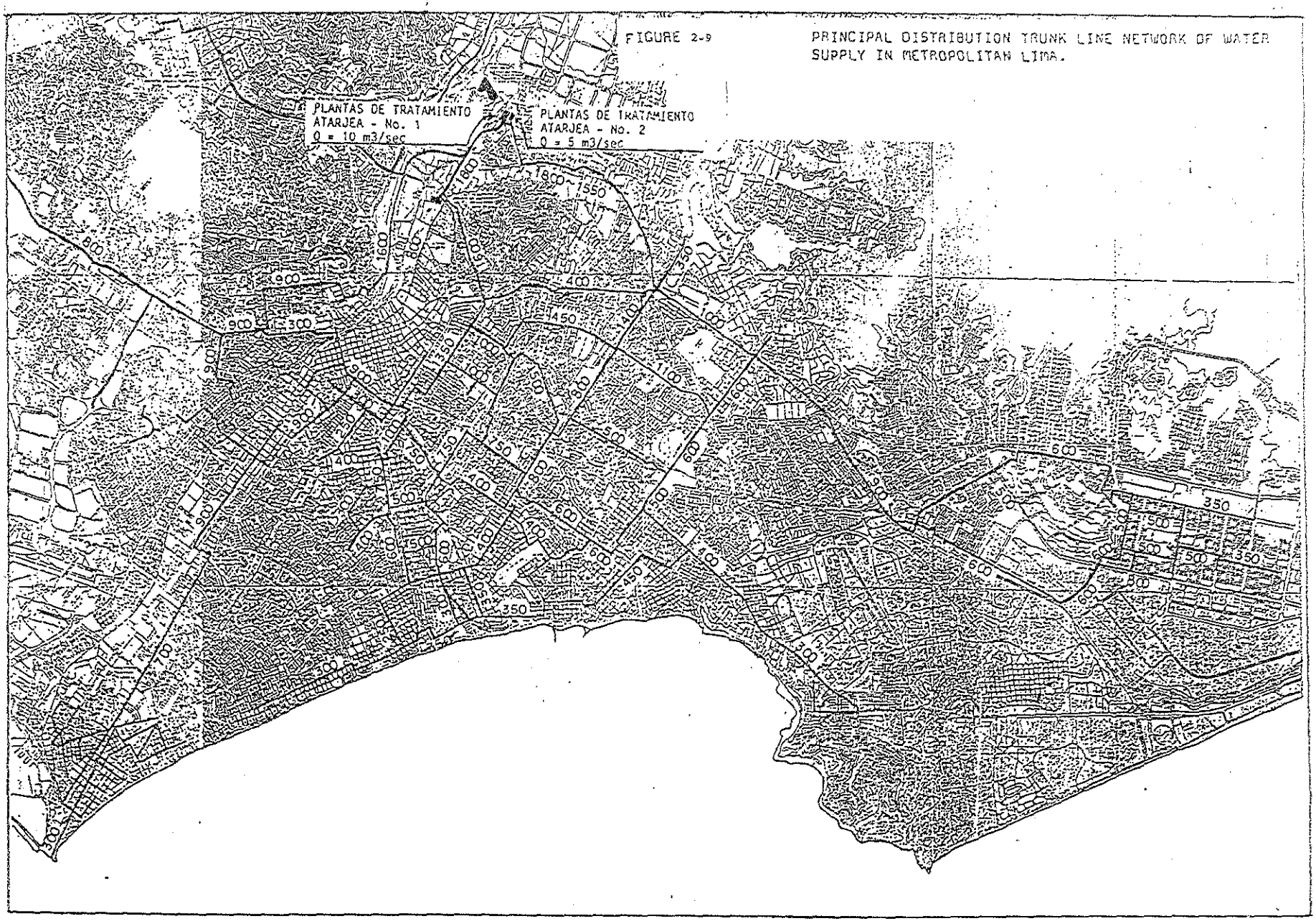


FIGURE 2-9 PRINCIPAL DISTRIBUTION TRUNK LINE NETWORK OF WATER SUPPLY IN METROPOLITAN LIMA.

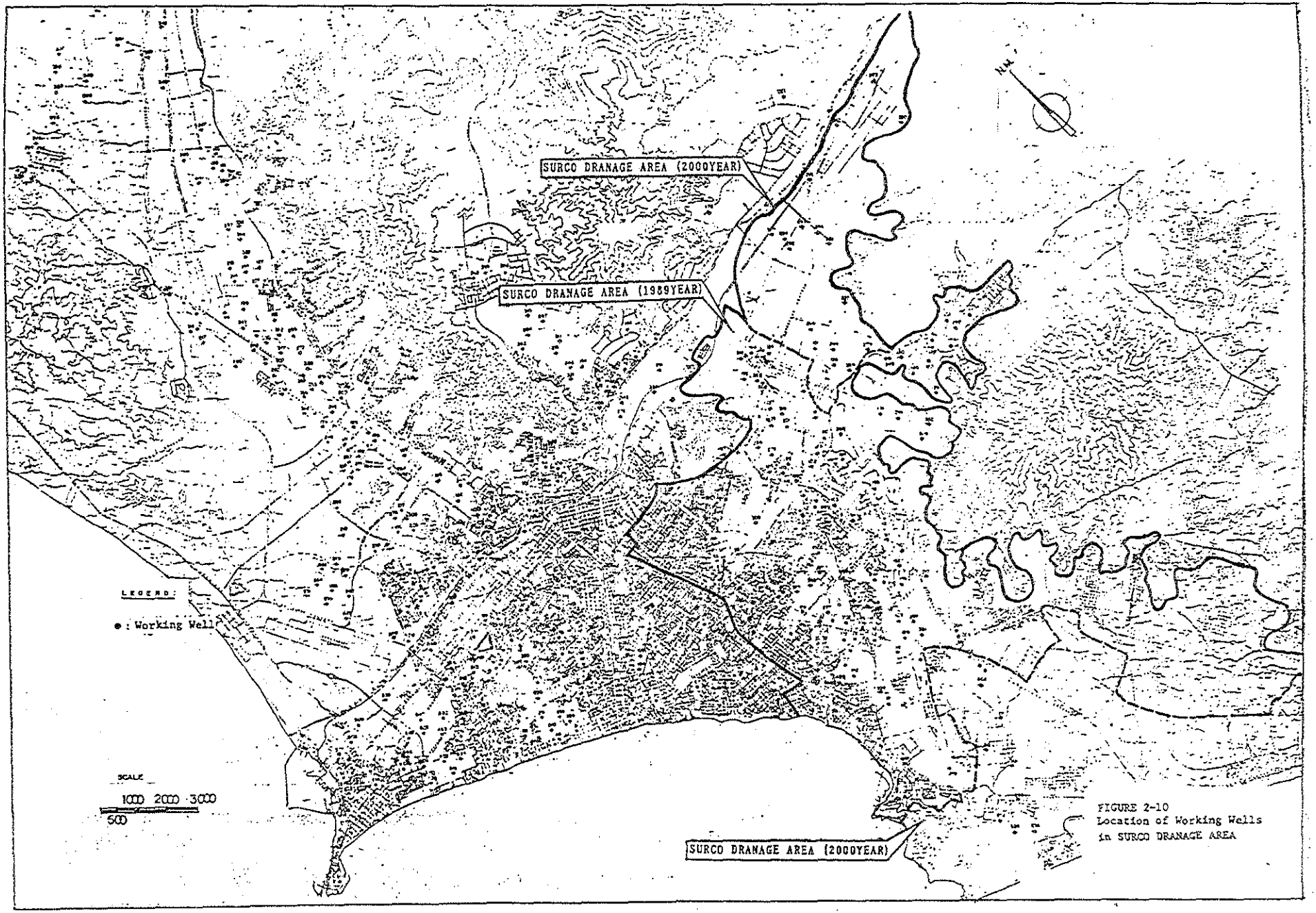


FIGURE 2-10
Location of Working Wells
in SURCO DRANAGE AREA

2.6.2 Drinking Water Production by SEDAPAL

The source of drinking water for the Metropolitan Lima is the Rimac River and wells. The water from the Rimac River is treated at the Atarjea Plant. Groundwater through wells is treated with chlorine according to SEDAPAL standards.

TABLE 2-31 shows the current status of drinking water supplied by SEDAPAL.

TABLE 2-31 CURRENT STATUS OF WATER SUPPLY BY SEDAPAL

	Surface Water (Rimac River)				Groundwater (Wells)			TOTAL
Month	Atarjea#1	Atarjea#2	Gallery	Sub Total	Operating	Stopped	Standby	Q
Jan./88	8,612	5,456	0.201	14.27	(259w) 7.32	(22w) -	(33w) -	21.59
Feb.	8,859	5,302	0.202	14.36	(259w) 7.29	(23w) -	(33w) -	21.65
Mar.	8,339	5,663	0.201	14.20	(258w) 7.30	(24w) -	(33w) -	21.50
Apr.	8,688	5,040	0.226	13.95	(261w) 7.45	(25w) -	(33w) -	21.40
May.	8,986	4,480	0.234	13.70	(263w) 7.37	(22w) -	(34w) -	21.07
Jun.	8,371	4,715	0.234	13.32	(258w) 7.35	(26w) -	(35w) -	20.67
Jul.	8,339	4,910	0.229	13.48	(254w) 7.27	(30w) -	(35w) -	20.75
Aug.	8,457	4,631	0.208	13.30	(258w) 7.25	(26w) -	(35w) -	20.55
Sep.	7,990	4,460	0.201	12.65	(263w) 7.22	(26w) -	(36w) -	19.87
Oct.	7,263	3,949	0.201	11.41	(261w) 7.29	(28w) -	(35w) -	18.70
Nov.	6,725	4,263	0.201	11.19	(263w) 7.20	(28w) -	(34w) -	18.39
Dec.	7,159	4,313	0.201	11.67	(262w) 7.15	(29w) -	(34w) -	18.82
Jan./89	8,717	4,496	0.211	13.42	(262w) 7.15	(29w) -	(34w) -	20.57
Feb.	8,694	4,895	0.224	13.81	(263w) 7.29	(28w) -	(35w) -	21.10

Source: GERENCIA DE PLANIFICACION YPRESUPUESTO AREA DE ESTADISTICA Y INFORMACION

According to the above data, the quantity of drinking water supplied by SEDEPAL in February 1989 was 21.10 m^3/sec/day.

In TABLE 2-29, the population served is approximately 6,461,000 and the average water consumption per capita is 0.244 m^3/day in 1989. (SEDAPAL demand projection for Lima and El Callao, 1988, Basic Unit of Accounted-for water).

Consequently, the unaccounted-for water is:

$$Q_2 = 21.10 \times 86,400 - 6,461,000 \times 0.244 = 246,556 \text{ m}^3/\text{day}$$

The ratio of unaccounted-for water (Q_2/Q_1) is:

$$Q_2/Q_1 = 246,556/21.10/86,400 = 0.135$$

Therefore, the ratio of unaccounted-for water comes to 13.5%

Unaccounted-for water is attributed to the following causes:

1) Loss of water due to obsolete piping and defective connection;
2) Illegal connection;
3) Defective water meter.

The volume of water produced by the Atarjea plant and the wells currently covers the demand of zones within the responsibility of SEDAPAL, hence all possible measures shall be being taken to avoid excessive water wastage through the eliminatation of illegal connections and proper maintenance of meters.

2.6.3 Water Supply Amount in the Surco Drainage Area

The study area covers the southern part of Lima involving 16 districts out of the city's 41 districts. The area of the 16 districts is 429.06 km^2 and the area of the Surco drainage area is 122.17 km^2 (1989).

The water supply to the Surco drainage area at present is under the responsibility of SEDAPAL. The percentage of served population in the Surco drainage area in terms of supply of drinking water is shown in TABLE 2-32. From this percentage, water supply amount in the Surco drainage area is estimated as shown in TABLE 2-33.

TABLE 2-32 POPULATION OF DISTRICTS AND SURCO DRAINAGE AREA

(ubit: 1,000 persons)

NAME OF DISTRICT	(A) POPULATION IN DISTRICTS 1989	(B) POPULATION IN SURCO D.A. 1989	SERVICE RATIO (B/A)
Lima	406.4	8.1	2 %
Ate	161.9	81.0	50
Barranco	48.1	48.1	100
Chorrillo	176.8	159.1	90
El Agustiuno	205.2	102.6	50
La Molina	83.0	66.4	80
La Victoria	291.3	270.9	93
Miraflores	113.1	50.9	45
San Borja	56.8	56.8	100
San Isidro	77.6	21.0	27
S.J.de Miraflores	242.9	9.7	4
San Luis	64.1	64.1	100
Santiago de Surco	201.1	191.0	95
Surqillo	101.2	101.2	100
Villa El Salvador	251.0	225.9	90
V.M.del Triunfo	306.3	275.7	90
TOTAL	2,786.8	1,732.5	62

TABLE 2-33 WATER SUPPLY AMOUNT OF DISTRICTS AND SURCO DRAINAGE AREA

NAME OF DISTRICT	(A) SERVICE RATIO 1989	(B) SUPPLY AMOUNT IN DISTRICT 1989	(C) AMOUNT IN SURCO D.A. (A x B)
Lima	2 %	2.13 m^3/s	0.043 m^3/s
Ate	50	0.40	0.200
Barranco	100	0.19	0.190
Chorrillos	90	0.48	0.432
El Agustiuno	50	0.43	0.215
La Molina	80	0.27	0.216
La Victoria	93	0.92	0.856
Miraflores	45	0.68	0.306
San Borja	100	0.29	0.290
San Isidro	27	0.60	0.162
S.J.de Miraflores	4	0.48	0.019
San Luis	100	0.22	0.020
Santiago de Surco	95	0.79	0.751
Surqillo	100	0.45	0.450
Villa El Salvador	90	0.38	0.342
V.M.del Triunfo	90	0.46	0.414
TOTAL	62	9.17	5.106

Source: Analisis de la Demanda para Lima y El Callao,1988

2.7 Other Infrastructures

2.7.1 Transport Facilities

The air, overland and maritime, transportation network which link the major Peruvian cities are all centered around Lima.

Air transportation routes radiate from the Jorge Chavez International Airport in Lima, and link the principal cities throughout the country in 23 places.

Overland transportation facilities consist of railroads and highways. There are 4 main railroad lines which are being operated by the National Railroad of Peru with main terminals in Lima, Cusco, Quillabamba and Puno.

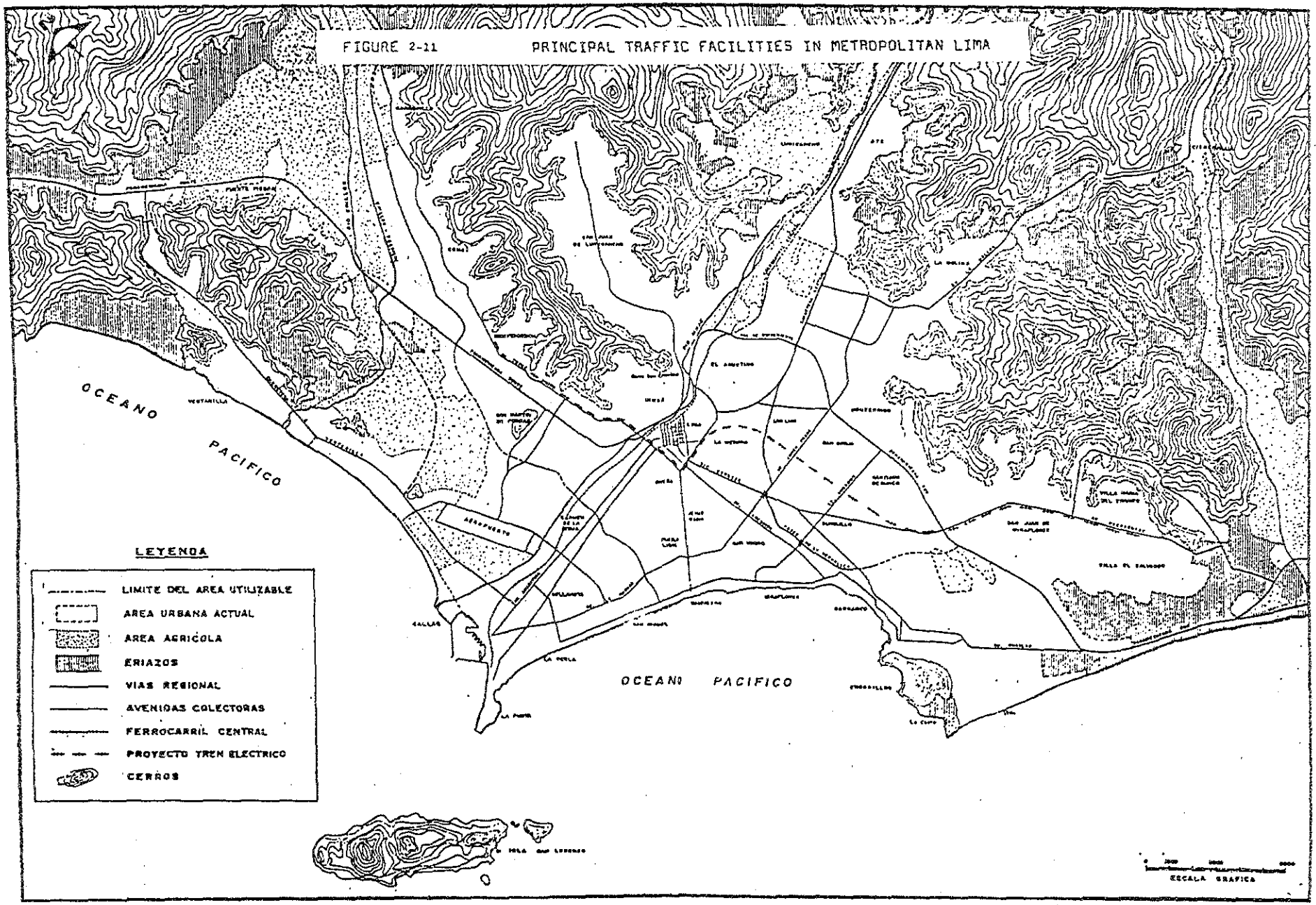
The only railroad line that passes through Desemparados station, a central station in Lima, has few passenger cars and is being used mainly for cargo transport. It links the port of Callao with La Oroya, a mining town. And then goes on to Huancayo, a distributing center of agricultural products. The construction of an urban railroad line connecting the southern part of Lima to the central area is underway. Designed mainly for carrying passengers, the line is expected to cope with the increase of population in the capital.

The most important highway networks in the country are the Panamericana which traverses Peru from North to South, and the Central Highway which crosses the Andes from Lima and then branches out into a network of roads.

In maritime transportation, the port of Callao in Lima, is the largest in Peru, and is the largest terminal point for domestic and overseas maritime transport.

FIGURE 2-11 gives a diagram of the principal transportation facilities in Lima.

FIGURE 2-11 PRINCIPAL TRAFFIC FACILITIES IN METROPOLITAN LIMA



2.7.2 Port

Peru has around 2,200 km of coastline extending from North to South along its western border on the Pacific Ocean. There are numerous small fishing harbors and ports in the country which have thrived for many years, fifteen of which are classified as principal ports (including the port of Nauta on the Ucayali River in the Amazon River basin).

Of these, the largest and most important is the port of Callao, considered the principal port of entry. Established near the Callao port are food-processing factories such as seafood processing plants, canneries, refrigeration plants, fishmeal plants, and etc., all of which are dependent on the fishing industry which brings in more than 180,000 gross metric tons of fish annually.

The Callao port is handling 65% of import cargo and 40% of export cargo passing through Peru, and is located strategically with respect to Metropolitan Lima and the rest of Peru.

Within the Study Area, there is also the Chorrillos Port, a fishing port which unloads some 960 gross metric tons of fresh fish every year mainly for the consumption of Lima.

Located in Ventanilla, north of Callao, is Peru's largest petroleum refinery, which processes 10,000 barrels a day, and is the main base for supplying fuel to the Callao port and to the Jorge Chavez International Airport.

TABLE 2-34 shows the volumes of marine products unloaded at fishing ports in Metropolitan Lima.

TABLE 2-34 MARINE PRODUCTS UNLOADED IN METROPOLITAN LIMA (1987)

PLACE (PORT)	TOTAL (GMT)	MAIN SPECIES	DIRECT HUMAN CONSUMPTION				FISHMEAL (GMT)
			FRESH	CANNED	FROZEN	TOTAL	
CALLAO	177,537	HORSE MACKEREL (TRACHURUS SYMMETRIUS M.) MULLET (MUJIL CEPHALUS) LORNA	8,518	17,627	696	27,097	150,440
CHORRILLOS	960	LORNA, MULLET SHELLFISH	960	-	-	960	-
PUCUSANA	63,133	MACHETE (BREVOORTIA MACULATA) SARDINES	6,239	2,248	27	8,514	54,619

Source: Fishing Sector Activities Report (1987), Office of Planning and Budget(MIPE)

2.7.3 Parks and Green Areas

Peru is divided into three main regions: the Amazon region of jungles and forests, the highlands of the Andes, and the coastal desert.

The Amazon region and the Andean mountain valleys are areas with abundant greenery, while the coastal desert is an arid region which covers 12% of the country.

Migration of people from the rural areas to Metropolitan Lima, which has been going on since the 1960s has increased rapidly in recent years.

This increase in population has been accompanied with an intensive effort to improve the environment, and has resulted in an upsurge of artificially irrigated greenery in the desert, using river waters and irrigation canal in Lima. At present, progress is being made in developing and transforming the surrounding desert into agricultural lands or green areas.

According to the Office of Park, Ministry of Housing and Construction (Servicio de Parque, Ministerio de Vivienda y Construccion, (SERPAR)), the following large parks in the Study Area are planned to be provided with ample green areas as shown in FIGURE 2-12.

a. Parque Zonal No. 23 : Huayna Capac
b. Parque Zonal No. 24 : Huascar
c. Parque Zonal No. 25 : Villa
d. Parque Zonal No. 26
e. Ruins of Pachacamac

a) Parque Zonal No. 23 : Huayna Capac

An area of 4.5 km^2 in the southern part of the district of San Juan de Miraflores, and an area of 0.5 km^2 in the northwestern part of Villa El Salvador, are being planned for conversion to parks for the purpose of providing people with the opportunity to enjoy clean and fresh air.

In the middle of the proposed park site at San Juan de Miraflores, the San Juan Stabilization Pond has been operated for the sewage coming from San Juan de Miraflores. Treated water from this plant has been reused to irrigate a wide portion of the area green.

b) Parque Zonal No. 24 : Huascar

This park covers approximately 4.5 km^2 of the Cerro de Lomo de Corvina area southwest of Villa El Salvador, and approximately 0.5 km^2 in the southern area of the district of Villa El Salvador.

The southern part of the Cerro de Lomo de Corvina hill will be connected into a green area, with the Cemetery Park in the middle, and a recreation park will be developed in the southern part of the district of Villa El Salvador.

Work on the Cemetery Park is progressing, but due to the lack of sufficient water for irrigation, that for the greenery is behind schedule.

c) Parque Zonal No. 25 : Villa

An area of approximately 4.5 km^2 in the southern part of Chorrillos, is being developed for agriculture and as a park.

The project is progressing steadily, and because of the abundant supply of water from a spring located at the center of the site, the area has become a large swampy land. Recently, wild birds have returned to this area which is designated as a bird sanctuary.

d) Parque Zonal No. 26

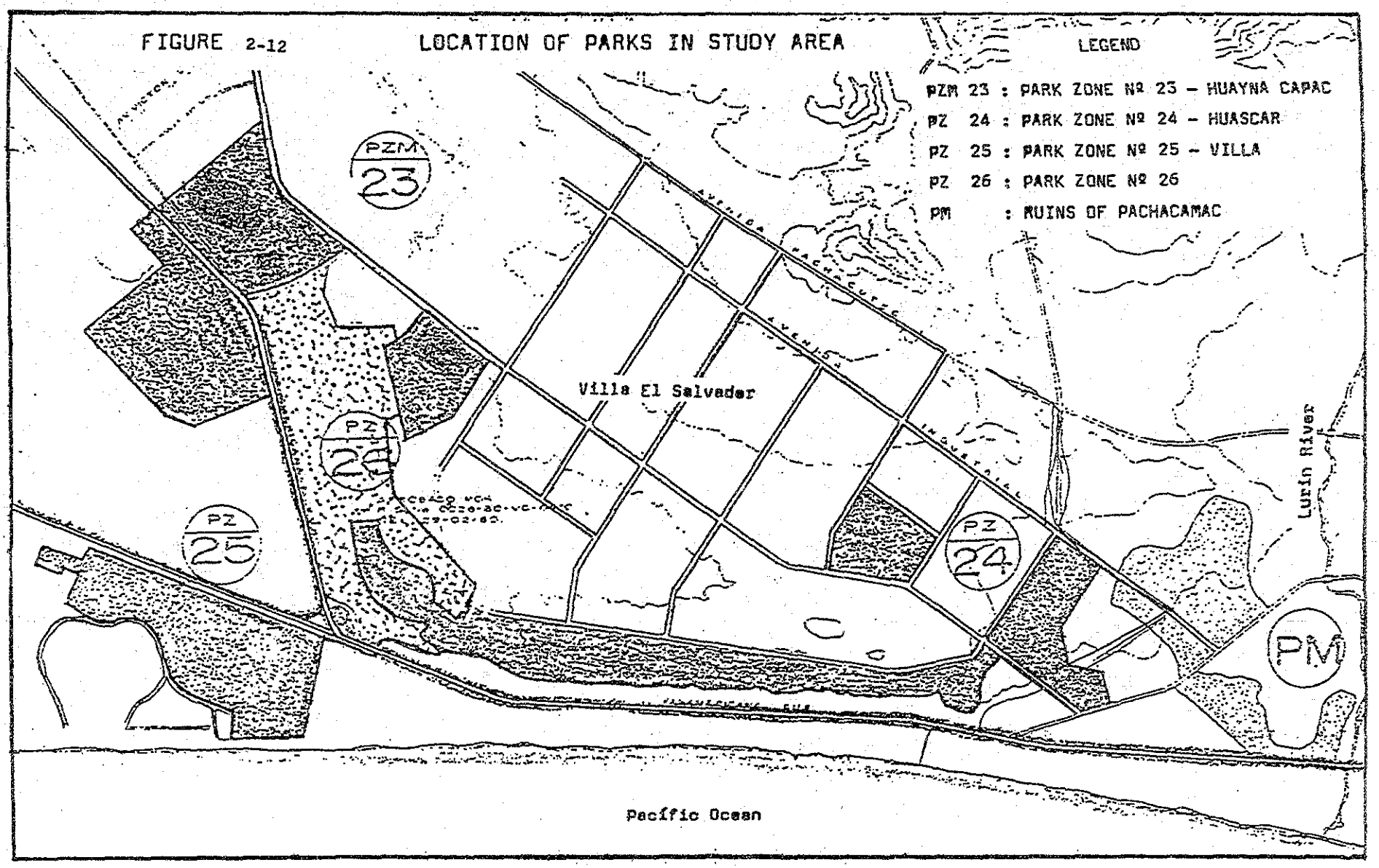
In the northwestern area of the district of Villa El Salvador, a planned large park covering 4.5 km^2, for people to enjoy fresh airs already showing signs of greenery growthe.

Stabilization ponds are being constructed in the middle of the area but these are not functioning as sewage treatment plants. Development of greenery in this particular area has been behind schedule.

e) Ruins of Pachacamac

Studies are presently being carried out for digging and preserving the ruins of Pachacamac, only a part of which have been restored as a park and tourist spot.

FIGURE 2-12 LOCATION OF PARKS IN STUDY AREA



CHAPTER 3

EXISTING SEWERAGE SYSTEM

CHAPTER 3 EXISTING SEWERAGE SYSTEM

3.1 Master Plan of Sewerage System

At present, the water supply and drainage system of Metropolitan Lima is operated by SEDAPAL, which falls under the jurisdiction of the Ministry of Housing and Construction (Ministerio de Vivienda y Construccion).

The first full-scale plan for construction of sewerage system in Lima was prepared in 1945 under the direction of Engineer Alfonso Pons Musso. Expansion work on the system, in the beginning, was made in accordance with this master plan, while later on had to be amended on many occasions. In 1981, with financing from the International Bank for Reconstruction and Development, a total revision was made on the master plan of Lima's water supply and sewerage system. This revised master plan is the present basis for the conduct of sewerage works in Lima. On the other hand, a feasibility study was done in 1985 for recycling sewage to irrigate part of the arid zone south of Lima. This project is based on the results of these studies.

(1) Master Plan of Water Supply and Sewerage System for Metropolitan Lima. (Engineering-Science, 1981)

a. General

This study which was done by an American consulting firm, Engineering-Science, involved the formulation of the Master Plan for the water supply and sewerage system of Metropolitan Lima, and was financed by the International Bank for Reconstruction and Development. It includes plans for improvement and reformation of the water supply and sewerage systems, as well as an investigation of the recycling of treated waste water. The report was presented in November 1981.

b. Outline of the Sewerage System Master Plan

1) Planned Area

The area covered by the plan is Metropolitan Lima, which is made up of Lima and Callao. The present status (1980) of land use in

the area is as follows:

TABLE 3-1 PRESENT LAND USE CONDITION WITHIN PLANNED AREA

Category	Area (ha)
1) Urban	25,300
2) Agricultural	23,800
3) Parks	1,470
4) Industrial and Commercial	4,700
5) "Pueblos Jóvenes"	2,800
TOTAL	58,070

2) Planning Duration

The duration of the plan is 30 years, from 1981 to 2010, using 1980 as the base year.

3) Planned Population

Based on the rate of population increase after the census taken in 1970, the future population was estimated as follows:

TABLE 3-2 FUTURE POPULATION WITHIN PLANNED AREA

Year	Population (in thousands) High/Medium Income	Low Income	Total
1980	1,955	3,065	5,020
1985	2,366	4,054	6,420
1990	2,722	5,074	7,800
2000	3,633	7,767	11,400
2010	4,828	10,322	15,150

4) Planned Sewage Quantity

Applying an adjustment factor to the estimated volume of water demand, the assumed effective sewage quantities are as shown in TABLE 3-3:

TABLE 3-3 FUTURE SEWAGE QUANTITY

Year	Sewage Quantity (Annual Average, m^3/sec) With Special Control	Without Special Control
1980	13.8	13.8
1985	14.2	16.7
1990	16.6	19.5
2000	23.5	27.7
2010	31.3	36.8

The maximum flow of sewage per day is estimated to be 110% of the annual average sewage flow.

c. Planned Facilities

Following is the summary of the planned facilities:

1) The Surco sewer system will maintain the same flow direction as the present system, but all sewage discharge into the rivers and the sea will be intercepted.

2) By the year 2000, 11.2 m^3/sec of sewage will be recycled. Of this, 5.5 m^3/sec will return to the subterranean water, 5.0 m^3/sec will be used for agriculture and 0.7 m^3/sec will be recycled for the irrigation of parks.

3) After primary treatment (extraction of floating materials), the remaining sewage will be discharged to the sea by way of submerged discharge pipes at three points: Callao, Maranga (Costanero), and Conchan (La Chira or Surco). The discharge to be carried by each pipe in the year 2000 will be, 8.06, 3.77 and 1.02 m^3/sec, respectively, under conditions of restricted demand and recycling of waste water. Otherwise, the discharges will be 14.74, 4.67 and 7.86 m^3/sec, respectively.

4) In zones that are not connected directly into the public sewerage system, the sewage will be treated for 6 months in an oxidation lagoon and discharged into nearby canals. It is

estimated that sewage discharged from these zones will reach 1.8m^3/sec in the year 2000.

5) By the year 1990 there will be 112 km long sewer pipe with diameter greater than 350 mm. From that time to the year 2000 there are plans to construct additional 57 km long pipelines.

6) The use of recycled water in agriculture, industry, irrigation of arid land, parks, and for groundwater recharge is being investigated. Sewage conveyance is being considered under discharge conditions of 4 m^3/sec and 5 m^3/sec, to be treated in oxidation lagoons with area of 160 ha. and 210 ha., respectively.

d. Relation to the Study

The updated water supply and sewerage system master plan of Metoropotan Lima corresponds with the base of the present project, hence planning and design criteria evolved therein should be considered as fundamental data for the Study.

(2) Feasibility Study for the Project to Recycle Sewage for Irrigation of Arid Zones, Located in the South of Lima (TAHAL-SANIDRO-SECOMAN-1985)

a. General

This study was performed by the Israeli consulting firm, TAHAL Consulting Engineers Inc., with financing from the Inter American Development Bank, as an irrigation project for approximately 5,000 ha. of desert on the San Bartolo plain. The project involves taking sewage from the Surco sewer trunk, treating it and transporting it through pipelines to the irrigation area.

b. Planned Facilities

There were 8 main alternatives studied in this study. The intake points and the transmission routes are same but the following conditions are different:

1) Sewage intake volume, water supply volume: 2.4 m^3/sec or 3.4 m^3/sec.

2) A different secondary treatment method; facultative lagoon, aeration lagoon, treatment by deep reservoir, aquifer treatment.

3) Establishment or non-establishment of additional treatment; Treatment by deep reservoirs or aquifer treatment.

The results of the economic analysis show alternative No. 7 to be very attractive. However, due to absence of unknown hydraulic parameters, alternative No. 5 was finally recommended. For the economic aspect alternative No. 5 is ranked only second to alternative No. 7. In future stages of the project alternative No. 7 will play an important role.

The outline of alternative No.5 is as follows:

1) Intake; From each interceptor pipe of Surco, Circunvalacion and Villa Maria, a total of 2.4 m^3/sec will be taken.

2) Transmission;

Intake point - San Juan primary treatment facility
16" dia., 8,100m long,
San Juan - Villa El Salvador Pumping Station
64" dia., 4,700m long,
P.S. - Lurin River
2 steel pipes, 24" dia., 1,500m long,
64" dia., 3,800m long.
Lurin River - San Bartolo
2 steel pipes, 4" dia., 6,800m long.
San Bartolo - Open Channel
1,000m long.

3) Treatment

(a) Primary treatment (sedimentation)
on nearby lands and in Park No.26 of Villa El Salvador

(b) Secondary treatment (aeration lagoon)
in San Bartolo

4) Direct Utilization, Utilization of the water through treatment

c. Relation to the Study

The content of the application for the present Study and the idea of the TAHAL study are same, but the intake amount and the transmission route are different.

3.2 Sewer Systems

(1) Present Condition

The sewerage system in the urban area of Metropolitan Lima, is about 130 years old, having been installed in 1859. In the urban areas of Lima and Callao the sewer network is able to serve 100% of the population but the network in the north, south and central marginal or peripheral areas is insufficient.

Currently SEDAPAL covers an area of 28,800 hectares. However, particularly in the old sections of the city, the network is so deteriorated that breaks along the line continually occur. In addition, because of the increase in discharge caused by population growth, the drainage capacity has become insufficient, causing frequent street flooding. Part of the sewer network is currently being expanded, notably that on the northern and southern edges of the city.

(2) Drainage Area

The sewerage system service area in the Metropolitan Lima can be divided into 7 areas as follows:

a) Comas area
b) Callao area
c) Costanero area
d) Surco area
e) Area No. 6
f) San Martin/Rio Bamba area
g) San Juan de Miraflores area

In the areas where there are no public sewerage system, factories and commercial centers have their own sewerage system. The majority of the sewer network works by gravity, but in some lowland areas pump systems are used. Sewage is being discharged into the ocean and river with no prior treatment whatsoever except in the San Juan de Miraflores zone and the Chosica, Chaclacayo zone.

FIGURE 3-1 shows the location of the main drainage canals or sewers and their respective discharge outfalls. The drainage flow from these main sewers and adjacent area are shown in TABLE 3-4.

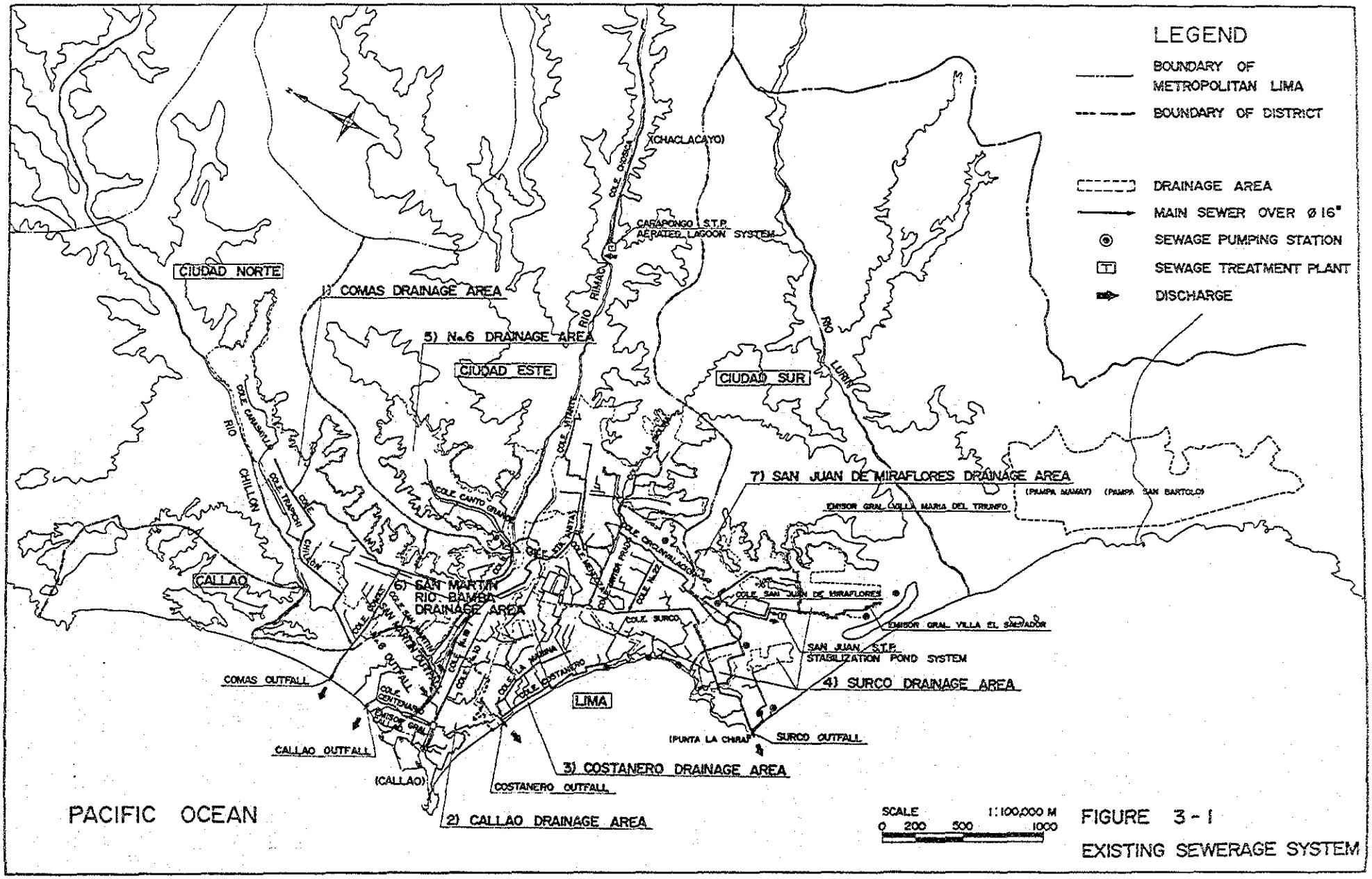


FIGURE 3 - 1
EXISTING SEWERAGE SYSTEM

TABLE 3-4 OUTLINE OF DRAINAGE AREAS

NAME	DRAIN.AREA (ha)	MAIN SEWER	DIA. (mm)	LENGTH (m)	CAPACITY (m^3/sec)	DISCHARGE (1988) daily avg.(m^3/sec)	REMARKS
Comas	4,000	Colector Comas	1,200 - 350	64,452	4.00	1.700 (1.70)	
Callao	5,100	Colector Centenario	1,300 - 350	61,050	6.27	3.016 (3.70)	
Costanero	4,000	Colector Costanero	1,300 - 350	63,350	4.34	3.038 (3.30)	
Surco	11,900	Colector Surco	2,100 - 350	144,091	10.77	4.770 (5.70)	Disc. 5.359 (1989)
No.6	2,300	Colector No.6	1,500 - 350	34,221	4.60	1.530	
San Martin Rio Bamba	700	Colector Conde Villa Zarumilla	900 - 350	11,106	0.32	0.280 0.210	2 outfalls
San Juan	800	Colector San Juan	700 - 350	5,730	0.38	-	Disc. 0.275 (1989)
TOTAL	28,800	-	-	384,000	-	-	

Source: SEDAPAL Measuring Date: 9/23/1988, June/1989
* Values in parenthesis are estimated.

a) Comas Drainage Area

The main sewer of this drainage area is the Colector Comas, which begins near 12.5 km of Avenida Tupac Amaru on the northern edge of Lima. It collects effluent from the sewers of: Ingenieria, Infantas, Palao, Naranjal, Garagay, Chillon, Ramal No.13 and No.17. Comas, Independencia and San Martin de Porres comprise the districts encompassed by the drainage area. Sewage is discharged into the Pacific Ocean 3.5 km south of the mouth of the Chillon River.

b) Callao Drainage Area

The branch includes the sewers: Sta. Anita, No.19, Varela, Tingo Maria, Naciones Unidas, San Jose, Argentina No.10, Maranga, La Perla, Arica, Ancash, Callao and Huascar. They all merge into the Colector Cente-

nario and discharge into the sea in the area north of the Rimac River. Among the districts included in the Callao drainage area are: Cercado de Lima, Zona Industrial, Brena, San Miguel, Bellavista, Carmen de la Legua, La Perla Callao, Chucuito and Punto. Since the Punta district is low, the sewage effluent is pumped up from the western part of Callao to the central meeting chamber.

Since 1987, Sewer No. 19 has been extended from Avenida Elmer Faucett to Avenida Nestor Gambetta, and connected to the sewer which originates in the zone of El Agustino, Cercado de Lima and even from Sta. Anita. For this reason this whole branch is included in the system of Sewer No. 19 which belongs to the Callao area. In the future, this branch can be extended to the district of Ate.

c) Costanero Drainage Area

This branch which was constructed in 1945 includes the sewers: Parodi, Limatambo, Shell, No.4, Costanero Tramo Miraflores, Jose Leal, Trinidad Moran, Jose Granda, Salaverry, No.12, No.13, Garzon, Sucre, San Miguelito, Bolivar, Marina No.16, Palomino, Universidad Catolica, No.1 and others. It covers the districts of: Brena, San Miguel, Pueblo Libre, Jesus Maria, Magdalena, Lince, San Isidro, Miraflores and the industrial zone of El Cercado.

The sewage is discharged into the sea in the district of San Miguel.

The drainage lines of this area are sewrelly deteriorated a condition complicated even more by the insufficient capacity of the pipes. The main sewers of Costanero, Salaverry and No. 12 sewers are the most deteriorated. For example, 350 to 500 mm diameter pipe sections are deteriorated at 12 places affecting a total of 12 km, for which immediate repair is necessary. Pumping stations are also installed at low areas.

d) Surco Drainage Area

This area is the largest within SEDAPAL's sewerage system. The main line is the Colector Surco, into which flow the sewers: Vitarte, Sta. Rosa, Mendoza, No. 21, Las Moreras, Los Chancas, Locumba, La Catolica, San

Pablo, No.2, NO.13, Monterrico, No.22, San Borja Este, San Borja Oeste, Alivio del Costanero, Larco, No.23, No.8, San Juanito, San Pedrito, Cimo, Balneario del Sur, No.25, La Molina, Los Portales, Mayorazgo, Sta. Patricia, La Molina Vieja, Villa Maria del Triunfo, and Villa El Salvador. It discharges into the Pacific Ocean in the area of "Punta la Chira" after passing through the Morro Solar hill by way of a tunnel 2,100 mm wide and approximately 3,700 m long.

There had been a project to connect the system from Chosica and Chaclacayo to the Colector Surco but in March 1988 construction ceased at 17 km of the Carretera Central (at the entrance to Huaycan), at the Carapongo sewage treatment plant which was provided as grant by the government of Japan, so sewage from these areas is discharged to the Rimac River after treatment.

e) No. 6 Drainage Area

This area is a long, narrow strip along the right side of the Rimac River. Colector No. 6 receives the discharge from the sewers: Canto Grande, Las Flores, Zarate, Piedra Liza, Leoncio Prado, No.3, and Habich. It covers the districts: San Juan de Lurigancho, Rimac, and San Martin de Porres. There currently exist two discharge zones in sewer No. 6. The one most used is in the area of Avenida Peru and Calle Villa Rica, discharging into the Rimac River. The other discharge zone is near Avenida Elmer Faucett. This discharge is used as irrigation water for cultivated fields located on the southern edge of the Jorge Chavez airport.

f) San Martin - Rio Bamba Drainage Area

This area is a relatively small strip along the Rimac River in the district of San Martin de Porres. Sewer No. 6 passes through this zone, dividing it into two sub-zones. One is the Rio Bamba sewer, which is located in the Zarumilla urbanization and discharges into the Rimac River. The other is made up of the two sewers, Conde Villa and San Martin and covers the urbanizations: Valdiviezo, Urb. Ama Kella, Urb. Conde Villa Senor, Urb. Peru, Urb. Playa Rimac, Urb. Previ and Urb. El Olivar.

g) San Juan de Miraflores Drainage Area

The Colector San Juan brings sewage to the waste water stabilization pond in the district of San Juan de Miraflores. This plant was constructed by the Ministerio de Vivienda y Construccion in 1964 and said ministry still maintains it under the area of Environmental Conservation.

Treated water is used as irrigation water in nearby cultivated areas, woods and parks totaling 400 ha. in area.

(3) Other Drainage Area

Apart from the 7 areas mentioned, there exists a very small network of drains in some factories, commercial centers, urbanizations and small settlements. A bulk of the sewage originating from these zones is discharged directly into the sea, river or an irrigation canal. Other establishments/housings have their own treatment plant but these do not meet standards satisfactorily and the wastewater is discharged without effective treatment.

In zones where there are no water supply and sewerage systems, leaching wells are used and wastewater is discharged directly to the soil in open areas.

The Atarjea purification plant takes water directly from the Rimac River. Whereas before 1988, sewage from the zones of Chosica and Chaclacayo was being discharged directly into the Rimac River, thereby contaminating it, wastewater is now being treated in the aerated lagoons prior to its discharge into the river.

The treatment capacity (12,000 m^3/day) of the plant is more than the zone's sewage flow, which indicates that it can handle a future population growth.

(4) Discharge from Private Wells

Before the construction of the Atarjea plant in 1957, the majority of consumers derived their potable water from private wells. According to

information from SEDAPAL, there are currently 1,500 to 1,800 private wells apart from the wells directly administrated by SEDAPAL. Fifty percent of these wells discharge into the public sewerage system and the rest are used for production processes and irrigation. However, there are no available definite data on this matter.

(5) Industrial Wastewater

The Surco drainage area in the study area is assumed to be discharging 0.323 m^3/sec of industrial wastewater from 249 factories in the area based on the latest investigation result conducted by SEDAPAL (refer to APPENDIX 3).

(6) Domestic Sewage Connections

There are currently around 566,600 domestic sewage connection points. According to a survey of SEDAPAL taken in April, 1989, 95% of the residences that have house connections of water supply also have drainage connections. Of the 611,133 house connection points, 596,431 were connected to the sewerage system.

The housing drainage connections require a junction box of 25cm x 45cm x H with a 5 cm deep sedimentation pit. The connection pipes to the sewer network are concrete pipes with average diameter of 150 mm.

3.3 Sewage Pumping Stations

The terrain of Metropolitan Lima slopes down gently from the foot of the Andes mountains towards the sea. Main sewers such as Surco, Costanero and Comas, discharge into the sea by gravity. Pumping stations are installed at some of the branch pipe lines in low-lying areas where the sewage cannot be conveyed into the mains by gravity flow.

There are around 30 sewage pumping stations under the control of SEDAPAL. The outlines of the principal pumping stations are shown in TABLE 3-5. Several other sewage pumping facilities are under construction.

TABLE 3-5 SEWAGE PUMPING STATIONS IN METROPOLITAN LIMA

No.	Name	District	Design Flow Rate (l/s)	Capacity of Pump (ϕ)	Total Electrical Capacity (kW)	Installed Year	Remarks
1	M. de la Marina	Miraflores	300	200 x 150 l/s 2sets 150 x 80 l/s 1set	113	1983	operation
2	B. Baños de Barranco	Barranco	50	100 x 25 l/s 3sets	54	1983	operation
3	Domosola	Miraflores			3		
4	Malecon Armendariz	Miraflores			75		
5	Malecon Iglesias	Chorrillos	40	125 x 40 l/s 2sets	18	1985	operation
6	Matellini	Chorrillos	25	100 x 25 l/s 2sets	22		operation
7	C.C. La Laguna 1	La Molina		80 x l/s 1set 100 x l/s 1set	24		operation
8	Los Alamos	Surco					
9	San J. de Miraflores	Sn.J.de Miraf.			150		
10	Canto Grande	Canto Grande Parque El Bosque					
11	Pro	Sn.M.de Porras					
12	Cocharcas	Chorrillos		100 x l/s 2sets	90		operation
13	Sta. Leonor	Chorrillos		80 x l/s 2sets	8		operation
14	Laguna de la Molina	La Molina		80 x l/s 2sets	3		operation
15	Jose Olaya	Surco		80 x l/s 1set	2		operation
16	Marbella del Mar	Magdalena	50	100 x 25 l/s 2sets	45		operation
17	Cedros de Villa	Chorrillos	270	200 x 90 l/s 3sets	111	1986	operation
18	S.Ignacio de Loyola	Sn.J.de Miraf.		80 x l/s 2sets	4		operation
19	Camara Unica del Callao	Callao	948	300 x 316 l/s 4sets	450	1954	operation
20	Camara No.2	V.El Salvador	30	100 x 15 l/s 3sets	41	1983	operation
21	Camara No.3	Lurin	15	100 x 15 l/s 1set	9		operation
22	Camara No.4, Pachacamac	V.El Salvador	100	150 x 50 l/s 3sets	165	1984	operation
23	Camara No.5	Virgen de Lourdes	12	100 x 12 l/s 2sets	18		operation

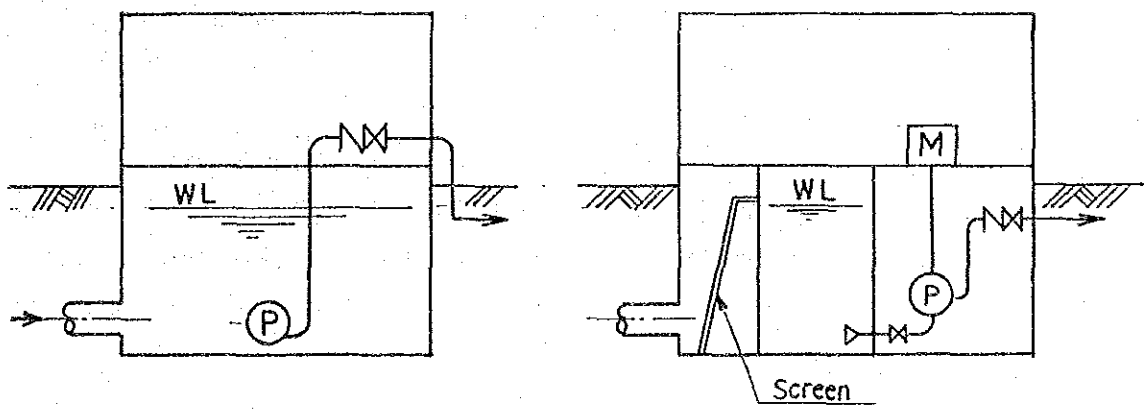
Source: SEDAPAL

- Capacity of Pumping Stations

Capacities of the pumping stations vary between 0.5 and 57 m^3/min. The largest is the Camara Unica de Bombeo de Desagues del Callao.

- Types and Diameters of Pumps

Submersible sewage pumps are normally used at smaller facilities while vertical shaft centrifugal pumps are used at medium and large facilities. The maximum diameter is 300 mm.



Submergible Type Pump Vertical Shaft Centrifugal Type Pump

FIGURE 3-2 Concept of Typical Pumping Station

- Operation Method

Automatic Operation according to pump well water levels is the method adopted in principle, but because of break-downs, the pumps are often operated manually on site through visual observation of the water levels or according to time schedules.

There are no facilities for measurements of flow and discharge amount is calculated from the duration of the pumping operation.

- Power Supply

The pumping stations are all operated using commercial power supply. A few of the pumping stations are equipped with emergency power supply units with engines. As mentioned in Section 2.5, sewage often flows out on the streets (specially in low-lying areas) during power cuts (often due to terrorist attacks), raising complaints from the residents.

- Screens and Grit Chambers

Most of the stations using vertical pumps are provided with screens (manual rakes) but none of the stations have grit chambers.

- Others

SEDAPAL also controls a large number of pumping stations for water supply. Two large scale booster pumping stations are under construction at Villa El Salvador. Outline of one of the pumping station is as follows:

Name:	CR-4 Pumping Station (Villa El Salvador)
Type of Pumps:	Vertical Mixed Flow Type
Specifications:	ϕ300 x 100 ~ 120 l/s x 81 m x 160 kW
Quantity:	10 sets
Receiving Voltage:	10,000 V
Transformer:	1,000 kVA x 2 units
Power Generator:	1 unit

3.4 Sewage Treatment Plants

3.4.1 General

Existing sewage treatment plants in Peru number more than 30 (refer to APPENDIX 4). Among them, San Juan Sewage Treatment Plant, Carapongo Sewage Treatment Plant and several waste stabilization ponds are located in Metropolitan Lima. The plants are categorized in accordance with the treatment method and scale as in TABLE 3-6. Besides these, Carapongo STP (aerated lagoon) began its operation in 1988.

TABLE 3-6 TYPE AND SCALE OF EXISTING SEWAGE TREATMENT PLANTS IN PERU

Treatment Method	INFLOW QUANTITY (m^3/day)				
	below 5,000	5,000 to 10,000	10,000 to 50,000	unknown	Total
Imhoff tank		1(1) *1		4	5(1)
Waste stabilization pond	5	2(1)	2(1)	10	19(2)
Aerated lagoon	2		2(1)		4(1)
Trickling filter			1	1	2
Total	7	3(2)	5(2)	15	30(4)

*1 Combination with two treatment methods in one plant.

According to TABLE 3-6, the waste stabilization pond method (especially facultative pond method) which constitutes 64 % of the total, is the most common sewage treatment method in Peru, followed by methods using Imhoff tank, aerated lagoon and trickling filter. Scales of treatment of many plants are not known but most are presumed to be small.

In most cases, waste stabilization ponds and aerated lagoons are selected because of their low costs of construction and maintenance, and they do not require high-level treatment techniques. Also, they are adaptable to a climate with warm temperature and little rainfall such as what is prevailing in the coastal area of Peru.

The outline and operation condition of San Juan Sewage Treatment plant and Carapongo Sewage Treatment are described in the ensuing sub-section.

3.4.2 San Juan Sewage Treatment Plant

(1) Outline

San Juan Sewage Treatment Plant is located in the southern part of Lima. It was put into operation under the facultative ponds method in 1966 for the San Juan de Miraflores Sewage Reuse Project. The treated sewage is reused for irrigation of agricultural land, forests and parks. The San Juan STP receives mainly domestic sewage from 3 low-lying areas (San Juan de Miraflores, Pamplona Baja, and Ciudad de Dios).

This plant occupies an important position in South America as the site of studies and experiments conducted on various matters concerning sewage treatment such as treatment effects and design conditions of stabilization ponds, evaluation of risks to hygiene arising from reuse of treated water for irrigation, and aquiculture using treated water. These researches are executed by researchers and support members of CEPIS (Pan-American Center for Sanitary Engineering and Environmental Sciences, WHO). Operation and maintenance of this plant is managed by the Ministry of Housing and Construction.

(2) Outline of Facilities

The plant consists of 2-cell facultative ponds as shown in the following flow diagram.

Flow Diagram

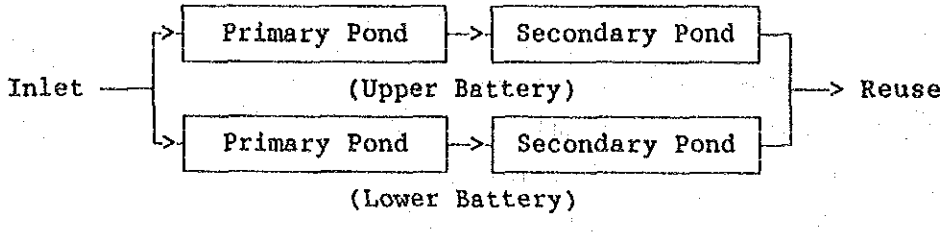


FIGURE 3-3 Flow Diagram of San Juan STP

Contents of Facilities

TABLE 3-7 Outline of San Juan STP

	Primary Pond			Secondary Pond			Total
	Upper	Lower	Sub Total	Upper	Lower	Sub Total	
Number of Pond	6	5	11	4	6	10	21
Water Depth (m)	1.30	1.30	—	1.30	1.3-1.6	—	—
Area (ha)	4.11	4.76	8.87	6.14	7.07	13.21	22.08

The layout of the ponds in the STP is shown in FIGURE 3-4. And the reuse plan of the treated sewage is presented in TABLE 3-8 and FIGURE 3-5. Raw sewage is mainly used for silviculture while treated sewage is used for agriculture and aquiculture.

TABLE 3-8 Reuse at San Juan Experimental Site

SILVICULTURE (1,600 ha)
- Creation of green belts, Recreational parks,
- Recovery of sanitary landfill site

AGRICULTURE (220 ha)
- Horticulture produce (squatters) - vegetables, fruit trees
- Forage crops (squatters) - alfalfa
- Animal feed for zoological park - papaya, banana, corn
- Commercial flower rising - roses

AQUICULTURE
- Fishculture - tilapia, giant malaysian shrimp
- Aquatic plants for poultry feed - duckweed

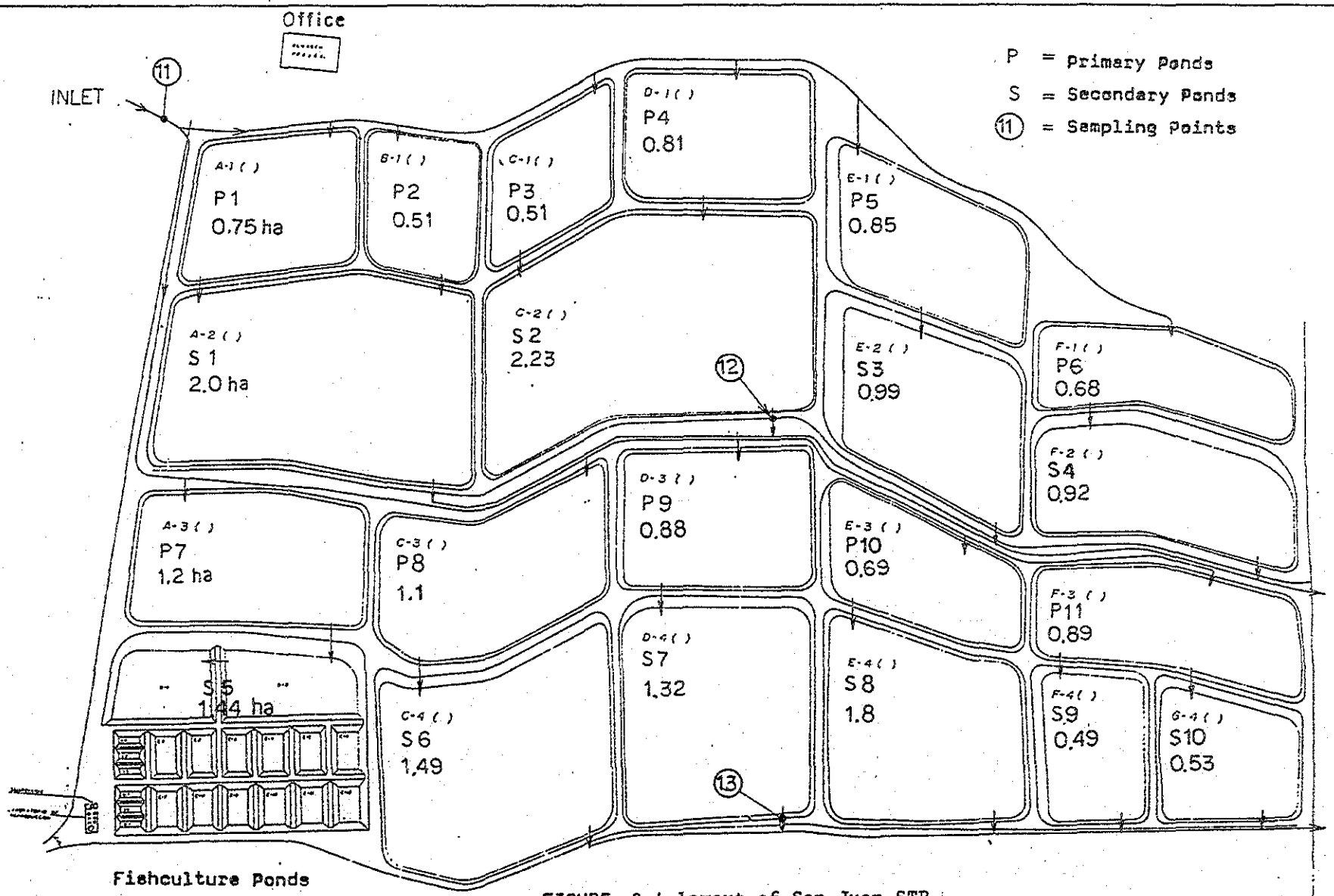


FIGURE 3-4 layout of San Juan STP

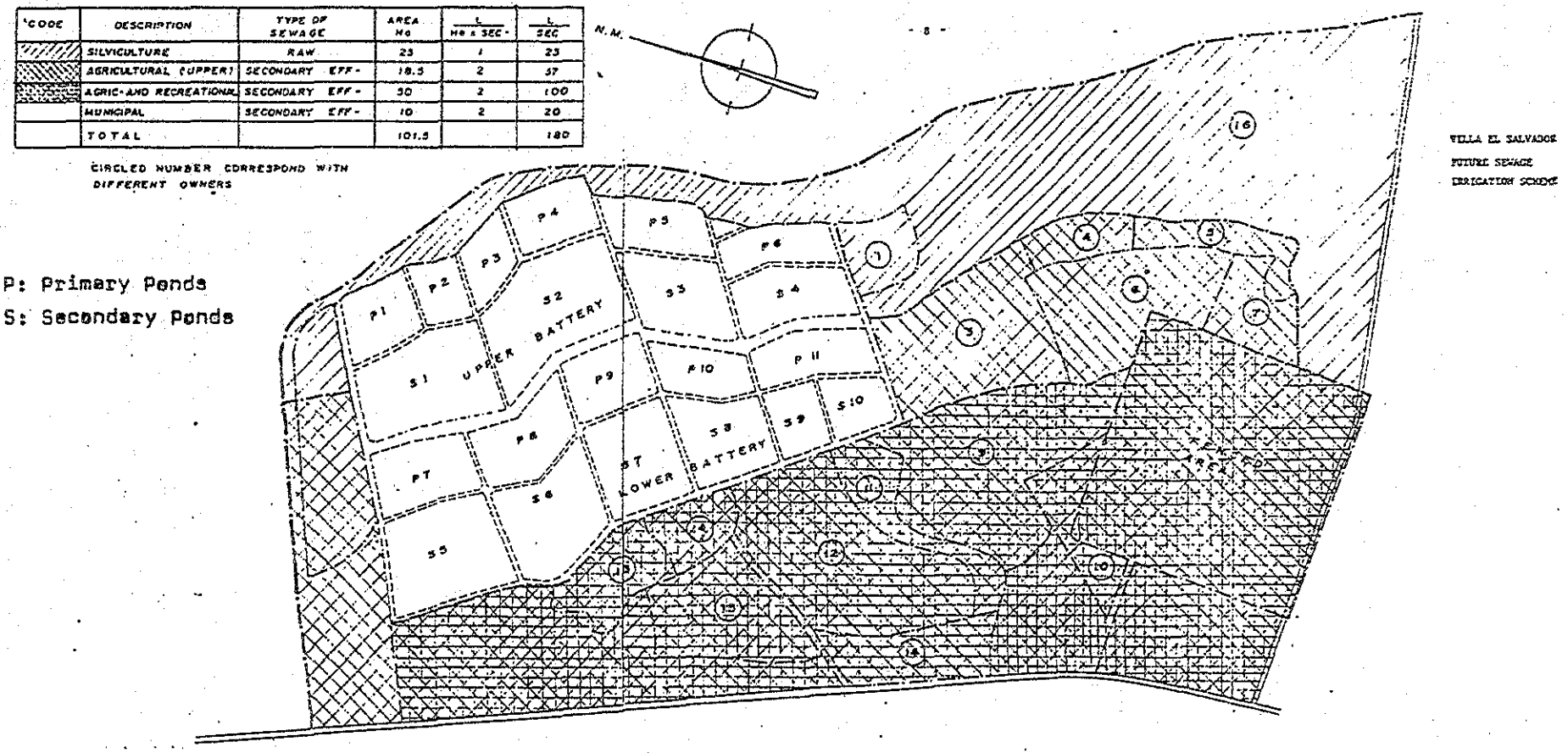


FIGURE 3-5 Reuse plan of Treated water

SOURCE: Evaluation of the SAN JUAN Stabilization Pons Final research report of the First phese,CEPIS,1980

(3) Operation Condition

Numerous reports have been made on San Juan STP by CEPIS and useful data and information have been provided regarding items such as design methods and removal of parasites and bacteria. In addition, flow measurement and water quality analysis was carried out by the Study team (refer to APPENDIX 5 for details). A summary of survey results is given in TABLE 3-9.

TABLE 3-9 Summary of Water Quality Analysis

	Measuring/ Sampling Date (1989)	Inflow Quantity (cu.m/day)	BOD_5 (mg/l)		Detention Time (day)
			Influent	Sec.Pond Effluent	
Upper Battery	Jun. 7	15,204	230-300	90-120	Approx. 6.4
	Oct. 9	-	214	51	-
	Nov. 8	-	228	56	-
Lower Battery	Jun. 7	10,769	230-300	120-120	Approx. 9.7
	Oct. 9	-	214	28	-
	Nov. 8	-	228	51	-

Treatment efficiency varies in accordance with the change of climate and inlet loading. Total coliforms and fecal coliforms have been reduced to the level of 10^5 - 10^7 and 10^4 - 10^5 respectively.

The BOD removal rate was 50 - 70 %, and the areal BOD load on the primary pond was 990 - 1,400 kg-BOD/ha/day in June, 1989. It was not in good condition due to overload.

In October to November, the BOD removal rate was 75 - 85 %, and the areal BOD load on the primary pond was 520 - 680 kg-BOD/ha/day. Although this was an improvement to the condition in June, the areal load was still high in comparison with the desirable value.

F. A. Yanez and concerns (CEPIZ) reported that the appropriate areal BOD loading on the primary pond for the climate condition in Peru is under 400 kg-BOD/ha/day, based on the result of their long-term research on the stabilization ponds in the STP.

The deposited sludge in the primary ponds is removed once every 5

years and once every 7 years in the secondary ponds.

The level of odor varies in accordance with the change of season. Particularly strong odor is emitted from the primary ponds at times of low temperature in winter.

3.4.3 Carapongo Sewage Treatment Plant

(1) Outline

This plant was constructed in 1987 and began operation in April 1988 for the purpose of treating the sewage discharged from Chosica and Chaclacayo districts which are located 20 km upstream from Lima along the Rimac River. Operation and maintenance of this plant is being carried out by the staff of Atarjea Water Treatment Plant of SEDAPAL.

(2) Facilities

The total design inflow quantity of the plant is 24,000 m^3/day. Presently, facilities for a capacity of 12,000 m^3/day or half the design inflow have been completed, the treatment method adopted for which is facultative aerated lagoon method. The use of oxidation ditch process is considered for future expansion.

Flow Diagram

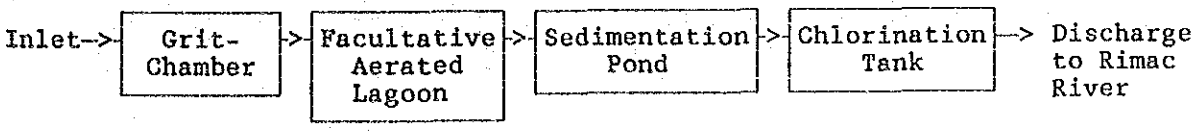


FIGURE 3-6 Flow Diagram of Carapongo STP

Design Water Quality

	Inflow	Effluent (designed)
BOD_5 (mg/l)	200	30
SS (mg/l)	200	60

Facilities

Grit-Chamber: Plug Flow Type
Width 1.0m x Length 8.5m x 2 basins

Facultative Aerated Lagoon:
Embanked Rectangular Type
94m x 94m x Depth 2.5m x 4 basins
Detention Time: 6.3 days

Sedimentation Pond:
Embanked Rectangular Type
Width 20m x Length 77.5m x Depth 2.5m x 4 basins
Detention Time: 1.0 day

Disinfection: Liquefied Chlorine Contact Method

Detailed flow diagram and a general layout plan are shown in FIGUREs 3-7 and 3-8.

(3) Operational Condition

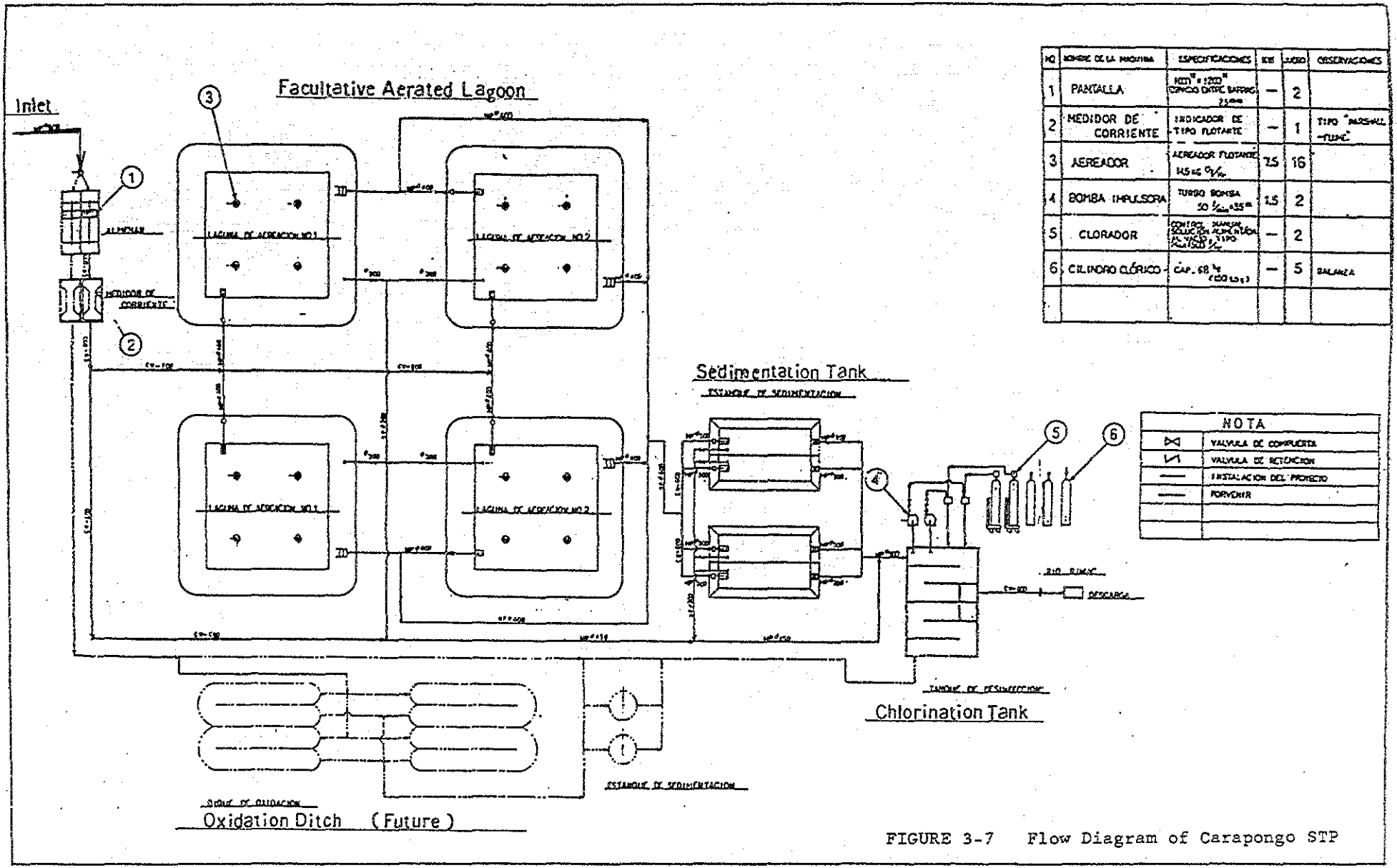
Records of monthly average inflow quantity, BOD_5 and SS from November 1988 to October 1989 analyzed by SEDAPAL are given in FIGURE 3-9. The Study team also carried out the inflow quantity measurement over 24 hours and water quality analyses (refer to APPENDIX 5 for details).

- Inflow Quantity

Based on FIGURE 3-9, the sewage inflow increased progressively with the installation of branch sewer lines since start of operation. The inflow was about 8,100 m^3/day in October 1989, equivalent to 70 % of planned sewage quantity.

- BOD_5, SS

Raw sewage quality varies widely because of the influence of the inflow of water from the irrigation canal ("acequia") to the sewerage system.



NO	NOMBRE DE LA MAQUINA	ESPECIFICACIONES	KW	LUGAR	OBSERVACIONES
1	PANTALLA		—	2	
2	MEDIDOR DE CORRIENTE	INDICADOR DE TIPO FLOTANTE	—	1	TIPO "PARSHALL" "FLUMC"
3	AEREADOR	AEREADOR FLOTANTE	7.5	16	
4	BOMBA IMPULSORA	TURBO BOMBA	1.5	2	
5	CLORADOR		—	2	
6	CILINDRO CLÓRICO	CAP. 68 Kg	—	5	BALANZA

FIGURE 3-7 Flow Diagram of Carapongo STP

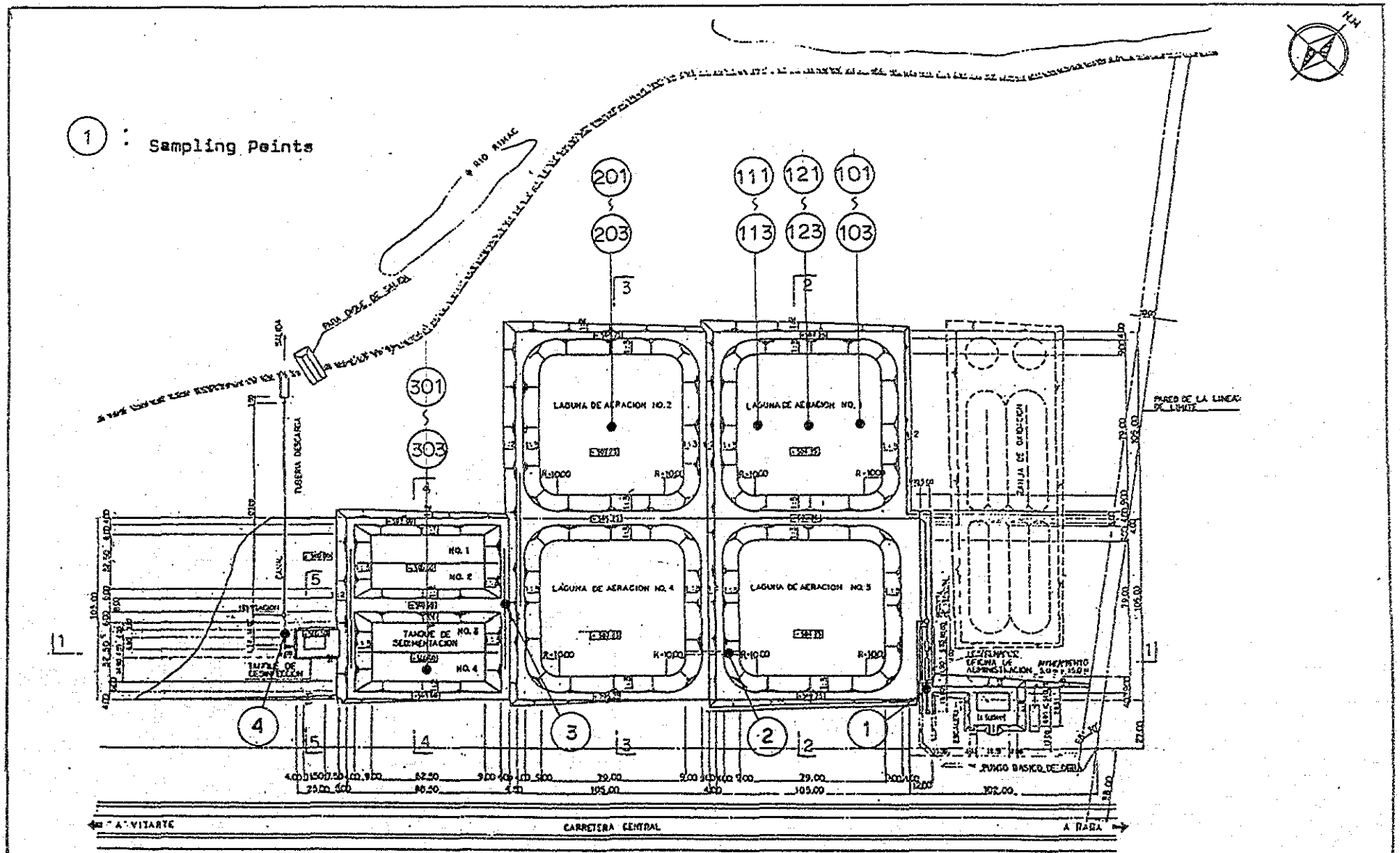


FIGURE 3-8 General Layout Plan of Carapongo STP

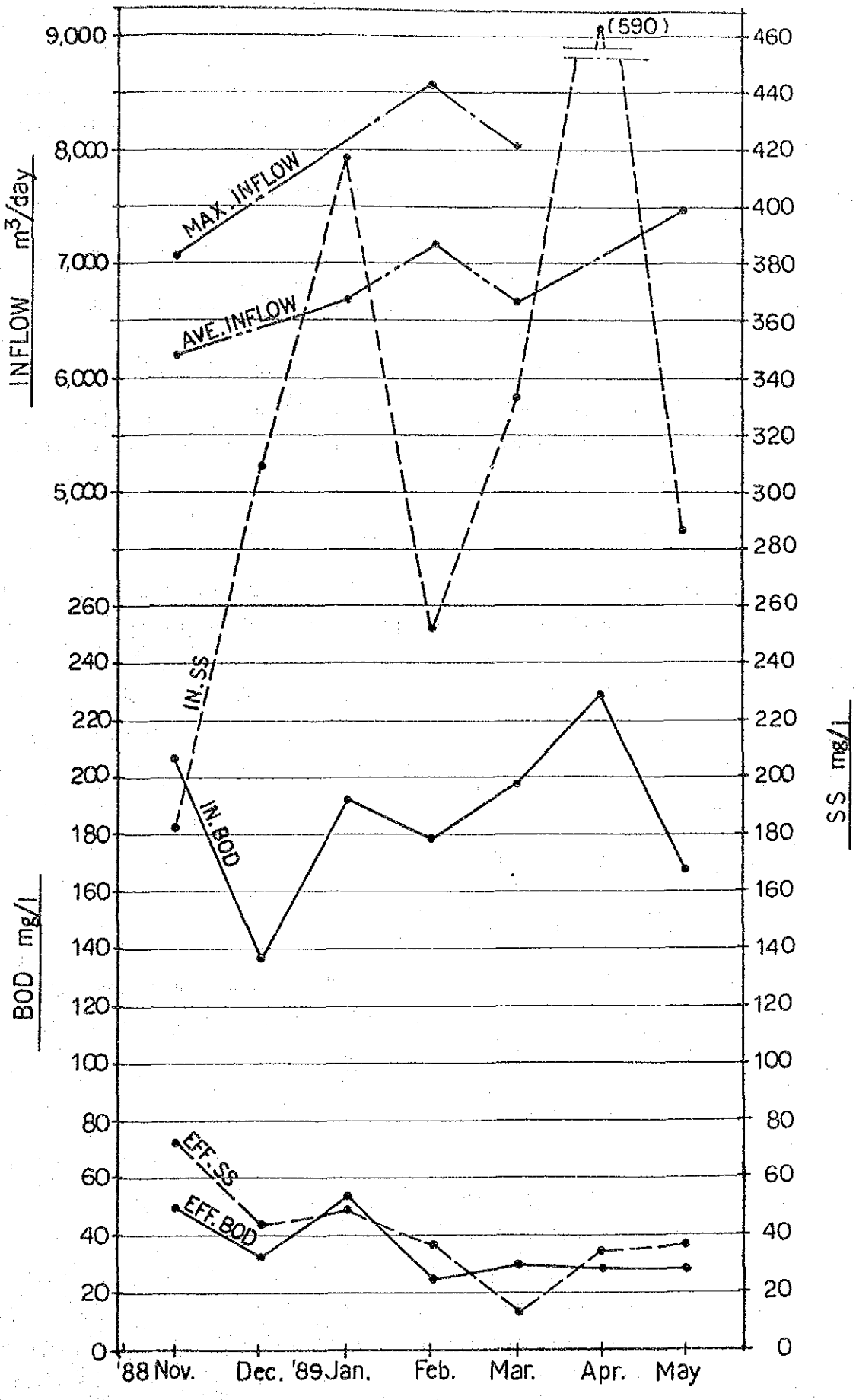


FIGURE 3-9 Monthly Average of Inflow, BOD and SS of Carapongo STP

Analyses of influent and effluent showed BOD_5 concentration of 170 - 230 mg/l and under 30 mg/l, and SS concentration of 250 - 400 mg/l and under 40 mg/l, respectively. These values satisfy the planned effluent water quality, hence it can be judged that this plant is in good operational condition.

- Coliforms

Total Coliforms was analyzed at the level of 10^6 - 10^5 CFU/ml for raw sewage and 10^2 - 10^3 CFU/ml for effluent. Chlorine feeding equipment installed in this plant has not been operated up to the present.

- MLSS

MLSS is an important index to judge the sludge accumulation condition at the bottom of Lagoon in order to maintain good operational condition. Sludge accumulation is remarkable in Lagoon No.1 at the upstream, where the MLSS is 130 - 1,600 mg/l at 1.2 m water depth and 2,000 - 7,000 mg/l at 2.3 m depth; concentration at central part of Lagoon is extremely high. In Lagoon No.2 and No.4 and Sedimentation Pond, MLSS is considerably lower than in Lagoon No. 1. Accumulated sludge is black in color and appears to be stabilized.

- Operation of Aerator

At present, all aerators are operated intermittently for around 12 hours per day. So far, there has been no trouble with the equipment up to this time.

- Observations

a) Mass generation of algae appeared during the summer season (December to February), a phenomenon mainly caused by a detention time longer than necessary. It is reported that the abnormal propagation of algae occurs after five to six day detention especially in tropical climate. The average inflow quantity from December 1988 to February 1989 was about 6,500 m^3/day so that the total detention time is calculated at 13.5 days.

Increase of inflow quantity will reduce the rate of algae generation. Also, because control of detention time is important to decrease the algae level, it is recommended that the number of operating lagoons be controlled in accordance with the sewage quantity.

b) Bad odor is felt only from the grit chamber and not felt from lagoons in the Carapongo STP, while strong odor is emitted in the San Juan STP.

c) In order to keep the treatment plant in good operational condition, it is necessary that accumulated sludge on the bottom of lagoon be removed periodically when MLSS concentration reaches 2,000 - 3,000 mg/l at 1.2 m depth at the center of the lagoon.

3.4.4 Other Waste Stabilization Ponds in Lima

In the southern area of Metropolitan Lima, there are other existing, on-going and planned stabilization ponds besides the San Juan STP. Treated sewage from all of these ponds are intended to be utilized for irrigation. Outline and situation of each stabilization pond, including the San Juan STP, are shown in TABLE 3-10 and FIGURE 3-10.

TABLE 3-10 OUTLINE OF STABILIZATION PONDS IN SOUTHERN PART OF LIMA

No.	Name	No. of Ponds	Location	Financing	Age	Remarks
A. Existing						
1.	San Juan	21	San Juan de Miraflores	Ministry of Housing & C.	25	Operating
2.	Apa Lurin	2	Villa El Salvador	Villa El Salvador	4	Operating but not in good condition due to overload
3.	Parque No.26*1	4	Parque No.26, Villa El Salvador	Municipio de Villa El Salvador	3	Operating from Oct. 1989
4.	Jose Galvez	4	Villa Maria del Triunfo	Agricultores de Jose Galvez y Pachacamac	6	Only 2 ponds operating, not in good condition
B. Under Construction						
5.	Parque No.26*1	4	Parque No.26, Villa El Salvador	Ministry of Agriculture	-	Excavating
C. Planned						
6.	Huascar	4	Parque No.24, Villa El Salvador	Municipio de Lima (SERPAR)	3	-

*1: At the Parque No.26, stabilization ponds of the same type as San Juan STP, are under construction covering all of the park area. Treatment capacity of operating ponds which is ultimately planed for 120 liters/sec, will only initially be 24 liters/sec in the first stage.

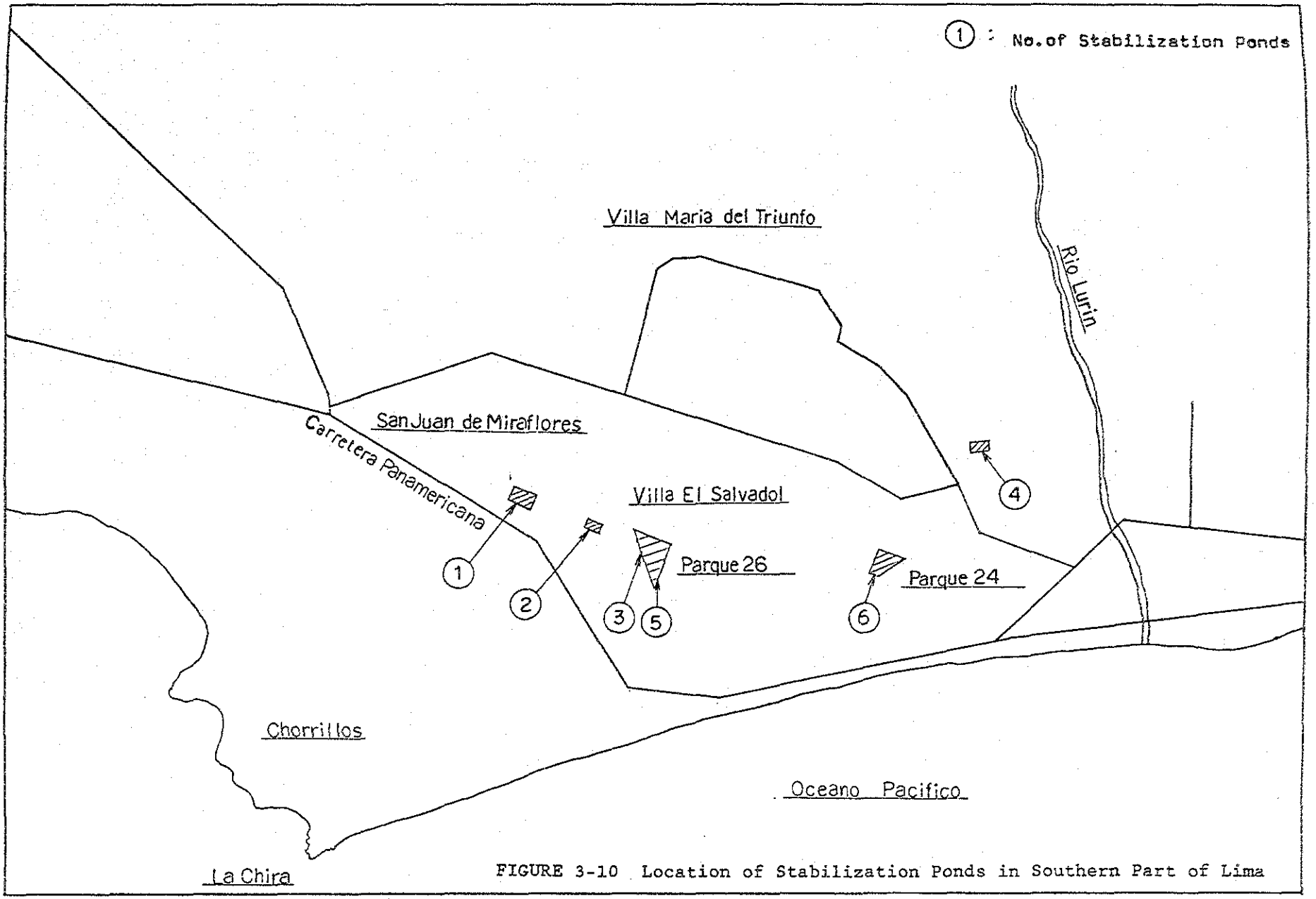


FIGURE 3-10 Location of Stabilization Ponds in Southern Part of Lima

CHAPTER 4

POPULATION

CHAPTER 4 POPULATION

4.1 Historical Trend of Population

Peru conducts national population every about ten years, the last one having been taken in 1981. Data on the latest 4 census years shown in TABLE 4-1 are considered the most reliable information on the population of Peru.

In all of these population counts, it had been impossible to cover the country's entire territory. According to the Institute National de Estadistica (INE, National Statistics Institute), rough approximations as that shown in TABLE 4-2 had to be made for population in areas that are hard to penetrate like the jungle zones. Total population is taken as the sum of the actual census count and the estimated population.

TABLE 4-2 TOTAL POPULATION IN PERU BY CENSUS YEAR

POPULATION	YEAR OF CENSUS			
	30/6/1940*	2/7/1961	4/6/1972	12/7/1981
TOTAL	7,080,000	10,420,357	14,121,564	17,762,231
NOMINAL OF CENSUS	-	9,906,746	13,538,208	17,005,210
OMITTED FROM CENSUS	-	412,781	543,556	727,021
ESTIMATED IN FORESTS	-	100,830	39,800	30,000

* Modified by INE
Source: INE

TABLE 4-1 POPULATION BY DISTRICT (CENSUS YEAR 1940,1961,1972,1981)

DISTRICT	9/6/1940	2/7/1961	4/6/1972	12/7/1981
LIMA	269,738	338,918	354,292	371,122
ANCON	1,386	3,802	5,581	8,425
ATE	10,602	78,578	60,542	145,504
BARRANCO	18,625	42,449	49,091	46,478
BRENA	-	99,810	112,202	112,398
CARABAYLLO	11,931	42,270	27,847	52,800
CHACLACAYO	1,109	9,363	21,390	31,592
CHORRILLOS	6,996	32,376	90,618	141,881
CIENEGUILLA	-	-	2,527	4,546
COMAS	-	-	173,101	283,079
EL AGUSTINO	-	-	117,077	167,771
INDEPENDENCIA	-	-	109,873	137,722
JESUS MARIA	-	-	84,128	83,179
LA MOLINA	-	-	5,951	14,659
LA VICTORIA	55,134	204,926	265,636	270,778
LINCE	25,636	82,393	83,064	80,456
LURIGANCHO-CHOSICA	7,472	32,561	51,366	65,139
LURIN	3,716	6,171	12,789	17,331
MAGDALENA DEL MAR	16,057	55,737	56,886	55,535
PUEBLO LIBRE	5,859	68,560	78,155	83,985
MIRAFLORES	45,489	88,446	99,804	103,453
PACHACAMAC	3,597	11,726	4,534	6,780
PUCUSANA	-	1,700	2,835	4,104
PUENTE PIEDRA	2,544	8,370	18,861	33,922
PUNTA HERMOSA	-	301	908	1,010
PUNTA NEGRA	-	345	744	553
RIMAC	57,154	144,320	172,564	184,484
SAN BARTOLO	-	952	1,458	2,913
SAN ISIDRO	8,778	37,925	63,296	71,203
S.J. DE LURIGANCHO	-	-	86,173	259,390
S.J. DE MIRAFLORES	-	-	106,755	165,765
SAN LUIS	-	-	24,007	57,269
SAN MARTIN DE PORRES	-	97,040	230,813	404,856
SAN MIGUEL	3,961	23,233	63,139	99,221
SANTA MARIA DEL MAR	-	-	44	96
SANTA ROSA	-	-	217	492
SANTIAGO DE SURCO	7,101	48,558	71,954	146,636
SURQUILLO	-	71,540	90,111	134,158
V.M. DEL TRIUNFO	-	-	180,959	313,912
Sub Total (PROV. LIMA)	562,885	1,632,370	2,981,292	4,164,597
CALLAO	70,425	155,953	198,573	266,374
BELLAVISTA	8,273	43,128	39,724	67,515
CARMEN DE LA LEGUA	-	-	26,043	36,037
LA PERLA	-	-	33,410	48,877
LA PUNTA	3,589	5,909	6,697	6,407
VENTANILLA	-	-	16,784	17,005
Sub Total (PROV.CALLAO)	82,287	204,990	321,231	442,215
Total (METRO. LIMA)	645,172	1,837,360	3,302,523	4,606,812
PERU	-	9,906,746	13,538,208	17,005,210
Proportion of Lima	-	18.5 %	24.4 %	27.1 %

Source: INE

TABLE 4-3 shows the distribution of the population according to the three regions; namely: coast, mountains and forest.

TABLE 4-3 DISTRIBUTION OF AREA AND POPULATION IN PERU BY REGION

(as of 1987)

	POPULATION (%)*	AREA (%)	CULTIVATED AREA (%)
PERU	100 (21,255,900)	100 (128,521,000 km)	100 (3,691,000 km)
COAST (COSTA)	52.2	11.6	21.8
MOUNTAIN (SIERRA)	36.6	28.1	61.8
FOREST (SELVA)	11.2	60.3	16.4

*: 1988
Source: INE

TABLE 4-4 shows the percentage of the population in the provinces of Lima and Callao which was not counted by census.

TABLE 4-4 RATE OF OMITTED POPULATION

(%)

PROVINCE	YEAR OF CENSUS			
	1940	1961	1972	1981
LIMA	2.52	2.98	3.40	4.95
CALLAO	2.52	2.68	3.31	2.88

Source: INE

As the period between each census year is very long, previous census data taken as bases for projection of the population are reckoned from June 30th of each year up to the current year. Interpolated population based on this calculation method is shown in TABLE 4-5.

TABLE 4-5 ESTIMATED POPULATION BY DISTRICT (as of July 30)

DISTRICT	1940	1961 1/	1972	1981 2/
LIMA	276,734	262,400	366,501	390,513
ANCON	1,428	4,000	5,792	8,865
ATE	11,061	80,900	63,235	138,746
BARRANCO	19,162	43,700	50,746	48,907
BRENA	-	102,800	116,031	118,271
CARABAYLLO	12,317	43,500	28,981	55,558
CHACLACAYO	1,160	9,600	22,195	33,243
CHORRILLOS	7,244	33,300	94,088	149,294
CIENEGUILLA	-	1,300	2,628	4,783
COMAS	-	97,400	179,819	297,870
EL AGUSTINO	-	77,100	121,445	176,537
INDEPENDENCIA	-	85,100	113,827	144,918
JESUS MARIA	-	86,600	86,991	87,525
LA MOLINA	-	2,100	6,218	29,786
LA VICTORIA	56,947	201,800	274,735	284,922
LINCE	26,443	84,800	85,878	84,660
LURIGANCHO-CHOSICA	7,731	33,500	53,220	68,542
LURIN	3,817	6,400	13,259	18,104
MAGDALENA DEL MAR	16,574	57,400	58,816	58,437
PUEBLO LIBRE	6,184	70,600	80,864	88,374
MIRAFLORES	46,757	91,100	103,235	108,859
PACHACAMAC	3,711	12,100	4,705	7,134
PUCUSANA	-	1,800	2,941	4,319
PUENTE PIEDRA	2,625	8,600	19,616	35,694
PUNTA HERMOSA	-	300	940	1,063
PUNTA NEGRA	-	400	768	582
RIMAC	58,841	148,600	178,538	194,123
SAN BARTOLO	-	1,000	1,518	3,067
SAN BORJA 3/	-	53,600	68,862	59,270
SAN ISIDRO	9,082	39,000	65,513	72,706
S.J. DE LURIGANCHO	-	23,300	90,393	272,943
S.J. DE MIRAFLORES	-	64,000	110,833	174,426
SAN LUIS	-	8,600	25,072	53,306
SAN MARTIN DE PORRES	-	99,900	239,973	426,010
SAN MIGUEL	4,115	23,900	65,559	104,405
SANTA MARIA DEL MAR	-	100	46	101
SANTA ROSA	-	100	226	518
SANTIAGO DE SURCO	7,397	46,600	69,817	147,105
SURQUILLO	-	23,500	29,792	98,269
VILLA EL SALVADOR 4/	-	-	-	142,567
V.M. DEL TRIUNFO	-	94,800	188,115	187,878
Sub Total (PROV. LIMA)	579,330	2,125,600	3,091,731	4,382,200
CALLAO	72,441	124,600	205,631	270,499
BELLAVISTA	8,580	44,300	41,239	69,148
CARMEN DE LA LEGUA	-	18,300	26,977	39,498
LA PERLA	-	22,000	34,627	48,362
LA PUNTA	3,686	6,100	6,916	6,416
VENTANILLA	-	17,200	17,341	20,177
Sub Total (PROV.CALLAO)	84,707	232,500	332,731	454,100
TOTAL (METRO. LIMA)	664,037	2,358,100	3,424,462	4,836,300
PERU 2/	7,080,000	10,217,500	13,954,700	17,754,800
Proportion of Metro. Lima	9.38%	23.08%	24.54%	27.24%
Average Annual Growth Rate of Lima		6.39%	3.46%	3.95%
- do - Callao		4.93%	3.31%	3.52%
- do - M.Lima		6.22%	3.45%	3.91%
- do - Peru		1.76%	2.87%	2.71%

1/ SEDAPAL (Adjusted the influence of independence of new districts)
2/ Proyecciones de Poblacion por Años Calendarios (Boletin Especial No.10), Dec.1986, INE
3/ Summation of a part of Santiago de Surco and Surquillo in proportion to belonging area before independence
4/ Adjusted with V. M. del Triunfo

According to this table, there was an overall average annual increase of 1.76 percent in the population of Peru from the period 1940 to 1961. During the same period, there was a 6.22% average annual increase in the population in Metropolitan Lima. The population of Lima which stood at only 9.38% of the total Peruvian population in 1940 constituted 23.08% of the national population in 1961, indicating a large influx of people to the capital from the rural areas. This tendency still continues, but has been diminishing recently. A slight decline of population growth rate compared to the previous period was registered from 1972 to 1981, as the national population increased only by 2.71%. However, during the same period, the population of Metropolitan Lima increased by 3.91% from 3.45%. Lima's population expressed as ratio to the national total increased from 24.54% in 1972 to 27.24% in 1981.

The concentration of population in Metropolitan Lima which has been greatly influenced by economic, social, and political factor seems to be diminishing except in the surrounding areas and in the "Pueblos Jóvenes".

4.2 Projection of the Future Population

There has been an apparent population explosion in Metropolitan Lima between 1981 and today but there are no recent specific statistical data to indicate the magnitude of such growth. Because of this it is impossible to project with confidence the future population by merely taking into account the birthrate and mortality. Various entities have projected the population of Metropolitan Lima, all of them using as bases, the data taken from the census of 1972 and 1981, duly adjusted them according to past trends.

In December 1981, the Engineering-Science, an American consulting firm, presented a report on the master plan for the water supply and sewerage systems of Metropolitan Lima. In this report, future population was calculated based on the data on the increase of district population as gathered from the "Oficina National de Estadisticas y Censo", INE.

In February, 1984, SEDAPAL calculated the future population based on census data taken in the years 1961, 1972 and 1981.

In June, 1985, TAHAL, an Israeli consulting firm, presented a report on a project for the utilization of recycled water in the southern part of Lima. Future population was calculated by projecting through a logistical curve, the census data of 1961, 1972 and 1981 in 11 districts (now 13).

In December 1986, INE developed a zonal population projection curve covering the period from 1980 to 1990. Rate of increase used in this projection was that obtained from the 1972 and 1981 census, which was extrapolated by means of a geometric curve extending to 1990.

As mentioned above, all of these projections have been based on the latest national census which was taken in 1981, hence their accuracy is not very reliable considering a quite distant base year.

The study team have tried to obtain more recent and precise information but all of the private and public entities which the team has visited use as base either the census of 1981 or the population projections calculated by INE.

These data seem to be unreliable, thus the study team attempted to calculate mathematically the future population based on the data of the last three census years through methods described in the following paragraphs (refer to APPENDIX 6 for details).

(1) Logistic Curve Method

This curve shows population change with respect to time which is assumed to start from zero in the distant past, initially increases slowly, rises abruptly at about midpoint, gradually decreases in growth rate as it passes the point of inflection, and reaches saturation point in the distant future.

The population of 1961, 1971* and 1981 were used as a base to calculate the saturated population (theoretical) through the logistic curve formula. Population in 1971* is calculated by interpolating the figures from the 1961 and 1981 census.

As a result of estimates made by the Logistic Curve Method, the

following population projections were obtained:

Year	Population
1989	5,896,600
1990	6,035,200
1995	6,673,600
2000	7,239,000

(2) Exponential Curve Method

This method can be applied to calculate future population under various increase or decrease conditions.

The projected population of Metropolitan Lima as calculated by the Exponentical Curve Method is:

Year	Population
1989	6,592,800
1990	6,858,600
1995	8,360,200
2000	10,206,400

(3) Geometrical Method

This method calculates the future population assuming that the rate of increase or decrease as obtained from past data remains constant.

Based on the rate of increase of population from 1972 to 1981, the resulting projections using the Geometric Method are:

Year	Population
1989	6,858,600
1990	7,200,400
1995	9,371,100
2000	12,655,700

TABLE 4-6 shows the actual and projected rates of population increase based on census and projections by various entities including those ob-

tained in this study through three different mathematical methods. These data are plotted in FIGURES 4-1 and 4-2.

TABLE 4-6 COMPARISON OF GROWTH RATE IN VARIOUS POPULATION PROJECTIONS

STUDY/CENSUS	YEAR CONDUCTED	AVERAGE ANNUAL GROWTH RATE (%) from 1940 to 1961	1961 to 1972	1972 to 1981	1981 to 1990	1990 to 2000
METROPOLITAN LIMA						
CENSUS	'40,'61,'72,'81	6.22	3.45	3.87	-	-
ES Master Plan 1/	Dec.,'81	-	-	-	4.51	3.87
SEDAPAL Analysis 2/	Feb.,'84	-	-	-	3.71	3.38
INE Estimation 3/	Dec.,'86	-	-	-	3.22	-
JICA Geometrical	Jun.,'89	-	-	-	4.77	6.23
JICA Exponential	Jun.,'89	-	-	-	3.63	3.37
JICA Logistic	Jun.,'89	-	-	-	2.56	1.68
PERU						
CENSUS	'40,'61,'72,'81	1.86	2.82	2.55	-	-
INE Estimation 3/	Dec.,'86	-	2.87	2.71	2.58	2.27

Note: 1/ Plan Maestro de Agua Potable y Desague para Lima Metropolitana, Engineering Science, December 1981
2/ Analysis de Poblacion, Vivienda y Cobertura, Oficina de Planification General, SEDAPAL, February 1984
3/ Peru: Proyecciones de Poblacion por Años Calendarios, Period: 1980-1990, Instituto Nacional de Estadistica, December 1986
4/ Yearly average growth rates are calculated by geometrical method.

The population increase rate for the period 1990 to 2000 which was obtained by the logistic curve formula seems to be much lower than the projection of INE. It is probable that the rate of increase of the population of Metropolitan Lima during this period will tend to taken off, but it is believed that such decrease in population growth will not be as appreciable.

The values obtained through the exponential curve formula indicate an acceptable trend compared to the behavior of population growth during past years. There are, however, some districts where results of calculations are obvio

The values obtained with the use of geometrical method tend to be very high. As the current trend seems to indicate a lower rate of increase, it is deemed that these values are excessive.

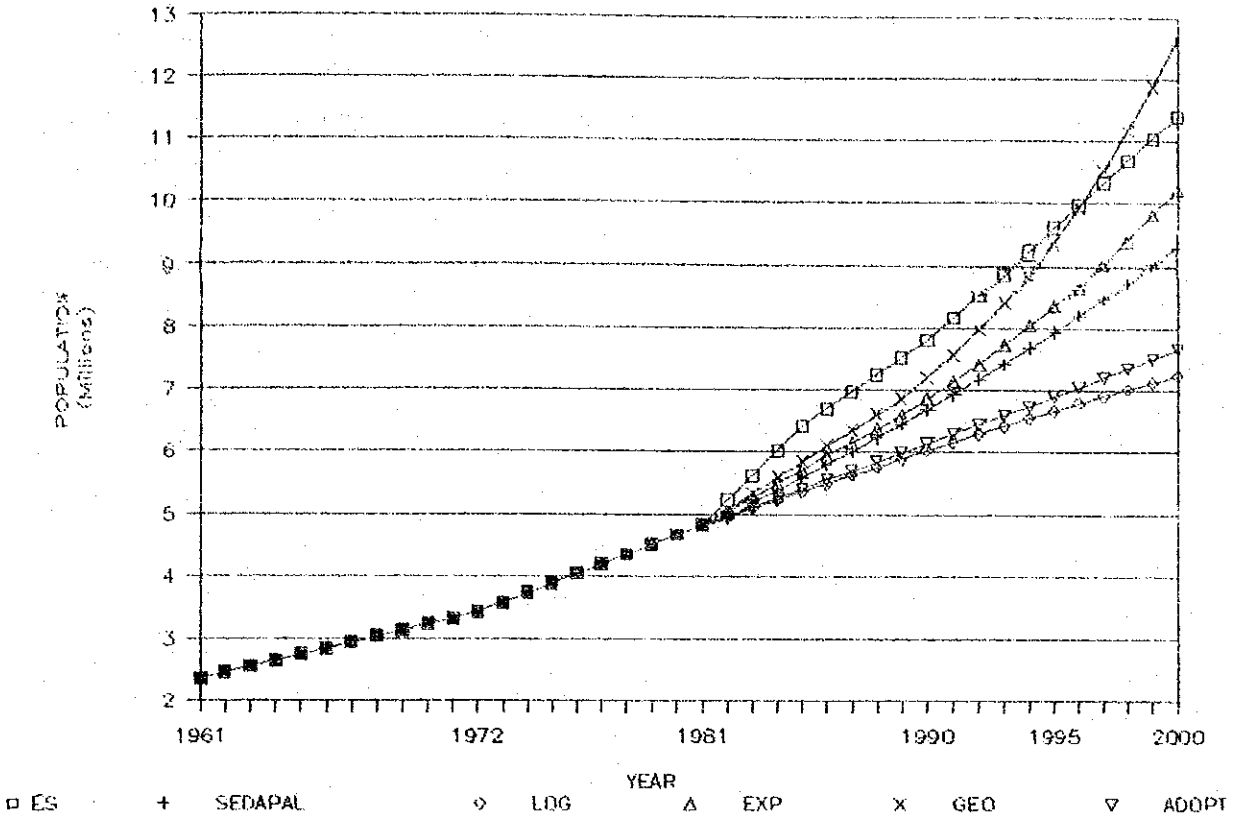


FIGURE 4-1 POPULATION PROJECTION (1981 - 2000)

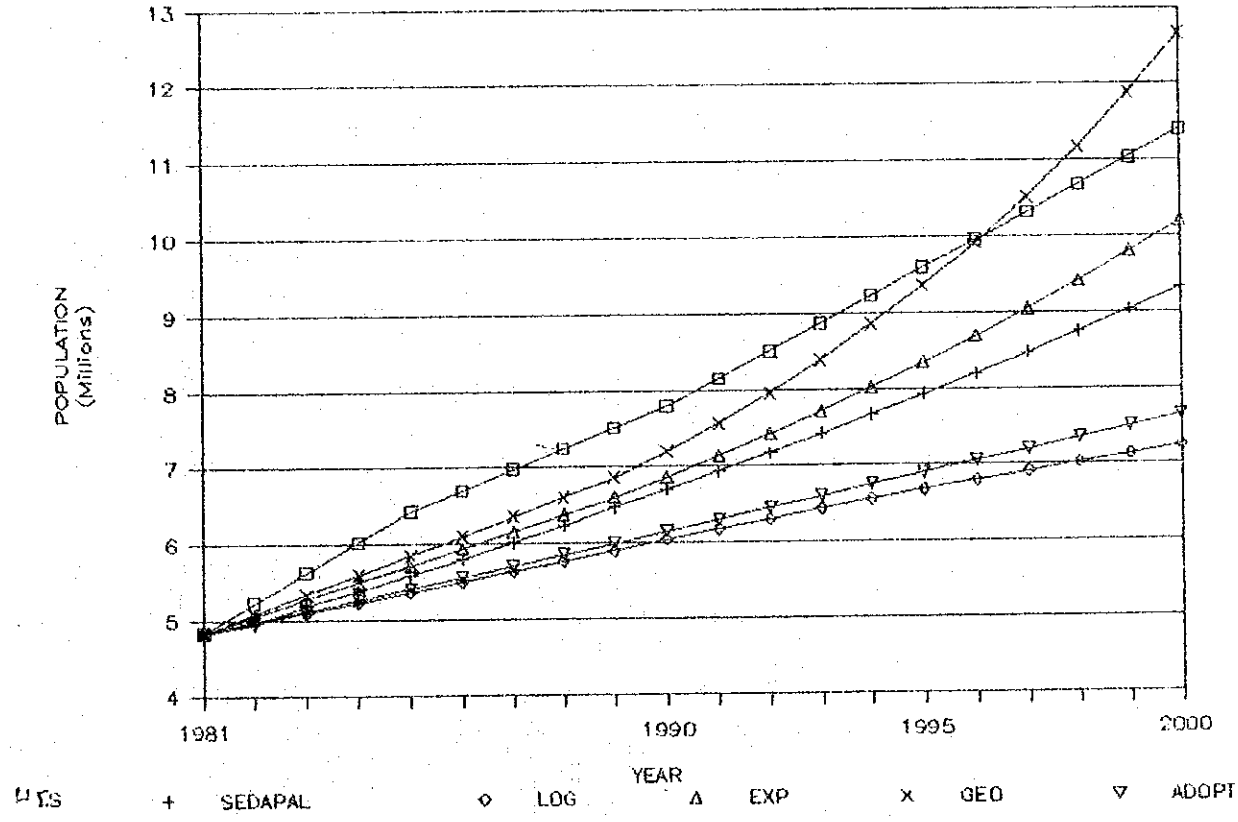


FIGURE 4-2 POPULATION PROJECTION (DETAIL)

Considering the results discussed above, the median values obtained from the three calculation methods for each district are adopted as future population data for the purposes of planning this Project. However, for those districts where the calculated growth rates are absurd (excessive), the values obtained from other formulas which are regarded to be appropriate are adopted instead.

Summarized hereunder, and detailed in TABLE 4-7 is the projected population of Metlopolitan Lima based on the aforementioned calculation procedure for growth rates.

Year	Population
1989	5,993,400
1990	6,145,200
1995	6,899,300
2000	7,661,400

TABLE 4-8 shows a comparison of the projected population calculated by different entities. It can be seen from the said table that for Metropolitan Lima, the adopted projected population for 1990 is only 4.4% less than that of the INE projection. Also, in the specific 13 districts relating to the Colector Surco, the difference between the two projections is 5.2 %. Both of these variances are regarded as within acceptable range.

TABLE 4-8 COMPARISON OF VARIOUS POPULATION PROJECTION

NAME OF STUDY	DATE OF ISSUE	Metro. Lima			13 Districts of Surco 5/		
		1990	1995	2000	1990	1995	2000
ES Master Plan 1/	Dec.,'81	7,800	-	11,400	3,079	-	4,310
SEDAPAL Analysis 2/	Feb.,'84	6,693	7,938	9,330	2,691	3,182	3,730
TAHAL Reuse Study 3/	Jun.,'85	-	-	-	2,642	-	4,040
INE Projection 4/	Dec.,'86	6,415	-	-	2,650	-	-
JICA Adopted	Jun.,'89	6,145	6,899	7,661	2,520	2,895	3,304
JICA Geometrical	Jun.,'89	7,200	9,371	12,656	2,787	3,481	4,461
JICA Exponential	Jun.,'89	6,859	8,360	10,206	2,936	3,751	4,823
JICA Logistic	Jun.,'89	6,035	6,674	7,239	2,443	2,747	3,038

Note: 1/ Plan Maestro de Agua Potable y Desague para Lima Metropolitana, Engineering Science, December 1981
2/ Analysis de Poblacion, Vivienda y Cobertura, Oficina de Planification General SEDAPAL, February 1984
3/ Estudio de Factibilidad del Proyecto de Reuso de Aguas Servidas para Irrigacion de Zonas Aridas al Sur d Lima, TAHAL-SANIDRO-SECOMAN, June 1985
4/ Peru: Proyecciones de Poblacion por Años Calendarios, Period: 1980-1990, Instituto Nacional de Estadistica, December 1986
5/ Districts related to the Colector Surco up to the middle point; Lima, Ate, El Agustino, La Molina, La Victoria, San Borja, San Isidro, San Juan de Miraflores, San Luis, Santiago de Surco, Surquillo, Villa El Salvador, Villa Maria del Triunfo

TABLE 4 - 7 PROJECTED POPULATION (METROPOLITAN LIMA, EXPONENTIAL, LOGISTIC AND GEOMETRICAL CURVE)

TYPE	DISTRICT	1961	1972	1981	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
E	LIMA	262,400	366,501	390,513	406,400	408,200	409,900	411,600	413,200	414,800	416,400	418,000	419,500	421,000	422,500	423,900
E	ANCON	4,000	5,792	9,865	12,500	13,100	13,600	14,100	14,700	15,200	15,800	16,400	17,000	17,600	18,200	18,800
E	ATE	80,900	63,235	138,746	161,900	164,800	167,700	170,600	173,500	176,300	179,200	182,100	185,000	187,900	190,800	193,700
E	BARRANCO	43,700	50,746	48,907	48,100	48,000	47,900	47,900	47,800	47,700	47,700	47,600	47,600	47,500	47,500	47,400
E	BRENA	102,800	116,031	118,271	119,700	119,900	120,000	120,200	120,300	120,400	120,600	120,700	120,800	121,000	121,100	121,200
E	CARABAYLLO	43,500	28,981	55,558	60,400	61,000	61,600	62,200	62,800	63,400	64,000	64,600	65,200	65,800	66,400	67,000
E	*CHACLACAYO	9,600	22,195	33,243	39,600	40,200	40,700	41,100	41,600	41,900	42,300	42,600	42,900	43,100	43,400	43,600
E	*CHORRILLOS	33,300	94,088	149,294	176,800	178,900	180,800	182,500	184,000	185,300	186,400	187,400	188,300	189,100	189,800	190,400
L	CIENEGUILLA	1,300	2,628	4,783	7,900	8,400	8,900	9,500	10,100	10,700	11,400	12,100	12,800	13,600	14,400	15,300
E	*COMAS	97,400	179,819	297,870	362,300	369,600	376,400	382,900	388,900	394,600	399,900	404,900	409,500	413,800	417,700	421,400
E	*EL AGUSTINO	77,100	121,445	176,537	205,200	208,400	211,600	214,500	217,300	220,000	222,500	224,800	227,000	229,100	231,100	232,900
E	INDEPENDENCIA	85,100	113,827	144,918	175,500	179,500	183,500	187,500	191,600	195,700	199,800	204,000	208,100	212,300	216,600	220,800
G	JESUS MARIA	86,600	86,991	87,525	88,000	88,100	88,100	88,200	88,200	88,300	88,400	88,400	88,500	88,500	88,600	88,700
E	LA MOLINA	2,100	6,218	29,786	87,000	92,600	102,900	114,000	125,900	138,700	152,300	166,900	182,400	198,800	216,300	234,800
E	LA VICTORIA	201,900	274,735	284,922	291,300	292,000	292,600	293,300	293,900	294,500	295,100	295,700	296,300	296,900	297,400	298,000
E	LINCE	84,900	85,878	84,660	83,600	83,500	83,400	83,300	83,200	83,100	83,000	82,900	82,800	82,700	82,600	82,500
G	LURIGANCHO-CHOSICA	33,500	53,220	68,542	85,800	88,300	90,800	93,400	96,000	98,800	101,600	104,500	107,500	110,500	113,700	116,900
G	LURIN	6,400	13,259	18,104	23,900	24,700	25,600	26,500	27,400	28,400	29,400	30,400	31,500	32,600	33,800	34,900
E	MAGDALENA DEL MAR	57,400	58,816	58,437	58,300	58,300	58,200	58,200	58,200	58,200	58,200	58,200	58,200	58,200	58,100	58,100
E	PUEBLO LIBRE	70,600	80,864	88,374	94,800	95,600	96,400	97,200	98,000	98,800	99,500	100,300	101,100	101,900	102,600	103,400
E	MIRAFLORES	91,100	103,235	108,859	113,100	113,600	114,100	114,600	115,100	115,500	116,000	116,500	116,900	117,400	117,800	118,300
E	*PACHACAMAC	12,100	4,705	7,134	7,700	7,900	8,000	8,200	8,300	8,500	8,700	8,800	9,000	9,200	9,400	9,600
L	PUCUSANA	1,800	2,941	4,319	5,700	5,900	6,100	6,300	6,500	6,700	6,900	7,100	7,300	7,600	7,800	8,000
L	PUENTE PIEDRA	8,600	19,616	35,694	60,000	63,700	67,500	71,500	75,700	80,100	84,500	89,200	93,900	98,800	103,800	108,900
G	PUNTA HERMOSA	300	940	1,063	1,200	1,200	1,200	1,200	1,300	1,300	1,300	1,300	1,300	1,300	1,400	1,400
E	PUNTA NEGRA	400	768	582	500	500	500	500	500	500	500	500	500	500	500	500
E	RIMAC	148,600	178,538	194,123	206,200	207,700	209,100	210,500	211,900	213,300	214,600	216,000	217,300	218,700	220,000	221,300
G	SAN BARTOLO	1,000	1,518	3,067	4,800	5,100	5,400	5,700	6,000	6,400	6,700	7,100	7,500	8,000	8,400	8,900
E	SAN BORJA	53,600	68,862	59,270	56,800	56,700	56,500	56,300	56,200	56,100	56,000	55,800	55,700	55,600	55,600	55,500
E	SAN ISIDRO	39,000	65,513	72,706	77,600	78,100	78,700	79,200	79,700	80,200	80,700	81,200	81,700	82,100	82,600	83,100
E	*S.J. DE LURIGANCHO	23,300	90,393	272,943	420,900	436,400	450,700	463,700	475,500	486,100	495,500	504,000	511,400	518,000	523,700	528,800
E	S.J. DE MIRAFLORES	64,000	110,833	174,426	242,900	252,200	261,600	271,100	280,700	290,500	300,400	310,500	320,600	330,900	341,300	351,900
E	*SAN LUIS	8,600	25,072	53,306	64,100	65,000	65,800	66,500	67,200	67,700	68,200	68,600	68,900	69,300	69,500	69,800
E	SAN MARTIN DE PORRES	99,900	239,973	426,010	624,600	651,300	678,400	705,800	733,600	761,800	790,300	819,200	848,400	878,000	907,900	938,100
E	*SAN MIGUEL	23,900	65,559	104,405	125,200	126,800	128,300	129,700	130,800	131,900	132,900	133,700	134,400	135,100	135,700	136,200
E L G	SANTA MARIA DEL MAR 1/	100	46	101	100	100	100	100	100	100	100	100	100	100	100	100
L	SANTA ROSA	100	226	518	900	1,000	1,100	1,200	1,300	1,400	1,500	1,600	1,700	1,800	1,900	2,100
G	*SANTIAGO DE SURCO	46,600	69,817	147,105	201,100	210,500	220,200	230,100	240,200	250,500	261,000	271,700	282,600	293,600	304,700	315,900
G	*SURQUILLO	23,500	29,792	98,269	101,200	101,600	101,900	102,100	102,400	102,500	102,700	102,800	102,900	103,000	103,000	103,100
E	VILLA EL SALVADOR	-	-	142,567	251,000	267,000	283,400	300,000	316,900	334,000	351,300	368,900	386,700	404,600	422,700	441,000
E	V.M. DEL TRIUNFO	94,800	188,115	187,878	306,300	323,000	339,900	357,100	374,400	392,000	409,600	427,500	445,500	463,600	481,900	500,300
	TOTAL (PROV. LIMA)	2,125,600	3,091,731	4,382,200	5,456,900	5,598,400	5,739,100	5,880,100	6,020,900	6,161,900	6,302,900	6,444,600	6,586,300	6,729,100	6,872,300	7,016,500
E	CALLAO	124,600	205,631	279,499	327,700	334,900	342,000	349,100	356,300	363,400	370,500	377,600	384,700	391,800	398,900	406,000
E	BELLAVISTA	44,300	41,239	69,148	79,100	80,300	81,600	82,800	84,100	85,300	86,500	87,800	89,000	90,300	91,500	92,800
E	*CARMEN DE LA LEGUA	18,300	26,977	39,498	44,500	45,100	45,600	46,200	46,600	47,100	47,500	47,900	48,300	48,700	49,000	49,300
E	*LA PERLA	22,000	34,627	48,362	55,800	56,700	57,400	58,200	58,900	59,600	60,200	60,800	61,300	61,800	62,300	62,800
E	LA PUNTA	6,100	6,916	6,416	6,300	6,300	6,300	6,300	6,200	6,200	6,200	6,200	6,200	6,200	6,200	6,200
G	VENTANILLA	17,200	17,341	20,177	23,100	23,500	23,900	24,300	24,700	25,100	25,500	26,000	26,400	26,900	27,300	27,800
	TOTAL (PROV. CALLAO)	232,500	332,731	454,100	536,500	546,800	556,800	566,900	576,800	586,700	596,400	606,300	615,900	625,700	635,200	644,900
	TOTAL (METRO. LIMA)	2,358,100	3,424,462	4,836,300	5,993,400	6,145,200	6,295,900	6,447,000	6,597,700	6,748,600	6,899,300	7,050,900	7,202,200	7,354,800	7,507,500	7,661,400

Legend: TYPE ; Type of adopted projection formula
E ; Exponential curve
L ; Logistic curve
G ; Geometrical curve
* ; Logistic curve is adopted instead of indicated formula type not to project too large population.

4.3 Future Population within the Surco Drainage Area

The population of the 16 districts in the drainage area of the Surco sewer as taken from TABLE 4-7 is shown in TABLE 4-9.

Based on the drainage area of each district served by the Surco sewerage system which is given in TABLE 4-10, the number of inhabitants by the drainage area for each district were computed and are listed in TABLE 4-11.

TABLE 4-10 AREA DISTRIBUTION OF SURCO DRAINAGE AREA

DISTRICT	TOTAL AREA (ha)	AREA IN SURCO D. (ha)		PERCENTAGE (%)	
		1989	2000	1989	2000
LIMA	2,121	34	34	2	2
ATE	9,822	795	3,851	8	39
BARRANCO	273	273	273	100	100
CHORRILLOS	3,681	918	2,973	25	81
EL AGUSTINO	1,836	350	381	19	21
LA MOLINA	4,169	1,460	2,504	35	60
LA VICTORIA	909	845	845	93	93
MIRAFLORES	912	407	407	45	45
SAN BORJA	1,046	1,046	1,046	100	100
SAN ISIDRO	1,007	274	274	27	27
S.J. DE MIRAFLORES	2,351	90	1,162	4	49
SAN LUIS	356	356	356	100	100
SANTIAGO DE SURCO	3,493	2,685	3,193	77	91
SURQUILLO	413	413	413	100	100
VILLA EL SALVADOR	3,368	955	2,627	28	78
V.M. DEL TRIUNFO	7,149	1,316	2,753	18	39
TOTAL	42,906	12,217	23,092	28	54

Note: 1. Area of 850 ha in San Juan de Miraflores belongs to the drainage area of the San Juan Sewage Treatment Plant.
2. The rest of Lima, El Agustino, La Victoria, Miraflores, and San Isidro belong to other drainage areas.
3. The rest of other districts are not served by sewerage system.

The population of the Surco drainage area was obtained based on all the above calculations. Extensions of service area for each year between 1989 and 2000 are interpolated based on the total estimated service area in the year 2000. The population is calculated at 1,732,500 for 1989 and 2,687,100 for the year 2000, an increase of 55.1% in 11 years or an average

annual growth rate of 4.1%.

These figures seem to be high when compared to the rates for Metropolitan Lima. This can be explained by the presence of "Pueblos Jóvenes" or new settlements which considerably add to the population in the area.

The projected population of the Surco drainage area is further broken down into three categories in accordance with the type of water supply and water consumption amount defined in the report for the Master Plan of Lima Sewerage System as follows:

Direct Service High Consumption Group - D/S.H
Direct Service Low Consumption Group - D/S.L
Indirect Service Group - ID

Areas covered by each category by district for the years 1989 and 2000 are given in TABLE 4-12 while the population data corresponding to each category and district for the same periods are listed in TABLE 4-13.

TABLE 4-9 PROJECTED POPULATION (DISTRICTS RELATED TO SURCO DRAINAGE AREA)

DISTRICT	1961	1972	1981	1989	1990	1991	1992	1993	1994	1995
LIMA	262,400	366,501	390,513	406,400	408,200	409,900	411,600	413,200	414,800	416,400
ATE	80,900	63,235	138,746	161,900	164,800	167,700	170,600	173,500	176,300	179,200
BARRANCO	43,700	50,746	48,907	48,100	48,000	47,900	47,900	47,800	47,700	47,700
CHORRILLOS	33,300	94,088	149,294	176,800	178,900	180,800	182,500	184,000	185,300	186,400
EL AGUSTINO	77,100	121,445	176,537	205,200	208,400	211,600	214,500	217,300	220,000	222,500
LA MOLINA	2,100	6,218	29,786	83,000	92,600	102,900	114,000	125,900	138,700	152,300
LA VICTORIA	201,800	274,735	284,922	291,300	292,000	292,600	293,300	293,900	294,500	295,100
MIRAFLORES	91,100	103,235	108,859	113,100	113,600	114,100	114,600	115,100	115,500	116,000
SAN BORJA	53,600	68,862	59,270	56,800	56,700	56,500	56,300	56,200	56,100	56,000
SAN ISIDRO	39,000	65,513	72,706	77,600	78,100	78,700	79,200	79,700	80,200	80,700
S.J. DE MIRAFLORES	64,000	110,833	174,426	242,900	252,200	261,600	271,100	280,700	290,500	300,400
SAN LUIS	8,600	25,072	53,306	64,100	65,000	65,800	66,500	67,200	67,700	68,200
SANTIAGO DE SURCO	46,600	69,817	147,105	201,100	210,500	220,200	230,100	240,200	250,500	261,000
SURQUILLO	23,500	29,792	98,269	101,200	101,600	101,900	102,100	102,400	102,500	102,700
VILLA EL SALVADOR	-	-	142,567	251,000	267,000	283,400	300,000	316,900	334,000	351,300
V.M. DEL TRIUNFO	94,800	188,115	187,878	306,300	323,000	339,900	357,100	374,400	392,000	409,600
TOTAL	1,122,500	1,638,207	2,263,091	2,786,800	2,860,600	2,935,500	3,011,400	3,088,400	3,166,300	3,245,500

DISTRICT	1996	1997	1998	1999	2000
LIMA	418,000	419,500	421,000	422,500	423,900
ATE	182,100	185,000	187,900	190,800	193,700
BARRANCO	47,600	47,600	47,500	47,500	47,400
CHORRILLOS	187,400	188,300	189,100	189,800	190,400
EL AGUSTINO	224,800	227,000	229,100	231,100	232,900
LA MOLINA	166,900	182,400	198,800	216,300	234,800
LA VICTORIA	295,700	296,300	296,900	297,400	298,000
MIRAFLORES	116,500	116,900	117,400	117,800	118,300
SAN BORJA	55,800	55,700	55,600	55,600	55,500
SAN ISIDRO	81,200	81,700	82,100	82,600	83,100
S.J. DE MIRAFLORES	310,500	320,600	330,900	341,300	351,900
SAN LUIS	68,600	68,900	69,300	69,500	69,800
SANTIAGO DE SURCO	271,700	282,600	293,600	304,700	315,900
SURQUILLO	102,800	102,900	103,000	103,000	103,100
VILLA EL SALVADOR	368,900	386,700	404,600	422,700	441,000
V.M. DEL TRIUNFO	427,500	445,500	463,600	481,900	500,300
TOTAL	3,326,000	3,407,600	3,490,400	3,574,500	3,660,000

TABLE 4-11 PROJECTED POPULATION (SURCO DRAINAGE AREA)

DISTRICT	TOTAL AREA (ha)	SURCO D.(%) 1/ 1989	SURCO D.(%) 1/ 2000	POP. R. (%) 2/ 1989	POP. R. (%) 2/ 2000	1989	1990	1991	1992	1993	1994	1995
LIMA	2,121	2	2	2	2	8,100	8,200	8,200	8,200	8,300	8,300	8,300
ATE	9,822	8	39	50	70	81,000	85,400	89,900	94,600	99,400	104,200	109,100
BARRANCO	273	100	100	100	100	48,100	48,000	47,900	47,900	47,800	47,700	47,700
CHORRILLOS	3,681	25	81	90	95	159,100	161,800	164,400	166,700	168,900	171,000	172,800
EL AGUSTINO	1,836	19	21	50	60	102,600	106,100	109,600	113,100	116,600	120,000	123,400
LA MOLINA	4,169	35	60	80	90	66,400	74,900	84,200	94,300	105,300	117,300	130,100
LA VICTORIA	909	93	93	93	93	270,900	271,600	272,100	272,800	273,300	273,900	274,400
MIRAFLORES	912	45	45	45	45	50,900	51,100	51,300	51,600	51,800	52,000	52,200
SAN BORJA	1,046	100	100	100	100	56,800	56,700	56,500	56,300	56,200	56,100	56,000
SAN ISIDRO	1,007	27	27	27	27	21,000	21,100	21,200	21,400	21,500	21,700	21,800
S.J. DE MIRAFLORES	2,351	40	86	41	85	100,700	114,600	129,300	144,700	161,000	178,000	195,900
(SÁN JUAN STP) 3/	(850)	(36)	(36)	(37)	(36)	(91,000)	(94,200)	(97,400)	(100,600)	(103,800)	(107,000)	(110,100)
SAN LUIS	356	100	100	100	100	64,100	65,000	65,800	66,500	67,200	67,700	68,200
SANTIAGO DE SURCO	3,493	77	91	95	100	191,000	200,900	211,200	221,700	232,600	243,700	255,100
SURQUILLO	413	100	100	100	100	101,200	101,600	101,900	102,100	102,400	102,500	102,700
VILLA EL SALVADOR	3,368	28	78	90	95	225,900	241,500	257,600	274,100	291,000	308,200	325,800
V.M. DEL TRIUNFO	7,149	18	39	90	95	275,700	292,200	309,000	326,300	343,800	361,700	379,800
TOTAL	42,906	-	-	-	-	1,823,500	1,900,700	1,980,100	2,062,300	2,147,100	2,234,000	2,323,300

DISTRICT	1996	1997	1998	1999	2000
LIMA	8,400	8,400	8,400	8,500	8,500
ATE	114,200	119,400	124,700	130,100	135,600
BARRANCO	47,600	47,600	47,500	47,500	47,400
CHORRILLOS	174,600	176,300	177,900	179,400	180,900
EL AGUSTINO	126,700	130,000	133,300	136,600	139,700
LA MOLINA	144,100	159,200	175,300	192,700	211,300
LA VICTORIA	275,000	275,600	276,100	276,600	277,100
MIRAFLORES	52,400	52,600	52,800	53,000	53,200
SAN BORJA	55,800	55,700	55,600	55,600	55,500
SAN ISIDRO	21,900	22,100	22,200	22,300	22,400
S.J. DE MIRAFLORES	214,600	234,200	254,800	276,200	298,500
(SAN JUAN STP) 3/	(113,300)	(116,500)	(119,700)	(122,900)	(126,100)
SAN LUIS	68,600	68,900	69,300	69,500	69,800
SANTIAGO DE SURCO	266,800	278,700	290,900	303,300	315,900
SURQUILLO	102,800	102,900	103,000	103,000	103,100
VILLA EL SALVADOR	343,700	362,100	380,700	399,600	419,000
V.M. DEL TRIUNFO	398,400	417,200	436,200	455,600	475,300
TOTAL	2,415,600	2,510,900	2,608,700	2,709,500	2,813,200

Note: 1/ Area collected by Surco Interceptor in each district
2/ Ratio of population collected by the Colector Surco in each district. Ratios from 1990 to 1999 are interpolated.
3/ Values for S.J. de Miraflores includes those of existing San Juan STP. Those are presented in parenthesis.

TABLE 4-12 AREA DISTRIBUTION ACCORDING TO WATER DEMAND

(Unit : ha)

DISTRICT	1989				2000				INCREASE RATE (B)/(A)
	AREA (A)	CLASSIFICATION			PLANNED AREA (B)	CLASSIFICATION			
		D/S.H.	D/S.L.	ID		D/S.H.	D/S.L.	ID	
Lima	34	22	9	3	34	22	9	3	0
Ate	795	294	446	55	3,851	1,425	2,157	267	4.84
Barranco	273	153	82	38	273	153	93	27	0
Chorrillos	918	183	422	313	2,973	595	2,081	297	3.24
El Agustino	350	46	165	139	381	50	293	38	1.09
La Molina	1,460	1,314	146	0	2,504	2,254	250	0	1.72
La Victoria	845	617	144	84	845	617	144	84	0
Miraflores	407	317	90	0	407	317	90	0	0
San Borja	1,046	544	429	73	1,046	544	429	73	0
San Isidro	274	222	52	0	274	222	52	0	0
S.J de Miraflores	940 (850)	141 (127)	724 (655)	75 (68)	2,012 (850)	302 (127)	1,549 (655)	161 (68)	2.14
San Luis	356	193	117	46	356	193	128	35	0
Santiago de Surco	2,685	1,127	1,316	246	3,193	1,341	1,565	287	1.19
Surquillo	413	252	136	25	413	252	136	25	0
Villa El Salvador	955	10	716	229	2,627	53	2,102	472	2.75
V.M.del Triunfo	1,316	40	1,132	144	2,753	83	2,395	275	2.09
TOTAL	13,067	5,475	6,126	1,466	23,942	8,423	13,473	2,046	1.83
RATIO(%)	100	42	47	11	100	35	56	9	

Note: Values of S.J. de Miraflores include those of existing San Juan Stabilization Pond.
Those are presented in parenthesis.

TABLE 4-13 DISTRIBUTION OF POPULATION BY DISTRICT

NAME OF DISTRICT	1989 (A) ESTIMATED POPULATION	1989 (A) SERVICE LEVEL DS/H	1989 (A) SERVICE LEVEL DS/L	1989 (A) SERVICE LEVEL ID	2000 (B) PROJECTED POPULATION	2000 (B) SERVICE LEVEL DS/H	2000 (B) SERVICE LEVEL DS/L	2000 (B) SERVICE LEVEL ID	RATE OF INCREASE (B/A)
Lima	8,100	5,240	2,140	720	8,500	5,500	2,250	750	1.05
Ate	81,000	29,960	45,440	5,600	135,600	50,180	75,950	9,470	1.67
Barranco	48,100	26,960	14,450	6,690	47,400	26,560	16,150	4,690	0.99
Chorrillos	159,100	31,720	73,130	54,250	180,900	36,200	126,630	18,070	1.14
El Agustiuno	102,600	13,480	48,370	40,750	139,700	18,330	107,430	13,940	1.36
La Molina	66,400	59,760	6,640	0	211,300	190,200	21,100	0	3.18
La Victoria	270,900	197,810	46,170	26,920	277,100	202,330	47,220	27,550	1.02
Miraflores	50,900	39,640	11,260	0	53,200	41,440	11,760	0	1.05
San Borja	56,800	29,540	23,290	3,970	55,500	28,860	22,760	3,880	0.98
San Isidro	21,000	17,010	3,990	0	22,400	18,150	4,250	0	1.07
S.J.de Miraflores	100,700	15,110	77,560	8,030	298,500	44,800	229,810	23,890	2.96
(San Juan STP)	(91,000)	(13,600)	(70,120)	(7,280)	(126,100)	(18,840)	(97,170)	(10,090)	(1.39)
San Luis	64,100	34,750	21,070	8,280	69,800	37,840	25,100	6,860	1.09
Santiago de Surco	191,000	80,170	93,610	17,220	315,900	132,680	154,830	28,390	1.65
Surqillo	101,200	61,750	33,330	6,120	103,100	62,900	33,950	6,250	1.02
Villa El Salvador	225,900	2,370	169,370	54,160	419,000	8,450	335,260	75,290	1.85
V.M.del Triunfo	275,700	8,380	237,150	30,170	475,300	14,330	413,490	47,480	1.72
TOTAL	1,823,500	653,650	906,970	262,880	2,813,200	918,750	1,637,940	258,510	1.55
Ratio (%)	100	36	50	14	100	33	58	9	