Table 2.3.4 Investment Records of Water Supply and Sewerage Systems in La Paz Department by Foreign Assistance Organization: 1987-1991

(Unit: US$1000)

Organization	1,987			1,988			1,989			1,990			1,991		
	Total	Local	Foreign	Total	Local	Foreign	Total	Local	Foreign	Total	Local	Foreign	Total	Local	Foreign
1. Water Supply and Sewerage Systems in Urban and Rural Areas															
BID *1 *2	170	0	170	4,462	1,265	3,197	463	208	255	4,927	0	4,927	1,864	0	1,864
CARE	313	0	313	246	226	20	385	385	0	183	183	0	237	237	0
Germany	-	-	-	-	-	-	391	0	391	1,098	0	1,098	582	0	582
Germany(GTZ)	-	-	-	1,515	1,515	0	1,089	58	1,031	1,298	317	981	-	-	-
JICA	-	-	-	-	-	-	15,690	2,023	13,667	8,518	66	8,452	-	-	-
USAID	-	-	-	163	0	163	-	-	-	44	0	44	-	-	-
World Bank *2	489	111	378	1,375	117	1,258	1,223	146	1,077	483	179	304	727	55	673
Local Fund Only	1,395	1,395	0	2,464	2,464	0	4,648	4,648	0	3,028	3,028	0	2,699	2,699	0
Total	2,367	1,506	861	10,225	5,587	4,638	23,889	7,468	16,421	19,580	3,773	15,807	6,109	2,991	3,118
2. Sewerage System in Urban Area															
BID *1	-	-	-	18	0	18	31	0	31						
Germany	-	-	-				367	0	367	937	0	937	574	0	574
World Bank	172	31	142	952	37	915	615	28	587	163	51	111	109	55	55
Local Fund Only	-	-	-	992	992	0	2,794	2,794	0	1,093	1,093	0			
Total	172	31	142	1,963	1,029	934	3,808	2,822	985	2,193	1,145	1,049	683	55	629

Source: Ref.I1 (Annex 1)

Note: *1 Banco Interamericano de Desarrollo (Interamerican Development Bank)

*2 US$28 thousand from BID(US$11 thousnd) and WB(US$17 thousand) was invested through UNICEF in 1988.

2.4 WATER QUALITY AND WATER USE

2.4.1 Water Quality Conditions

(1) General

A water quality survey was carried out in this study to understand the overall water quality conditions in the study area. The water quality was determined at the following points:

- River water; 9 sampling points along the Choqueyapu River and 7 points in the tributaries of the Choqueyapu River.
- River sediment; 5 points along the Choqueyapu River.
- Irrigation water; 1 point in Mecapaca
- Ground water; 7 points for wells and springs in the study area.
- Industrial wastewater; 3 factories located in the catchment area of the Choqueyapu River.
- Mining wastewater; 1 point in the upstream of the Irpavi River.

Location of these points are shown in Fig. 2.4.1 and Fig. 2.4.2. Outlines of the results of the water quality surveys are as follows:

(2) River Water

The river system in the study area consists of the following major streams:

- Main Stream : Choqueyapu River
- Major tributaries: Orkojahuira River
Irpavi River
Huañajahuira River

The water qualities of the above rivers in the urbanized area have been confirmed by the water quality survey to be similar to those of influent to wastewater treatment plants rather than those of river water. The observed values of BOD of the above rivers in the urbanized area were in a range from 100 to 300 mg/l as shown in Table 2.4.1.

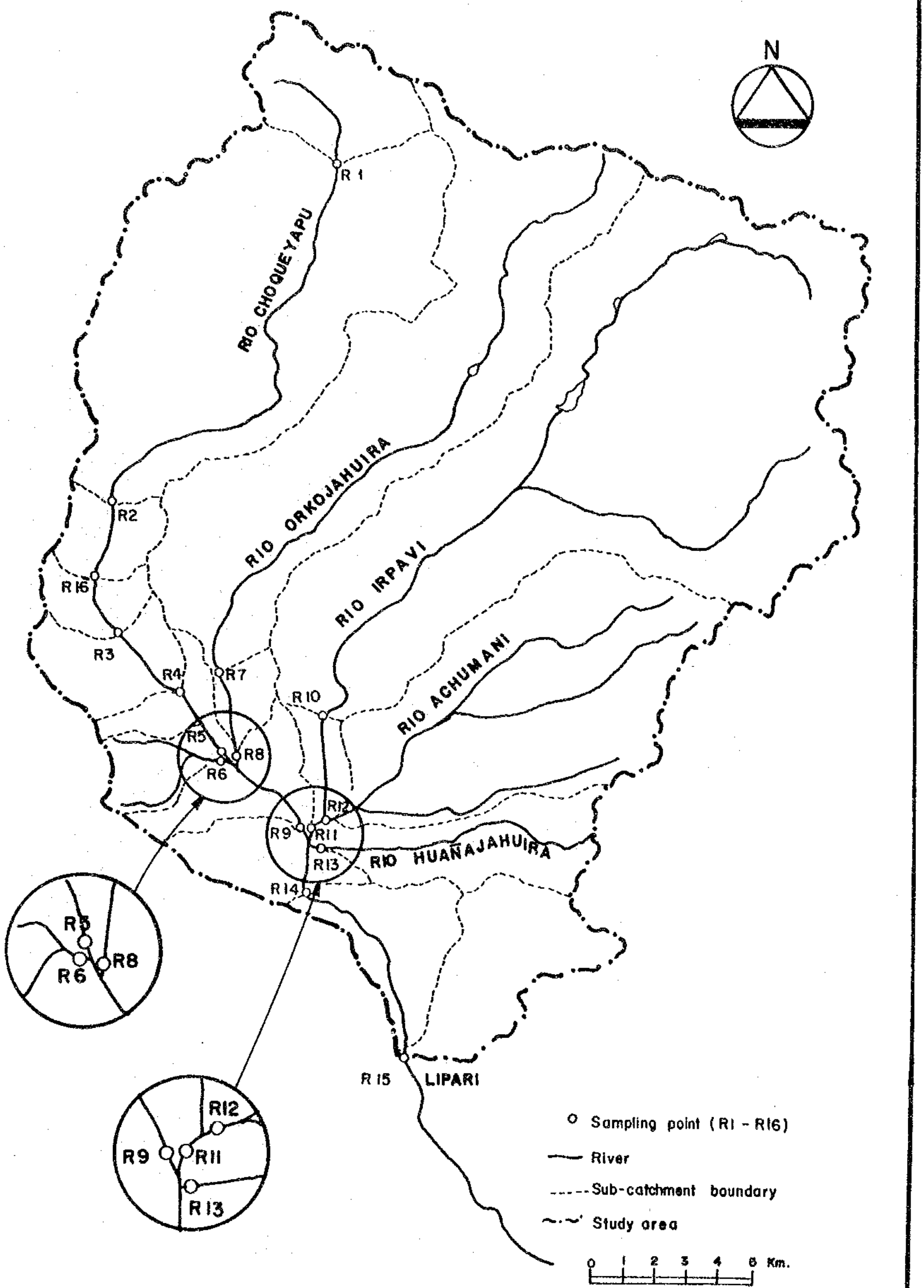


Fig. 2.4.1 Sampling Points for River Water Quality Survey

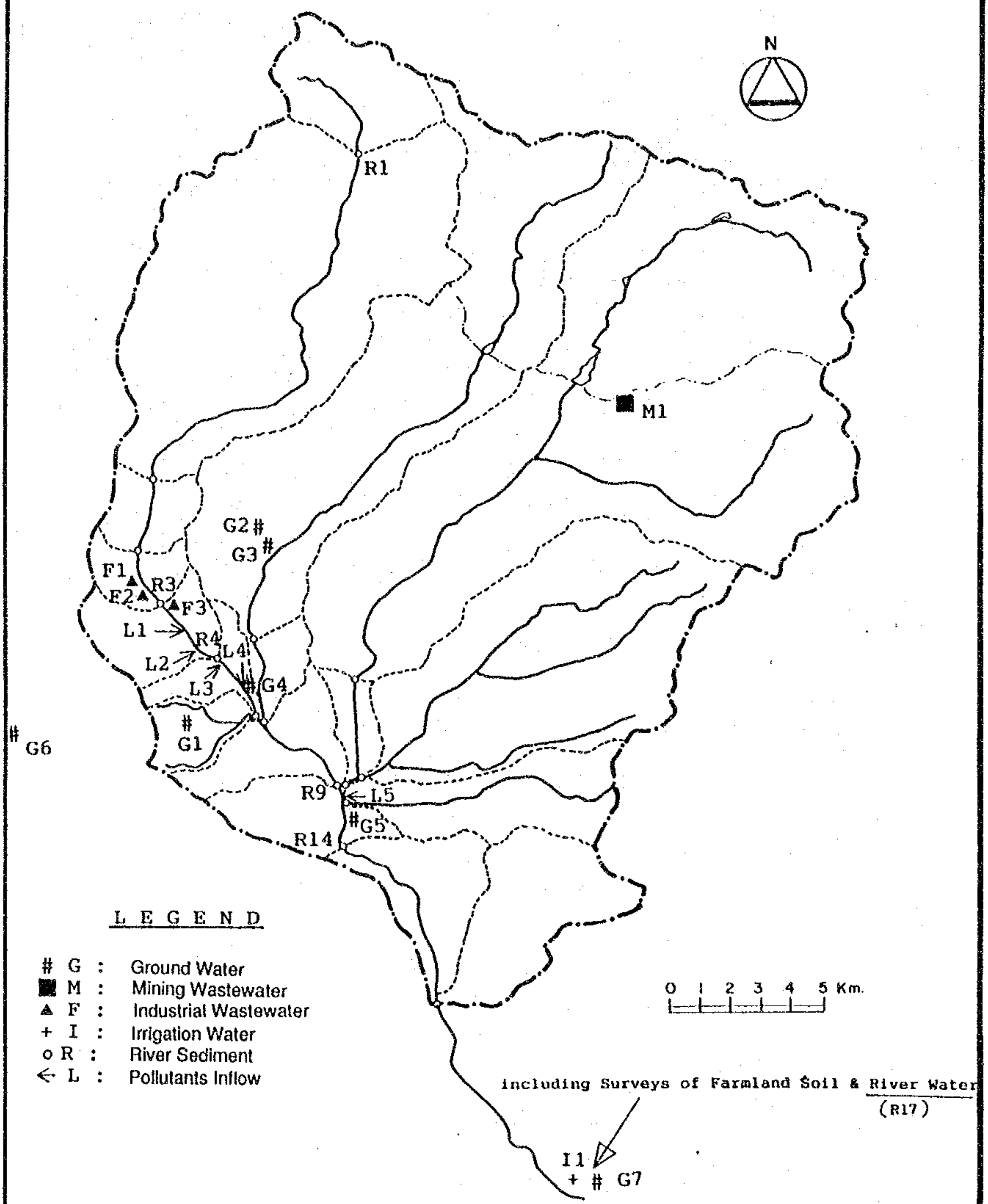


Fig. 2.4.2 Sampling Points for Surveys Other Than River Water Quality Survey

TABLE 2.4.1 Results of Water Quality Analysis for the Choqueyapu river and its Main Tributaries

		Choqueyapu River									Tributaries (Downstream)					Tributaries	
		R1	R2	R16	R3	R4	R5	R9	R14	R15	R6	R8	R11	R12	R13	R7	R10
		Alto Achachicala	Achachikala	Achachikala Plant	Challapampa	Av. del Ejercito	Ork. confluence	Irpavi confluence	Aranjuez	Lipari	Kotauma	Orkojahuira	Irpavi	Achumani	Huañajahuira	Orkojahuira	Irpavi
Items	Date	0 km	15.5 km	17.5 km	20 km	22.5 km	25 km	29 km	31 km	38 km							
BOD	23-Mar	3.3	5.1	-	305	313	233	185	69	77	101	89	28	28	101	70	7.5
(mg/l)	1-Apr	1.5	2.1	3.4	39	126	180	170	108	81	97	105	15.5	152	138	77	2.4
	22-Apr	1.3	2.2	2.4	65	115	127	109	75	51	57	59	3.9	51	101	24	2.1
	29-Apr	1	2.1	5.7	74	169	151	97	76	58	57	55	6.5	52	109	133	1.8
SS	23-Mar	3.3	349	-	358	273	305	654	400	465	3030	756	352	160	298	850	118
(mg/l)	1-Apr	1.8	347	592	472	276	334	825	875	1810	6570	1500	231	1640	584	1350	180
	22-Apr	7.2	416	228	452	282	345	1100	880	740	3170	1640	307	620	880	1530	201
	29-Apr	1.8	347	235	415	354	268	774	791	655	2440	1590	576	474	394	1270	155
DO	23-Mar	5.7	6.3	-	5.9	6.4	3.6	3.9	4.0	4.7	4.4	4.4	4.8	4.6	3.4	4.1	5.0
(mg/l)	1-Apr	3.7	4.0	4.3	4.0	3.7	3.7	4.1	4.2	4.3	4.2	4.3	4.3	4.1	2.9	4.0	4.5
	22-Apr	2.3	2.7	2.9	2.8	2.4	3.3	3.6	3.2	3.7	3.3	3.7	4.3	3.2	2.6	3.4	4.0
	29-Apr	3.7	4.1	4.1	4.6	3.8	2.6	3.1	3.0	2.9	2.9	3.5	3.4	2.9	2.3	3.2	3.5
Coliform	23-Mar	1.0E+02	1.0E+02	-	2.0E+05	1.8E+05	8.6E+05	1.6E+07	7.3E+05	6.0E+05	6.5E+05	3.6E+06	1.4E+05	2.5E+05	9.6E+06	1.1E+05	1.7E+03
(cells/	1-Apr	2.0E+02	1.9E+03	4.0E+04	3.0E+05	1.0E+06	2.4E+06	2.4E+06	7.4E+05	5.5E+06	2.1E+06	1.5E+06	2.2E+05	1.0E+06	3.6E+06	1.2E+06	2.8E+03
100ml)	22-Apr	1.3E+03	1.3E+03	6.6E+04	1.2E+05	2.9E+06	1.1E+06	3.0E+06	1.5E+06	8.6E+06	3.6E+06	2.2E+06	4.0E+05	2.0E+06	5.3E+06	1.7E+06	4.2E+03
	29-Apr	0.0E+00	1.2E+03	1.5E+05	7.5E+05	2.4E+06	3.5E+06	4.4E+06	5.2E+06	5.2E+06	2.8E+06	1.6E+07	4.2E+05	4.3E+06	5.1E+06	1.8E+06	6.4E+03
Flow rate	23-Mar	0.33	0.60	-	0.12	0.57	1.11	1.40	3.32	2.68	0.16	0.48	1.05	0.17	0.03	0.36	0.85
(m3/sec)	1-Apr	0.22	0.53	0.49	0.67	0.99	1.58	2.05	2.55	3.03	0.16	0.35	0.76	0.09	0.05	0.24	0.67
	22-Apr	0.11	0.31	0.30	0.62	1.03	1.31	1.55	2.48	2.82	0.20	0.28	0.60	0.05	0.02	0.27	0.82
	29-Apr	0.08	0.17	0.24	0.31	0.74	1.34	1.58	2.62	3.00	0.19	0.37	0.56	0.07	0.03	0.23	0.54

(Table 2.4.1-5/7/1993)

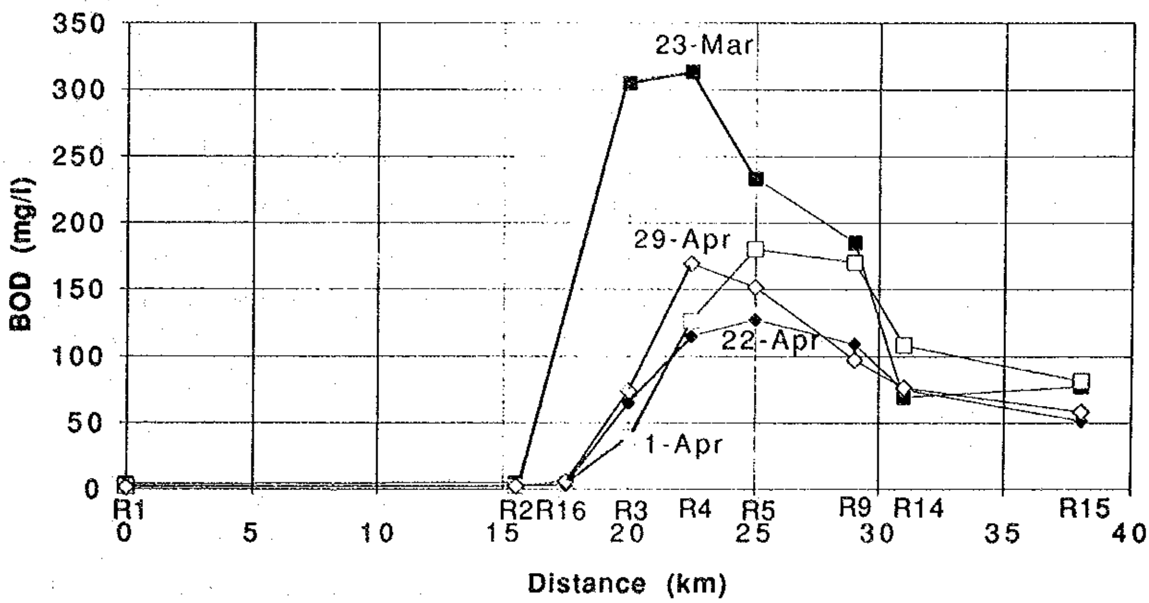
1) The Choqueyapu River

As illustrated in Fig. 2.4.3, the BOD concentration of the Choqueyapu River sharply increases at the point of the entrance to the urbanized area (No. R3). When river water is being withdrawn by the Achachicala water treatment plant located near R16 point, the BOD value jumps to the level exceeding 300 mg/l, and remains as high as 180 mg/l at the confluence with the Irpavi river (No. R9). Even in normal periods, the BOD values are in a range of 100 mg/l to 180 mg/l up to the Irpavi confluence. It is evident that the river water in most parts of the Central Zone of the City is badly polluted. However, the Choqueyapu river in the urbanized area is mostly covered and is used for roads, buildings and play grounds. Even in the open sections, i.e., between Calle Colón and Avenida del Ejecrito (No. R4), and the downstream reach from the bridge at Avenida Libertadores, the stream is deep at the bottom of the valley, being more than 10 m deep. Thus, people have few chances to recognize the actual quality of the river water. In addition, vigorous aeration of the river water due to steep river gradient reduces the generation of septic conditions, so that deterioration of aesthetic condition is less than might be expected. Still, many residents in the downstream zones, where residential areas are developed at the same level of the river, are suffering from the obnoxious odor and poor aesthetic condition of the river.

Moreover, such deteriorated water quality conditions cause damage to irrigation uses of the Choqueyapu River. The river water is utilized as irrigation water for farm lands located downstream from the Lipari bridge. While the water quality survey result shows a slight improvement of the water quality from Aranjuez (R14) to Lipari (R15) as shown in Fig. 2.4.3, which is due to the river's self-purification capacity, the BOD concentration at Lipari remains at a level over 50 mg/l. Visual impression of the water is still similar to that of sewage. Hesitation about eating vegetables irrigated by such river water is very common among the citizens of La Paz, and farmers in the area have been suffering from the unpopularity of their products in the market.

2) Rivers Other than the Choqueyapu River

Conditions of the rivers other than the Choqueyapu river are almost the same as the Choqueyapu river. As shown in Table 2.4.1, the BOD concentration values at the most downstream points of these rivers ranged from 100 to 200 mg/l. They are not only major pollutant sources for the Choqueyapu River, but also cause unpleasant living conditions to the residents along them.



Note : During the survey of March 23, the Achachicala water treatment plan was taking river water from just below the point R16. This caused the reduction of the flow rate and therefore the high BOD concentration in the downstream, since there were factory wastewater discharges between R16 and R3 as usual.

Fig. 2.4.3 BOD Changes Along The Choqueyapu River

3) Heavy Metals

Apart from the organic pollution mentioned above, pollution by heavy metals is another concern in the study area because some rivers have mining activities in their catchment areas. However, the results of the heavy metal analysis did not show particular evidence of the heavy metal pollution suspected due to mining activities except that the concentration of iron was as high as some tens mg/l in most sampling points. This is assumed to be due to iron ores that are exposed in various places in the upstream of the rivers. A high concentration of iron in the water may cause problems in water treatment for potable water, but iron in water itself is not a hazardous material.

One concern is the mercury (Hg) concentration at the downstream of the Cotahuna River (No. R6). A high concentration of Hg (0.05 mg/l) was observed once among the four observations. Moreover, higher concentrations of other parameters such as Pb, Mn, Cu and Fe were observed in this point, too. While the levels of such heavy metal concentration are not yet judged to be hazardous, it is recommended to continue monitoring of heavy metals at this point because the Cotahuna River catchment area contains an old sanitary landfill site.

(3) River Sediments

River sediments were measured at the five points along the Choqueyapu River once during the study. All the sediments had a smell of sewage except the sample collected at Alto Achachicala (No. R1). However, the water content and ignition-loss (I-L), which are indexes of the organic material content in sediments, were less than 30% and 10%, respectively. These are considered very low percentages as sediments of an organically polluted river. It is considered that the suspendable materials discharged to the river hardly settle on the river bed due to the rapid flow of the river water. This may be advantageous so as not to create the anaerobic condition in the river bed, which adversely affect the river water quality.

The contents of As and Hg in a sample from near Avenida del Ejercito (No. R4) were as high as 25.1 ppm and 15.9 ppm, respectively. The point is at the outlet of the culverted section in the Central zone. The wastewaters from several factories, as well as the sewage collection system of SAMAPA, are discharged to the river in the culverted section. The high concentrations of heavy metals are not assumed to be due to the accumulation of those contained in the wastewater, because sedimentation of the materials in the water is estimated very small as mentioned above. Therefore, it is suspected that some materials containing heavy materials were being discharged in the culverted section or near the sampling point.

(4) Groundwater

The waters from the wells surveyed, including waters from springs, were good enough to be acceptable for potable water in terms of organic, bacteriological and heavy metal concentrations. This does not mean that those waters are recommended for drinking use, because the constancy of the water quality has not been confirmed, but it suggests that sub-surface flows may be a potential alternative source for irrigation water.

(5) Industrial Wastewater

Due to the uncooperative attitudes of the factories and the inaccessibility to the outlets of the wastewater, only three industrial wastewaters were analyzed. Three analyses are not enough to understand characteristics of the industrial wastewaters, which vary widely depending on kinds of the products, types of the manufacturing and scales of the production.

(6) Mining Wastewater

A mining wastewater sample was collected from a mining company which produces zinc, lead and silver located in the upper catchment of the Irpavi River. The wastewater from the ore dressing process is discharged after treatment by cyanide. The result showed that wastewater contained some heavy metals with fairly high concentrations : Fe (59.1 mg/l), Mn (12.4 mg/l), Cd (0.24 mg/l), Pb (2.1 mg/l) and Zn (23.2 mg/l). Although further treatment is recommended to prevent heavy metal contamination around the discharge point, it may have little effect on the water quality of the Irpavi River downstream since it is diluted by other tributary inflows.

2.4.2 Water Use

(1) General

The rivers in the urban area are mostly used for drainage of stormwater and wastewater, and many of them are covered especially in the Central zone. Beneficial uses such as water supply, irrigation, fishery, recreation and aesthetics are limited except for the rural area.

(2) Water Supply Use

Part of the water supply in La Paz City is drawn from Hampaturi reservoir, which is located in the upstream of the Hampaturi/Irpavi River, and from Incachaca reservoir in the upstream of the Orkojahuira River. However, most of water supply sources are outside the study area. The intake volumes and other information are given in Section 2.4.3.

In the rural area and part of the city area where public water supply is not provided, people use water from wells, springs, rain and water venders.

Deep wells were used occasionally for drinking water even in the urban area, but all of them have now been abandoned.

(3) Industrial Water Use

Some factories still draw water from on-site wells. In particular, a beer company is known to consume a large amount of groundwater. However, most of the factories depend on the piped water and the volume of the groundwater for the industrial use is not considered to be large as a whole, because the groundwater level is very deep in La Paz City and the locally available quantity of the spring water is limited.

(4) Irrigation

The agricultural land use and production in the study area are small-scaled. The cultivation in the upper reaches of the city is mainly for self consumption. Comparatively large farmlands are developed along the lower reaches of the Choqueyapu River, from where some vegetables and flowers are supplied to La Paz.

Also in the context of agricultural development in the lower reaches, the water quality improvement of the Choqueyapu River has been of considerable interest recently. CORDEPAZ constructed a pilot treatment plant to improve the quality of irrigation water and plans to expand the project. (refer to Section 2.6.3).

Fishing activities have not been reported in the study area or in the lower reaches of the Choqueyapu River.

(5) Quarrying

Quarrying activities are frequently observed along the rivers in the study area. According to an estimate of HAM-GTZ, 548,000 m^3 of sand and gravel, 59,000 m^3 of clay, and 14,000 m^3 of organic soils are extracted every year in the Choqueyapu River basin, and these activities undoubtedy affect the river water quality.

2.4.3 Water Supply

(1) General

Pipe water supply services in La Paz City and El Alto City are provided by the Municipal Corporation of Potable Water and Sewerage (SAMAPA). SAMAPA was established in April 20, 1966 by virtue of Government Ordinance No. 7597, and took over the responsibility from the Municipality of La Paz to provide water supply services (1971), and the sewer services (1978). The following description is based on the Refs. L2 through L6.

(2) Water Supply System

The overall water supply system of SAMAPA consists of four systems at present, three of which depend on surface water: namely, Achachicala, El Alto and Pampahasi. The fourth is the groundwater supply system of El Alto.

Figure 2.4.4 shows the areas covered by these systems. The study area is covered by the Achachicala and the Pampahasi systems and a part of the El Alto surface water system. In the other areas where distribution pipes are not furnished, drinking water is provided by private wells, springs and water tank lorries.

The Achachicala system started to supply water to the Central zone of La Paz City in 1935. The water sources are Milluni and Tuni reservoirs and the Choqueyapu River. The maximum capacity of the treatment plant is 86,400 m^3/day. The area served at present is 1,950 ha and the population supplied is around 324,000.

The Pampahasi system started to supply water to the southern and the eastern districts of La Paz City in 1946. The sources of water are Hampaturi and Incachaca reservoirs. The present treatment plant began to operate in 1971, and the maximum capacity is 36,000 m^3/day. The distribution area is 2,400 ha and the population served is 234,000.

The El Alto system started supplying water to a large part of El Alto City and the western and the northern districts of La Paz City in 1979. The water source is the Tuni reservoir. The maximum capacity of the treatment plant is 53,400 m^3/day. The distribution area is 4,326 ha and the population served is 397,000.

The El Alto groundwater system started to supply water to the western new towns in El Alto City in 1980. The source of water is 30 deep wells developed in the Seco

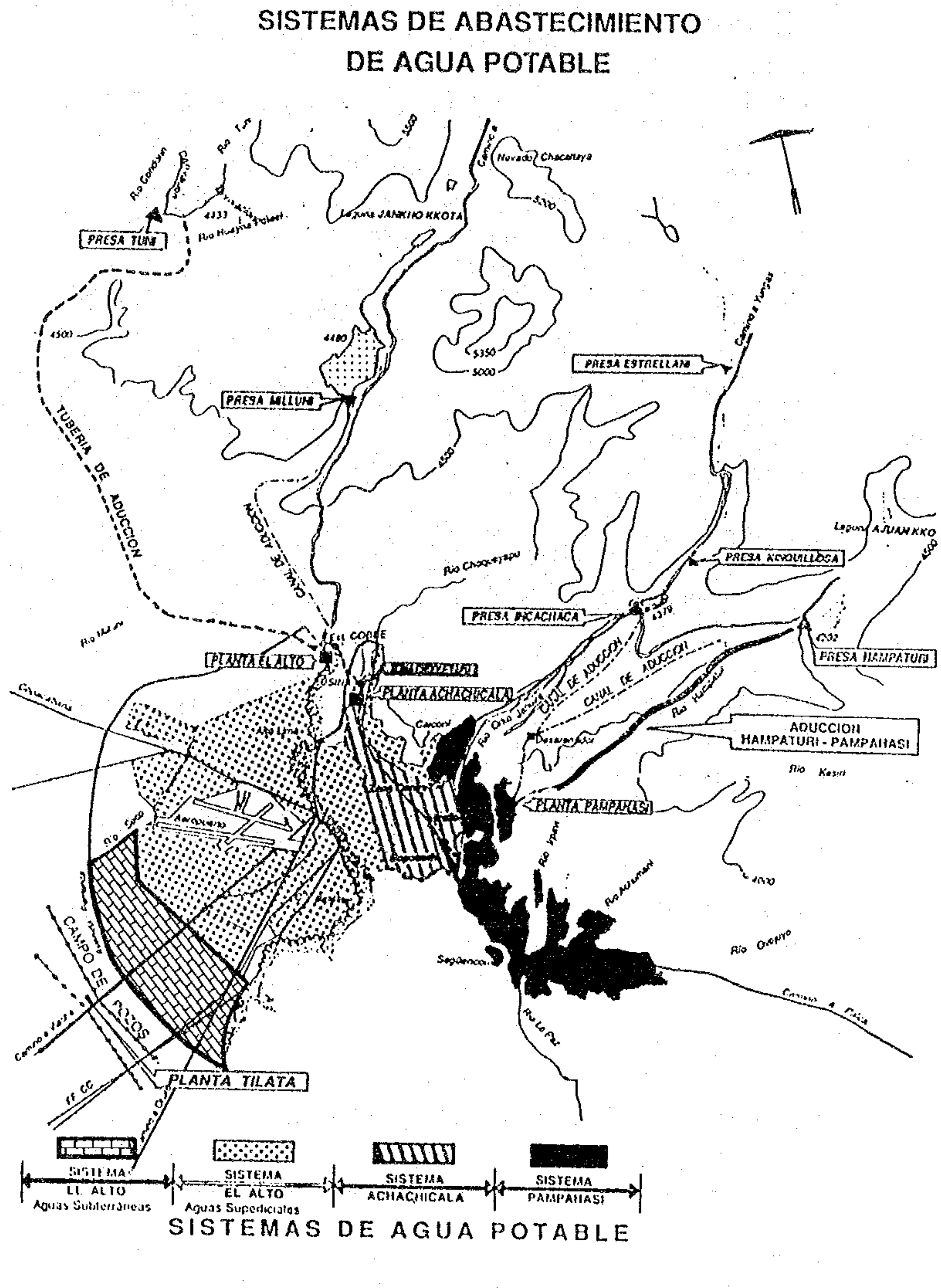


Fig. 2.4.4 Water Supply Systems of SAMAPA

River basin. The capacity of water production is 30,000 m^3/day, and the treatment plant is located in Tilata. The service area of water supply is around 2,656 ha.

Fig. 2.4.5 shows the scheme of the above water supply systems.

(3) Water Quantity From Each Source

The piped water in La Paz City is taken from the Choqueyapu River in addition to the Milluni and Tuni reservoirs basins. The annual volume of water received by the treatment plants in the recent 4 years is shown in Table 2.4.2. The Achachicala plant has received about 20 million m^3 of water a year, most of which (50-81%) is taken from Milluni. But the raw water of Milluni has a poor water quality because the reservoir is affected by tailings of an abandoned mine. The rest of water comes from Tuni reservoir and the Choqueyapu River, with the ratio from each fluctuating. In 1991, SAMAPA took 16.6 million m^3 of water form the Milluni reservoir and 2.9 million m^3 from the Tuni reservoir to the Study area. In addition, more than 3.8 million m^3 of water was taken to La Paz City from the El Alto water supply system.

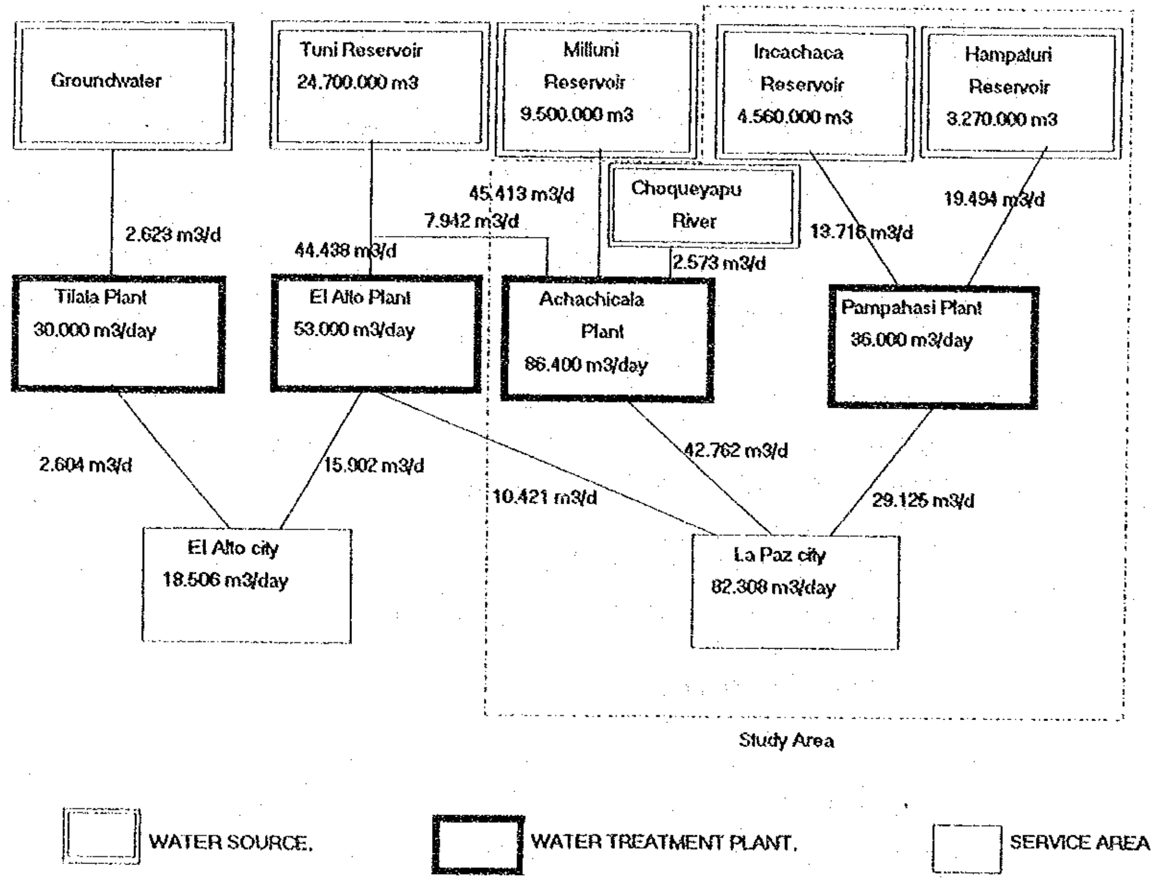
The total amount of water supplied from outside of the study area to La Paz City was equivalent to an annual average of 0.74 m^3/sec. in 1991.

(4) Water Usage by Category

Table 2.4.3 shows the annual volume of piped water consumption by 5 categories of water usage in 1991. About 30.0 million m^3 (82.308 m^3/day = 0.85 m^3/s) was supplied in La Paz City, and the breakdown by 5 categories is as follows:

Water Use	Water Supplied (m^3/year)	Annual Average (m^3/day)	Percentage (%)
Domestic	18,465,102	50,589	61.5
Commercial	4,387,534	12,048	14.6
Industrial	2,106,988	5,773	7.0
Governmental	4,411,057	12,085	14.7
Public tap	661,680	1,813	2.2
Total	30,032,361	82,308	100.0

The monthly fluctuation of the water usage is shown in Table 2.4.4. Water supply increases around September and decreases around February.



Notes:

1. The figures in the column of reservoir indicate the capacity of each reservoirs.
2. The figures in the coulumn of trealment plan indicate the maximum water production capacity.
3. The figures between reservoirs and plants indicate the annual average volume received to the plant in 1991.
4. The figures betweem plants and service area indicate the annual average volume of water consumption in 1991.

Fig. 2.4.5 Schematic Diagram of the Water Supply System in La Paz City and El Alto City

Table 2.4.2 Annual volume of water received to the plant by water sources

<1988>

Plant	Tuni	Milluni	Choqueyapu	Hampaturi	Incachaca	Total
Achachicala	1,680,912 (7.8%)	16,704,287 (77.4%)	3,194,367 (14.8%)			21,579,566 (100.0%)
Pampahasi				7,144,355 (66.4%)	3,607,120 (33.6%)	10,751,475 (100.0%)
El Alto	16,327,194 (100.0%)					16,327,194 (100.0%)
Total	18,008,106	16,704,287	3,194,367	7,144,355	3,607,120	48,658,235

<1989>

Plant	Tuni	Milluni	Choqueyapu	Hampaturi	Incachaca	Total
Achachicala	7,553,738 (36.6%)	10,369,869 (50.3%)	2,704,533 (13.1%)			20,628,140 (100.0%)
Pampahasi				7,306,797 (68.8%)	3,316,637 (31.2%)	10,623,434 (100.0%)
El Alto	16,292,323 (100.0%)					16,292,323 (100.0%)
Total	23,846,061	10,369,869	2,704,533	7,306,797	3,316,637	47,543,897

<1990>

Plant	Tuni	Milluni	Choqueyapu	Hampaturi	Incachaca	Total
Achachicala	1,542,362 (7.8%)	13,533,809 (68.4%)	4,712,809 (23.8%)			19,788,980 (100.0%)
Pampahasi				7,354,995 (68.0%)	3,457,834 (32.0%)	10,812,829 (100.0%)
El Alto	16,861,195 (100.0%)					16,861,195 (100.0%)
Total	18,403,557	13,533,809	4,712,809	7,354,995	3,457,834	47,463,004

<1991>

Plant	Tuni	Milluni	Choqueyapu	Hampaturi	Incachaca	Total
Achachicala	2,898,682 (14.2%)	16,575,565 (81.2%)	939,010 (4.6%)			20,413,257 (100.0%)
Pampahasi				7,115,436 (58.7%)	5,006,260 (41.3%)	12,121,696 (100.0%)
El Alto	16,219,813 (100.0%)					16,219,813 (100.0%)
Total	19,118,495	16,575,565	939,010	7,115,436	5,006,260	48,754,766

Source : SAMAPA

(Table 2.4.2-2/1/93)

Table 2.4.3 Volume of Piped Water Supplied in 1991

Unitts: Upper · m3/year
Lower · m3/day

Category	Connection	La Paz City				El Alto City	Total
		Achachicala System	Pampahasi System	El Alto System	Total		
Domestic	Measured	7,617,941	7,439,314	1,809,435	16,866,690	2,576,806	19,443,496
	Not measured	329,892	513,013	755,507	1,598,412	1,395,474	2,993,886
	Total	7,947,833	7,952,327	2,564,942	18,465,102	3,972,280	22,437,382
		21,775	21,787	7,027	50,589	10,883	61,472
Commercial	Measured	3,316,416	694,723	251,946	4,263,085	406,344	4,669,429
	Not measured	61,376	17,550	55,523	134,449	8,885	143,334
	Total	3,377,792	712,273	307,469	4,397,534	415,229	4,812,763
		9,254	95	842	12,048	1,138	13,186
Industrial	Measured	1,464,684	340,195	290,010	2,094,889	331,424	2,426,313
	Not measured	10,608	1,275		12,099		12,099
	Total	1,475,292	341,470	290,010	2,106,988	331,424	2,438,412
		4,042	436	795	5,773	908	6,681
Govern-mental	Measured	2,078,922	646,099	247,529	2,972,550	422,915	3,395,465
	Not measured	664,349	622,568	151,590	1,438,507	201,694	1,640,201
	Total	2,743,271	1,268,667	399,119	4,411,057	624,609	5,035,666
		7,516	3,476	1,093	12,085	1,711	13,786
Public tap	Measured						
	Not measured	64,080	355,800	241,800	661,680	460,800	1,122,480
	Total	64,080	355,800	241,800	661,680	460,800	1,122,480
		176	975	662	1,813	1,262	3,075
Total	Measured	14,477,963	9,120,331	2,598,920	26,197,214	3,737,489	29,934,703
	Not measured	1,130,305	1,510,206	1,204,636	3,845,147	2,066,853	5,912,000
	Total	15,608,268	10,630,537	3,803,556	30,042,361	5,804,342	35,846,703
		42,762	29,125	10,421	82,308	15,902	98,210

Source: SAMAPA

Note 1) Volume in El Alto city does not include the El Alto ground water system

(Table 2.4.3-5/7/1993)

Table 2.4.4 Monthly Variation of Water Supplied in La Paz City in 1991

	Domestic		Commercial		Industrial		Governmental		Public tap		Total	
	Month.ave (M3/day)	C.M.F.	Month.ave (M3/day)	C.M.F.	Month.ave (M3/day)	C.M.F.	Month.ave (M3/day)	C.M.F.	Month.ave (M3/day)	C.M.F.	Month.Ave (M3/d))	C.M.F.
January	54,520	1.08	12,677	1.05	6,242	1.08	9,141	0.76			82,580	1.00
February	52,840	1.04	12,398	1.03	5,463	0.95	8,421	0.70			79,122	0.96
March	45,025	0.89	11,076	0.92	4,681	0.81	10,733	0.89			71,515	0.87
April	52,311	1.03	12,939	1.07	5,764	1.00	13,681	1.13			84,695	1.03
May	48,294	0.95	11,722	0.97	5,268	0.91	12,850	1.06			78,134	0.95
June	48,831	0.96	11,831	0.98	5,887	1.02	13,367	1.11	3,156	1.02	83,072	1.01
July	47,509	0.94	11,869	0.98	6,125	1.06	13,015	1.08	3,050	0.99	81,568	0.99
August	51,880	1.03	12,080	1.00	5,701	0.99	13,040	1.08	3,046	0.98	85,747	1.04
September	52,811	1.04	12,633	1.05	6,168	1.07	13,550	1.12	3,148	1.02	88,310	1.07
October	51,566	1.02	11,823	0.98	6,016	1.04	13,058	1.08	3,050	0.99	85,513	1.04
November	50,376	1.00	11,738	0.97	5,967	1.03	11,928	0.99	3,144	1.02	83,153	1.01
December	51,390	1.02	11,854	0.98	5,982	1.04	12,017	1.00	3,054	0.99	84,297	1.02
Annual average	50,613		12,053		5,772		12,067		3,093	1	82,309	

Source: SAMAPA

Note: Coefficient of monthly fluctuation (C.M.F.)= (Monthly average volume)/(Annual average volume)

Table 2.4.5 shows the yearly changes of the water usage in La Paz city. Water supply by the Achachicala system did not increase much in 1991, whereas the water usage from Pampahasi and El Alto systems increased rapidly in 1991.

SAMAPA divides the water supply area into 50 zones (No. 1 to No. 52), 42 of which are in La Paz city and the other 8 zones in El Alto city. Monthly water supply and daily average volume per connection in 1991 by zones and consumers categories are shown in Table 2.4.6.

Table 2.4.7 shows the number of connections and monthly water supply in 1991 for the large water consumers. As will be described in Section 4.2, major factories consume large quantities of water , and seven of them consume over 3,270 m3 a day, 56.7% of the total industrial water consumption.

Table 2.4.5 Change of monthly water consumption in La Paz

System	Category	Number of connection				Water Consumption (m3/month)			
		1988	1989	1990	1991	1988	1989	1990	1991
Achachicala	Domestic	16,369	16,558	16,588	16,799	714,894	702,900	642,648	676,361
	Commercial	2,276	2,654	2,956	2,989	274,276	302,922	282,878	282,647
	Industrial	185	189	170	157	147,308	116,591	113,957	135,464
	Governmental	281	283	329	415	171,143	178,399	175,397	234,998
	Public tap	83	75	73	76				9,120
	Total	19,193	19,759	20,116	20,436	1,307,621	1,300,812	1,214,880	1,338,590
Pampahasi	Domestic	17,949	19,256	19,935	20,636	487,411	599,194	637,297	685,265
	Commercial	569	706	790	824	40,337	48,544	53,199	59,372
	Industrial	82	93	86	80	12,627	18,445	34,220	26,217
	Governmental	79	77	90	145	39,914	39,597	58,000	97,866
	Public tap	482	429	424	424				50,880
	Total	19,161	20,561	21,325	22,109	580,289	705,780	782,716	919,600
El Alto	Domestic	12,887	13,808	14,585	14,962	197,489	210,748	207,626	231,464
	Commercial	518	768	745	738	27,351	29,891	26,100	25,458
	Industrial	52	60	58	59	26,350	22,876	22,822	23,750
	Governmental	36	38	45	70	12,098	11,975	24,310	39,658
	Public tap	312	279	249	289				34,680
	Total	13,805	14,953	15,682	16,118	263,288	275,490	280,858	355,010
Total	Domestic	47,205	49,622	51,108	52,403	1,399,794	1,512,842	1,487,571	1,593,090
	Commercial	3,362	4,128	4,491	4,551	341,964	381,357	362,177	367,477
	Industrial	319	342	314	296	186,285	157,912	170,999	185,431
	Governmental	396	398	464	630	223,155	229,971	257,707	372,522
	Public tap	877	783	746	789				94,680
	Total	52,159	55,273	57,123	58,669	2,151,198	2,282,082	2,278,454	2,613,200

Source : SAMAPA

Table 2.4.5-2/1/93

Table 2.4.6 Volume of water consumption by zones as of December, 1991

	Zone	Water Consumption (m3/month)						Daily average volume per connection (liter/day)				
		Domes-tic	Commer-cial	Indust-rial	Govern-mental	Public tap	Total	Domes-tic	Commer-cial	Indust-rial	Govern-mental	Public tap
1	Achachicala	32,751	2,258	9,640	27,036	2,880	74,565	584	1,056	15,548	87,213	na
2	Agua de Vida	13,820	5,784	83	11,172	600	31,459	1,126	2,423	1,339	12,427	na
3	Bello Horizonte	31,205	5,986	88	3,556	240	41,075	1,333	2,099	2,839	8,194	na
4	Belen	18,262	38,819	1,192	14,696	na	72,969	1,698	5,421	4,806	16,931	na
5	Callampaya	11,977	4,007	1,252	62	360	17,658	431	1,002	10,097	1,000	na
6	Calconi	136,444	11,667	22,390	7,573	9,960	188,034	873	1,530	19,007	11,633	na
7	Challapampa	17,421	3,750	11,713	5,297	1,200	39,381	1,154	2,160	19,886	13,144	na
8	Chamoco Chico	6,174	85	87	124	5,040	11,510	224	457	935	1,333	na
9	Vino Tinto	10,689	628	112	na	4,800	16,229	427	810	1,204	na	na
10	Gran Poder	22,969	7,913	441	295	120	31,738	767	1,182	7,113	1,903	na
11	Los Andes	28,015	2,826	405	2,355	600	34,201	563	960	4,355	7,597	na
12	Mariscal Santa Cruz	26,388	3,421	1,590	200	1,560	33,159	528	862	8,548	1,290	na
13	Miraflores	45,671	9,031	2,600	21,891	240	79,433	1,411	2,158	5,991	44,135	na
14	Miraflores Sur	60,320	15,162	1,912	62,042	na	139,436	1,525	2,964	4,744	30,324	na
15	Norte	28,877	8,863	6,372	14,373	na	58,485	1,700	2,383	22,839	14,489	na
16	Obispo Indaburo	11,274	800	90	na	480	12,644	405	922	1,452	na	na
17	Obrajes	87,939	12,440	472	14,064	2,640	117,555	1,416	5,145	2,538	20,622	na
18	Pura Pura	36,968	2,771	24,345	3,244	2,160	69,488	923	1,397	29,086	10,465	na
19	Rosario	12,234	10,028	828	1,381	na	24,471	1,370	2,327	6,677	11,137	na
20	Villa San Antonio	56,014	2,509	326	1,826	16,440	77,115	551	843	1,753	2,945	na
21	San Juan	23,243	939	276	488	480	25,426	934	1,212	2,968	3,148	na
22	Kantutani, S.Jorge	65,317	25,912	10,982	26,750	120	129,081	4,900	4,200	39,362	17,610	na
23	Sn Sebastian	22,645	29,688	73,220	22,692	na	148,245	2,379	3,726	157,462	23,613	na
24	Santa Barbara	17,366	27,265	1,326	8,377	240	54,574	1,587	5,638	10,684	13,511	na
25	San Pedro	25,952	33,149	6,641	14,867	na	80,609	2,082	4,795	26,778	16,537	na
26	San Pedro Alto	22,089	2,742	440	1,579	360	27,210	948	1,340	2,028	8,489	na
27	Seguencoma	35,019	1,551	27	8,055	360	45,012	1,276	2,943	871	21,653	na
28	Sopocachi	70,836	14,207	562	7,775	720	94,100	1,624	2,362	3,022	8,957	na
29	Sopocachi Alto	70,532	17,810	754	1,463	960	91,519	1,367	3,830	4,865	3,630	na
30	Tacagua	4,993	240	na	14	6,240	11,487	255	645	na	226	na
31	Tembladerani	45,666	6,637	932	680	1,200	55,115	734	1,622	5,011	2,194	na
32	14 de Septiembre	20,145	15,434	690	7,638	120	44,027	872	1,999	7,419	20,532	na
33	Nuevo Potosi	25,603	1,593	na	3,715	1,200	32,111	463	918	na	13,315	na
34	Villa G. Villarroel	27,621	1,236	56	5,382	8,520	42,815	607	814	1,806	21,702	na
35	Villa Pabón	16,116	3,264	573	8,454	720	29,127	952	1,698	3,081	30,301	na
36	Villa	38,505	5,394	774	3,192	4,800	52,665	752	1,832	6,242	17,161	na
37	Villa Victoria	20,964	2,500	68	838	720	25,090	621	960	731	3,862	na
38	Munaypata	26,079	4,210	na	1,282	6,480	38,051	419	3,609	na	8,271	na
39	Calacoto	268,998	23,382	1,782	56,401	1,080	351,643	1,762	878	3,593	37,130	na
40	Villa de la Cruz	15,258	381	na	na	3,960	19,599	541	1,194	na	na	na
41	Augui Samaña	2,433	37	40	na	840	3,350	677	1,130	1,290	na	na
42	Bella Vista	32,292	1,156	350	1,373	6,240	41,411	822	na	1,613	6,327	na
	Total	1,593,084	367,475	185,431	372,202	94,680	2,612,872	45,583	85,446	449,583	574,951	na

Note: Data not available
Source: SAMAPA

Table 2.4.7 Number of Connection and Water Consumption for the Large-scale Consumers In La Paz

Category	3,000 m3/month and over		1500-2999 m3/month		750-1499 m3/month	
	Number of connection	Total water consumption (m3/month)	Number of connection	Total water consumption (m3/month)	Number of connection	Total water consumption (m3/month)
Industrial	10	109,500	13	26,343	16	17,637
Factory	8	95,853	12	23,662	10	11,607
Hotel	2	13,647	1	2,681	6	6,030
Commercial	1	5,062	7	13,477	17	18,934
Governmental	11	70,479	28	58,594	52	2,624
Others	6	27,308	17	31,816	42	47,959
Total	38	321,849	78	156,573	143	104,791

Source : SAMAPA

Note : Monthly water consumption is given as an average volume for 6 months from July to December, 1991

2.4.4 Water-borne Diseases

The classical water-borne diseases are due to highly infective organisms under the levels of pollution that readily occur. The two main diseases, having a high mortality if untreated, are typhoid and cholera. Including these two classical water-borne diseases, the La Paz sanitation unit of MPSSP reports the following seven diseases that infect people in the La Paz Department during 1988 and 1990: gastroenteritis, salmonella, amebiasis, hepatitis, typhoid, dysentery and malaria in order of infection number in urban areas in 1990. The incidence of infection are shown in Table 2.4.8.

As seen in Table 2.4.8, cholera did not appear during 1988 - 1990. However, it occurred in Rio Abajo, downstream of the Lipari on the Choqueyapu River, in August 1991, and spread over the Department. Earlier, in February 1991, cholera occurred in the Republic of Peru. Since then the Bolivian government prepared for an emergency. A half year later, the first case occurred in Rio Abajo. Table 2.4.9 shows the number of infections accumulated from August to December in 1991 within the territory of the La Paz sanitation unit. During the period, 124 patients were confirmed as cholera cases and 43 were listed as suspicious cases of cholera. Cholera panic has quieted down, but the sanitation unit is still taking special precautions against cholera. Although the infection route has been researched by WHO, the decisive route and its causal relation have not been clearly explained so far.

In November 1991, WHO submitted a report on reflections and considerations regarding the cholera epidemic (Ref.H4) to the government of Bolivia. The report attributed the water pollution of the Choqueyapu River to the introduction of cholera into the Rio Abajo communities where they consumed the river water for drinking and crop cultivation. After initial dissemination in La Paz City, it was feared that the consumption of fresh vegetables coming from Rio Abajo might cause the cholera

Table 2.4.8 Contagion Number of Water-borne Diseases in La Paz Department: 1988-1990

(Unit: Persons)

CIE Code	Water-borne Disease	1988 Total	1988 Urban	1988 Rural	1989 Total	1989 Urban	1989 Rural	1990 Total	1990 Urban	1990 Rural
1. Population (1000)*1		2,258	1,075	1,182	2,264	1,075	1,189	2,155	1,075	1,080
2. Diseases										
002	Typhoid Fever	278	-	-	337	188	149	350	227	123
003	Salmonella	998	-	-	957	690	267	1,146	838	308
004	Dysentery	272	-	-	148	87	61	232	106	126
006	Amebiasis	363	-	-	391	204	187	529	308	221
009	Gastroenteritis	10,548	-	-	9,466	5,444	4,022	14,157	10,179	3,978
070	Hepatitis	248	-	-	277	262	15	405	308	97
084	Malaria	215	-	-	-	-	-	1,465	2	1,463

Source: Ref.L17, L18 and L19

Note: *1 The numbers are appeared in the above sources.

*2 "Urban" includes El Alto City

Table 2.4.9 Contagion Number of Cholera in La Paz Sanitaion Unit: August 25 - December 28, 1991

(Unit: Persons)

Item	Total Total	Total Conf.	Total Prob.	Urban Conf.	Urban Prob.	Rural Conf.	Rural Prob.
1. Age Group							
0 - 4	6	5	1	1	1	4	0
5 - 14	12	12	0	8	0	4	0
15 - 29	32	23	9	10	1	13	8
30 - 44	36	25	11	14	3	11	8
45 - 59	39	28	11	18	2	10	9
60 - 74	35	25	10	13	3	12	7
75 and over	7	6	1	3	0	3	1
2. Total	167	124	43	67	10	57	33

Source: Sanitation Unit of La Paz

Notes: "Conf." means the number of infected cases.

"Prob." means the number of suspicious but not confirmed cases.

"Urban" does not include El Alto City.

infection. However, the analysis of causes indicated that the transmission could be attributed to consumption of other street foods and drinks of dubious quality, and not only of fresh vegetables. Finally, the report recommended looking for alternatives in Rio Abajo, such as: (a) to find other non-contaminated water sources like ground-water, (b) to look for other types of products not carrying a sanitary risk, and (c) to construct treatment facilities which guarantee the necessary water quantity and quality for irrigation.

2.5 WATER POLLUTION SOURCES

2.5.1 General

The following activities are recognized as potential river water pollution sources in the study area:

- Domestic activities.
- Public and commercial activities.
- Industrial activities.
- Agricultural activities.
- Stock-farming activities.
- Mining activities.

Among them, domestic, public, commercial and industrial activities are densely concentrated in the area of the City of La Paz, and agricultural, stock-farming and mining activities are scattered in the upstream areas of the rivers.

The contributions to the present water pollution of the rivers by the activities in the upstream areas are considered to be small. The population in this area is only about 1500 (refer to the section 2.2.1) and their water consumption would be small. In addition, there is no wastewater discharge facilities, thus the amount of domestic wastewater in those areas is negligible as compared to the river flow. The type of agriculture is rather primitive, using little fertilizer. Stock-farming is of the pasturage type, discharging no wastewater. Most of the livestock excreta discharged on the ground would be decomposed and absorbed by the soil before flushing down to the river. The mining activities are one of the potential causes of inorganic contamination of river water in general, but it is very rare that their wastewater contains organic pollutants. This feature has been also confirmed by the water quality survey of one of the mines located in the upstream areas of the Irpavi River. Also, the results of the water quality survey conducted in this study has proven that significant pollution does not exist in the upstream section of the rivers.

On the other hand, the activities in the urbanized area are considered to severely contribute to the pollution of the rivers, as can be seen from the fact that the water quality indexes indicating organic pollution conditions sharply increase as the Choqueyapu River flows into the urbanized area. Therefore, it is necessary to recognize such activities as the major pollutant sources affecting the present pollution conditions. In addition, the present sewage collection system, though it is not a pollutant source, is also very important factor in the understanding of the present pollution conditions because it carries the wastewater generated at each pollutant source efficiently to the river without any treatment.

Hereinafter, the characteristics of the major pollution sources, as well as the sewage collection system and the solid waste disposal system are discussed.

2.5.2 Sewage Collection System

Major parts of the City of La Paz, both in the Central zone and the South zone, are covered with sewage collection systems provided by SAMAPA and private developers.

The areas covered by these systems are shown in Fig. 2.5.1. The systems covers 1,800 ha, which is 32 % of the total city area, and collects wastewater from the activities located in the service area. The estimated population in the area covered by the system is about 400,000, about 56 % of the total population. The amount of the wastewater collected by the system is assumed to be much larger than that estimated from the coverage ratios of the areas and/or population, because most of the commercial or public activities and some of large factories are located in these areas.

The systems consists of the sewage collection pipe lines and the stormwater collection pipe lines, i.e., the separated system, and the outlets of both lines to the rivers. Figs 2.5.2 and 2.5.3 show typical examples of these systems prepared by SAMARA. As can be seen in the figures, both lines discharge to the rivers directly. Fig 2.5.2 shows the area in the Central zone, where the discharges are to the main river (the Choqueyapu River) or to small tributaries. Those small tributaries are natural streams but actually function as stormwater drainages and sewage channels. Fig. 2.5.4 shows such small tributaries in the area to be used as sewage channels. In the area shaded in Fig. 2.5.4, most of the tributaries are covered, thus they serve as part of the sewage collection system.

In the South zone (Fig. 2.5.3), the discharges to the tributaries are less than those in the Central zone and most of the sewage collected is transferred downstream by the pipes which can be regarded as trunk lines. Therefore, it may be easy to locate

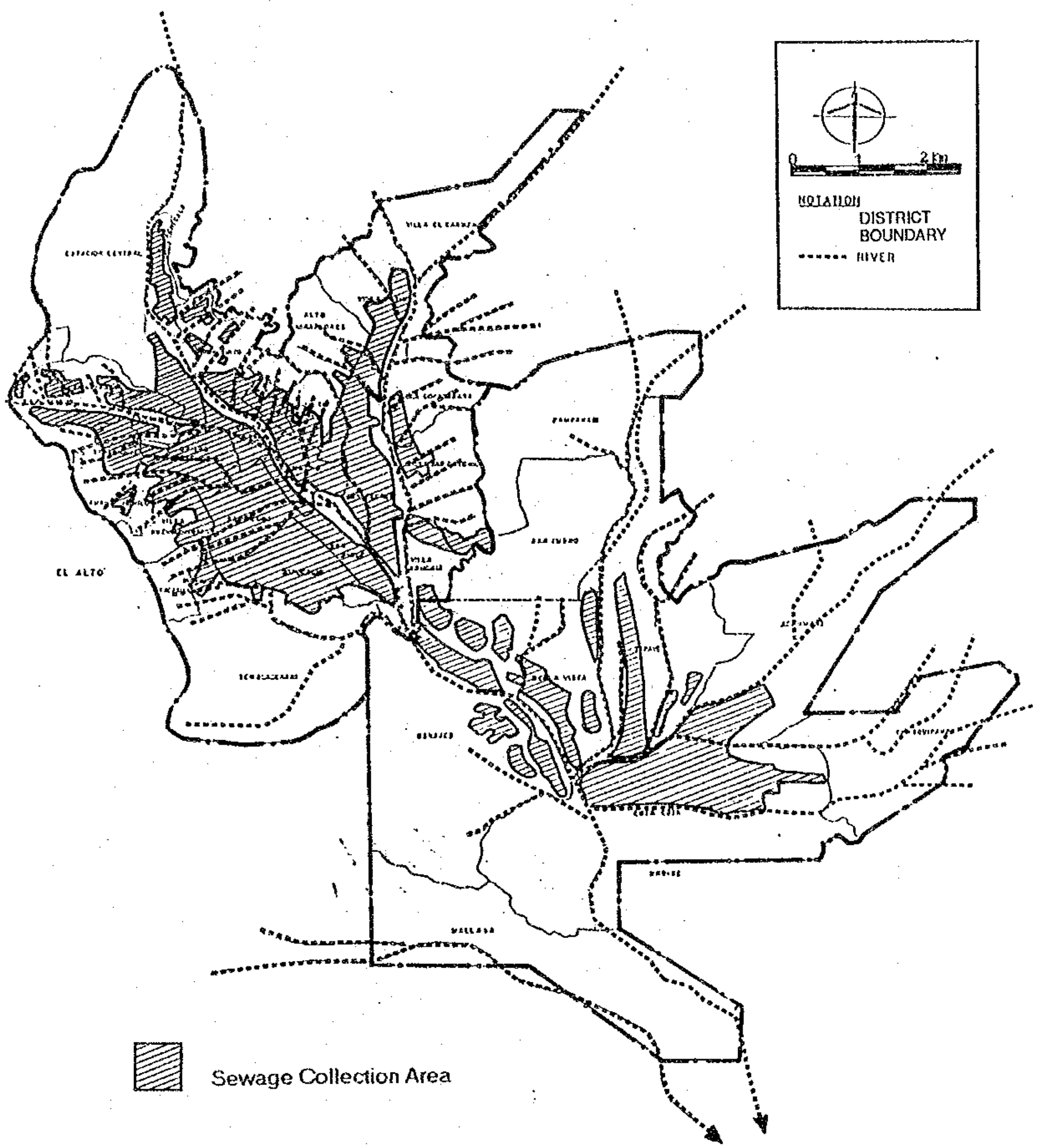


Fig. 2.5.1 Areas Covered With the Sewage Collection System La Paz

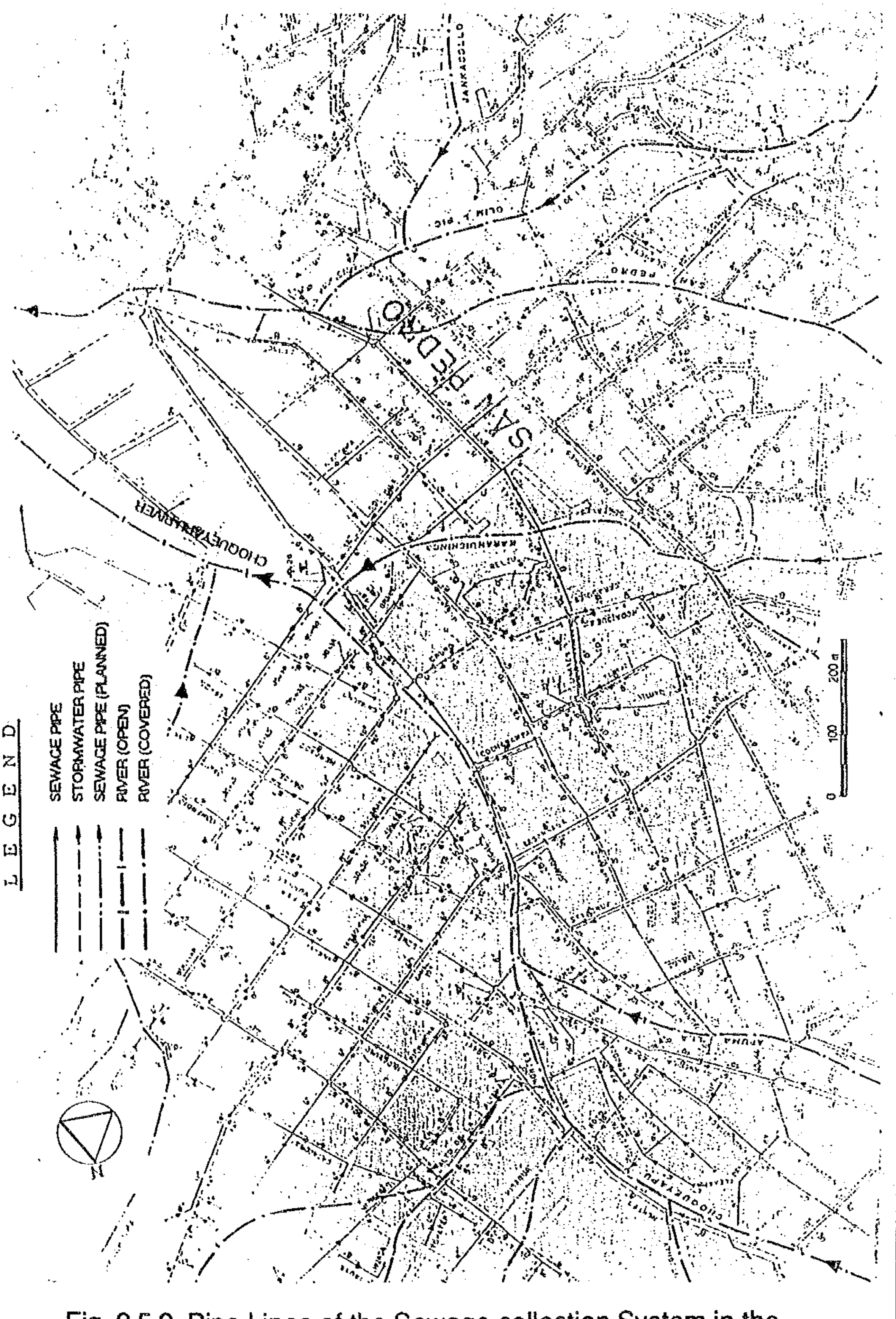


Fig. 2.5.2 Pipe Lines of the Sewage collection System in the Central Zone

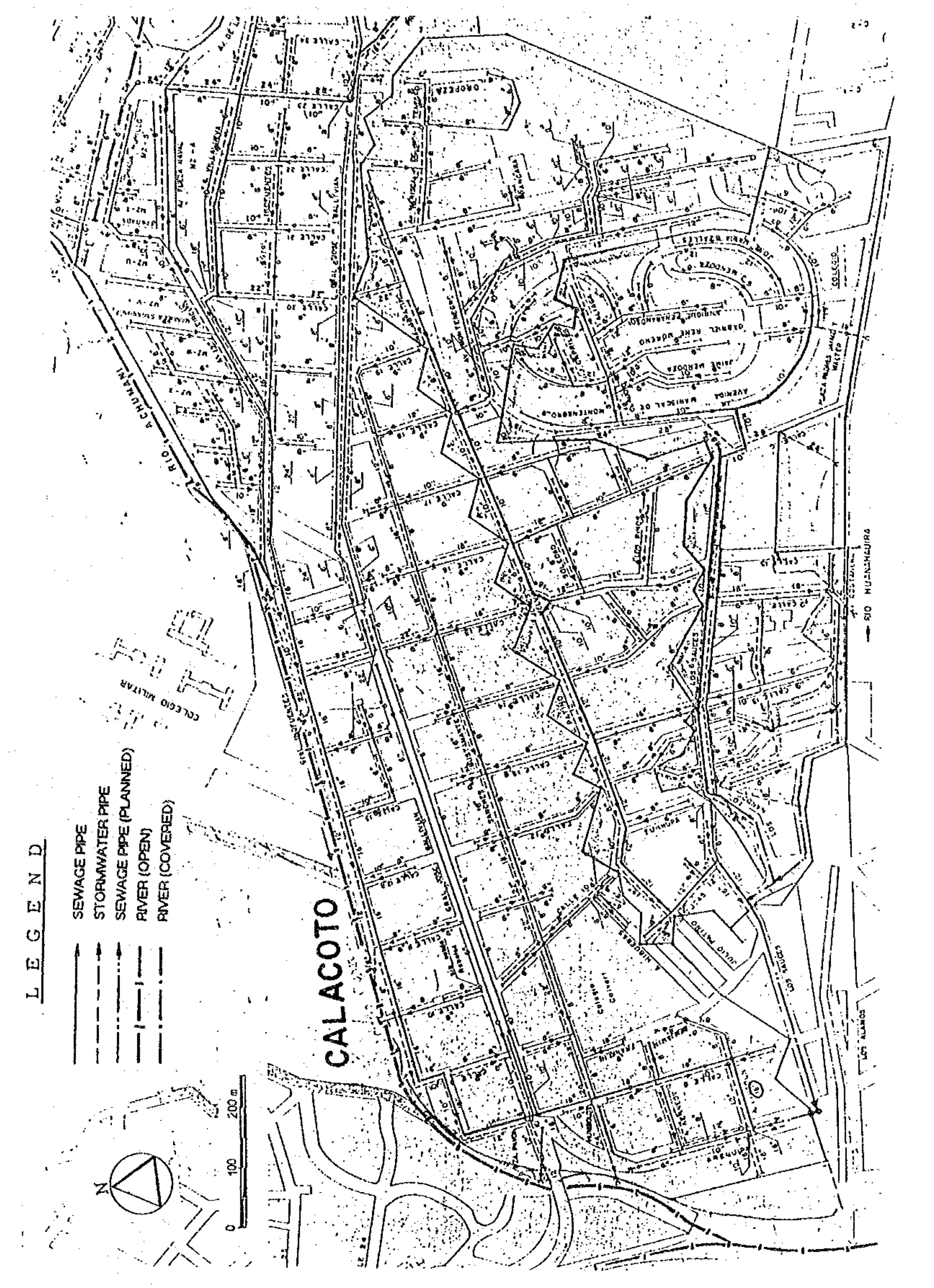


Fig. 2.5.3 Pipe Lines of the Sewage Collection System in the South Zone

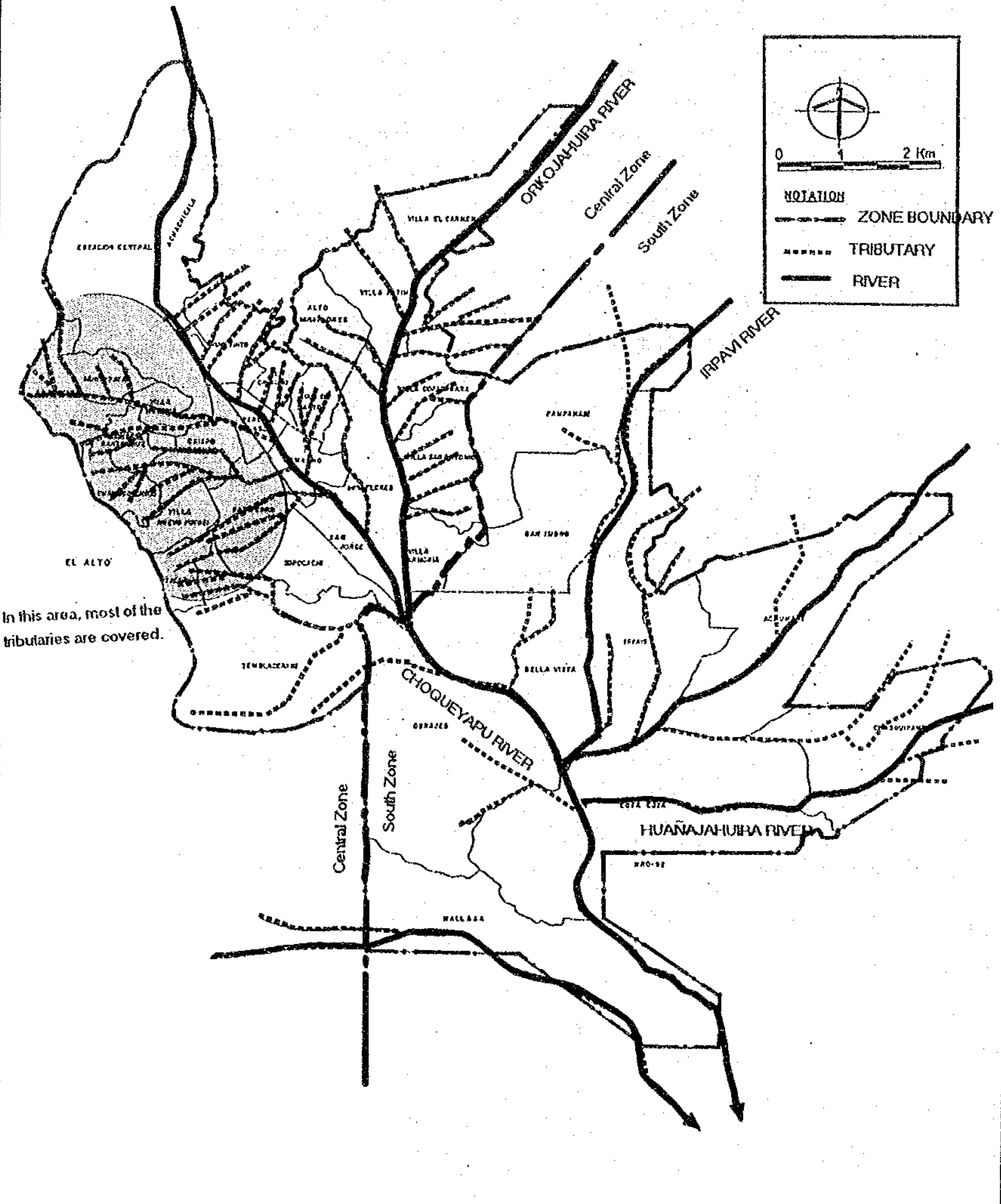


Fig. 2.5.4 Main Rivers and Their Tributaries in La Paz

the treatment facilities in the South zone, but complex interceptors would be required in the Central zone if all the sewage discharged to the rivers and tributaries is to be collected.

Another point to be noted in the system is the connections of sewage pipes to stormwater lines and vice versa. According to the SAMAPA's estimation, the number of the bad connections account for 40 % of the total connections. If this estimates is right, the system should be considered as the combined type rather than the separated type.

2.5.3 Domestic Wastewater

The features concerning domestic wastewater in the City of La Paz are discussed in this section from the view points of the water supply system and the wastewater disposal system. The former affects the wastewater generation and the latter affects the amount of wastewater reaching the river system.

(1) Water Supply System

The water supply system in the City of La Paz is operated by SAMAPA as discussed in Section 2.4.3. There are three types of the water supply as follows:

- The areas where water is supplied by SAMAPA through house connections. (Zone 1 and Zone 2)
- The areas where water is supplied by SAMAPA through the public hydrants. (Zone 3)
- The areas where water is not supplied by SAMAPA and people use water from private wells or water venders. (Zone 4)

The distribution of the above types of area is shown in Fig. 2.5.5 and the estimated population in each area is shown in Table 2.5.1.

Table 2.5.1 Area and Population by Type of Water Supply

Type of Water Supply	House Connection	Public Hydrant	No supply	Total
Area (ha)	3,940	260	1,400	5,600
(%)	(70.4)	(4.6)	(25.0)	(100.0)
Population	644,000	14,500	60,500	719,000
(%)	(89.6)	(2.0)	(8.4)	(100.0)

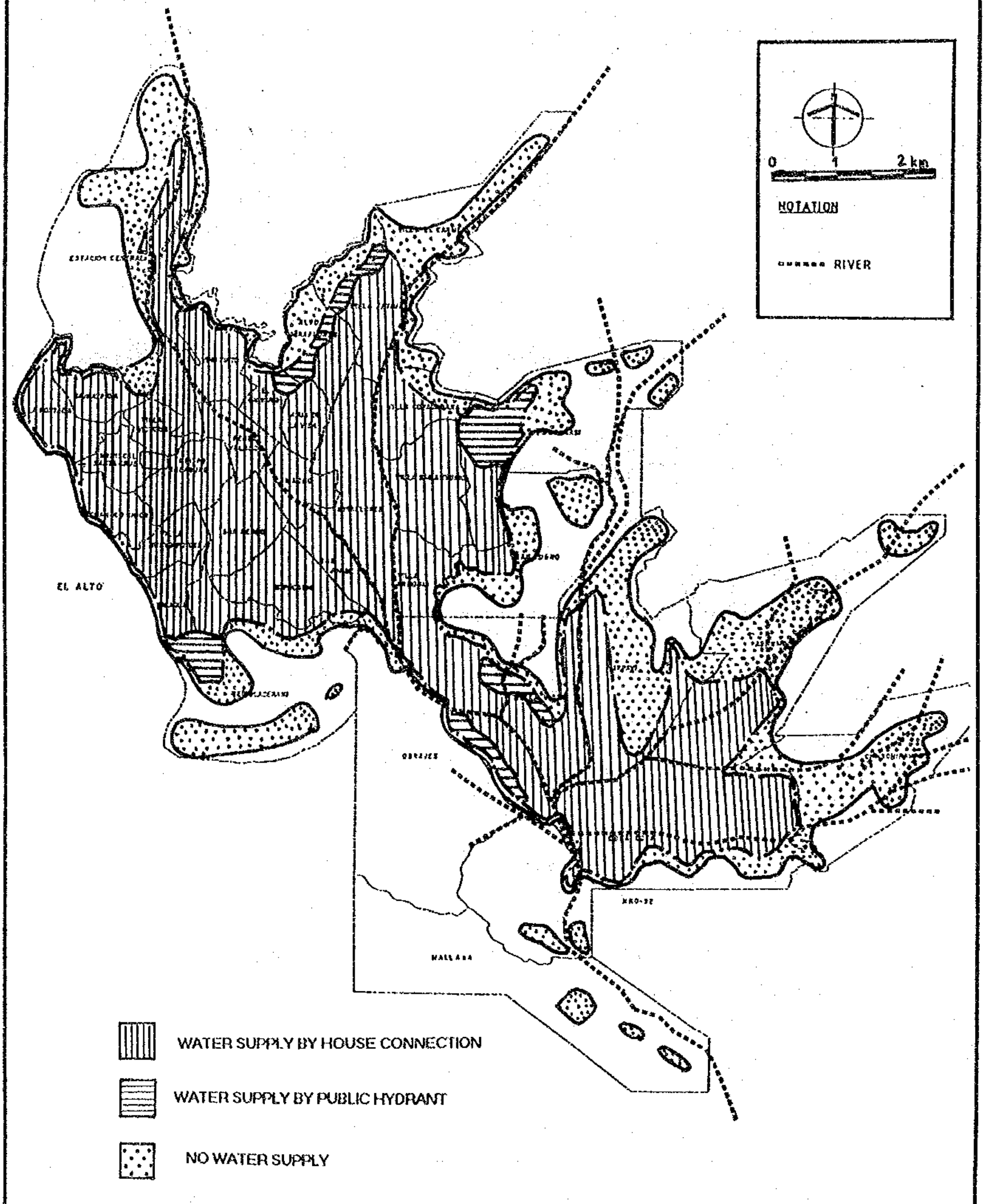


Fig. 2.5.5 Types of Water Supply in La Paz

(2) Wastewater Disposal System

In some areas in the City of La Paz, wastewater is collected by the sewage collection system and discharged to the rivers. In other areas, there are two types of wastewater disposal. In the areas located near the rivers, the wastewater is discharged to the river not through the sewage collection system, but through pipes or privately installed open channels. In other areas, there is no wastewater discharge or disposal facilities and the wastewater is spilled around the house and flows along roads. Some of the wastewater may reach the rivers but it mostly penetrates into the ground.
The location of the avove types of area is shown in Fig. 2.5.6 and the population in each area is shown in Table 2.5.2.

The characteristics of the wastewater differs between the areas where disposal facilities are provided and not provided. People do not have a flush toilets in areas without wastewater disposal facilities while flush toilets are very common in areas with the wastewater disposal facilities.

Table 2.5.2 Area and Population by Type of Wastewater Disposal

Type of Sewage Disposal	Sewage Collection System	Discharge to Rivers	No Facilities	Total
Area (ha)	1,800	650	3,150	5,600
(%)	(32.1)	(11.6)	(56.3)	(100.0)
Population	403,000	123,200	193,500	719,700
(%)	(56.0)	(17.1)	(26.9)	(100.0)

The amounts of wastewater and pollutant load per capita in the respective types of area will be described in Chapter 4.

2.5.4 Industrial Wastewater

(1) Number and Types of Industry

Table 2.5.3 shows the number of factories in the study area having 4 or more employees, by the type of industry, based on the Ref. A9. There were a total of 769 factories in operation in 1989. Among them, the total number of factories of the food and the textile industries accounts for almost 50 % of the total as shown in Fig. 2.5.7. As for the scale of these businesses, Fig. 2.5.8 shows that the number of the small scale businesses dominates in the total number.

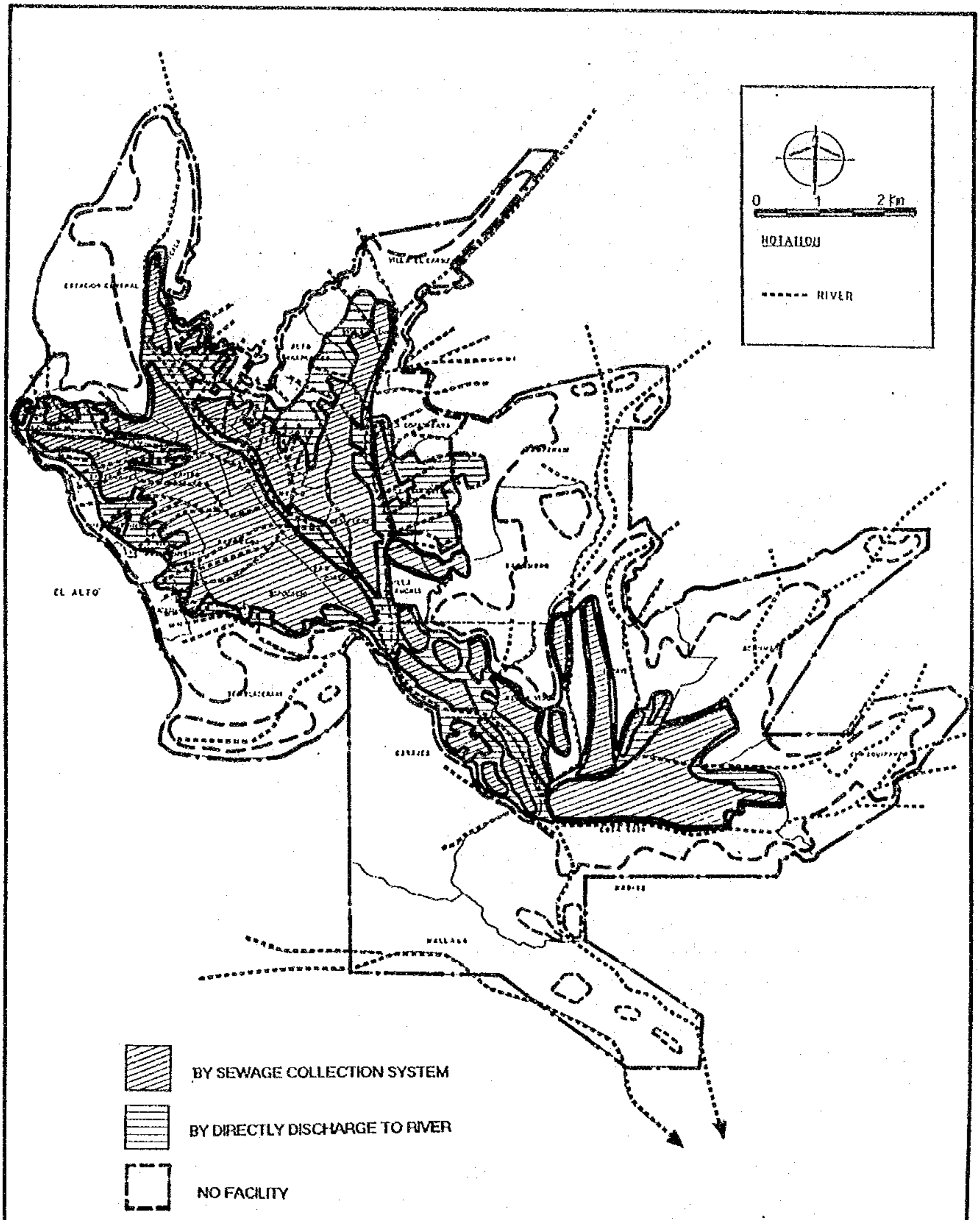


Fig. 2.5.6 Types of Wastewater Disposal in La Paz

TABLE 2.5.3 Numbers of Factories and Employees Classified by Type of Industry

No	Type of Industry	Classification by Number of employees									
		4 - 14		15 - 29		30 - 99		100 -		Total	
		No. of Factory	Total No. of employee	No. of Factory	Total No. of employee	No. of Factory	Total No. of employee	No. of Factory	Total No. of employee	No. of Factory	Total No. of employee
31	Food, beverage, and tabacco industries	165	1,029	28	577	10	619	11	1,637	214	3,862
32	Textile and leather industries	117	774	20	376	22	1,096	8	1,442	167	3,688
33	Woodwork industry	90	548	6	105	5	258	1	103	102	1,014
34	Paper industry, including printing and publishing	96	646	6	122	6	397	3	741	111	1,906
35	Chemical industry	26	119	16	339	15	767	3	689	60	1,914
36	Non ferrous metal industry	32	222	5	109	2	107			39	438
37	Iron and steel industries	4	32	1	15	1	52			6	99
38	Machine industry	39	274	9	163	8	383			56	820
39	Other industries	12	66	2	30					14	96
	Total	581	3,710	93	1,836	69	3,679	26	4,612	769	13,837

Source: Ref. A9

This suggests that the wastewaters of most factories have a high concentration of organic pollutants because the wastewater from the food and the textile industries are very rich with organic substances, and implementation of the wastewater treatment may be difficult because small businesses cannot usually afford such investments.

(2) Quantity

The water consumption rates of the factories are summarized in Table 2.5.4 based on Ref. G2. This shows the amounts of the water supplied by SAMAPA. The wastewater quantities will be more than those shown in the table when the ground water usage is considered. However, most of the wells in the factories are known to have been abandoned for several years, thus the wastewater quantity in most factories is considered to be equivalent to the values in the table. In the table, it is remarkable that one factory in the food industry uses about 55 thousand m^3/month, which accounts for 74 % of the total of the food industry and 43 % of the total for all the industries. In addition, this factory is said to use the ground water from their own wells in the factory site. Although the quantity of the well water consumption is not known, the total quantity of wastewater from this factory probably exceeds 50 % of the total for all the industries.

Fig. 2.5.9 shows the ratios of the total water usage, i.e., wastewater quantity by type of industry. The total of the food and the textile industries, which have wastewaters containing high concentration of the organic substances, accounts for almost 75 % of the total. Fig. 2.5.10 shows the distribution of the total monthly water usage of the factories by the scale of factories in terms of water usage. The total wastewater quantity (water usage) of the factories with more than 3,000 m^3/month wastewater accounts for 70 % of the total, while the number of factories using more than 3,000m^3/month is only 20 % of the total. This indicates that the effects of the implementation of the industrial wastewater control would be significant even when the application of the control is limited to the factories having a large scale of wastewater discharge. The effect of such wastewater control on the water quality of the Choqueyapu River will be large particularly because most of the factories with a large scale of wastewater discharge are located in the upstream part of the city along the Choqueyapu River as shown in Fig. 2.5.11.

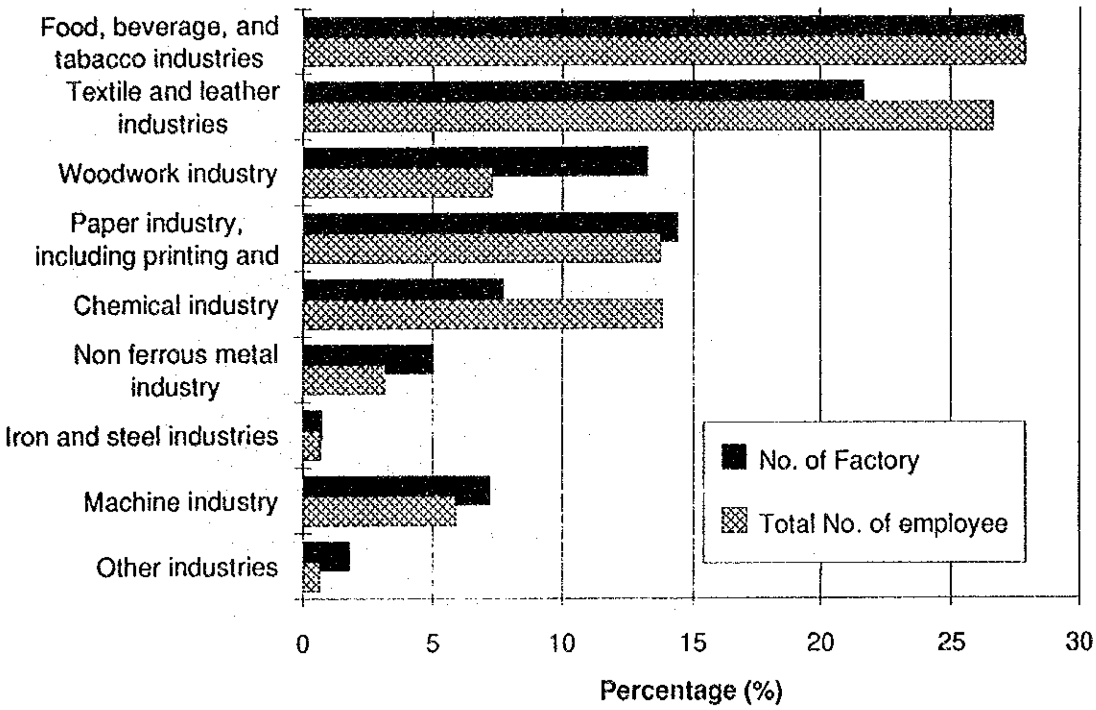


Fig. 2.5.7 Comparison of Numbers of Factories and Employees by Type of Industry in La Paz

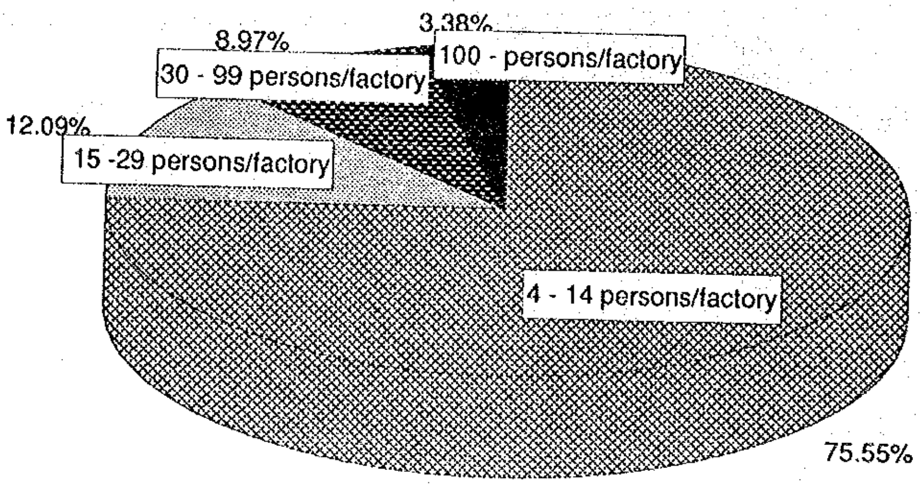


Fig. 2.5.8 Comparison of Number of Factory by Scale of Business in La Paz

Table 2.5.4 Water Usage by Factories

No	Type of Industry	Classification by Water Consumption (cum/month)									
		750 - 1499		1500 - 2999		3000 - 15000		15000-		Total	
		No. of Factory	Total monthly water consumption (cum/m)	No. of Factory	Total monthly water consumption (cum/m)	No. of Factory	Total monthly water consumption (cum/m)	No. of Factory	Total monthly water consumption (cum/m)	No. of Factory	Total monthly water consumption (cum/m)
31	Food, beverage, and tabacco industries	2	2105	4	7876	2	9170	1	55445	9	74596
32	Textile and leather industries	1	1054	5	9642	1	9837			7	20533
33	Woodwork industry										
34	Paper industry, including printing and publishing					1	10449			1	10449
35	Chemical industry			1	1845	1	6940			2	8785
36	Non ferrous metal industry	1	1347	2	4299					3	5646
37	Iron and steel industries									0	0
38	Machine industry									0	0
39	Other industries*	5	5721	1	3962					6	9683
	Total	9	10227	13	27624	5	36396	1	55445	28	129692

Source: Ref.G2

Note: * Includes three factories of which type of industry are unknown.

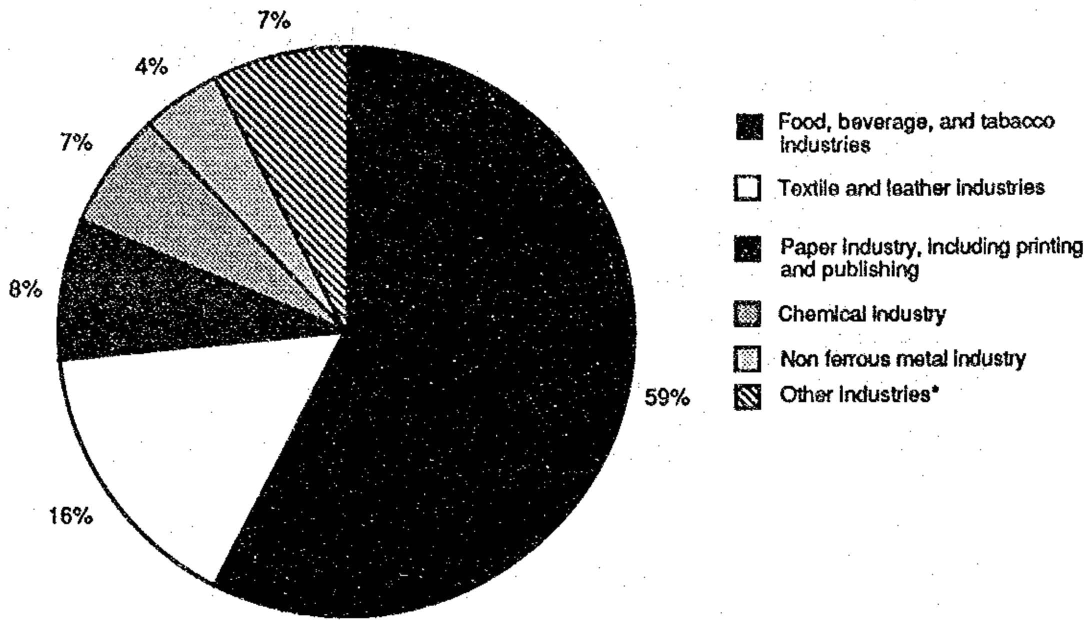


Fig. 2.5.9 Ratios of the Total Water Usage by Type of Industry

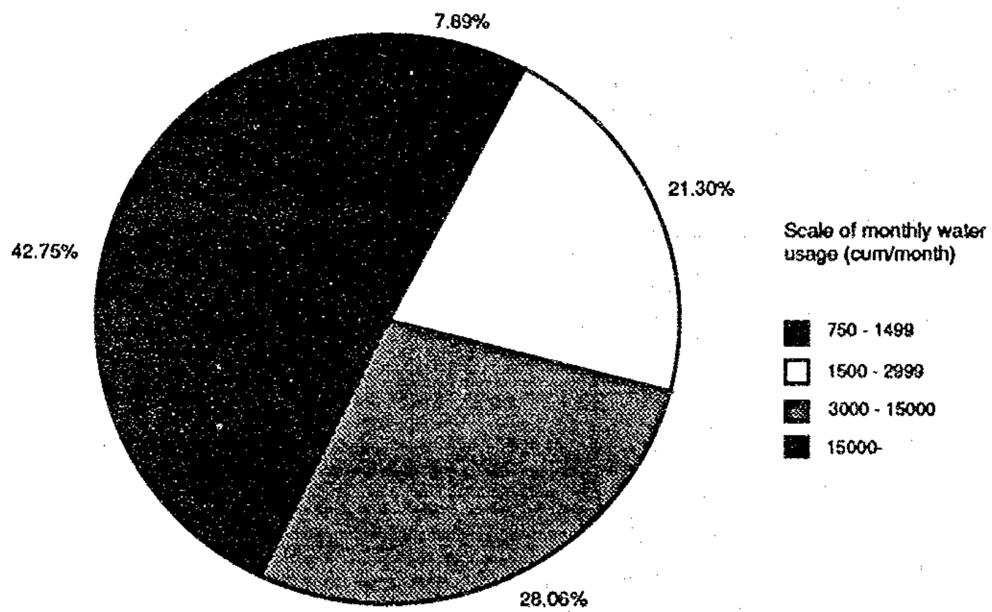


Fig. 2.5.10 Distribution of Total Monthly Water Usage of Industry by Scale

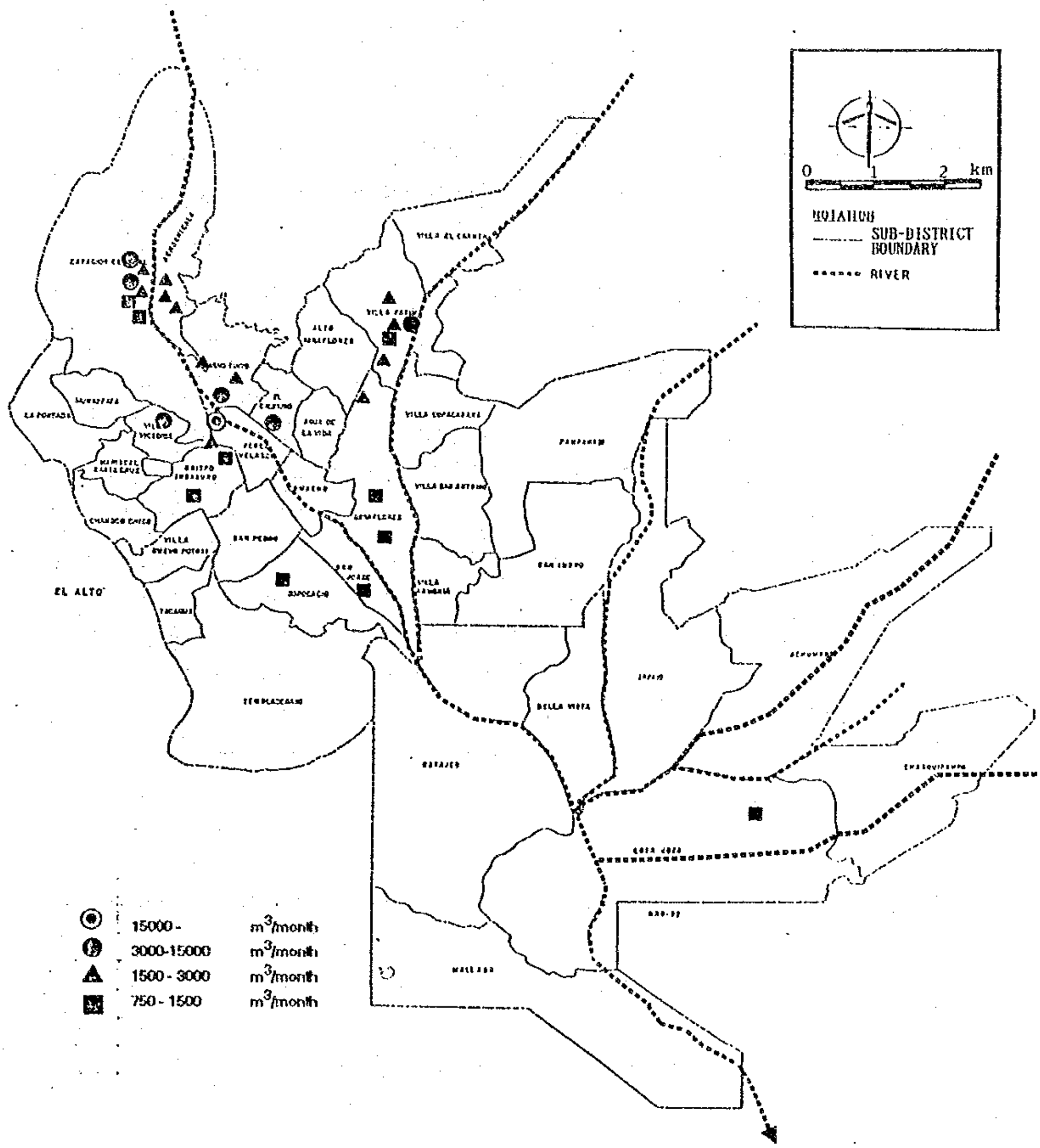


Fig. 2.5.11 Location of the Factories with Large Water Consumption

(3) Quality

The available data on the quality of the industrial wastewater in La Paz and El Alto are those provided by SAMAPA (Ref. G2) as shown in Table 2.5.5. At an early stage of the present study, these data were reviewed and the water quality survey for the industrial wastewater was planned to supplement the insufficient data. However, due to the uncooperative attitude of most of the factories, the quality survey failed except in two factories of the paper industry.

Table 2.5.6 shows the average wastewater quality by types of industry.

(4) Wastewater Treatment System

No evidence indicating the existence of any wastewater treatment facility in the factories has been found during the curnet study. The reason for this is that there have been no laws/regulations to control industrial wastewater effluents. However, the regulation for industrial wastewater (Ref. K3) is now in force (refer to the Section 2.3.2). From now on, industries will be forced to install wastewater treatment facilities to meet the regulation for wastewater quality. In the current study, a questionnaire was sent to 92 factories to ask their plan to treat the wastewater, as well as other information relating to production activities. However, no answers were received. Also, a majority of the factories visited for the interview survey declined to answer.

2.5.5 Other Wastewaters

Table 2.5.7 shows the water usage by the large scale consumers other than factories. The public facilities in total have a large water usage at 131,697 m^3/month, being about the same as the industrial use at 131,122 m^3/month. The public facilities consist of schools, hospitals, stadiums, parks, and other buildings for public uses. In terms of quality, it is considered to be the same as the domestic wastewater. However, for the hospital wastewater, special consideration should be taken to prevent pathological contamination. Before it is discharged to the river or sewerage system, the wastewater should be sterilized.

TABLE 2.5.5 Industrial Wastewater Qaulity in La Paz and El Alto

No.	Type of Industry	COD mg/l	BOD mg/l	SS mg/l
2	31 brewer	3,021	1,497	292
3	31 brewer	7,940	3,110	350
4	31 brewer	996	772	294
64	31 brewer	1,974	761	1,110
65	31 brewer	1,794	600	1,332
66	31 brewer	4,630	3,000	1,882
8	31 food	8,558	1,632	3,841
9	31 food	9,301	1,394	4,330
10	31 food	9,144	1,928	4,406
76	31 meat	1,784	630	1,188
77	31 meat	2,455	720	1,114
78	31 meat	24,784	1,328	3,600
72	32 acryl textile	140	60	
73	32 acryl textile	148	20	165
74	32 acryl textile	195	18	170
75	32 acryl textile	170	10	186
86	32 detergent (soap)	18,133	5,400	9,500
87	32 detergent (soap)	98,872	36,000	66,541
88	32 detergent (soap)	26,878	22,500	8,237
11	32 leather	3,793	1,082	12,687
12	32 leather	3,434	1,155	10,972
13	32 leather	7,460	600	46,401
5	32 textile	4,397	318	26,420
6	32 textile	1,095	121	1,387
14	32 textile	27	0	244
15	32 textile	3,768	1,130	2,275
16	32 textile	877	618	633
23	32 textile	612	99	287
24	32 textile	1,829	153	8,174
25	32 textile	3,060	523	4,008
58	32 textile	907	110	958
59	32 textile	944	121	843
60	32 textile	753	132	720
50	32 wool	357	164	88
51	32 wool	1,845	665	174
52	32 wool	1,041	339	124
7	34 paper	37,367	17,400	4,099
30	35 dyeing	346	166	80
31	35 dyeing	1,238	364	436
32	35 dyeing	452	278	2,670
20	35 medicine	1,312	168	323
84	35 medicine	2,240	1,150	552
85	35 medicine	27,418	1,350	2,984
37	35 medicine	602	150	1,847
38	35 paint	2,664	714	5,181
39	35 paint	2,018	918	2,284
40	35 paint	3,647	1,200	10,272
61	39 meatal furniture	117	20	187
62	39 meatal furniture	45	10	123
63	39 meatal furniture	8	0	79
*	34 paper	701	129	996
*	34 paper	805	305	452

Sourses: *Present study, others are Ref. D10

Table 2.5.6 Average Wastewater Quality by Type of Industry

	Type of Industry	No of Samples	COD mg/l	BOD mg/l	SS mg/l
31	Food Industry	12	6,365	1,448	1,978
	brewer	3	3,986	1,793	312
	bevarage	3	2,799	1,454	1,441
	food	3	9,001	1,651	4,192
	meat	3	9,674	893	1,967
32	Textile and Leather	24	7,531	2,972	8,748
	acryl textile	4	163	27	174
	detergent (soap)	3	47,961	21,300	28,093
	leather	3	4,896	946	23,353
	textile	11	1,661	302	4,177
	wool	3	1,081	389	129
34	paper	3	12,958	5,945	1,849
35	Chemical Industry	13	4,194	646	2,663
	dyeing	3	679	269	1,062
	medicine	4	7,893	705	1,427
	paint	3	2,776	944	5,912
39	Other Industry (Metal Furniturs)	3	57	10	130
Average of all samples			6731.8	2251.96	5225.510204

Source : Prepared using Table 2.5.5

Table 2.5.7 Monthly Water Consumption by Large Scale Consumers Other Than Factories

	Scale of Mothly Consumption (cum/month)							
	750 - 1499		1500 - 2999		3000 -		total	
Type of Facilities	No. of facilities	Total Water Consumption (cum/month)	No. of facilities	Total Water Consumption (cum/month)	No. of facilities	Total Water Consumption (cum/month)	No. of facilities	Total Water Consumption (cum/month)
Public Facilities	52	2,624	28	58,594	11	70,479	91	131,697
Hotels	6	6,030	1	2,681	2	13,647	9	22,358
Commercial Buildings	17	16,934	7	13,477	1	5,062	25	35,473
Others	42	47,959	17	31,816	6	27,308	65	107,083

Source: Ref G1

2.5.6 Solid Waste Disposal

(1) Disposal System

The present situation in the management of solid wastes in the City of La Paz was investigated by means of interviews at the Bureau of Urban Sanitation (Dirección de Saneamiento Urbano; DSU) of HAM-LP and a field reconnaissance during the period of February through April, 1992. The understanding on the situation thus acquired is described below.

1) Collection of Domestic Solid Wastes

The amount of domestic solid wastes generated in the City of La Paz is estimated by DSU at about 350 - 380 ton/day. Of this amount, 300 - 320 ton is regularly collected with the collection ratio steadily increasing.

DSU has some 70 collection/transport trucks of which 50 were donated through a grant aid program of JICA. This number is sufficient to cover the entire residential area of the City. However, the number of waste receptors is not sufficient to cover the whole area. At present, there are 35 JICA supplied, large-size, transportable containers and 60 medium-size, fixed-type receptors. The former are placed beside the principal streets and the latter are placed generally around the river-courses. There is a shortage of about 85 of the former type. Because of this shortage, some large waste producers, such as large hotels, are said to let the collection trucks pick up their wastes directly at the sites, off the formal collecting routes, by offering tips. This practice reduces the efficiency of waste collection, and its cost is not recoverable. Since the steel-made, transportable type of containers costs about US$ 8,000 - 10,000 per unit, DSU is planning to produce brick or concrete-made containers through the cooperation of the military force. They are also strengthening the monitoring of the collection trucks so that they follow the formal collection routes.

With these efforts, DSU was confident that the amount of solid waste collection will increase to 350 ton/day by the end of 1992.

Uncollected wastes are disposed of irregularly in nearby places such as river banks and slopes. DSU recently set up a campaign with the help of the military force to clean up those irregular dumping sites. For example, a party consisting of some 100 city employees and some 200 soldiers cleaned up a sloped area bordering the City of El Alto collecting 200 ton of dumped wastes in one day. DSU intends to continue this campaign.

2) Collection of Industrial Solid Wastes

The Study Team, during the field reconnaissance, noticed places on the outskirt of the City where factory solid wastes and/or construction wastes mainly of waste bricks were irregularly left.

The amount of industrial solid wastes generated is not known to DSU. DSU is prepared to collect factory solid wastes at each site with a modest charge of Bs. 40 /ton while the actual cost is Bs. 90 - 95 /ton. But the majority of factories are not yet willing to accept this service. DSU is continuing their efforts to control factory solid wastes, and their prospects appear to be bright.

One result of their efforts is the introduction of a system in which citizens report illegal dumping of wastes to DSU which immediately takes the necessary actions including letting offenders clean up the sites or fining them. Incorporated in this system is the introduction of the persons who keep a lookout for offenders to give them advice and warning, or to report to DSU. These persons are offered food, instead of wages, that have been donated through foreign aid.

As regards construction wastes, the Bureau of Public Works, HAM-LP is responsible for specifying disposal sites.

Ninety-five percent of hospital wastes are collected at present by DSU as the result of the campaign initiated 2 years ago.

3) Final Disposal of Solid Wastes

At present, collected solid wastes are transported to a transfer station located on the right bank of the Choqueyapu River near Obrajes, where the wastes are re-loaded to large-size dump trucks. The wastes are then transported to a final disposal site for landfill. The site is located in the hilly area in Mallasa on the right bank of the Choqueyapu River about 2.5 km downstream from Aranjuez.

The Mallasa landfill site has been used formally since August 1991, and its capacity is estimated to be sufficient to accept the wastes for the next 10 years. There is a weighing facility at the entrance.

The bed material of the landfill site consists mainly of clay which prevents leachate from seeping out of the landfill. The wastes are compacted and covered daily with sandy soil. Hospital wastes are buried at a clay-dominant portion and covered with lime.

DSU once tried to investigate the landfill leachate by making test holes, but no measurements have been conducted because of the budget shortage.

Methane gas (CH_4) formed through anaerobic digestion of waste materials is not collected but is released into the atmosphere.

4) Health Problem in the Areas Without the Wastes Collection Service

The uncollected portion of the solid wastes is largely generated in the outskirts of the City. According to DSU, the frequency of children getting diarrhea in these areas is much higher than in the areas serviced with solid wastes collection. A study showed that the children below 5 years old in the outskirts get diarrhea 6 times a year in average and the average height of 5 year old children is 12 cm less as compared with children in the other areas who do not get diarrhea. The frequency of outbreaks of cholera has been also high statistically in these outskirt areas where the solid wastes are not collected.

5) Privatization of the Solid Waste Disposal Service

Aiming to increase the efficiency of the solid waste disposal service, DSU is planning to transfer most of the service operations to the private sector, and is elaborating the technical and organizational details for the tender which, DSU expected, would be held within the year 1992.

(2) Possible Contribution to Water Pollution

1) Uncollected Solid Wastes

As described hereinbefore, the solid waste disposal system in the City of La Paz has been much improved in the recent years, because the City acquired the equipment, though not yet adequate, and they have been making various efforts for regular collection of the wastes and removal of the wastes from irregularly dumped sites. Thus, the amount of solid wastes dumped into the rivers has drastically reduced from the year 1987 when the World Bank reported the contribution of solid wastes to the river water pollution (Ref. H2). Moreover, although about 30% of solid wastes is considered to be biodegradable in a relatively short period, not all of this portion contributes to the measurable BOD or COD value of the river water. The parts of the biodegradable portion of solid wastes that are measurable in the water quality analysis are those substances that readily dissolve into water and small particles suspendable in the river water. However, these substances are considered to constitute a small part of the entire biodegradable portion of solid wastes. On the other hand, there are other parts that are not measurable in the water quality analysis but consume dissolved oxygen of the river water. These are relatively large size substances flowing in the river water or settled to the river bed. However, the average speed of biodegradation of these substances is considered to be much lower than that of the substances measurable in the water quality analysis.

From the factors described above, the contribution of uncollected solid wastes to the water pollution of the Choqueyapu River is considered to be insignificant at present as compared with the domestic and the industrial wastewaters, as concerns water quality parameters such as BOD, COD and DO.

2) Leachate From the Sanitary Landfill

Leachates from sanitary landfills, if they are not treated, may constitute a significant source of water pollution. In the City of La Paz, there is an old site for sanitary landfill in Sopocachi located on the left bank of the Kotahuna River just upstream from the confluence with the Choqueyapu River. This site had been used for the final disposal of the solid wastes until the Mallasa site opened for sanitary landfill. During the field reconnaissance of the JICA study team, no leachate outflows were observed at either the Sopocachi or Mallasa site, although there may be such outflows especially during and after significant precipitation.

Among the 15 measuring points in the river water quality survey, described in Section 2.4.1, included is one point (R6) in the Kotahuna River located downstream from the Sopocachi landfill site. Within the catchment area of the R6 point, there are dwelling areas with a total population of some 30,000 or more as well as the Sopocachi landfill site. If the Sopocachi landfill is a significant source of water pollutants, the water quality of this point would exhibit the particular characteristics of the landfill leachate.

Table 2.4.8 shows the concentrations and the loads of BOD and SS at point R6. The values were extracted from the results of the river water quality survey.

Table 2.5.8 Concentration and Load of BOD and SS at Pt.R6

Date	March 23-24		April 1-2		April 22-23		April 29-30	
Item	BOD	SS	BOD	SS	BOD	SS	BOD	SS
Concentration (mg/l)	101	3,030	96.5	6,570	57	3,170	57	2,440
Load (ton/day)	1.40	41.9	1.33	90.8	0.99	54.8	0.94	40.1

The BOD concentration values are on the order of 1/2 to 1/4 of those of raw domestic sewage.

The BOD load passing Pt. R6 is on order of 1 ton/day which is considered roughly equivalent to the generation load of BOD by some 20,000 persons. From these figures, it is not obvious whether or not the landfill leachate has a significant influence on the BOD value of Pt. R6.

The loading of SS at Pt. R6 is very large. This may be due to the collapse-prone characteristics of the soils in the catchment area.

The concentration of heavy metals at Pt. R6 showed a noticeable feature of this point. Among the 15 points surveyed, the concentration of total iron (Fe) was highest at Pt. R6 in all 4 times of the survey. The concentration of Hg and Pb was highest at 3 times, and Mn and Cu 2 times.

The high concentration of Fe and Mn may be attributed to the soil characteristics of the catchment area. However, there is a possibility that the source of some of the other metals is the leachate from the landfill.

3) Summary

Solid wastes not collected and dumped in the river banks or elsewhere are not considered to significantly affect the water quality of the Choqueyapu River. It is not obvious whether the leachates from the sanitary landfill sites are significant sources of organic pollutants to the Choqueyapu River. The old sanitary landfill at Sopocachi may be a source of some heavy metals such as Hg. In conclusion, the influence of solid wastes to the organic pollution of the rivers in the study area is not considered to be significant.

2.6 RELEVANT PLANS

2.6.1 National Plans

(1) Long-term Development Plan

In August 29, 1985, the government promulgated the new economic policy (Government Decree No.21060). The new policy aimed at quickly restoring macro economic stability, but it did not focus on long-term economic development. The government then formed the "Social and Economic Development Strategy, 1989-2000" (Ref. I4) and published it in April 1989. Its sum and substance are as follows.

- To improve labour productivity and to intensify price competition in the international market, by means of shifting the type of industrial development from labour-intensive to capital-intensive

- To evolve agricultural cooperatives to protect and to promote small- scale farming

- To establish countermeasures for in-migration into urban areas from traditional farming and mining areas

- To magnify the road network system, particularly feeder lines to regional centers from surrounding areas

- To improve the export network of natural gas to Argentine and Brazil, to integrate the electricity network among regions, and to provide water supply and sanitation projects

- To increase foreign currency earning by means of development of non- traditional industries

- To strengthen the "National Development Fund", which is now applied for projects in regional communities, to make applicable to urban development

Table 2.6.1 shows the growth rates of GDP between 1989 and 2000, projected in the "Strategy" (Ref.I4). The average growth rate during this period is estimated at 4.9% per annum. During the first four years, it is estimated at 4.5% per annum, and for the next four years it is expected to increase to 5.3% per annum. This is because the natural gas project between Bolivia and Brazil will be implemented, and the operation will start in this period. During the final four years, the rate is considered to stabilize to 4.7% per annum.

Table 2.6.1 Growth Rates of Principle Indicators in Bolivia: 1989-2000

(Unit: % per annum)

Item	1989-1992	1993-1996	1997-2000	1989-2000
1. Gross Domestic Product (GDP)	4.5	5.3	4.7	4.9
Agriculture	4.1	4.1	4.2	4.1
Mining	11.1	13.5	13.6	12.7
Petroleum & natural gas	6.9	12.0	6.4	8.4
Manufacturing	7.1	7.6	8.3	7.6
2. Population				
Urban population	2.8	2.8	2.8	2.8
Economically active population	4.4	4.4	4.4	4.4
Employment in urban area	2.7	2.8	2.9	2.8
	4.5	4.2	3.8	4.2
3. Per Capita Growth				
GDP	1.7	2.5	1.8	2.0
Personal consumption	-1.3	0.7	1.3	0.2
4. Gross Fixed Capital Formation	32.6	4.0	2.9	12.4
5. Domestic Saving	33.7	11.2	13.8	19.1
6. Foreign Trade				
Foreign export *1	21.0	17.7	6.3	14.8
Foreign import *1	25.5	12.8	-1.1	11.9

Source: Ref.I4 (Table 1.6)
Note: *1 Evaluated both goods and services at current US$ prices.

During the same period, the average population growth rate of the country is projected to be 2.8%. Then, the growth rate of GDP per capita is estimated at 2.0%. As a result, GDP per capita in 2000 is projected to increases by 27% from that in 1989.

As shown in the table, foreign exports are projected to grow at 14.8% per annum on average during 1989 and 2000. This high growth rate is to be accomplished by an endeavor to boost capital investment during the period 1989-1990.

Table 2.6.2 shows the annual transition of GDP by major economic sectors through the year 2000. Table 2.6.3 shows also the transition of GDP composition in the same period. In these tables, the extraction, manufacturing and utility sectors are expected to grow more quickly than other sectors in the national economy.

(2) National Plan for Potable Water and Sanitation (1992-2000)

The national Plan for Potable Water and Sanitation, 1992-2000 (Ref.I1) has been established by DINASBA, MAU and was published on May 19, 1992.

According to this plan, the national coverage of the population in water supply and sewerage at present and the year 2000 are projected as follows:

National Coverage of Water Supply and Sewerage

		1991	2000
Water Supply:	National (%)	53	70
	Urban (%)	74	80
	Rural (%)	31	60
Sewerage:	National (%)	24	53
	Urban (%)	35	65
	Rural (%)	14	50

A total of US$ 768 million is to be invested to achieve the above coverage by 2000. A breakdown of this investment is as follows:

	Millions of US$
Water Supply	326
Sewerage	346
Study and Planning	51
Technical Assistance	45
Total	768

Table 2.6.2 Growth Rates of GDP and Value Added of Major Economic Sectors: 1989-2000

(Unit: %)

Economic Sector	1989	1990	1991	1992	1993	1994
1. Agruculture	3.8	3.9	4.2	4.5	3.9	4.0
2. Mining & Metallurgy	8.9	9.7	12.9	12.9	11.8	14.1
3. Manufacturing *1	6.2	6.9	7.4	7.7	12.5	6.3
4. Petroleum & Natural Gas*2	10.7	9.9	5.2	1.9	4.1	35.2
5. Elec. Gas & Water Supply	5.2	9.1	9.8	8.4	6.0	63.0
6. Transportation	0.0	1.4	2.5	3.4	4.3	6.1
7. Construction	-4.2	10.0	16.4	4.7	2.3	5.1
8. Services *3	3.4	2.5	1.9	1.4	1.1	0.8
GDP at Factor Price	4.1	4.5	4.6	3.9	4.4	7.2
GDP at Market Price	4.3	4.7	4.7	4.4	4.6	7.1

Economic Sector	1995	1996	1997	1998	1999	2000
1. Agruculture	4.2	4.4	4.6	4.6	3.8	3.8
2. Mining & Metallurgy	14.1	14.2	14.2	14.1	13.1	13.1
3. Manufacturing *1	6.0	5.6	4.9	9.8	9.1	9.1
4. Petroleum & Natural Gas*2	4.4	7.2	8.0	5.9	5.9	5.9
5. Elec. Gas & Water Supply	33.8	28.9	2.5	2.6	2.8	3.0
6. Transportation	6.2	6.4	6.7	7.1	7.2	7.4
7. Construction	1.2	2.0	0.0	2.3	1.2	2.7
8. Services *3	0.6	0.5	0.4	0.3	0.2	0.2
GDP at Factor Price	4.5	5.0	4.5	5.1	5.0	5.1
GDP at Market Price	4.7	4.9	4.3	4.8	4.7	4.9

Source: Ref.14 (Table 1.7)

Notes: *1 Excluding metallurgy and petroleum refinement

*2 Including petroleum refinement

*3 Trading, communication, financing, public and other services

Table 2.6.3 Projected Composition of Major Economic Sectors in GDP: 1988-2000

(Unit: %)

Economic Sector	1988	2000	1989-1992 Average	1993-1996 Average	1997-2000 Average	1989-2000 Average
1. Agruculture	18.6	17.1	18.3	17.7	17.3	17.8
2. Mining & Metallurgy	6.0	14.4	6.9	9.2	12.9	9.7
3. Manufacturing *1	10.4	14.2	11.0	12.3	13.4	12.2
4. Petroleum & Natural Gas*2	7.2	10.7	7.8	9.3	10.5	9.2
5. Elec. Gas & Water Supply	1.0	2.4	1.0	1.9	2.5	1.8
6. Transportation	7.7	7.7	7.1	6.9	7.4	7.1
7. Construction	3.7	3.2	3.8	3.8	3.3	3.6
8. Services *3	44.0	28.5	42.2	36.3	30.6	36.4
GDP at Factor Price	98.6	98.2	98.1	97.4	97.9	97.8
Indirect Tax, etc.	1.4	1.8	1.9	2.6	2.1	2.2
GDP at Market Price	100.0	100.0	100.0	100.0	100.0	100.0

Source: Ref.I4 (Table 1.7)

Notes: *1 Excluding metallurgy and petroleum refinement

*2 Including petroleum refinement

*3 Trading, communication, financing, public and other services

Of the total investment amount planned, US$ 360 million has been already guaranteed, and the rest is in the process in dealings with several international organizations.

2.6.2 Urban Development

The City of La Paz does not have an authorized comprehensive plan for urban development. The present situation and the future view of the city development, as explained in interviews at the Bureau of Urban Development and Planning (Dirección General de Dessarrollo Urbano; DGDU), HAM-LP are described below.

(1) Present Situation

The city has been developed by following the natural topography, therefore, the central axis of the urbanization is the Choqueyapu River. Both the population and automobiles tend to concentrate along this axis causing various problems including the pollution of the river. The DGDU thinks it necessary to disperse this concentration in order to correct the situation.

The DGDU in 1983 prepared a map of future land use and township patterns (Ref.I3) based on a comprehensive geological study conducted in 1976 for overall development of the metropolitan area. This map is to be revised in line with the above considerations.

The DGDU intends to develop a comprehensive city development plan based on the result of the latest national census which was conducted on June 3, 1992.

(2) Future View

The DGDU envisages a development model in which the City of La Paz will have multiple urban centers. The whole urban area will be divided into several districts each having a branch office of the Municipality.

At Present, the following division is being considered.

Central District
South District
East District
Western Slope District
Eastern Slope District

Of the above, the South District, now called the South Zone, already has a branch office of the Municipality. In the future, there will be 8 or so districts by further dividing some of the above districts.

Transportation systems such as a ring road and/or a mono-rail system are being considered for the linkage of urban centers of the districts.

In any case, however, the urban area within the City of La Paz is not expected to expand significantly from the present. Instead, urban expansion will be realized in the City of El Alto. Since there are some 70,000 to 80,000 commuters from El Alto to La Paz at present, development of a suitable transportation system between the two cities is being considered.

2.6.3 Water Resources Development and Water Supply

There is no authorized water resources development plan or water supply plan in the study area.

SAMAPA recognizes a necessity of development of new water supply sources to cope with the increasing water demands of the metropolitan area.

SAMAPA is considering their development plan from two aspects, i.e., improvement of the quality and increasing of the quantity. They are taking water for the Achachicala plant from the Milluni reservoir, which is suspected to be polluted by effluents from the abandoned mines. One plan is to construct another reservoir upstream from the existing reservoir. In another, they are seeking an alternative source in the Choqueyapu river basin, i.e., construction of a dam in the Choqueyapu river as a measure for the basin management.

For the said Choqueyapu dam, DICOMAC is planning to start a study, including the possibility that the dam, which will be constructed for the purpose of water supply and flood control, can be used for other purposes. Although the plan is not yet finished, it is considered favorable from the viewpoint of water quality improvement if the dam is to be planned so as to increase the downstream flow rate in the dry season. If this is not possible, it should be planned so that the present flow rate of the Choqueyapu River in the dry season can be maintained.

CORDEPAS is conducting a pilot project by constructing a pilot plant to treat the Choqueyapu river water in order to meet the quality requirement of the irrigation water for vegetable production in the farm lands downstream of the City of La Paz. Since the plant evaluation was started in May, 1992, no results have yet been presented. If the results are promising, they intends to construct practical-scale treatment plants for those farm lands.

2.6.4 Sewerage Development

A comprehensive plan for developing sewerage and stormwater drainage systems in the metropolitan area was prepared in 1982 through the technical cooperation of the then West Germany (Refs. F1 through F15). The sewerage development plan covered the Central and South Zones of the City of La Paz as well as the City of El Alto, then a part of the City of La Paz, and Achocalla Zone.

For the Central and the South Zones of the City of La Paz, one wastewater treatment plant was planned to be installed in Aranjuez beside the Coqueyapu River to treat all wastewater from these zones. Wastewaters in these areas were to be collected separately from stormwater through sewer networks and finally to be transferred to the treatment plant through a main sewer interceptor. The construction costs for this sewerage system were estimated to be as follows:

Components	Construction cost (1000 $US)
Principal sewers and a main interceptor (68.9 km)	13,255
Sewer networks (4,687 hectares)	57,886
House connections (47,800)	15,668
Aranjuez treatment plant (360,000 m^3/day)	117,487
Sludge pumping station (1,320 m^3/day)	2,586
Sludge utilization facility (1,320 m^3/day)	381
Chlorination facility (temporary)	2,697
Total	209,960

The above sewerage development plan, however, has not been implemented largely because of the high cost which exceeded the financial capacity of the country. The planned site for the treatment plant is no longer available at present because it has been developed for other purposes including houses and recreational facilities.

In consequence, there is no workable sewerage development plan at present for treating wastewater from the Central and South Zones of the City.

2.7 SUMMARY OF THE PROBLEMS

The problems associated with the water pollution of the rivers in the study area that have been found through the present study are summarized below.

(1) Extent of the Water Pollution

The river water in the urban area of the City of La Paz is severely polluted. The concentration of BOD, which indicates the degree of pollution by organic substances, is in a range between 100 mg/l and 300 mg/l in the urbanized area. This level is similar to that of ordinary domestic sewage. The BOD value at the Lipari bridge, the downstream end of the City of La Paz, is around 50 mg/l to 80 mg/l exceeding the maximum allowable limit of 50 mg/l in the Bolivian standards for irrigation water for ordinary crops, and far above the limit of 5 mg/l in the same standards for freshly eaten vegetables.

Since a large part of the Choqueyapu River and many of its small tributaries are covered and these spaces are used for roads, play grounds and buildings in the central zone of the city, the deteriorating effects of the water pollution may not be perceived often. But in the south zone of the city, where the rivers are mostly open-channeled, offensive odors, aesthetic degradation due to the color of the water, and in some areas, breeding of flies are experienced particularly in the dry season.

Damage by the river water pollution is particularly severe among the farmers in the downstream areas. Since the outbreak of cholera in August 1991, the farmers have been forced to switch their products from freshly eaten vegetables to other less marketable or less profitable crops.

(2) Pollution Sources

Estimates of the BOD load of wastewaters generated in the study area indicate that the domestic wastewater accounts for some 50% or more, the industrial wastewater some 30% or more, and the rest is shared by commercial and institutional wastewaters. There may be a contribution to some extent by irregularly disposed of solid wastes and leachates from sanitary landfills, but these are considered to be insignificant in the terms of BOD loading as compared with the above wastewaters.

(3) Wastewater Collection and Disposal System

In the central zone of the City, there are many tributaries to the Choqueyapu River, and many of them are covered and used for wastewater collection as well as for stormwater drainage. The situation is somewhat more orderly in the south zone and the rivers are mostly open-channeled. The wastewaters are discharged into these rivers without treatment via relatively well-developed sewer networks, via stormwater collection pipes or ditches, or directly.

From the view point of river water quality protection, the development of sewer networks without treatment facilities is a serious problem, because all of the collected wastewater reaches the river, and the amount of wastewater generation tends to increase at a source when it is connected to a sewer pipe.

In terms of development of efficient sewerage systems with treatment plants, the connections of sewer pipes to stormwater drainage lines or vice versa that are prevailing in the city also create a difficult problem.

One of the most difficult problems concerning treatment of wastewater is the scarcity of lands usable for the treatment plants. This situation is most severe in the central zone.

(4) Consciousness Among Industries

The wastewaters from the factories in the city comprise a significant portion of the total pollutant load.

Considerable efforts have been made by the authorities and the institutions concerned in attempting to investigate the technical characteristics of the industrial wastewaters and their source facilities.

During the period of the first Site Study in early 1992, the Study Team and the Bolivian counterpart Team tried their best to obtain such information. However, the real situations at many of the factories have not yet been understood sufficiently. This is largely because of the uncooperative attitude of those factories. It is quite understandable that the factories hesitate to disclose technical details concerning their wastewaters. However, such an attitude will prevent development of a rational water pollution control plan in which each person or polluter is to contribute a fair share of the cost to be incurred in the implementation of the plan according to his contribution to the pollution and his financial capacity.

It is of great importance that the industries be encouraged to deepen their consciousness on the abatement of the water pollution.

(5) Urban Development Planning

There is no comprehensive urban development plan for the City of La Paz in order to achieve an orderly and efficient development aimed at improving the quality of the living environment. This situation may be attributed, to a large extent, to the unexpectedly high rate of the population growth experienced in recent decades. The result is that the authorities have been occupied with fulfilling immediate necessities rather than in preparing a long-term development plan. Therefore, developments of housing, roads, water supply, electricity, sewerage and so on have been inclined to proceed within the field of vision of each sector without adequate coordination among various sectors. Without a rational and comprehensive city development policy that has precedence over the policies of each sector, real improvement of the quality of living environment will be difficult to achieve.

(6) Institutional Requirements

Although there have been no effective legal means in Bolivia to control water pollution until recently, the introduction of the General Law of Environment provides a bright prospect for the future. However, a great deal of work must be done to establish an overall legal system consisting of practical rules and regulations, and to develop adequate national and local organizations with a sufficient number of competent personnel to implement this legal system. In order to succeed, a high degree of determination of relevant authorities and cooperation of citizens and industries are required.

(7) Economic Condition

In order to reduce significantly the amount of pollutant load in the rivers, a large sum of public and private investments is required. In Bolivia however, capital resources for water pollution control are not sufficient so as to meet everyone's satisfaction in the improvement of the quality of environmental waterbodies.

Therefore, development of a pollution control plan must be made within the limit of capital availability for initial investments and the limit of affordable contribution of the public for its implementation and management.

CHAPTER 3
GENERAL FRAMEWORK FOR THE BASIC PLAN

3.1 TARGET YEARS

Most enlisting national and local plans preceding the current study target the year 2000. Various projected values, such as of population, industrial production and land use are given for the year 2000. If importance is put on compatibility with such higher ranked plans, the Basic Plan should also adopt the year 2000, too. However, the eight years between the planning year (1992) and the target year is considered too short a time period for the Basic Plan for of the following reasons:

- It is foreseen that improvement or installation of the sewerage system will be one of the major components of the Basic plan. In design of a sewerage system, capacities of facilities are determined based on the volume of wastewater expected in the future. If the system is designed based on the values after 8 years, the capacities would be exceeded by the amount of wastewater soon after the commencement of operations, considering the project implementation to take several years.

- Implementation of a sewerage basic plan is usually divided into several phases, each taking about 5 years. This is because progress of implementation is intended to follow the yearly increase of wastewater generation so as to avoid excess investment, as well as that the large amount of construction works takes a long period of time and requires large budgets.

On the other hand, to set up a target year with too long a term would cause a difficulty in the prediction of various factors that affect the project components. If a target year is set up with a forty or fifty year term, the prediction of the framework of the project, such as population, industrial production and so on, would become more uncertain.

Considering the above, it is judged to be proper to set up the target year at the year 2010 by assuming that the implementation of the Basic Plan will be divided into 4 phases each with a 5 years term. It would then take about 20 years to complete it. Therefore, the formulation of the Basic Plan will be based on the predicted values of various factors in the year 2010. However, for the time schedule for the implementation of the project, it may not be possible to complete the project by the target year, because major portions of the project are expected to be financed by foreign funds and it is not certain whether such financing can be implemented as scheduled along with the progress of the project. Although the target year determined here will be used for the year to predict future conditions, it should not be regarded as the absolute target for implementation.

3.2 GOALS

The final goal of the Basic Plan is to achieve the required water quality improvements in the entire study area, that is the catchment area of the Choqueyapu River above the Lipari bridge. The goals are described as follows.

3.2.1 Evaluation Points for Water Quality Improvement

(1) General

The evaluation points for the water quality improvement, selected so as to be able to assess the water quality conditions in the entire catchment, are shown in Table 3.2.1.

Table 3.2.1 Evaluation Points for Water Quality Improvement

Points	Characteristics
Achachicala (R2)*	To indicate the water quality of the Choqueyapu River upstream of the urbanized area
Ave. Ejercito (R4)*	To indicate the water quality in the urbanized area
Calacoto (R9)*	To indicate the water quality of the Choqueyapu river below the confluence with the Orkojahuira River
Lipari bridge(R15)*	To indicate the water quality for irrigation water
Most downstream of the Orkojahuira river (R8)*	To indicate the water quality of the Orkojahuira River
Most downstream of the Irpavi river (R11)*	To indicate the water quality of the Irpavi River
Most downstream of the Achumani river (R12)*	To indicate the water quality of the Achumani River

* Numbers refer to the sampling points in this study. Refer to Fig. 2.4.1

(2) Urgent project

Apart from the above general water quality evaluation points for the whole basin, it is proposed to set up evaluation points for an urgent project. The deterioration of the water quality conditions of the Choqueyapu River is so severe that one can not wait for the completion of the entire projects of the Basic Plan. Consequently, it will be necessary to implement an urgent project to improve the present conditions.

One of the evaluation points should be set up at the Lipari bridge, because water at this point is causing damages to the farming downstream. Another point is proposed to be set up at the confluence with the Orkojahuira River. The obnoxious conditions due to polluted water are experienced mainly in the residential area downstream of this point. While the pollution conditions of the area above this point may be severer than at the downstream section, actual unpleasant conditions are not felt as much because most of this section is culverted or runs at the bottom of a deep valley. Therefore, the following two points on the Choqueyapu River are proposed as evaluation points for an urgent project:

- Lipari bridge
- Confluence with the Orkojahuira River

3.2.2 Water Quality Target

The water quality target is determined so that the improved water quality permits the expected water uses in each river or in each section of the rivers.

(1) Water use

The following existing water uses in the study area were observed and no other significant water uses other than for waste disposal have been reported:

- Water source for municipal water supply (Achachicala water treatment plant).

- Irrigation water source for the farming lands upstream and downstream of the Lipari bridge.

The water quality targets required to ensure the above water uses are determined by referring to standards/criteria that specify the required water quality for each water use. Some examples of such requirements from the

Bolivian Environmental Standards and the Japanese Environmental Standards are shown in Table 3.2.2.

Table 3.2.2 Examples of the Water Quality Standards for Several Water Uses

Standards	Class	Expected Water Use	BOD (mg/l)	SS (mg/l)	DO (mg/l)	Coliform Bact (MPN/100ml)
Bolivian	A	- Water Supply by Simple Treatment - Irrigation for freshly eaten vegetable - Bathing	5	1000	70%	5000
	B	- Water Supply by Conventional Treatment - Greening - Water for Animal	10	1500	60%	10000
	C	- Water Supply by Special Treatment - Protection of urban environment - Irrigation for ordinary crops	50	2000	50%	20000
Japanese	A	- Water Supply by Simple Treatment - Bathing	2	25	7.5	1000
	B	- Water Supply by Conventional Treatment	3	25	5	5000
	C	- Industrial water	5	50	5	-
	D	- Irrigation Water	8	100	2	-
	E	- Protection of urban environment	10	-	2	-

Note: Partially extracted from the Bolivian Environment Standards and the Japanese Environment Standards.

(2) Water quality target

The water quality targets for the Basic Plan are shown in Table 3.2.3, considering the expected water uses of each evaluation point and necessary water quality for each water use.

The required water quality for each point is determined based on the Bolivian Standards. However, the water quality parameters include only BOD, DO and Coliform Bacteria, although the Standards specify SS too. The SS concentrations in the rivers in this area are mainly caused by soil erosion in the catchment area, which is difficult to control by means of water treatment, thus it is not considered to be practical to include SS in the water quality target.

Moreover, the required water quality for the area downstream of the urbanized area, i.e. the Lipari bridge (R15) where the water is expected to be used for irrigation for freshly eaten vegetables, is referred to as Class C, whereas this should refer to Class A in the Standards. The BOD concentration for Class A is 5 mg/l in the Standards and such a low level of BOD concentration can be achieved only by applying advanced wastewater treatment technology (tertiary treatments). Because of the high cost it is obviously out of consideration to propose a tertiary treatment in the Basic Plan. Therefore, the required water quality at this point is that of Class C in order to make the Basic Plan economically feasible.

Table 3.2.3 Water Quality Targets

Evaluation Points*	Location	Required Water Conditions	Required Water Quality	
R2	Upstream of urbanized area of each river	Water quality which is suitable for conventional water treatment for potable water and/or which does not worsen natural environment.	BOD: DO: Coliform:	10 mg/l 60 % 10,000 MPN/100ml
R9, R8, R11, R12	In urbanized area	Water quality which does not generate obnoxious conditions along the stream.	BOD: DO: Coliform:	50 mg/l 50 % 20,000 MPN/100ml
R15	Downstream of urbanized area	Same as above. For the Choqueyapu river, water quality suitable for irrigation water	BOD: DO: Coliform:	50 mg/l 50 % 20,000 MPN/100ml

* refers to Table 3.2.1 and Fig. 2.4.1.

A BOD concentration of 50 mg/l is based on the value for Class C water as shown in the Bolivian Environment Standards, which is much higher than those in the Japanese standards. In the case of Japanese standards, it is considered that the BOD value has been determined so that septic conditions are not caused in the river when water stagnates, because water often stagnates at the mouth of most rivers in Japan. Since the rivers in the study area are all steep, it is not expected that water will stagnates, resulting in septic condition. Therefore, although improving up to a level of 50 mg/l of BOD may not be sufficient, it will be acceptable as a tentative target because it can at least mitigate the present unpleasant color and smell of the water.

The proposed target for BOD concentration at the Lipari bridge is also based on the Bolivian Standards. This may not be suitable for irrigation water to be used for production of vegetables to be eaten raw, which the farmers in the area used to practice and desire presently. However, what is important for irrigation water seems to be the bacteriological or parasitological conditions rather than the organic pollutant concentration that BOD indicates. It is necessary to treat all the human excreta discharged in the area for completely controlling the bacteriological and parasitological contamination and obviously it is impossible until all the projects of the Basic Plan will have been completed. Therefore, the tentative target for the Lipari Bridge is set up based on the idea that the bacteriological and parasitological contamination could be mitigated in a considerable extent if the organic contamination is reduced to the level of BOD

50 mg/l. In case where the improvement is not enough for irrigation water, it is proposed to install water intake facilities , such as shallow wells in the vicinity of the river and water collection pipes (infiltration galleries) under the river bed.

3.3 PLANNING AREA

The study area covers the entire catchment of the Choqueyapu River above the Lipari bridge, comprising the catchments of the Orkojahuira, Irpavi, Achumani, Huañajahuira, and other rivers, as shown in Fig.1.3.5. It is required that the Basic Plan attempts to improve the river water quality of the whole area.

As results of the water quality survey in this Study and the review of previous studies, it is evident that the water pollution problems are significant only in and downstream of the urbanized areas, and that the water pollution is being caused by wastewaters from various urban activities being discharged to the rivers without treatment. The measures to be proposed in the Basic Plan for water quality improvement will naturally focus on the reduction of the pollutant discharge from urban activities. Therefore, areas covered by the water quality improvement measures are mostly limited to the urbanized areas in the study area.

3.3.1 Current Urbanized Areas

The current urbanized and semi-urbanized areas are scattered as shown in Fig. 3.3.1. Most of the urbanized areas with high population density are spread in the catchment of the Choqueyapu and the Orkojahuira rivers. Urbanized areas with lower population density are developed along the lower Irpavi, Achumani and Juañajahuira Rivers in the South Zone and are scattered in their catchments.

3.3.2 Future Urbanized Area

Fig. 3.3.2 indicates the expected scattering of the urbanized and semi-urbanized areas in the year 2010. These future urbanized areas have been projected by considering the population growth in the currently less populated areas and also expansion of the urbanized areas based on the planned urbanized area indicated in the Landuse Plan Map (Ref. I3).

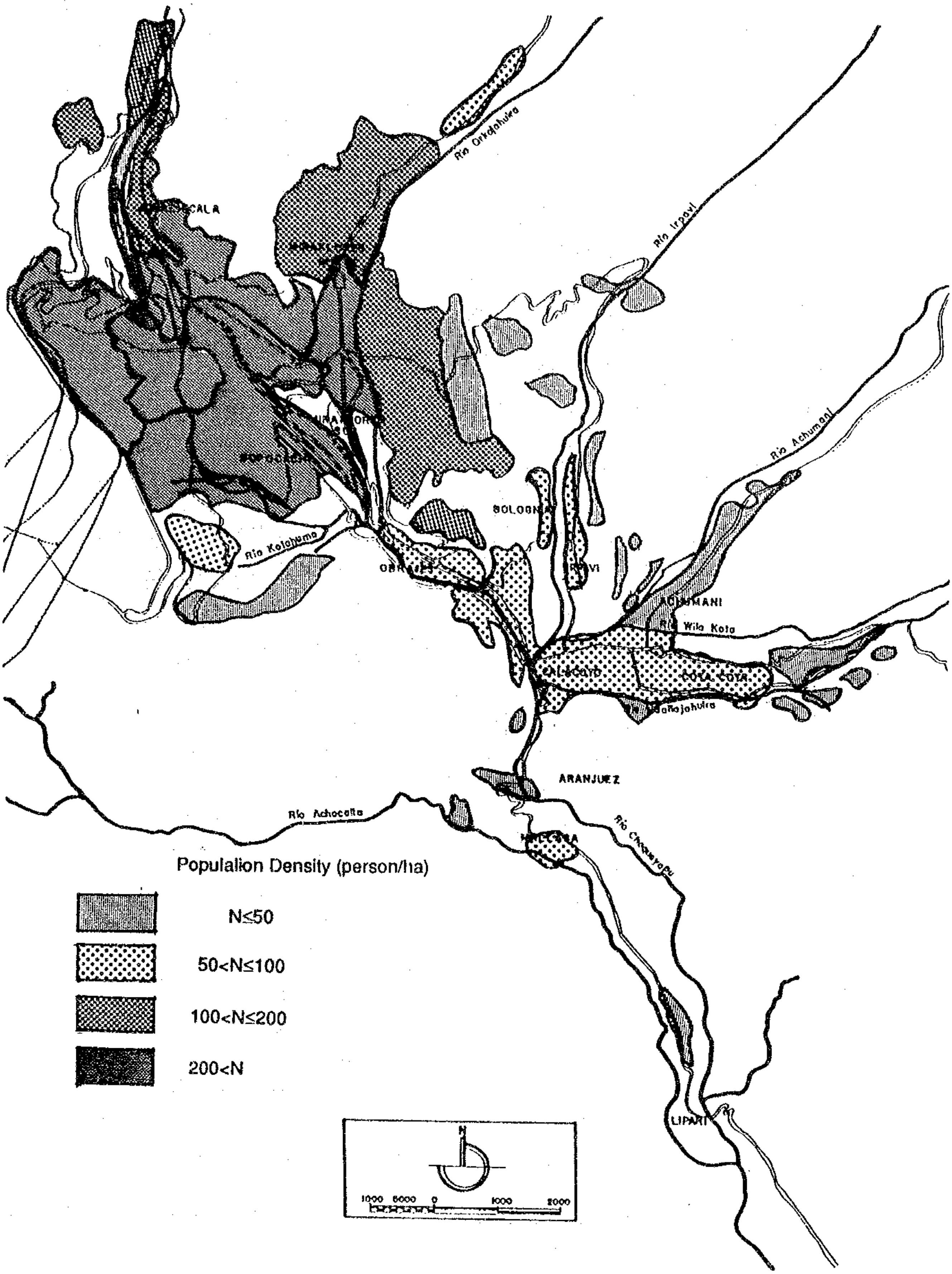


Fig. 3.3.1 Existing Urbanized and Semi-Urbanized Areas

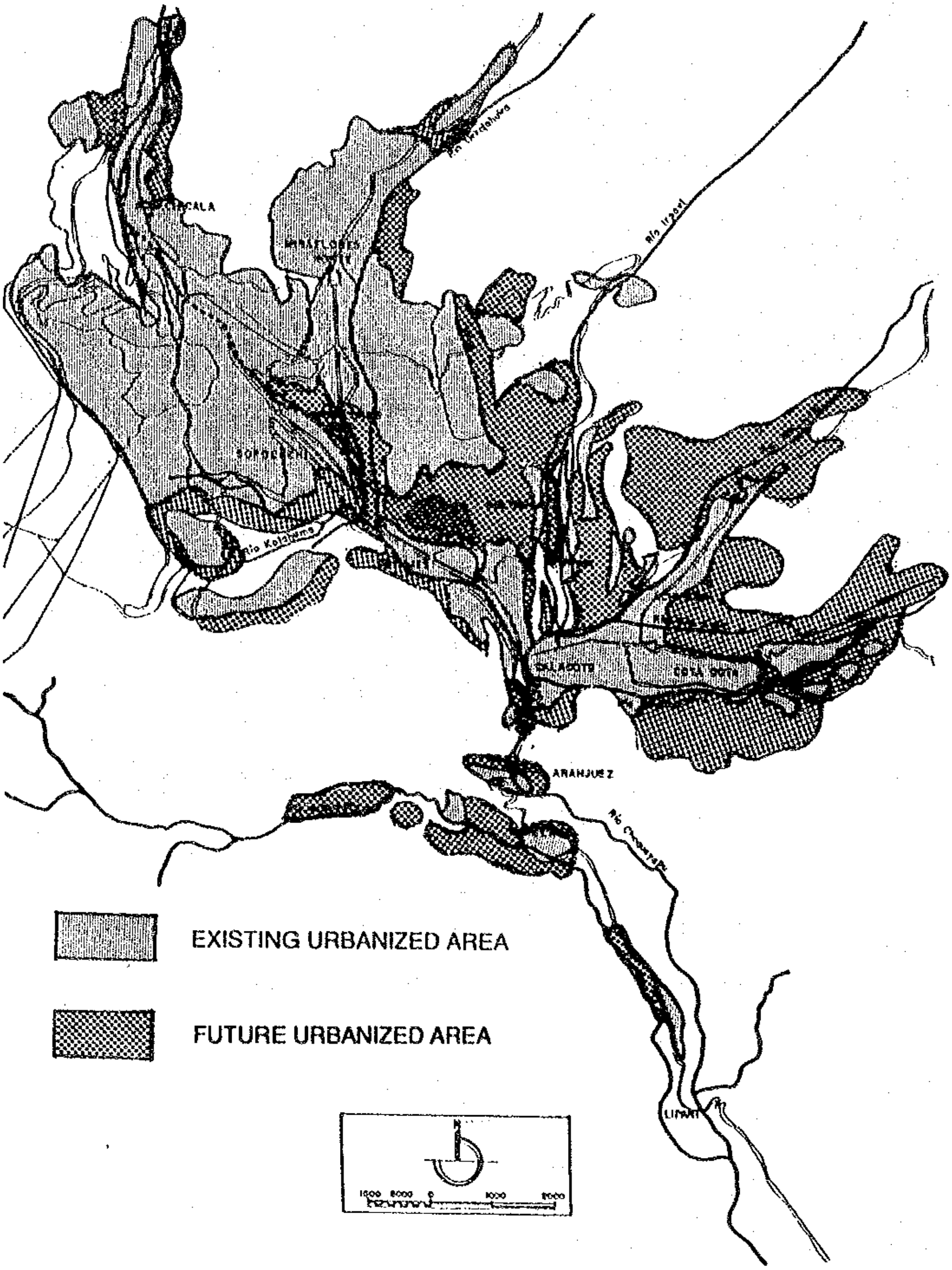


Fig. 3.3.2 Future Urbanized and Semi-Urbanized Area