5.1.3 Municipalities in Metropolitan Area

Municipalities included in the Study Area are Guatemala City, Mixco, Villa Nueva, Villa Canales, Chinautla, San Miguel Petapa, San Pedro Ayampuc and Santa Catarina Pinula. Brief surveys as to water supply and sewerage services in major municipalities except Guatemala City were separately conducted. The results are presented in Table 5-1 and subsequent paragraphs.

Table 5-1 Water Supply and Sewerage Services of Major Municipalities

Municipality	Mixco	Chinautla	San Miguel Petapa	Villa Canales	Santa Catarina Pinula
Total population	312,772	64,420	37,272	64,044	35,856
# Municipality staff	850	60	44	84	79
# connection of piped water	30,000	2,900	Not available	13,000	2,915
Water charge	flat rate Q10 flat rate Q15	Q1.5/m^3 to 100 customers, Q1/m^3 to 2,800 customers	Q10 for 30m^3, 25% excess for over 30m^3	flat rate Q0.5 flat rate Q5.5 flat rate Q10	flat rate Q6
# staff working for water supply	150	6 for O/M + some 20 for all field works	no exclusive staff	12for O/M+7 for collection of all charges	12
Meter	partly installed but unmetered	installed and metered	installed and metered	partly installed but unmetered	nil
Collection place	main office + 2 suboffice	main office	main office	main office +7 collection office	main office
sewerage services	partly provided	nil	nil	partly provided	provided to 1,108 users
# staff for sewerage or drainage	80 for drainage	drainage staff are common to water supply	nil	nil	8
sewerage charge	nil	nil	nil	nil	flat rate Q5

Source : Study Team

a) Mixco

As a considerably large municipality, the Mixco Municipality has various departments and divisions such as Mayor's office, Secretariat, Legal Office, Finance, Works, Registry, Water Supply, Administration, Human Resources, Public services, Community Development, Municipal Police, and Municipal Court. The total staff number is 850, of which 150 and 80 staff are respectively working for water supply and drainage. At present, the initial non-recurring connection costs for piped water supply are (i) Q1,000 of water right fee, (ii) Q55 of connection fee, and (iii) Q25, Q35, Q50, or Q100 of title fee depending on the system. In addition, a new user has to buy a meter priced between Q200 and Q300.

For monthly water charge, a flat rate of Q10 or Q15 is applied depending on areas. The sewerage charge is also levied in certain areas which amounts to flat rate of Q5 per month. Collections of water and sewerage charges are made at the Municipal Office and two other suboffices.

b) Chinautla

The Chinautla Municipality has three divisions: Treasury, Secretariat, and Public Services. The total staff number is 60, of which 6 staff are assigned to O/M of water supply and drainage. In addition, 20 construction workers and a few administrative staff are partly involved in water supply and drainage services. Boring of well is contracted out. Community participation programs to provide water supply and drainage by asking community's labor contribution are encouraged. The Municipality has offered no sewerage services whatsoever but wishes to provide them in the future. The initial connection fees for piped water total Q1,800, consisting of Q1,500 of water right fee and Q300 of connection and meter fees. The monthly water charge is a proportional rate of Q1.50/m^3 for about 100 customers in residential areas and a proportional rate of Q1/m^3 for the other 2,800 customers. Meters are installed at all connections and read monthly by the Municipality staff. Collections are made at the Municipal Office.

c) San Miguel Petapa

The San Miguel Petapa Municipality has three divisions which are Mayor's office, Secretariat, and Treasury. 44 staff are currently employed, of which 11 are assigned administrative jobs and 33 are working in the field. They are covering all municipal services including water supply. There is no sewerage service. The connection fees for piped water supply total Q2,125 which are comprised of (i) Q1,750 of water right fee, (ii) Q350 of meter fee, (iii) Q15 of connection fee, and (iv) Q10 of title fee. These are all initial non-recurring fees. For monthly water charge, a flat rate of Q10 is applied up to 30m^3 consumption. For over 30m^3, 25% of excess is charged. Collections are made only at the Municipal Office.

d) Villa Canales

The Villa Canales Municipality has four divisions, namely, Mayor's office, Secretariat, Treasury, and Registry. There are currently 84 staff in total. Those engaged in the water supply services number in 12 and belong to the Mayor's office. The Municipality currently offers limited sewerage services whose O/M is contracted out but no service charge is levied. The initial connection fee is Q387: flat rates are employed as monthly water tariff: they vary depending on villages which ranges from Q0.5 to Q5.5. As of February 1996, a mark up to

Q10 has been agreed by some villages. Billings are made by the Treasury and collected at the Head Office and seven sub offices.

e) Santa Catarina Pinula

The Santa Catarina Pinula Municipality's organization are classified into four divisions: Mayor's Office, Treasury, Legal Office, Technical Division. The total staff number is 79. The Water Supply Division has 12 staff who are engaged in O/M of water supply. The sewerage system covers part of the Municipality area with 8 staff working exclusively. A new customer of piped water has to pay initially Q800 of water right fee and Q40 of connection fee. In addition, a water meter has to be purchased. The present monthly water charge is set at Q6 of flat rate without regard to consumption. The sewerage charge is set at Q5 of flat rate. The Municipality has not yet read meters. Collections of bill are only made at the Municipality Office.

5.2 FINANCIAL SITUATION

5.2.1 Central Government

In 1991 the government proposed measures to stabilize the national economy because of budgetary crisis. An emergency tax bond was issued for Q700 million. Electricity prices were raised. The Congress passed a major tax reform which simplified income taxes, unified value added tax (VAT) at 7% and raised petrol taxes. The central government's finances were brought back into balance in 1991 and 1992, as shown in Table 5-2. After 1993, however, it seems to have deteriorated again as deficits recorded at Q513 million in 1993 and Q361 million in 1994.

There is no information segregated into the water and sanitation sector in the central government expenditure. Table 5-3 shows that the expenditure for public health and environmental sanitation disbursed by Ministry of Health, accounting for around 1% of GDP during the last five years. Of the expenditure by the Ministry, 12% to 23% was disbursed for capital investment of public health and environmental sanitation.

Finally, the environmental sanitation sub-sector, mainly used for water and sanitation projects, accounted for Q93 million or 0.17% of GDP (maximum among five year's record) in 1988 and Q40 million or 0.04% (minimum) in 1990. During years, the investment for water and sanitation sub-sector looks to have fallen down abruptly, despite the fact that the percentage of the total public investment to GDP has not decreased since much 1988.

Table 5-4 shows investment programs for the potable water and environmental sanitation sector by the central government after 1993. These projects are mostly proposed for rural areas where rural communities have little financial power of development. Total amounts spent on development for respective years are as follows: Q135 million in 1993; Q225 million in 1994; Q337 million in 1995; and Q328 million in 1996. Of the total amount (Q1,026 million) for the four years, Q683 million or two-thirds comes from foreign financial sources.

Table 5-2 Revenue and Expenditure of Central Government: 1990-1995

(Unit: Million Quetzals)

Item	1988	1989	1990	1991	1992	1993*1	1994*1
REVENUE	2,299	2,414	2,796	4,313	5,752	6,258	7,449
Recurrent Revenue	2,299	2,414	2,796	4,282	5,740	6,246	7,110
1. Tax Revenue	1,811	1,863	2,360	3,470	4,511	5,435	6,372
- Direct Taxes	452	452	552	1,085	1,081	1,270	1,511
- Indirect Taxes	1,359	1,411	1,809	2,385	3,431	4,165	4,561
- Others	-	-	-	-	-	-	300
2. Non-tax Revenue	120	229	222	162	334	810	738
3. Other Revenue*2	336	288	176	574	813	-	-
4. Special Revenue	32	35	38	76	82	-	-
Capital Revenue	0	0	0	31	13	13	339
EXPENDITURE	2,584	3,131	3,503	4,313	5,751	6,771	7,840
Recurrent Expenditure	2,074	2,386	2,906	3,524	4,187	5,040	5,402
1. General Expenses	1,329	1,527	1,933	2,099	2,730	2,961	3,216
2. Interest of Debts	302	327	389	752	532	806	996
- Domestic	258	272	322	346	364	377	631
- Foreign	44	55	67	406	168	429	364
3. Transfer Payment	443	532	585	673	925	1,273	1,191
- Public Sectors	224	297	248	416	527	-	650
- Private Sectors	211	235	322	243	374	-	506
- Foreign Sectors	8	0	14	15	23	-	35
Capital Expenditure	510	745	597	789	1,564	1,731	2,438
1. Direct Investment	330	508	417	519	645	637	1,658
2. Transfer Payment	180	237	180	269	919	496	780
- Public Sectors	131	227	178	267	913	-	724
- Private Sectors	47	9	-1	3	0	-	25
- Foreign Sectors	2	0	1	0	6	-	31
3. Financial Investment	-	-	-	-	-	599	-
SURPLUS/DEFICIT	-285	-717	-707	0	2	-513	-391

Source: (1) Projecto de Presupuesto General de Ingresos y Egresos del Estado 1994, Sept. 1993, GOG
(2) Financial Situation of Central Government, SEGEPLAN

Note: *1 Estimation in the above source (1)
*2 Transfer revenue as donation or grant from foreign countries, etc.

Table 5-3 Public Investment for Environmental Sanitation and Public Health: 1988 - 1993

(Unit Million Quetzals)

	1988	1989	1990	1991	1992	1993
1 GDP	20,545	23,685	34,317	47,033	53,949	63,563
2 Expenditure of Central Government	2,584	3,131	3,503	4,313	5,751	6,771
3 Budget for Health and Social Welfare Sector	291	319	318	416	525	-
a. Recurrent Expenditure	198	246	278	366	452	-
b. Capital Expenditure	93	74	40	50	73	105
4 Public Investment	590	755	932	1,024	1,567	1,984
a. Public Health and Social Welfare Sector	93	74	40	50	73	105
- Environmental Sanitation Sub-sector	35	24	15	22	33	47
- Other Sub-sectors	59	50	25	28	40	57
Percentage Share of GDP						
1 GDP	100.00	100.00	100.00	100.00	100.00	100.00
2 Expenditure of Central Government	12.58	13.22	10.21	9.17	10.66	10.65
3 Budget for Health and Social Welfare Sector	1.42	1.35	0.93	0.88	0.97	-
a. Recurrent Expenditure	0.96	1.04	0.81	0.78	0.84	-
b. Capital Expenditure	0.45	0.31	0.12	0.11	0.14	-
4 Public Investment	2.87	3.19	2.72	2.18	2.90	3.12
a. Public Health and Social Welfare Sector	0.45	0.31	0.12	0.11	0.14	0.16
- Environmental Sanitation Sub-sector	0.17	0.10	0.04	0.05	0.06	0.07
- Other Sub-sectors	0.29	0.21	0.07	0.06	0.07	0.09

Source: Analisis Sectorial de Agua Potable y Saneamiento, Nov. 1994, SEGEPLAN, EMPAGUA, UNICEF, etc.

Table 5-4 Investment Program for Potable Water and Environment Sanitation Sector: 1993 - 1996

(Unit Million Quetzals)

Implementing/Assistance Organization	Total Budget	1993 Local	1993 Foreign	1994 Local	1994 Foreign	1995 Local	1995 Foreign	1996 Local	1996 Foreign	After 1997 Local	After 1997 Foreign
1 Planning Program (Pre-negociation Stage)											
- Guatemala Only	70.2	8.3	0.0	2.9	8.8	2.9	4.6	3.2	4.4	7.8	27.2
- Bilateral	42.7	20.0	12.0	0.3	1.2	0.5	2.2	0.2	6.3	0.0	0.0
- Japan	41.0	20.0	12.0	0.3	1.2	0.5	2.2	0.0	4.9	0.0	0.0
- Germany	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.2	1.5	0.0	0.0
Total	112.9	28.3	12.0	3.2	10.0	3.4	6.8	3.4	10.8	7.8	27.2
2 Implementing Program											
- Guatemala Only	712.7	20.9	0.0	29.6	0.0	41.5	36.7	23.3	42.1	188.5	319.3
- Bilateral	692.5	7.7	14.7	47.9	45.0	33.2	99.1	22.4	76.0	36.2	276.4
- Japan	421.2	0.0	0.0	25.9	28.8	5.1	39.0	8.9	39.1	38.2	236.2
- Germany	162.6	0.5	6.1	10.5	5.6	13.4	32.6	3.4	31.1	-11.3	37.6
- USAID	108.8	7.2	8.5	11.6	10.6	14.6	27.5	10.1	5.8	9.3	2.6
- Multilateral	485.6	11.3	40.4	22.0	67.4	24.9	91.5	19.5	130.8	10.0	67.7
- IDB	435.7	5.3	26.5	18.9	60.4	21.9	84.6	16.5	123.8	10.0	67.7
- UNICEF	49.9	6.0	13.9	3.1	7.0	3.0	7.0	3.0	7.0	0.0	0.0
Total	1,890.8	39.9	55.1	99.5	112.4	99.6	227.3	65.2	248.8	234.7	663.4
Grand Total	2,003.7	68.2	67.1	102.7	122.4	103.1	234.1	68.6	259.6	242.5	690.6
	2,003.7	135.3		225.1		337.2		328.2		933.1	

Source : SEGEPLAN

5.2.2 Guatemala City and Municipalities in the Study Area

The study area for this current project is mostly occupied by the city proper of Guatemala Municipality. Thus, Guatemala City is deeply concerned with this Study. The financial allowance of the municipal government is the key issue for financial aspects of the project.

a) General Balance of Guatemala City

Table 5-5 shows actual records of revenue and expenditure of Guatemala Municipal Government during 1990-1993. For these four years, the government recorded an overall surplus except in 1990. Main sources of revenue were divided into tax and non-tax revenues. Besides these main sources, the municipal government gets (i) subsidy from the central government and (ii) donation from citizens and organizations in the City.

Tax revenue varied from Q22 million or 46% of the total revenue in 1990 and to Q32 million or 25% in 1993. In 1990, the municipal government did not receive a subsidy from the central government, so the percentage of tax revenue looked large. Among the tax revenue, nearly one-third of the total accrued from direct taxes and the rest from indirect taxes. The direct taxes are composed of local inhabitants tax and fixed property tax. The indirect taxation consist of taxes on liquor, beer, tobacco, gasoline, urban transportation, registration, admission, etc. Major items of non-tax revenue accrued from municipal services and rental income of municipal lands. The subsidy from the central government is an important source of income for the municipality. As seen in the table, its amount was not stable, which serious influence on the municipal financial balance.

The total revenue was Q47 million in 1990 and increased to Q131 million in 1993. This was an incremental increase of Q84 million or 178% compared with 1990's total, although there was nearly 40% inflation during these years. The fluctuation of revenue during the period was caused by the unsteady subsidy from the central government as mentioned above.

In 1993, the municipal expenditure was classified as follows: for personnel expenditure Q52 million or 46% of the total expenditure; for non-personnel expenditure, Q27 million or 24%; for material purchasing, Q13 million or 12%; for transfer payment to public organizations including EMPAGUA, Q18 million or 16%; for others, Q3 million or 2%. Incidentally, EMPAGUA got a subsidy of Q6 million from the municipal government in 1993. This was disbursed as supporting personnel expenses of EMPAGUA.

Table 5-5 Revenue and Expenditure of Guatemala Municipal Government: 1990-1993

(Unit: 1000 Quetzals)

Item	1990	1991	1992	1993
Revenue	46,946	154,354	199,507	130,713
1. Tax Revenue	21,568	26,912	29,699	32,189
-1 Direct Taxes	10,009	8,347	10,861	11,261
- Local Inhabitants Tax	2,627	2,833	3,360	3,832
- Fixed Property Tax	7,383	5,514	7,501	7,429
-2 Indirect Taxes	11,558	18,565	18,838	20,928
- Liquor Tax	111	213	285	172
- Beer Tax	232	164	155	75
- Tobacco Tax	253	248	236	202
- Gasoline Tax	876	1,597	767	524
- Urban Transportation	5,354	10,366	10,242	11,768
- Registration Tax	536	554	580	720
- Admission Tax	682	772	1,375	1,128
- Other Taxes	3,515	4,650	5,199	6,339
2. Non-tax Revenue	24,057	26,425	45,092	65,575
- Rent of Public Lands	5,351	5,835	6,493	9,004
- Rent of Building	970	1,066	1,716	2,452
- Income from Financial Assets	1,383	1,932	2,239	3,867
- Sales of Goods	1,003	2	2,303	3,316
- Municipal Services	8,677	13,010	26,196	36,987
- Fines	3,291	1,198	1,291	988
- Other Services	3,382	3,381	4,855	8,961
3. Transfer from Central Government	0	97,117	120,846	30,663
4. Donations	1,321	3,901	3,869	2,286
Expenditure	69,230	140,165	184,395	112,045
Personnel Expenditure	27,352	38,994	46,944	51,715
Official Staff	21,323	27,354	31,882	34,534
Day Laborer	5,116	11,003	14,328	16,378
Others	913	636	734	803
Not-personnel Expenditure	11,995	13,679	27,194	26,691
Public Services	7,069	10,402	23,277	17,698
Publication	1,431	760	1,465	1,775
Interest, Commission & Insurance	2,072	1,209	1,271	5,517
Other Services	1,424	1,309	1,181	1,702
Material Purchasing	9,989	8,417	9,647	13,282
Transfer Payment	19,785	78,814	99,530	17,618
Personnel Payment	4,399	5,021	5,682	6,513
Subsidy to Institutions	14,605	70,418	85,835	3,447
Urban Road Services	0	2,267	6,980	6,035
Others	781	1,107	1,033	1,623
Incidental Expenses	109	247	376	469
Uncollected Charges	0	14	703	2,271
Surplus/Deficit	-22,284	14,190	15,112	18,668

Source: Informe de Auditoria Financiera al 31 de Diciembre de 1993, 1992, 1991, Municipalidad de Guatemala

The total expenditure was Q69 million in 1990 and increased to Q112 million in 1993. This was an incremental increase of Q43 million or 62% compared with 1990 total, although inflation raised prices nearly 40% during these years. The fluctuation of revenue during the period seems due to the subsidy to public institutions concerned.

According to the municipal financial report, investment for the environmental sanitation sector by the municipal government was Q0.5 million or 1.0% of the total investment. The figures in other years are enumerated in Table 5-6. The investment amount for the sector fluctuated for the four years from the minimum Q0.05 million or 0.2% of the total investment in 1991 to Q4.06 million or 12.6% in 1990. The average of investment for the sector was Q1.23 million for the four years.

Table 5-6 Investment by Guatemala City

(Unit: 1000 Quetzals)

Item	1990	1991	1992	1993
All Sector	32,269	31,621	47,193	46,472
Environmental Sanitation Sector	4,061	50	341	487
Share of Environmental Sanitation Sector	12.6	0.2	0.7	1.0

Source : Guatemala City

b) Assets of Guatemala City

Assets of Guatemala City comprise (i) current assets, which include the surplus of the previous fiscal year in the form of savings and tax accounts receivable, (ii) fixed assets, which include machinery, office furniture, office buildings and on-going projects, (iii) deferred assets, which include research and project planning by the municipal government, (iv) intangible assets, mainly bonds and loans to EMPAGUA, and (v) other assets such as funds for amortization and special works in the city. The total amount of the assets was Q492 million in 1993 as shown in Table 5-7. It increased by Q175 million or 55% of the 1990's total assets since.

The municipal government still has assets of water and sanitation facilities, as seen in the table. In 1993 they were assessed as Q4.6 million for water distribution works and Q193.1 million for on-going structures divided into Q82.1 million for the water system and Q111.0 million for the sewerage system.

The increment of assets was supported mostly by the increase of fixed liability. In particular, the liability from external organizations sharply increased for four years, i.e., Q69 million in 1990 to Q244 million in 1993. Other liabilities and municipal treasury recorded a relatively less difference between 1990 and 1993, although some recorded a little fluctuation during the period.

Table 5-7 Balance Sheet of Guatemala Municipal Government: 1990-1993

(Unit: 1000 Quetzals)

Item	1990	1991	1992	1993
Assets	317,460	429,870	472,745	492,245
Current Assets	27,872	23,805	33,003	33,608
Cash & Savings	4,891	3,013	2,228	2,994
Taxes Receivable	23,716	21,093	30,585	30,532
Others	-735	-301	190	81
Fixed Assets	200,005	366,919	392,125	414,202
Machinery & Equipment	37,785	38,391	38,641	39,272
Real Estate	12,255	12,262	12,262	12,736
Roads and Communication	29,858	33,024	33,063	35,042
Water Distribution Works	4,581	4,581	4,581	4,581
Others	1,075	1,092	1,092	1,100
Structures in Process	114,452	277,569	302,486	321,472
Water System	-	82,028	79,910	82,045
Sewerage System	-	117,644	115,432	111,027
Others	-	77,897	107,144	128,400
Intangible Assets *	2,844	5,548	4,988	4,834
Deferred Assets	65,192	12,000	10,562	10,590
Researches and Projects	3,477	6,410	8,549	8,623
Others	61,715	5,589	2,013	1,967
Other Assets	21,547	21,599	32,067	29,010
Fund for Amortization	2,431	5,944	4,765	6,546
Fund for Special Works	8,956	11,559	23,384	15,934
Others	10,160	4,095	3,919	6,531
Treasury & Liability	317,460	429,870	472,745	492,245
Liabilities	117,607	275,338	301,677	298,804
Current Liability	22,974	20,351	36,771	27,126
Fixed Liability	91,203	247,417	257,022	269,339
Bonds	3,843	3,233	2,611	1,972
Internal Liability	404	394	273	131
External Liability	68,735	225,509	233,541	243,678
Accounts Payable	18,222	18,282	20,597	23,559
Deferred Liability	3,430	7,569	7,884	2,339
Municipal Treasury	199,853	154,532	171,068	193,441
Municipal Patrimony	58,668	63,319	63,319	63,290
Assistance of Central Government	159,001	71,678	71,678	71,678
Accumulated Surplus/Deficit	-7,530	-6,117	10,159	29,046
Contribution of EMPAGUA	758	758	758	758
Others	-11,044	24,893	25,153	28,668

Source: Informe de Auditoria Financiera al 31 de Diciembre de 1993, 1992, 1991, Municipalidad de Guatemala

Note: * Mainly bond and loan to EMPAGUA

Table 5-8 gives Financial indices showing the status of municipal finance.

Table 5-8 Financial Indices of Guatemala City

Item	1990	1991	1992	1993
Current Ratio	1.2	1.2	0.9	1.2
Acid Ratio	0.2	0.1	0.1	0.1
Worth Debt Ratio	1.7	0.6	0.6	0.6
Ratio of Fixed Assets to Long-term Capital	0.7	0.9	0.9	0.9

Source : Study Team

Current ratio is calculated as a quotient of current assets over current liability and indicates medium term solvency. The ratios except for 1992 were more than 1.0, so the municipal government seems to has sound solvency. Acid ratio is a quotient of cash and savings over current liability and indicates short term solvency. The ratio should preferably be almost 1.0 or at least more than 0.4. The ratios for the government were less than 0.2, so the government has little solvency from the short term view point. However, since the municipal government is considered to have little opportunity to liquidate liabilities swiftly, the ratio does not always keep above 0.4.

Worth debt ratio is a related of own capital, i.e., municipal treasury, to total liability. It indicates management stabilization of an entity. Since the municipality increased external liabilities sharply for these years, the ratio has deteriorated drastically as shown in the above table. Ratio of fixed assets to long-term capital is a quotient of fixed assets to total of own capital and fixed liabilities, and indicates management invulnerability. It should be more than 1.0. The ratios in the above table were 0.9 in the latter three years, so the invulnerability seems to be slightly low.

c) Financial Status of Other Municipalities Concerned

Besides Guatemala Municipality, the study area includes seven municipalities around the capital city. It does not include not their whole administrative areas but some parts of them. They are as follows in order of present population: Mixco, Villa Nueva, Chinautla, Villa Canales, Santa Catarina Pinula, San Miguel Petapa and San Pedro Ayumpac.

Table 5-9 shows the financial status of Santa Catarina Pinula Municipality during the latest five years, 1990-1994. Its revenue and expenditure in 1994 were Q2.9 million and Q3.8 million, respectively. Thus, the municipality had a deficit of Q0.9 million in 1994. It recorded deficit continuously for the five years.

Table 5-9 Revenue and Expenditure of Santa Catarina Pinula Municipality

(Unit: 1000 Quetzals)

Item	1990	1991	1992	1993	1994
Revenue	**355.2**	**366.5**	**725.4**	**1,337.5**	**2,909.3**
License	132.0	170.7	280.2	583.9	554.5
Concession of Water	27.6	21.7	18.8	60.8	571.4
Water Charge	30.0	31.2	31.4	61.6	222.4
Slaughter	86.0	61.3	96.6	128.1	144.2
Donation	26.6	33.9	180.4	348.9	373.3
Others	53.1	47.7	118.1	154.1	1,043.5
Expenditure	**822.2**	**738.4**	**1,861.2**	**2,935.3**	**3,776.7**
Personnel	187.6	268.7	390.3	485.5	745.2
Road Maintenance	68.7	35.4	21.6	55.7	438.8
School Construction	28.5	16.2	27.8	107.6	521.0
Water System	13.5	60.5	403.1	829.6	748.7
Sewerage System	46.0	2.6	337.2	616.0	104.4
Amortization	0.0	0.0	120.0	180.0	188.8
Others	478.0	354.9	561.2	660.9	1,029.9
Surplus/Deficit	**-467.0**	**-371.9**	**-1,135.8**	**-1,597.8**	**-867.4**

Source: Financial Statements of Santa Catarina Pinula Municipality, 1990-1994

Table 5-10 shows the financial status of Villa Canales Municipality in 1994. Table 5-11 illustrates that of Mixco Municipality in 1995. Villa Canales' revenue and expenditure were recorded at Q2.6 million and Q3.5 million respectively. Mixco's revenue and expenditure were recorded at Q25.7 million and Q27.6 million, respectively. Both municipalities recorded deficit on their financial balance: -Q9 million or 34% of the total revenue of Villa Canales and -Q1.9 million or 8% in Mixco.

Table 5-10 Revenue and Expenditure of Villa Canales Municipality

(Year 1994, Unit: 1000 Quetzals)

Revenue	**2,567.4**
Contribution & Taxes	328.8
License	35.5
Concession of Water	72.9
Water Charge	119.7
Donation	1,634.3
Others	376.2
Expenditure	**3,457.0**
Personnel	773.7
Road Maintenance	235.2
School Construction	7.3
Water System	1,714.6
Drainage System	208.7
Amortization	125.5
Others	392.1
Surplus/Deficit	**-889.7**

Source: Financial Statements of Villa Canales Municipality, 1994

Table 5-11 Revenue and Expenditure of Mixco Municipality

(Year 1995, Unit: 1000 Quetzals)

Revenue	**25,683.4**
Contribution & Taxes	10,235.9
License	1,605.0
Concession of Water	564.5
Water Charge	3,450.3
Central Government	5,289.9
Others	4,537.8
Expenditure	**27,629.0**
Personnel	10,235.9
Road Maintenance	1,871.1
Water System	1,050.9
Drainage System	550.8
Amortization	750.0
Others	13,170.4
Surplus/Deficit	**-1,945.6**

Source: Financial Statements of Mixco Muincipality, 1995

Table 5-12 shows the budget of Chinautla during the latest four years, 1992-1995. Its revenue and expenditure in 1995 were both estimated at Q3.2 million. This amount was slightly smaller than that of the previous year of Q 3.5 million.

Table 5-12 Budget of Chinautla Municipality

(Unit: 1000 Quetzals)

Item	1992	1993	1994	1995
Revenue	**2,014.3**	**2,521.8**	**3,493.5**	**3,223.7**
License	33.0	55.0	100.0	100.0
Pavement	550.0	732.8	550.0	40.0
Concession of Water	45.6	48.0	100.0	300.0
Water Charge	46.0	85.0	120.0	160.0
Garbage Collection	42.0	48.0	84.0	120.0
Donation	160.9	117.6	250.9	200.0
Subsidy	635.0	898.2	1,599.6	1,636.8
Others	501.8	537.3	689.0	666.9
Expenditure	**2,014.3**	**2,521.8**	**3,493.5**	**3,223.7**
Personnel	407.6	486.2	618.0	688.7
Road Maintenance	650.5	709.9	775.1	350.0
School Construction	40.0	50.0	150.0	160.0
Water System	240.0	317.4	331.5	600.5
Sewerage System	30.0	33.0	33.0	50.0
Amortization & Interest	40.6	38.6	38.0	36.8
Others	605.6	886.7	1,548.0	1,337.7
Surplus/Deficit	**0.0**	**0.0**	**0.0**	**0.0**

Source: Financial Statements of Chinautla Municipality, 1992-1995

Since the total population of Santa Catarina Pinula in 1994 was estimated at 29,919, the per capita revenue and expenditure in the same year were Q97 and Q126, respectively. These figures were not so different from the 1993's values of Guatemala Municipality, Q115 and

Q99. However, since the population of Villa Canales and Chinautla in 1994 and Mixco in 1995 was estimated at 58,996, 67,027 and 439,950, the per capita revenue of the respective municipalities was estimated at around Q48, Q44 and Q58. These figures were almost half of Santa Catarina Pinula and Guatemala Municipality.

The financial balance of water and sanitation services in Santa Catarina Pinula in 1994 was: Q0.79 million of revenue, consisting of Q0.57 million of concession of water and Q0.22 million of water charge; Q0.85 million of expenditure consisting of Q0.75 for water system and Q0.10 million for drainage system; and finally Q0.06 million of deficit. The services are operated and maintained by private firms on a contract basis.

In the same manner, Villa Canales in 1994 recorded as follows: Q0.19 million of revenue; Q1.92 million of expenditure; and Q1.73 million of deficit. Mixco recorded in 1995: Q4.01 million of revenue; Q1.60 million of expenditure; and Q2.41 million of surplus. That of Chinautla in 1995 was: Q0.65 million of revenue; Q0.16 million of expenditure; and Q0.49 million of deficit.

5.2.3 EMPAGUA

EMPAGUA is a leading public body which covers most parts of the study area in terms of water supply, sewage treatment and sanitation services. It is responsible for water supply and sewage services, but does not cover individual sanitation facilities and small sewerage treatment plants in collective estates.

a) General Balance of EMPAGUA

Table 5-13 shows a balance between revenue and expenditure for EMPAGUA during 1991-1994. In each four year, the overall balance of EMPAGUA recorded a surplus except in 1992. In 1994 EMPAGUA dissolved an accumulated deficit and went into the black. Main sources of the revenue were potable water and sewage services which accounted for Q96 million or 86% of the total revenue in 1994. These revenues were divided into three parts: Q75 million (67% of the total revenue) for water supply services; Q18 million (16%) for sewage services; and Q3 million (3%) of premium allotment from beneficiaries. Besides these main sources, EMPAGUA gets some revenues from: sales of accessories for water supply system such as water meters and boxes; and subsidy from the governments. Although subsidy has been provided by both central government and Guatemala Municipality, after 1995, it is unified into the subsidy by Guatemala Municipality only.

Table 5-13 Revenue and Expenditure of EMPAGUA: 1991-1994

(Unit: 1000 Quetzals)

Item	1991	1992	1993	1994
Revenue				
1. Services to Consumers	36,400	44,407	70,107	95,849
-1 Water Supply Services	36,390	43,327	59,954	74,764
-2 Sewage Services	10	1,080	10,153	17,547
-3 Allotment to Beneficiaries *1	0	0	0	3,537
2. Water Meters and Accessories	1,342	4,769	4,500	4,462
-1 Installation of Water Meters	198	1,386	1,795	2,052
-2 Sales of Water Meters	11	2,027	1,668	1,449
-3 Accessories & Others	1,133	1,356	1,036	961
3. Sundry Receipts	2,104	1,758	3,642	4,027
4. Subsidy and Contribution	6,144	6,873	40,657	7,698
-1 Subsidy of Government *2	5,809	6,021	39,615	7,019
-2 Contribution of Drainage	335	852	1,043	679
5 Bond Issuing *1	4,850	449	921	-2
Total	50,841	58,257	119,826	112,034
Expenditure				
1. Operation Expenditure	47,286	72,119	98,752	90,676
-1 Managing Board	1,721	1,978	2,298	2,960
-2 Planning	493	1,250	1,615	1,445
-3 Water & Sanitation Works	2,853	5,533	8,222	2,987
-4 Operation & Maintenance	19,284	41,258	59,617	54,727
-5 Administration *3	14,958	12,781	15,894	18,227
-6 Depreciation	7,374	8,586	10,398	9,841
-7 Bad Debt Loss	603	731	706	488
2. Rehabilitation & Maintenance	840	1,802	1,404	4,597
-1 Water & Sanitation Facilities	677	1,537	926	3,896
-2 Operation & Maintenance	163	265	478	382
-3 Others	0	0	0	319
3. Non-operating Expenditure	1,485	1,496	1,536	1,637
-1 Interest on Loans	924	787	686	2,113
-2 Others	561	709	850	-476
Total	49,611	75,416	101,692	96,910
Surplus/Deficit	1,229	-17,159	18,134	15,124

Source: Estados Financieros, Al 31 de Diciembre de 1994, 1993, 1992 y 1991, EMPAGUA
Liquidacion del Presupuesto General de Ingresos y Egresos Ejercicio Fiscal 1994, EMPAGUA
Presupuesto General de Ingresos y Egresos Ejercicio Fiscal 1995, EMPAGUA

Note: *1 Bond is transferred to allotment contribution from beneficiaries.
*2 After 1995 subsidies come from Guatemala Municipality only, although until 1994 they ha
come from both Central Government and Guatemala Municipality
*3 Including other functions

The main revenue from consumer services has continuously increased as shown in the table. However, it looks difficult for EMPAGUA to keep financially sound without government subsidy. In 1991 and 1993, the balance would have recorded deficit without the subsidy. In spite of that, the amounts of the subsidy fluctuated year by year as seen in the table.

It is said that EMPAGUA has several difficulties concerning its revenue. Its tariff is simplified and not based on the different consumption ranks for various users such as industries. In addition, its invoice system does not function well. The collection and accounting system of water and sewage service charges is not integrated. It was estimated that the invoices volume in 1993 was only 59% of the volume produced. If true, 41% of the produced volume might be lost as management losses. Accordingly, taking into consideration of physical losses such as leakage from the piping network, the total losses of water could be more than 50% of the produced volume. In the same manner, the sewage system is considered to be managed at the same low level of efficiency as the water supply system.

b) Assets of EMPAGUA

Assets of EMPAGUA consist of current assets, which include not only general assets such as cash but also estimation of uncollected charges; fixed assets, which include water supply and sewerage facilities and equipment for O/M; and deferred assets, which include research, rehabilitation and works in progress. As shown in Table 5-14, the total amount of the assets was reported as Q433 million in 1994. It increased Q58 million or 15% of the 1991's total assets during the latest four years.

The assets of water supply facilities owned by EMPAGUA was evaluated at Q105 million in 1994, which includes intake facilities, conveying pipelines, pumping stations, treatment plants and distribution piping networks. The assets of sewerage and drainage facilities was evaluated at Q197 million in the same year.

The increment of assets was supported by the increase of accumulated surplus in 1994. The amount of liability during the four years have kept constant at around Q300 million, although current liability decreased Q24 million and fixed liability increased by the same amount during the period.

Table 5-14 Balance Sheet of EMPAGUA: 1991-1994

(Unit: 1000 Quetzals)

Item	1991	1992	1993	1994
Assets				
1. Current Assets	33,533	29,898	47,435	54,234
-1 Cash	119	153	94	175
-2 Savings	12,244	11,744	13,917	10,239
-3 Accounts Receivable	21,024	17,701	33,575	43,200
-4 Estimation of Uncollected Charges	-603	-1,172	-2,095	-2,583
-5 Premium of Water Services	750	1,472	1,944	410
-6 Advance Payment, etc.	0	0	0	2,793
2. Fixed Assets	271,698	278,748	307,029	318,948
-1 Intake Facility	3,655	3,591	5,922	5,731
-2 Conveying Pipe Line	1,821	4,852	5,341	5,071
-3 Pumping Stations	7,799	7,051	7,818	8,739
-4 Treatment Plants	2,317	1,770	1,777	1,669
-5 Distribution System	79,992	81,691	82,491	83,939
-6 Sewerage & Drainage Works	171,271	174,056	193,829	197,493
-7 Land	183	183	183	183
-8 Buildings & Structures	75	70	64	59
-9 Construction Equipment	131	-125	-88	41
-10 Transportation Equipment	-126	403	612	896
-11 Other Fixed Assets	4,579	5,205	9,078	15,127
3. Differed Assets	70,113	83,226	70,296	60,241
-1 Research & Studies	6,974	7,689	4,691	4,848
-2 Rehabilitation of Water System	21,138	25,644	29,118	18,984
-3 Works in Progress	18,845	21,867	13,357	11,658
-4 Inventory Stock of Materials	10,290	13,306	8,657	14,610
-5 Others	12,866	14,720	14,473	10,141
Total	375,344	391,871	424,761	433,422
Capital and Liability				
1. Liability	303,142	319,673	344,648	304,523
-1 Current Liability	64,314	73,215	72,164	42,337
- Accounts Payable	62,493	69,953	67,517	37,201
- Accrued Payroll	209	1,013	1,471	2,614
- Reserve for Accumulated E	1,612	2,249	3,176	2,522
-2 Fixed Liability	237,402	245,117	272,049	261,163
-3 Deferred Liability	1,425	1,341	435	1,023
2 Capital	72,202	72,299	80,113	128,900
-1 EMPAGUA Capital	104,698	124,251	107,414	107,598
-2 Accumulated Surplus/Deficit	-32,495	-51,953	-27,301	21,302
Total	375,344	391,971	424,761	433,422

Source: Estados Financieros, Al 31 de Diciembre de 1994, 1993, 1992 y 1991, EMPAGUA
Liquidacion del Presupuesto General de Ingresos y Egresos Ejercicio Fiscal 1994, EMPAGUA
Presupuesto General de Ingresos y Egresos Ejercicio Fiscal 1995, EMPAGUA

Table 5-15 gives financial indices indicating the status of EMPAGUA's management conditions. In 1994, the current ratio was 1.3, so EMPAGUA seems to has good solvency. In other years, however, the ratios were less than 1.0, the solvency was not in good conditions. Acid ratios were kept at less than 0.2, so EMPAGUA has little solvency from the short term view point. Since EMPAGUA should be considered to have little opportunity to liquidate liabilities abruptly the same as the municipal government, the ratio might not be always more than 0.4.

Table 5-15 Financial Indices of EMPAGUA

Item	1990	1991	1992	1993
Current Ratio	0.5	0.4	0.7	1.3
Acid Ratio	0.2	0.2	0.2	0.2
Worth Debt Ratio	0.2	0.2	0.2	0.4
Ratio of Fixed Assets to Long-term Capital	0.9	0.9	0.9	0.8

Source : Study Team

The worth debt ratio has been improved from 0.2 in 1991 to 0.4 in 1994, although EMPAGUA increased external liabilities for four years. The conditions of the capital fund are not good because its funds rely on debts excessively. The fixed assets to long-term capital ratios in the above table were 0.9 in the former three years and went down to 0.8 in 1994, so the invulnerability might move to worsen slightly.

5.2.4 Financial Constraints

a) Public Expenditure for Sewerage Schemes

Public expenditure in the water and environmental sanitation sector by the central government is used for mostly rural areas. Works in urban areas are funded by autonomous bodies, such as municipalities and public corporations. In some private estates in urban areas, projects in this sector are developed by the private firms.

In the Study Area, existing small scale sewage treatment plants are developed and managed by developers who implement the development schemes. Aside from them, EMPAGUA is expected to cover environmental sanitation services in the whole area. EMPAGUA, however, has no sewage treatment plants so far. At present, it expands sewer pipe network only. During 1990-1995, EMPAGUA has implemented sewer pipe expansion projects as shown in Table 5-16.

Table 5-16 Sewer Pipe Expansion Projects by EMPAGUA

Year	Number of Expansion Projects	Investment Amount (Million Quetzals)
1990	6	1.78
1991	18	5.68
1992	24	4.84
1993	15	8.63
1994	7	4.25
1995	10	8.44

Source : EMPAGUA

b) Financial Sources for Sewerage Development Schemes

It would be rare for a sewage treatment project to be financed entirely from one source only. For a project, several financial sources are generally applied to meet the total project cost. Thus, it is important to have information of available financial sources. The following financial sources are available for this kind of project: EMPAGUA's own funds, procuring from bond issuing, accumulated surplus, capital increase, etc.; grants from the central government and the municipal governments concerned; public loans from government financial institutions; private loans from banks; and foreign assistance.

Foreign assistance may take two forms: loans and grants. It can also be classified into two types by organization: bilateral aid such as provided by JICA and OECF in Japan, USAID, GTZ, etc.; and multilateral aid such as provided by World Bank, IDA, IDB, etc. Major international organizations financing sewage projects propose various terms of loans as indicated in Table 5-17. Thus, an implementing entity can apply to these organizations.

Table 5-17 Sources of Foreign Loans and their Terms as of July 1995

Organization		Interest Rate	Period (years)		Charges		
		(%)	Repayment*1	Grace	Item	Rate(%)	
1. WB		7.72%	15 ~ 20	3 ~ 5	Commitment Charge	0.25%	*2
2. IDA		0 %	40	10	Service Charge	0.75%	*2
			35	10			
3. IDB	Ordinary Fund	8.1%	15 ~ 25	4 ~ 6	Commitment Charge	0.75%	*2
					Inspection Fee	1.0%	*3
	Special Fund	1 ~ 4%	25 ~ 40	5 ~ 10	Commitment Charge	0.5%	*2
					Inspection Fee	0.5%	*3
4. OECF		2.64%	28.3 *4	9.2 *4			

Remark: IDA - International Development Association
Note: *1 Including grace period
*2 Applied to an amount not committed
*3 Applied to total amount of loan
*4 Average of loan committed in the past

EMPAGUA has experience of procuring its funds through various financial organizations in the past. In the last 20 years, foreign aid has been provided by IDB, BFCE, WB, BCIE and OECF. Their terms and conditions of loans are tabulated in Table 5-18.

Table 5-18 Loans Applied to EMPAGUA Projects

	Organization	Total Amount (Million)	Interest Rate (%)	Period (years)		Charges		Contracted Year
				Repayment*	Grace	Item	Rate(%)	
1	IDB	US$10.0	1% up to 1985 2% after 1985	20 years	10 years	Commitment Charge	0.5%	1975
2	IDB	US$35.5	1% up to 1988 2% after 1988	20 years	10 years	Commitment Charge	1% up to May 1988 2% after 1988	1978
3	BFCE	FFr5.4	8.55%	10 years	-	Commitment Charge	5%	
4	BFCE	FFr5.4	8.1%	30 years	-	Commitment Charge	5%	1987
5	WB	US$23.0	1%	14 years	4 years	Commitment Charge	0.25%	1987
6	BCIE	US$1.2	13 - 14%	3 years	2 years	Other Charges	US$3,408	1990
7	OECF	Yen 4,711	2.7%	30 years	10 years	Service Charge	0.1%	1991

Remark: BFCE - Banque Francaise du Commerce Exterieur
BCIE - Banco Centroamericano de Integracion Economica
Note: * Including grace period

c) Average scale of investment in developing countries

According to the "World Development Report 1994", an average scale of investment for economic infrastructure in developing countries was reported as approximately 4% of GDP, which amounted to US$200,000 million or one-fifth of the entire investment for all sectors. In middle-income countries whose GDP per capita is between US$675 and US$8,356, an average investment for the water and sanitation sector was recorded as around 7% of the infrastructure investment.

GDP per capita of Guatemala in 1994 was estimated at around Q74.6 billion, as shown in Table 3-2. Assuming that GDP grows at a rate of 4.0% per annum which was the growth rate in 1994, it can be estimated at approximately Q77.6 billion in 1995 at 1994 constant prices. Accordingly, the national capital investment for economic infrastructure was estimated as Q3.10 billion per annum. Then, the investment for water related sectors can be estimated at Q220 million in 1995. Moreover, if the investment for sewage sector is assumed as one-third of the national investment for water sector, it would be Q72 million.

d) Limitations of Foreign Assistance

Arrears of both interest and principal repayments accumulated to US$283 million in 1994. Then, the debt-service ratio was 10.9% in 1994, as shown in Table 3-6. It has dropped down to the level of the early 80's and safely below the critical level of 20%. Then, there would be little problem for the country to get foreign aid from the financial point of view.

At the same time, foreign assistance of grant is acceptable for capital investment of projects. However, since GDP per capita of the country exceeded US$1,000 already, foreign countries, particularly Japan, might hesitate to propose grant assistance to Guatemala.

e) Trend of National Investment in Sewage Sector

Since investment for the sewage sector is not segregated in the government's financial statements, it is impossible to identify a trend in total investment for the sector. In the central and municipal governments, the sector is included in the environmental sanitation sector. Gathering all information related to the sewage sector from the aforesaid sections, total investment amounts are tabulated in Table 5-19:

Table 5-19 Investment in Sewage Sector

(Unit: Million Quetzals)

Entity	Sector	1990	1991	1992	1993	1994	1995
Central	Environmental Sanitation	15.1	22.2	32.9	47.0	135.3	225.1
Guatemala City	Environmental Sanitation	4.1	0.1	0.3	0.5	-	-
EMPAGUA	Sewage Sector	1.8	5.7	4.8	8.6	4.2	8.4
Total	-	21.0	28.0	38.0	56.1	139.5	233.5

Note: Figures for Guatemala City were actually disbursed but others were budget.

The total amount of Q234 million in 1995 is not small as compared with the international average of Q220 million, calculated in the previous subsection c). The problem is whether or not this investment could be carried on in the future. Moreover, if the investment for the sewage sector was only Q8.4 million by EMPAGUA in the country, it would be too small to maintain favorable environmental conditions in the metropolitan area.

f) Consideration of Cost Recovery

From the point of view of financial management, it is difficult in general to keep a sound balance with respect to sewage treatment services. Service charges are generally too low as compared with both capital costs and O/M costs. In fact, there would be few projects which keep a steady financial balance. Even in Japan, most sewerage schemes are managed on the basic principle of recovering O/M costs only. Initial investment costs are mostly subsidized by the central government. This is called "O/M cost recovery" policy.

Yet, even sewage treatment projects should aim at recovering the entire capital and O/M costs, a so called "full recovery" policy. For this reason, the following difficulties are generally noted. (i) Every scheme has its economic life, after which, the scheme has to be rebuilt or undergo major rehabilitation. At that time, the managing body faces the same difficulties as the initial financial problem. (ii) It is difficult for developing countries in particular to find financial sources therefore, recovering the entire costs makes it easier for a

managing body to approach financial sources. In this section, accordingly, the ceiling of capital investment is discussed from this basic point of view, "full recovery policy".

g) Revenue from Sewage Treatment Services

In order to manage a new sewage treatment business soundly, current revenue accruing from sewage treatment services has to fully cover not only current expenditure but also capital expenditure. Since a tariff is not established for sewage treatment services at present, the revenue from this project is estimated on the basis of an estimate of the treatment cost.

h) O/M Cost of Sewage Treatment

The O/M costs depend on the treatment system applied to a project. According to the IDB report in 1976, the O/M cost of a plant was estimated at Q0.0047/m^3. Assuming that (i) average water consumption volume is 250 lpcd, (ii) the discharge rate to sewerage is 70% of water consumption, and (iii) the price index between 1976 to 1996 is 1,150, the O/M cost would be reevaluated at Q0.054/m^3 in 1995.

i) Capital Costs

Capital costs were estimated as the total of both the repayment and the interest on the loan during the repayment period. Annual capital costs were assumed to be an average of the total for the duration of repayment period.

j) Limit of Capital Investment

The limit of capital investment was estimated on the basis of the amount of annual capital expenditure. The available capital expenditure was derived from the difference between the total revenue and O/M costs. Using the limit of capital investment and available capital expenditure, the limit of capital investment was estimated using various assumptions.

k) Trend of Capital Investment

As discussed in the previous subsection c), the central government will disburse more than Q200 million on the environmental sanitation sector in 1995. This is the largest allocation by the central government to date. Before 1993, however, the allocation was too small as compared with the international standard. Thus, central government should continue the present policy for environmental issues. Otherwise, it will be difficult to catch up with the international standard level.

Yet, the financial allocation for sewage sector is still small as discussed in the previous subsection e) and EMPAGUA has disbursed less than Q10 million annually. When the project to be proposed in this study is implemented, EMPAGUA would disburse more than ten times the amount in the present budget. This might bring about new difficulties in financial management.

l) Sources for Capital Investment

The limit of capital investment, which corresponds to capital expenditure, depends on the terms of the sources of finance. If a loan source having a lower interest rate and a longer repayment period is assumed, a larger loan could be expected for capital investment. Thus, the investor should choose the most advantageous source of loans.
Table 5-17 shows available foreign sources of loans. In the past experience of EMPAGUA, the financial sources for loans for the water sector were: World Bank, IDB, OECF, BCIE (Banco Centroamericano de Integracion Economica) and BFCE (Banque Francaise du Commerce Exterieur) as shown in Table 5-18, and JICA in the case of grants.

m) Capability of Management

Management capability might depend on the ability of the managing organization and the acquirement of management experience. Supposing that the capacity grows at a rate of 4% per annum, the same average growth rate as the GDP of the country, the revenue of EMPAGUA would reach more than Q255 million in the year 2010. It is almost 2.3 times the present revenue.

5.2.5 Results of Public Attitude Survey

The public attitude survey was conducted to find out residents' financial situation, health conditions, willingness to pay, satisfaction with EMPAGUA's service, environmental concerns, view on the need for sewerage and sanitation facilities, etc. Table 5-20 displays the summary of the results which are detailed in the Supporting Report D.

a) Income level

The income levels are classified as Q5001 or more for high income, Q2001 through Q5000 for middle income and Q2000 or less for low income. The average family income of those surveyed can be assumed to be about Q3000.

Table 5-20 Selected Results of Public Attitude Survey (1/2)

	Low Income	Middle Income	High Income	Total
Number of Samples	100	59	42	201
1. Housing Data				
b. Type of house				
b.1 Humble cottage	22	1		23
b.2 Lower grade	4		1	5
b.3 Normal	61	20	2	83
b.4 Medium high	13	37	28	78
b.5 High grade		1	11	12
c. Proprietorship				
c.1 Own Housing	65	43	36	144
c.2 Rented Housing	35	16	6	57
2. Age of Household Head	48.2	47.3	51.4	48.6
3. Principal Employment				
a. Business Owner	8	5	20	33
b. Owner of Unregistered Small Business	4	2		6
c. Self Employed	26	11	6	43
d. Employee of a registered company	36	23	11	70
e. Public Official	20	19	5	44
f. Domestic Employee	1			1
g. Other	5	1	1	7
4. Number of Household Members	6.0	5.3	5.3	5.6
5. Monthly Family Income				
a. Q. 0 through 500	11			11
b. Q. 501 through1000	32			32
c. Q. 1001 through 1500	40			40
d. Q. 1501 through 2000	17			17
e. Q. 2001 through 2500		9		9
f. Q. 2501 through 3000		13		13
g. Q. 3001 through 3500		8		8
h. Q. 3501 through 4000		7		7
i. Q. 4001 through 4500		6		6
j. Q. 4501 through 5000		16		16
k. Q. 5001 or more			42	42
Average income (Q/month)	1065	3555	7000	3036
6. Sanitary System				
a. Disposal of Excrement				
a.1 On the ground				
a.2 Latrine or Cesspit	4	1		5
a.3 Simple toilet		1		1
a.4 Lavatory	96	57	42	195
b. Disposal of served water				
b.1 Cesspit	2			2
b.2 Septic Tank and Absorption Wells	1		1	2
b.3 Septic Tank	2	3	2	7
b.4 Public Sewers	92	56	39	187
b.5 Throwing Water on the ground	3			3
7. Water Sources				
a. Domestic municipal service	89	57	40	186
b. Municipal Service by Public Spout or Basin	3			3
c. Private Water System Service	2	1	1	4
d. Spring Water or fountain				
e. Wells, exclusive of the house	4			4
f. Truck or Water Tank	6		2	8
g. Rain Water	1	6	1	8
h. Bottled Water	13	28	29	70

Source : Study Team

Table 5-20 Selected Results of Public Attitude Survey (2/2)

	Low	Middle	High	Total
8. Monthly Water Consumption				
a. 0 through 10 m3	28	12	1	41
b. 11 through 20 m3	23	11	4	38
c. 21 through 30 m3	13	18	7	38
d. 31 through 40 m3	2	5	2	9
e. 41 through 50 m3	1	2	5	8
f. 51 through 70 m3	2	2	2	6
g. 71 through 90 m3	1	1	4	6
h. 91 through 120 m3				0
I. 121 through 150 m3			1	1
j. 151 m3 or more	3	1		4
Average Consumption (m^3)	23	25	43	27
9. Monthly Water Charge				
a. Q. 0 through 10	24	7	1	32
b. Q. 11 through 20	16	13	3	32
c. Q. 21 through 30	23	18	3	44
d. Q. 31 through 40	5	8	7	20
e. Q. 41 through 50	3	6	6	15
f. Q. 51 through 60	2	1	2	5
g. Q. 61 through 70	6		5	11
h. Q. 71 through 80	1		1	2
I. Q. 81 through 90	5		3	8
j. Q. 91 through 100	1		2	3
k. Q. 101 or more	11	4	8	23
Average Charge (Q)	39	32	64	42
11. Why Wastewater Treatment is Needed				
a. To avoid bad odors	129	74	53	256
b. To avoid the proliferation of mosquitoes	137	85	60	282
c. To improve the agricultural production	76	58	29	163
d. To maintain the potable water sources	141	101	37	279
e. To maintain sufficient water for the industrial use	59	45	25	129
f. To keep the ecosystem of animals and plants	64	89	75	228
g. To increase the value of the properties	32	29	20	81
h. To avoid the damage to habitants with city drainage	136	122	80	338
i. Other	5	17	7	29
j. There are no reason of importance	6	1		7
12. Willingness to Pay (Q/month/household)	9.3	15.3	19.1	13.3
14. Service Level of Potable Water Supply				
a. General opinion				
a.1 Good service	32	15	4	51
a.2 Normal service	44	30	30	104
a.3 Bad service	24	14	8	46
b. Regularity of water service				
b.1 Continuous Service	20	8	9	37
b.2 Daily service 1-4 hours	14	7	3	24
b.3 Daily service 5-8 hours	22	17	22	61
b.4 Daily service 9-24 hours	19	16	4	39
b.5 Each two days service 1-4 hours	1	1		2
b.6 Each two days service 5-8 hours	1	6	1	8
b.7 Each two days service 9-24 hours	12	2		14
b.8 Each three days service 1-4 hours	1			1
b.11 Unknown service schedule	5	2	3	10
c. Opinion about the water quality				
c.1 Reliable	60	36	20	116
c.2 Not Reliable	40	23	22	85

Source : Study Team

b) Sanitary level

For all income levels, installation of a lavatory and its connection to the public sewers is almost standard, with a 97% lavatory use rate and 93% connection to public sewers connection rate.

c) Water Sources

Although the domiciliary municipal service is the most popular water source among all the income levels, there still exists small numbers of households, especially in the low income level, which rely on other water sources. The overall coverage rate of the municipal water supply system is 93%.

d) Monthly water consumption

77% of the overall number who replied to this question consume less than $31m^3$ per month. The average consumption volume can be assumed to be about $23m^3$ for low income, $25m^3$ for middle income and $43m^3$ for high income households with $27m^3$ to be the overall average.

e) Monthly water charge

73% of those who replied to this question pay less than Q51 per month which includes not only the charge of municipal water but also other sources such as bottled water. The average water charge can be assumed to be about Q39 for low income, Q32 for middle income, Q64 for high income households and Q42 for overall. One of the reasons why the low income class pays more than the middle class could be that some low income households are still dependent on more costly water sources such as a private water system or water truck. It can be generally said that the low income class are paying for water with more than 2% of the income, while the middle and high income are paying less than 1% for water.

f) Consciousness to the need for waste water treatment

Only 3% think that waste water treatment is unimportant. Among the major reasons why they think it necessary are (i) to avoid damage to inhabitants who receive city drainage; (ii) to avoid the proliferation of mosquitoes; (iii) to maintain potable water sources; (iv) to avoid bad odors; and (v) to protect the ecosystems of animals and plants.

g) Willingness to Pay

The average monthly prices which the low, middle, and high income household is willing to pay are calculated as Q9.3, Q15.3 and Q19.1 respectively. The overall average turns out to be Q13.3.

h) EMPAGUA's services

77% of overall samples replied that the service level is good or normal, although only 19% receive a continuous service. 58% regard the water quality as reliable.

i) Disease record

Amebic disease and enteroviruses have a relatively high incidence rate among the diseases listed in the survey.

5.3 EMPAGUA ADMINISTRATIVE SYSTEM

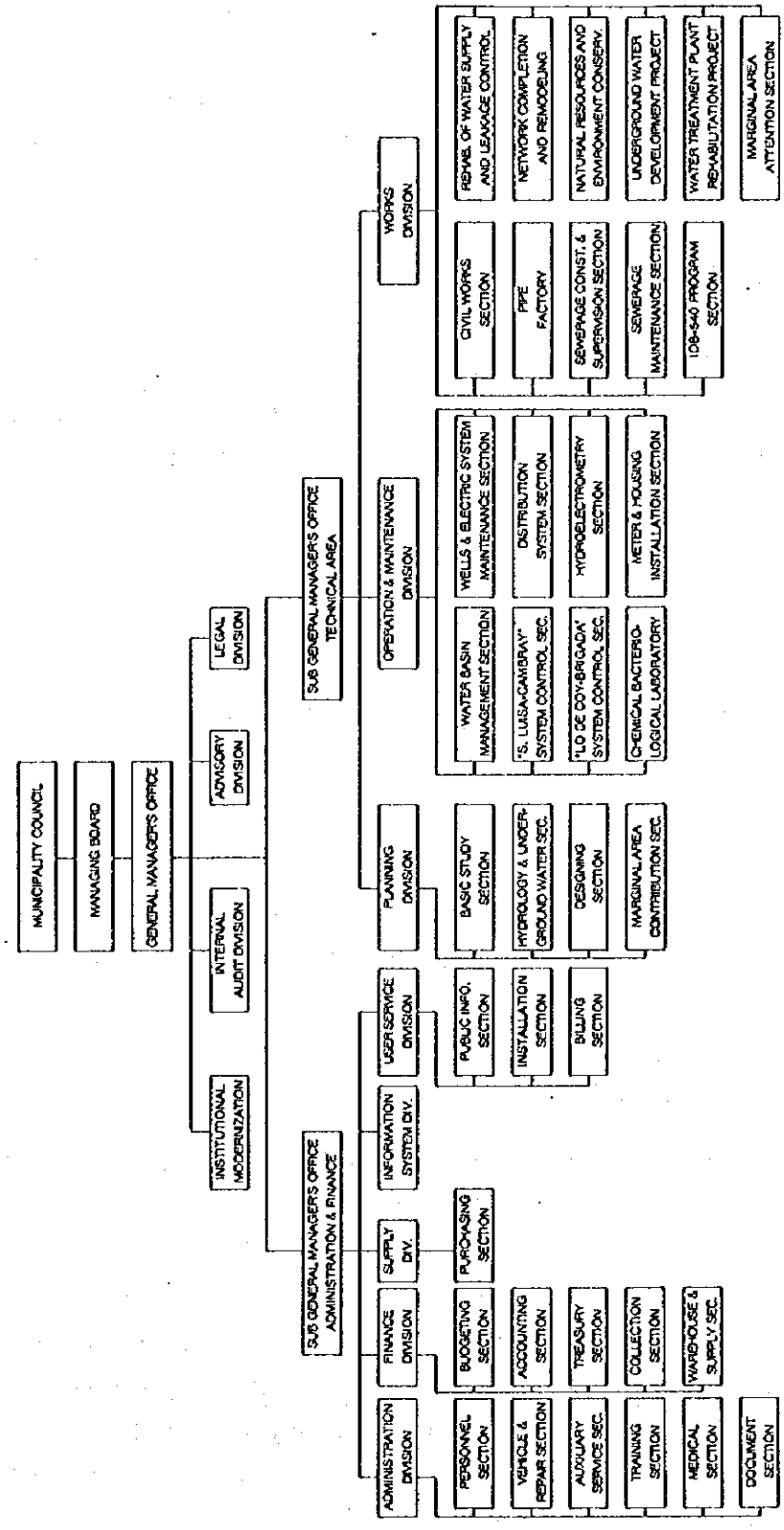
5.3.1 Organization

a) Structure

EMPAGUA's organization chart as of February 1996 is presented in Fig. 5-2, wherein the dependency of EMPAGUA on Guatemala Municipality is notable. The Municipality's Council and Managing Board has jurisdiction over the General Manager's Office. The former consists of the Mayor of Guatemala, syndics and counselors. The latter consists of the Mayor of Guatemala, counselors, delegates from the Ministry of Finance and INFOM, and EMPAGUA's directors. These two units play an important role in deciding key issues such as change of tariff.

Another distinctive characteristic is that only a few units are clearly engaged in some stage of wastewater management (*i.e.* Sewerage Construction & Supervision Section, Sewerage Maintenance Section, and IDB-540 Program Section). At present, there is no clear organizational recognition in most of the units, as to how much time the employees are devoting to water supply and how much to wastewater management. The classification of each unit is described in H2 of Supporting Report H.

Fig. 5 - 2



THE REPUBLIC OF GUATEMALA GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)	THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE EMPAGUA ORGANIZATION CHART

b) Staffing

Table 5-21 shows the deployment of employees as of February 1996. The classification of each position is described in H2 of Supporting Report H. EMPAGUA has 1,798 employees of whom 13 are considered to be in senior management positions, 17 are skilled specialists, 302 hold administrative posts, 518 are working in technical area and 948 are unskilled workers. This distribution is illustrated in Fig. 5-3.

The upper chart of Fig. 5-4 illustrates how the employees of EMPAGUA are classified by age and experience. This composition by age bracket is compared with the labor force in Guatemalan Metropolitan area as shown in the lower chart of Fig. 5-4. It can be said that EMPAGUA's employees are older than the Guatemala Metropolitan average. Further data of EMPAGUA's employees are analyzed in H3 of Supporting Report H.

c) Privatization

The privatization of EMPAGUA has been spotlighted from time to time. The general opinion at the beginning of 1996 is that it is still premature to go for a full scale privatization including public offering of shares, sale of shares to a private buyer, etc. The preconditions for privatization are yet to be satisfied due to the following circumstances:

- There is no water law established;
- The present water supply operation is not profitable enough primarily because the tariff is relatively low and difficult to raise;
- To a certain extent, a monopolistic character has to be guaranteed to the water supply Operation, which has not yet been achieved;
- Politically and financially, EMPAGUA is dependent on the Municipality of Guatemala. This will be an obstacle to possible expansion of the service area to outside the city, alteration of the organization, or liquidation and redeployment of assets.

Notwithstanding the above mentioned difficulties, another modality of privatization or out-sourcing has actually come into effect at EMPAGUA. Meter reading and delivery of bills among others are most notable areas. The former task has been partially contracted out to a private company since 1987 and the latter has been contracted out since 1980. Both tasks are now only supervised by EMPAGUA and this contracting-out has brought EMPAGUA considerable savings in terms of costs and human resources. In order to take advantage of the merit of contracting-out, it is recommended that all units of EMPAGUA be diagnosed in the light of efficiency to find out if they are suitable for out-sourcing.

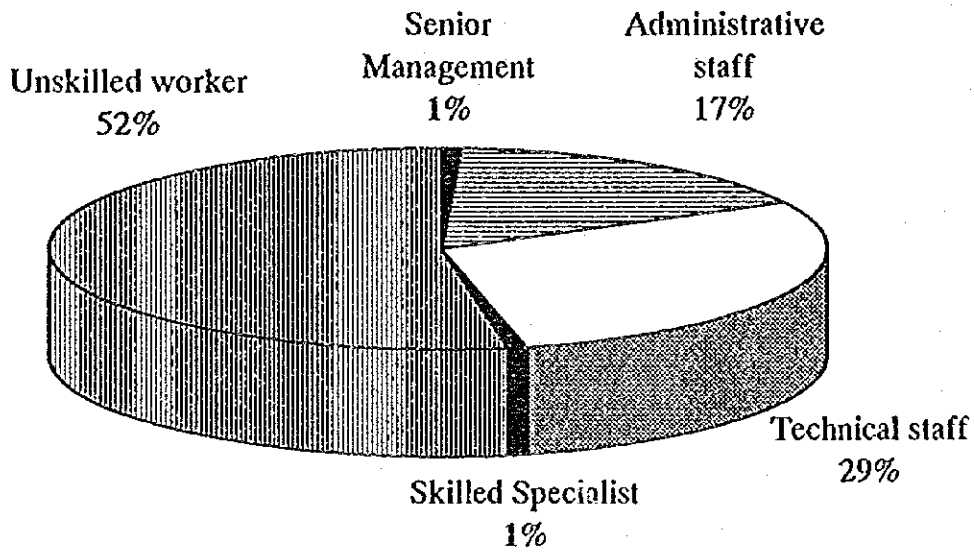
Table 5-21 EMPAGUA Employee Deployment

(As of February 1996)

Job Category	Senior management				Skilled specialist			Administrative staff							Technical staff								Unskilled worker			Total
Number of Employees	13				17			302							518								948			1798
Section \ Functional Position	General manager	Sub-general manager	Division head	Project delegate	Advisor	Internal auditor	Specialist	General affair staff	Section head	Auditing staff	Administrative assistant	Clerk	Secretary	Warehouse worker	Technician	Programmer	Assistant section head	Circuit inspector	Financial specialist	Specialized worker	Watchman	Operator	Forest Guard	Chief worker	Operative worker	Total
MANAGING BOARD													1													1
GENERAL MANAGER'S OFFICE + ADVISORY DEPT.	1				4							1	3				3									12
INSTITUTIONAL MODERNIZATION SECTION			1				2																			3
LEGAL DIVISION			1				3	1				1	1				3									10
AUDITING DIVISION						1	1		1	11			2						2							18
SUB GENERAL MANAGER'S OFFICE (ADMI. & FINANCE)		1											2												2	5
ADMINISTRATION DIVISION			1					1					1												1	4
PERSONNEL SECTION								1	1			16	3		2		2								2	27
VEHICLE & REPAIR SECTION								1	1			4	1		1					9					57	74
AUXILIARY SERVICE SECTION								1				4	1		1						12				33	52
TRAINING SECTION								5	1			3	1													10
MEDICAL SECTION									1						1											2
DOCUMENT SECTION									1			2														3
FINANCE DIVISION			1								1															2
BUDGETING SECTION									1						4		1									6
ACCOUNTING SECTION									1				1		13		1									16
TREASURY SECTION								1	1			6	1		14		1								1	25
COLLECTION SECTION								2	1		2	9	2				1								20	37
WAREHOUSE & SUPPLY SECTION								1	1			4		13											1	20
SUPPLY DIVISION			1						1			2	2													6
PURCHASING SECTION								1	1			4	1												1	8
INFORMATION SYSTEM DIVISION			1					1	1				1			3	4				1				1	13
USER SERVICE DIVISION			1				1	1			1		2				1									7
PUBLIC INFORMATION SECTION								23	1			5													1	30
INSTALLATION SECTION								4	1			17	3							1					2	28
BILLING SECTION								1	1			5	2				1			4				7	35	56
SUB GENERAL MANAGER'S OFFICE (TECHNICAL AREA)		1											1													2
PLANNING DIVISION							1					1	1							1						4
BASIC STUDY SECTION							1					1								3					12	17
HYDROLOGY & UNDERGROUND WATER SECTION									1						1		1								9	12
DESIGNING SECTION							1		1			1	3		14									1	22	43
MARGINAL AREA IMPROVE. CONTRIBUTION									1						1											2
OPERATION & MAINTENANCE DIVISION							1	1	2				2													6
WATER BASIN CONSERV. AND MANAGEMENT									1												1			2	49	52
"LO DE COY-BRIGADA" SECTION									2				1		3		1	8		3	6	35		1	27	88
"S. LUISA-CAMBRAY-ILUSIONES" SECTION																	3	18		1	1	41	6		18	88
WELLS & ELECTRIC SYSTEM SECTION								2	1			4	1		20		3	3		2		138	5		41	220
DISTRIBUTION SECTION								1	3			4	2		1		5				9	44		23	100	192
CHEMICAL-BACTERIOLOGICAL LABORATORY									1								1			3						5
HYDROELECTROMETRY SECTION									1						1		1	1						1	4	9
METER & HOUSING INSTALLATION SECTION									1			8	2				3			1	3			13	54	85
WORKS DIVISION			1					1	1				1				1								1	6
CIVIL WORKS SECTION									1			7			1		1			3	3			4	70	90
NATURAL RESOURCES & ENVIRONMENT															2										4	6
SEWERAGE CONSTRUCTION & SUPERVISION								3	1			4	1		4		1			5				10	102	131
SEWERAGE MAINTENANCE SECTION									1			2	1		3		1			6	2			7	61	84
IDB-540 PROGRAM SECTION																								2	15	17
PIPE FACTORY								1	1			4								1				1	38	45
MARGINAL AREA ATTENTION SECTION									1		2	3														6
REHAB. OF WATER SUPPLY & LEAKAGE CONTROL																									42	42
NETWORK COMPLETION & REMODELING								1	1						1		2				3			5	30	43
TREATMENT PLANT REHABILITATION SECTION									2				1		2										1	6
UNDERGROUND WATER PROJECT (EMERGENCY 1)			1	1			1	2	2			2			2		2			1	3			4	21
T O T A L	1	2	9	1	4	1	12	57	43	11	6	122	50	13	92	3	44	30	2	44	43	260	11	77	660	1798

Source : EMPAGUA

Fig. 5 - 3



Total 1798 employees as of February 1996

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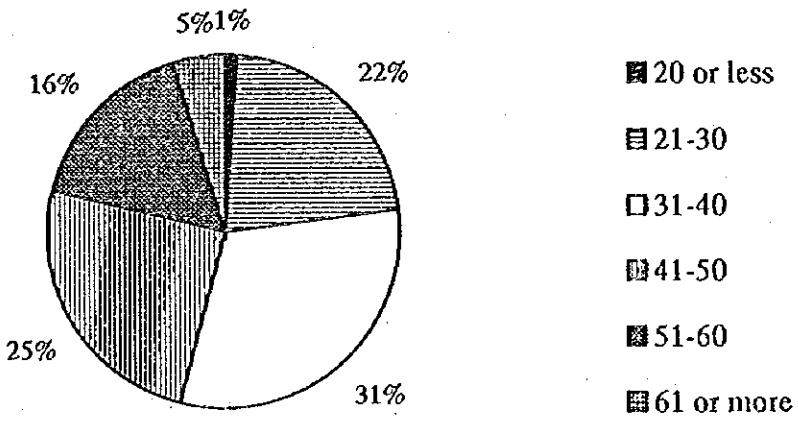
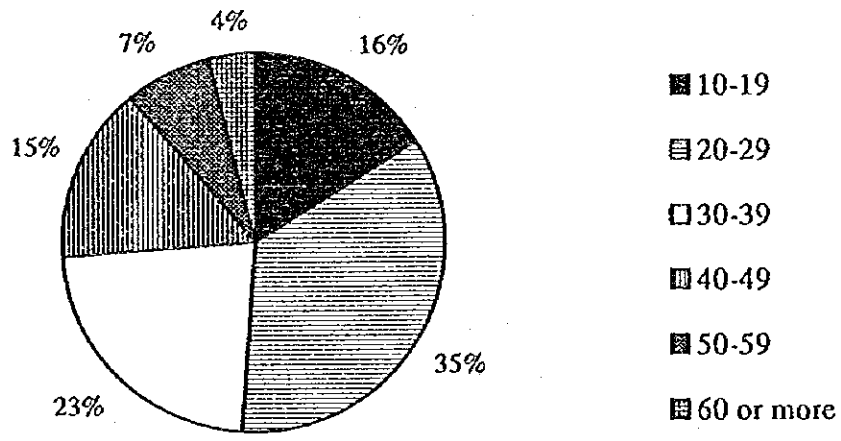
Fig. 5 - 4

Age Distribution of EMPAGUA Employees



Age Distribution of Labor Force in Metropolitan Area



THE REPUBLIC OF GUATEMALA GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)	THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE COMPARISON OF LABOR FORCE BY AGE

5.3.2 Personnel Management

a) Salary

The monthly salary of EMPAGUA's employees ranges from 835 to 7,080 quetzals as of 1996. The detailed salary structure and additional salaries are described in H4 of Supporting Report H. The actual salary structure including additional salaries almost follows the standard of Guatemala Municipality. The raise of salary base is not necessarily approved every year but when it is made, the incremental amount is same to all employees. For example, at the beginning of 1996, the base was evenly raised by Q260.

b) Recruitment and Promotion

In general, EMPAGUA has been limiting the increase of employees, thus, there has not been many chances of recruitment in recent years. Some 15 new positions are annually needed to be filled. In most cases, the positions are filled by internal promotion or transfer and only when there is no appropriate candidate found in EMPAGUA, new employees are recruited externally. In external recruitment, INTECAP plays an important role, preparing the selection test and evaluating the candidates on behalf of EMPAGUA in order to make a fair judgment.

Promotion for higher job category and progression within the same job category are generally based on performance of employee. The educational background and the job experience also count but the length of service and age are normally irrelevant. There exists no rational system for a superior to evaluate the performance of his or her inferior.

c) Training

The Training Section was created in 1990 as the result of the human resource development program financed by the World Bank. Before 1990, EMPAGUA did not have any training section and the training courses were held sporadically. Its isolated location from the Head Office is worth notice, which is convenient not only for training courses but also for some executive meetings and internal examinations to be held. Accordingly the functions of this unit also include taking care of all these activities.

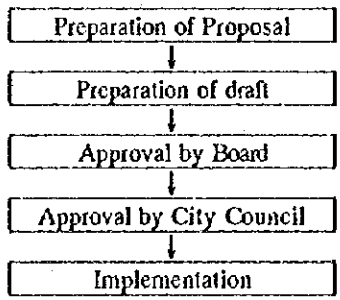
The training scheduling of EMPAGUA is based on annual requirements that each section head submits to the Training Section before starting a fiscal year. However, as described in H5 of Supporting Report H, actual programs have not been executed as planned and the scale of annual training varies considerably from year to year.

5.3.3 Information System

There are considerable number of reports and information produced at EMPAGUA, as shown in H6 of Supporting Report H. Those information already contain sufficient data which reflect the status of EMPAGUA's operation. However, most of information are reported only up to the division head and their contents appear to be too raw for other senior management to digest easily. A little information is distributed to all senior management. The function of the Information Section seems still limited and no information center exists where information processing and distribution are centralized. To solve the situation, EMPAGUA has a plan to strengthen the information system and install computer terminals at necessary places including management's desks.

5.3.4 Budgeting

The budget is prepared once a year. Finance Division is responsible and its Budgeting Section is mostly involved in the budget preparation. The budgeting process is as follows:



(i) Preparation of budget proposal in each division - In July, Finance Division distributes circulars and forms to other division heads requesting them to submit their budget proposal for the forthcoming year.

(ii) Preparation of draft budget - Upon receipt of the forms around September, Finance Division sums up the figures from each division, based on which, screening and negotiation are made by the division head concerned. As the result, the draft budget is prepared in September.

(iii) Approval by Board of Directors - Board of Directors evaluates the draft budget and may reduce or increase any of the budgeted items. The approval is given in November.

(iv) Final Approval by City Council - The approval by the City Council is usually given before the end of November.

(v) Implementation of budget - The new year budget is implemented in January. After implementation, if any of the budget founds insufficient, transfers from other superfluous budgets is attempted. Supplementary budget may be also prepared during the year.

At present, the budgeting system is not always related to the past performance. Each division head submits the budget of next year whose amount tend to be inflated. This is most distinctive in the capital investment budgeting. According to EMPAGUA's data, the execution rates of capital investment budget from 1991 to 1994 are considerably low, ranging between 30% and 50% approximately. This low execution rate implies that there exists improper distribution of financial resources.

5.3.5 Commercial Procedures

a) Tariff Structure

EMPAGUA carries out regulation of public water services for consumers within the service area of EMPAGUA. The relevant regulation was revised in August 1992 and again in September 1994. However, the proposed tariff in 1994 was not completely approved by the authority. According to the present tariff structure of EMPAGUA, typical users of the services are monthly charged as shown in Table 5-22.

Table 5-22 Present Tariff Structure

(Unit: Quetzals/Household)

Water Consumption Volume (m^3/month)	Water Charge	Sewage Charge	Total Charge
10	2.00	0.00	2.00
20	4.00	0.90	4.80
30	18.00	3.60	21.60
40	24.00	4.80	28.80
50	60.00	10.00	70.00
60	70.00	12.00	82.00

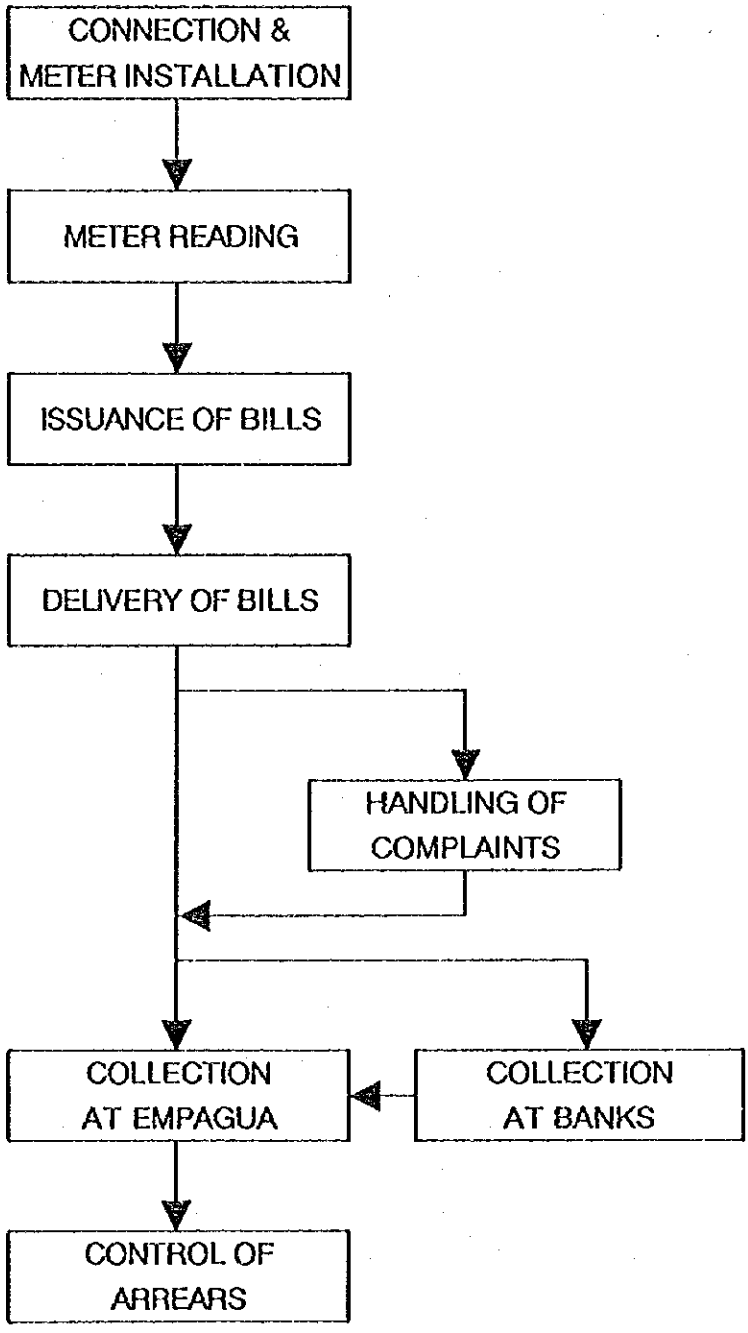
Source : EMPAGUA

Tariff analysis is further made in H7 of supporting Report H.

b) Billing and Collection System

Fig. 5-5 highlights the billing and collection system employed at EMPAGUA, which mainly consists of (i) connection, (ii) meter installation, (iii) meter reading, (iv) billing, (v) handling of customer complaints, (vi) collection, and (vii) control of arrears. Each step and relevant tasks are further described in H8 of Supporting Report H.

Fig. 5 - 5



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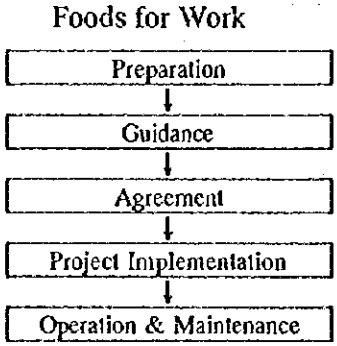
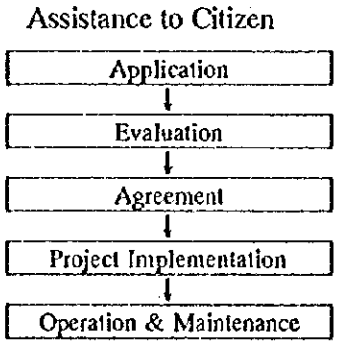
5.3.6 Community Participation

Since 1986, the Guatemala Municipality has been encouraging the community participation in provision of infrastructures such as water supply, drainage, paving of sidewalk and street inlet. There are two major types of participation program. The first one, "Foods for Work" is usually applied to settlements in extreme poverty. Its process flow can be characterized as follows:



While the second one, "Assistance to Citizen" is generally practiced in higher income areas where minimum life-line infrastructures have been already provided. Its process flow is characterized as follows:



Both programs have common objectives which include (i) to provide residents with basic infrastructure; (ii) to save public expenditure for capital investments; (iii) to enhance community awareness regarding the importance of basic infrastructure; and (iv) to encourage the residents in creating a self-support and team working spirit.

The clearest distinction between the two programs lies in the initiative of residents. In principle, "Foods for work" programs are planned by the Municipality, while "Assistance to Citizen" are originated on residents' own initiative. Accordingly, the two programs differ also in residents' receipt of remuneration in exchange for their participation in project. Under the "Food for Work", residents receive an allowance in kind, which is not the case with "Assistance to Citizen."

CHAPTER 6

EXISTING WASTEWATER MANAGEMENT

6 EXISTING WASTEWATER MANAGEMENT

6.1 EXISTING SEWERS

In the Guatemala Metropolitan Area, since construction began about 55 years ago, the sewerage system has been introduced gradually and extended on various subsequent occasions. It may be assumed that at present about 82% of Guatemala City is covered either by public or private sewerage. Due mainly to the topography of the City area, the sewerage system is divided by the Continental Divide into two sewerage districts, i.e. North and South districts.

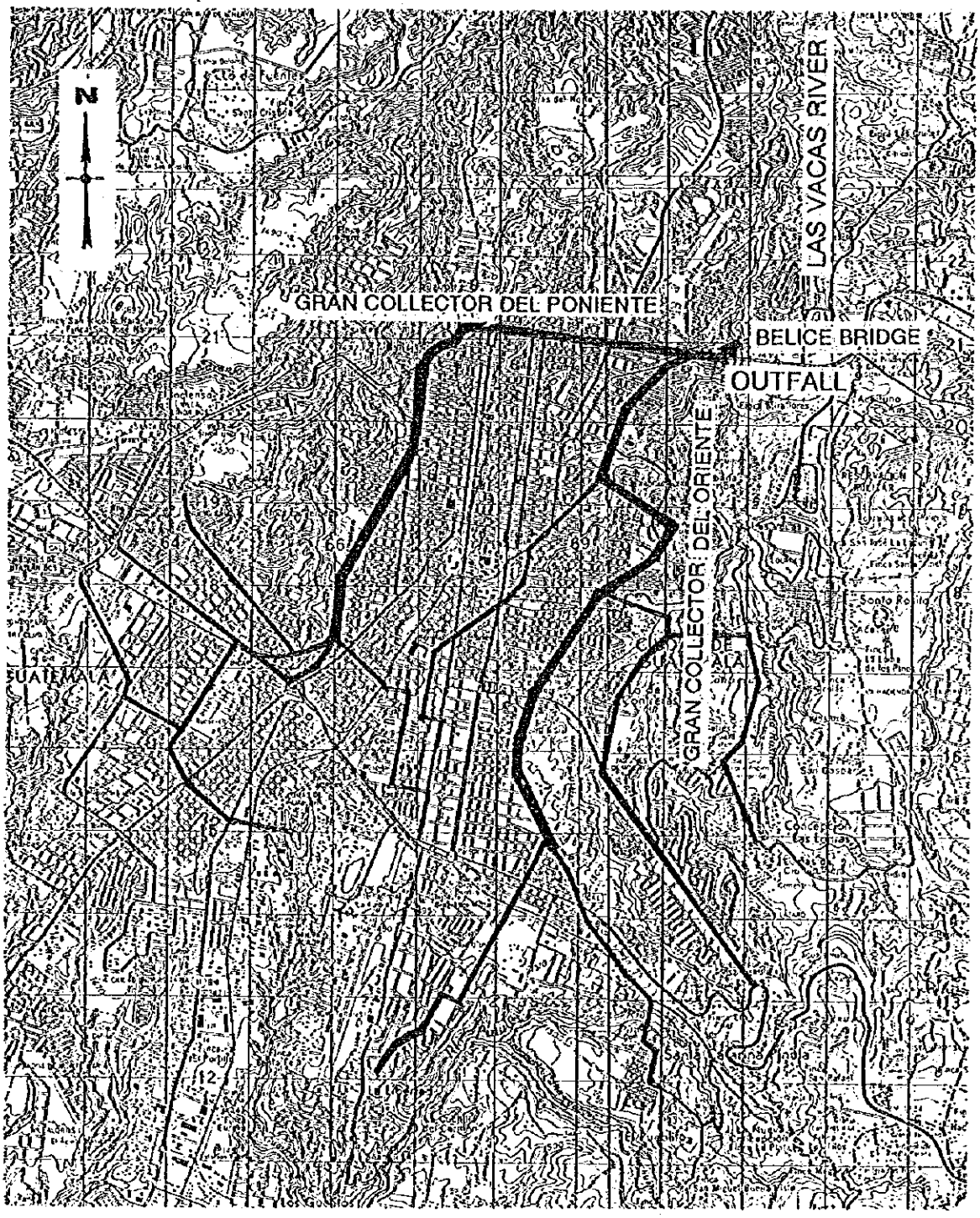
Most of the northern portion of the City is provided with a combined system with stormwater outfalls upstream of the final disposal points at public watercourses (Fig. 6-1). During rainfall, excess stormwater mixed with wastewater spills over into public watercourses. Most of the wastewater generated in the northern part of the City is collected in branch sewers and laterals and flows down to the rivers. In the 1980's, two combined trunk sewers were constructed in the east ('Gran Colector del Oriente') and west ('Gran Colector del Poniente') of the City to convey wastewater coming mainly from the areas near the international airport. These two trunks join together and the wastewater is finally emptied to the Las Vacas River, causing serious river water contamination. The Las Vacas River later joins the Montagua River.

The government has a plan that wastewater from the City should be diverted as much as possible towards the Atlantic Ocean so as to prevent further contamination of rivers and of Lake Amatitlan which is already at a deplorably high level.

The areas south of the Continental Divide are less sewered than those in northern areas. Most wastewater is treated either by individuals or communities or, in some cases directly disposed of to nearby waterways or into the ground. It is observed that many of these treatment and disposal facilities are not functioning as intended, thus contaminating the receiving waters. The recent rapid rise in population concentration in the southern areas increased water consumption which in turn increased wastewater generation, hence, much raw wastewater is entering drains and rivers and finally flows into Lake Amatitlan.

The public sewerage system is not provided with treatment works, except for small individual treatment plants for communities. Thus, most of the collected raw wastewater is directly disposed of to the nearby public watercourses causing serious water contamination

Fig. 6 - 1



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and odor problems in nearby areas at many locations of the City. The sewer facilities are in general designed and constructed according to the "Design Guidelines" of EMPAGUA.

Certain maps and drawings are available showing trunk sewer layout plans, the location of outfalls and individual small scale treatment works, and sewer structures: however, such detailed data as hydraulic computation sheets, existing pipe lengths, areas covered by sewerage, sewer profiles, etc. could not to be collected. Collection of this data and information was still underway at the end of the reporting period.

6.2 FUNCTIONING OF EXISTING SMALL-SCALE SEWAGE TREATMENT PLANTS

6.2.1 Introduction

In the Study Area, there are about ten (10) small-scale sewage treatment plants and many septic tanks treating domestic wastewater from colonies (settlements).

Even though they are small- scale, the role of these plants is important considering the fact that the sewerage system, which covers more than half of the central part of the metropolitan area, is without a single treatment plant.

However, these small-scale plants are owned by many different institutions including private companies and their functioning / operational conditions were unknown.

Therefore, in this Study these sewage treatment plants were surveyed, data was collected and the possibility of rehabilitation for further use was studied. Based on the data obtained, this report was prepared as the basis for planning future rehabilitation and to consider the further role of these facilities in the Wastewater Management M/P.

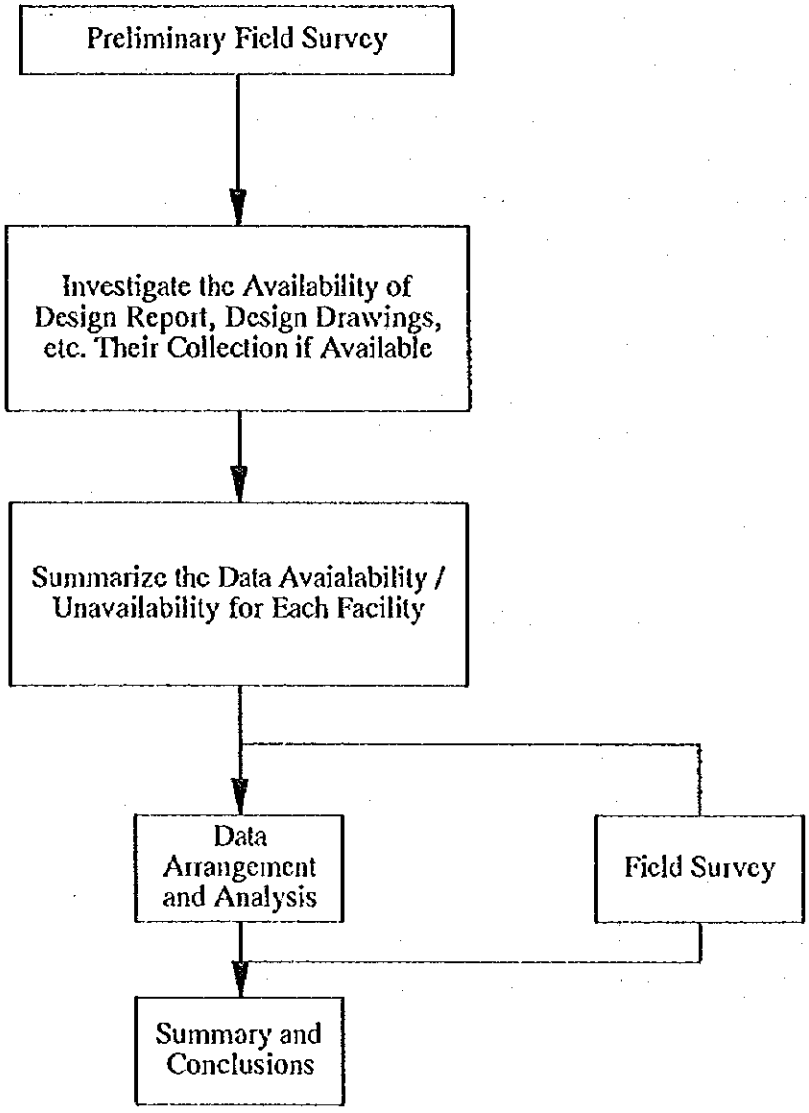
The survey was divided into two as follows;

- Facility survey
- Water and sludge quality survey

The facility survey was conducted on all significant, known facilities, (to the extent that was possible), and the water and sludge quality survey was conducted on the plant which was considered to be working as near normal as possible.

Fig. 6-2 shows the Facility Survey flow chart.

Fig. 6 - 2



THE REPUBLIC OF GUATEMALA GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)	THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE FLOW CHART FOR FACILITY SURVEY OF EXISTING SMALL-SCALE SEWAGE TREATMENT PLANTS

The following are the main items surveyed; full details of the survey are described in Supporting Report G.

a) **Condition Survey**
   - schematic of treatment flow
   - structural conditions of each facility (cracks, deterioration etc.)
   - visual survey of facility (structural intactness, materials used etc.)

b) **Hearing**
   - sludge removal drying intervals / methods
   - sludge disposal
   - problems in O/M

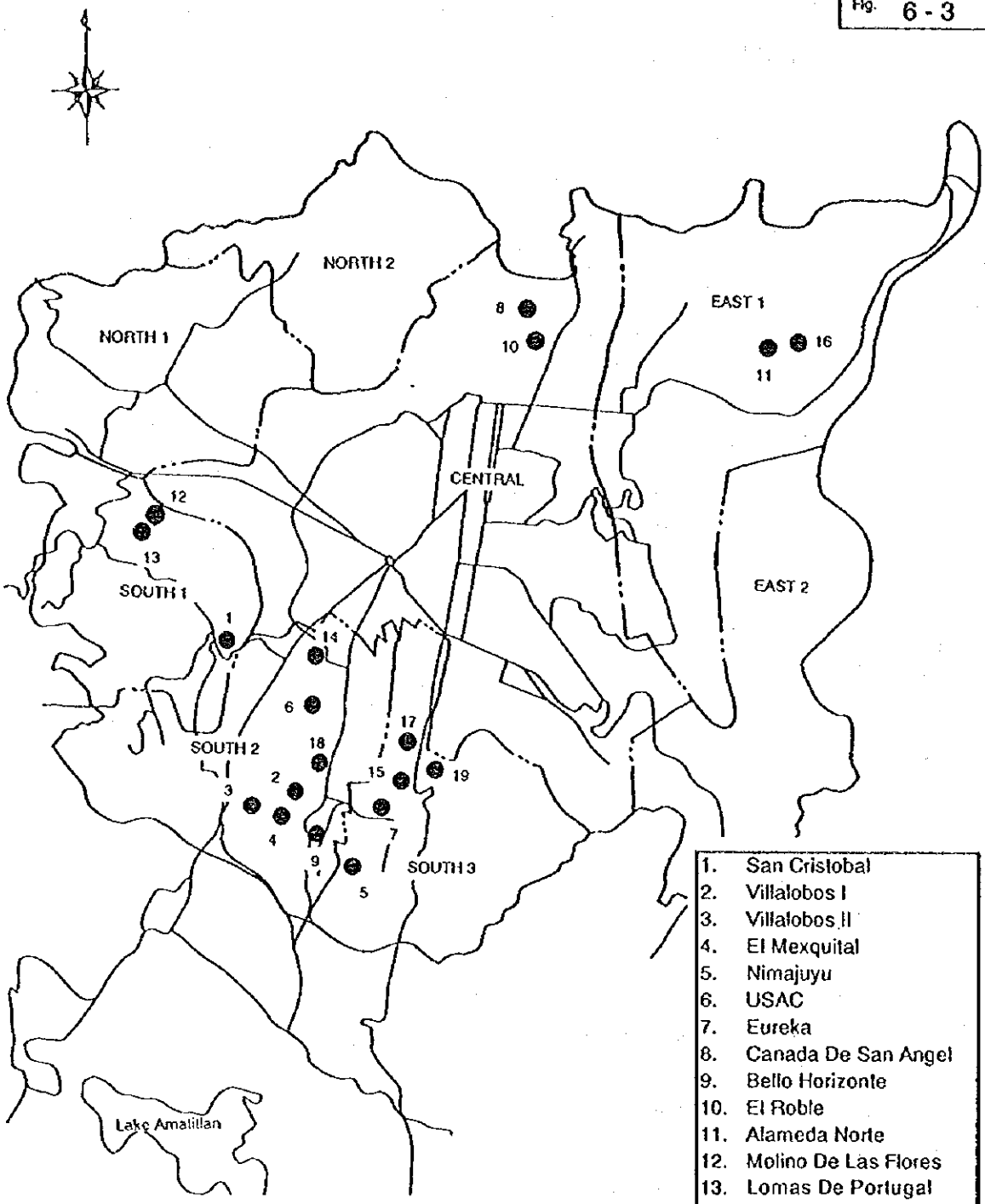
c) **Data Collection**
   - drawings (design drawings)
   - design reports
   - design calculations

Results of the preliminary field survey are as shown in Table 6-1 and the location of plants surveyed are shown in Fig. 6-3. A total number of twenty three (23) facilities were identified by EMPAGUA for survey which included small-scale sewage treatment plants and septic tanks etc.

The results from the preliminary field survey were inevitably 'rough', due to the reasons shown below,.

1) Many different public institutions (excluding EMPAGUA) and private companies are involved. Further, BANVI which constructed most of the plants is closing down and it was not possible to contact the engineers responsible for the design or O/M. Management of records was very poor and a complete record of design drawings and design reports could not be found for a single treatment plant.
2) Most of the facilities were constructed up to about 10 years ago and those who designed the facilities could not be contacted.
3) In Guatemala, designers hold the copyright to design reports, design drawings etc. and they, rather than the owners of the facilities, keep those documents. Since the facilities were constructed years before, the documents could not be located.
4) O/M of the facilities was sub-standard and, except for 2 or 3 plants, O/M was not conducted at all. Since those responsible were sometimes not available, a hearing could not be conducted for all plants.

Fig. 6 - 3



THE REPUBLIC OF GUATEMALA GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)	THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE LOCATION OF EXISTING SMALL SCALE SEWAGE TREATMENT PLANTS

Table 6-1 Results on the Preliminary Survey of Existing Small-scale Sewage Treatment Plants (1/3)

No.	Name	Existing / under construction	Owner / responsible institution	Date of Visit	Process	Operational State	Income level of served area	Number of households served	Availability of Drawings
1	San Cristobal	E	MIXCO	21-4-95	Oxidation ditch-->sedimentation-->infiltration well sludge drying bed	inlet blocked, most of the flow by-passed, activated sludge in the ditch was not good, Final Clarifier full of sludge, infiltration well(approx. 2m diameter & 70 m depth) under construction		25,000 houses	NO
2	Villa Lobos I	E	BANVI	28-4-95	Sedimentation-->trickling filterS(I,II,III)-->Final Clarifier, Sludge Digester-->Sludge Drying Bed	distributor pipes are at disconnected state	low	10,000 - 15,000 houses	YES
3	Villa Lobos II	E	BANVI	20-4-95	Sedimentation-->trickling filters(I, II)-->Final Clarifier Sludge drying beds	inlet screen blocked and flow by-passed without any treatment	low	2000 people	YES
4	El Mexquital	E	DAVIS	2-5-95	Sedimentation-->trickling filter(I, II, III)--> Final Clarifier, Sludge Digester-->Sludge Drying Bed	flow by-passed because of blockage between sedimentation tank and filter I for last two years	low		YES
5	Nimajuyu	E	BANVI	20-4-95	Sedimentation-->trickling filter(I, II)--> Final Clarifier, Sludge Drying Bed	trickling filter distributor pipe blocked	medium-medium	3,500 apartments	YES

Note : E : existing, NE : not existing, TBC : to be constructed, UR : under rehabilitation
Source : Study Team

Table 6-1 Results on the Preliminary Survey of Existing Small-scale Sewage Treatment Plants (2/3)

No.	Name	Existing / under construction	Owner / responsible institution	Date of Visit	Process	Operational State	Income level of served area	Number of households served	Availability of Drawings
6	USAC	E	USAC	16-5-95	Sedimentation -->Trickling filter(I, II, III) --> Final Clarifier Digester--> Sludge drying beds		institutional		NO
7	Eureka	E/UR	Private	21-4-95	Sedimentation --> Trickling Filter --> Final Clarifier Digester	Trickling filter under rehabilitation, sedimentation tank under construction	medium-medium		YES
8	Ca ña da De San Angel	E	Constru-Banco	21-4-95	Imhoff Tank-->Filtration		high	200 apartments	NO
9	Bello Horizonte	E	BANVI	20-4-95	Sedimentation-->trickling filter (I,II) -->final clarifier Sludge Drying beds	Primary sedimentation tank full of scum/sludge, filter distributors and filter I--filter II connection pipe blocked	medium-low	800 houses	YES
10	Roble	E	Private	28-4-95	Imhoff Tank--> Ground infiltration	not working, covered with soil	medium-high	200 houses	YES
11	Alamada Norte	E	BANVI	20-4-95	Imhoff tank	Not working	medium-low		NO
12	Molino de Las Flores	E	MIXCO	21-4-95	Septic tank --> ground infiltration	Water-way has developed along the slope second stage is discharged to Molino River	medium-high		NO
13	Lomas de Portugal	E	MIXCO	21-4-95	Septic tank --> ground infiltration	no trace of being used since construction, no influent	medium-high		NO

Note : E : existing, NE : not existing, TBC : to be constructed, , UR : under rehabilitation
Source : Study Team

Table 6-1 Results on the Preliminary Survey of Existing Small-scale Sewage Treatment Plants (3/3)

No.	Name	Existing / under construction	Owner / responsible institution	Date of Visit	Process	Operational State	Income level of served area	Number of households served	Availability of Drawings
14	El Carmen	E	Private	24-4-95	Septic Tank -->ground infiltration	covered with soil	high		NO
15	Morse	E	Private	28-4-95	Septic Tank --> ground infiltration	covered with soil			NO
16	Pinares del Norte	TBC	CIVISA	20-4-95	*Septic Tanks*	five combined-sewer outlets for 5000 houses	medium-medium	5000 houses	YES
17	Aurora II	E	USAC	19-4-95	Pilot plants		medium-high		NO
18	Central de Mayoreo	E	MUNI	28-4-95	Imhoff tank--> Ground infiltration Sludge drying beds	yet to be used	market (institutional)		NO
19	Elgin Sur	E		18-4-95	Trickling filter	Not working	high		NO
20	Justo Rufino Barrios	E	BANVI	21-4-95	Waste Stabilization Ponds	could not be found			
21	Santa Elena II	NE		24-4-95		destroyed and poached			-
22	El Paraiso Iy II	NE		24-4-95					-
23	Venezuela	NE		24-4-95		connected to Nimajuyu	medium-high		-

Note : E : existing, NE : not existing, TBC : to be constructed, UR : under rehabilitation
Source : Study Team

Based on the results of the preliminary survey, excluding those facilities which were considered not worthwhile for a further survey, a field survey and evaluation was conducted. The total number of facilities surveyed was fourteen (14).

Under the circumstances described above, the field survey was conducted and the results are reported in Section 6.2.4.

6.2.2 Water Quality Survey of Performance of Existing Treatment Plant

Villa lobos I treatment plant was selected for the water quality survey. This is one of the largest treatment plants and in a "relatively good" working condition. Fig. 6-4 shows the schematic flow diagram which consists of primary sedimentation, trickling filters (I, II & III), and final clarifier. Sludge from the primary sedimentation tank and final clarifier are digested in an open digester and dried on drying beds (presently not functioning).

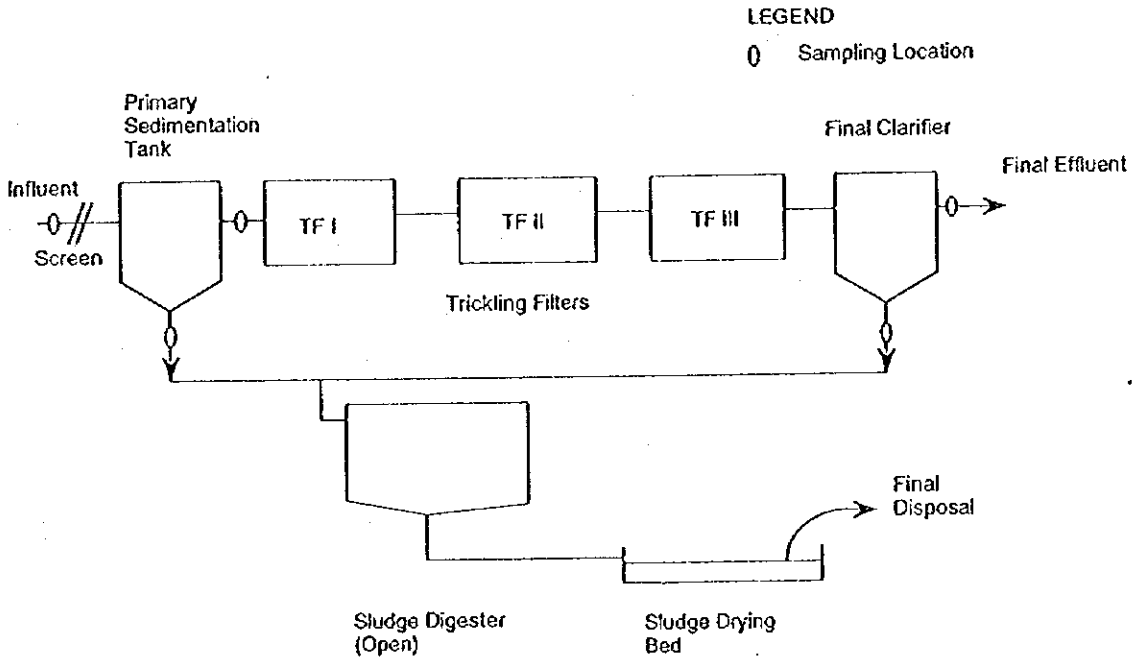
Water samples of influent, primary sedimentation tank effluent and final clarifier effluent were collected. Sampling was carried out between 7:30 and 16:00 and three samples were collected at each location. Influent flow rates were measured. Two sludge samples, one each from the primary sedimentation tank and the final clarifier, were collected for analysis.

Table 6-2 shows the result of the water and sludge quality analysis. Table 6-3 shows the average concentrations of BOD_5, COD, SS, T-N and T-P.

Based on daytime concentrations, overall removal rates were 79.4%, 77.4% and 88.4% for BOD_5, COD and SS, respectively. Given the minimal maintenance and the state of the trickling filters, the higher removal rates are encouraging. If proper maintenance were provided, further improvement in removal rates could be expected. Removal rates were Relatively high partly because of the high raw sewage concentration.

Volatile Solids in the primary sedimentation tank sludge and final clarifier were 66.6% and 70.2% respectively.

Fig. 6 - 4



THE REPUBLIC OF GUATEMALA GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)	THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE SCHEMATIC FLOW DIAGRAM FOR VILLALOBOS 1 SEWAGE TREATMENT PLANT

Table 6-2 Results of the Water Quality Survey on Existing Small-Scale Sewage Treatment Plant (Villalobos I)

Parameter		Raw Sewage			Primary Effluent			Final Effluent			Sludge	
											Primary	Secondary
		11-05-95									11-05-95	25-05-95
		8:00	12:30	15:00	8:00	12:30	15:00	8:00	12:30	15:00		
Flowrate, l/s		63.3	20.7	9.7	-	-	-	-	-	-	-	-
Temperature, °C	Ambient	23	24	24								
	Sample	24	24	24								
pH		7.1	7.7	7.4	7.3	7.1	7.2	7.5	7.6	7.4	-	-
BOD5, mg/L		573	397	696	207	218	233	122	106	110	13,810	12,899
COD, mg/L		637	441	756	208	287	282	115	158	139	19,808	19,889
SS, mg/L		484	176	230	80	140	155	52	60	24	23,700	2,650
T-N, mg/L		76.3	58.3	70.0	69.9	63.8	49.7	31.4	66.0	45.9	1,609	1,876
Fecal Coliform, MPN/100 mL		40E+04	28E+05	02E+06	01E+08	15E+06	>24E+07	01E+08	02E+08	02E+08	-	-
T-P (Total Phosphorous), mg/L		9.0	7.2	9.5	6.6	8.3	8.0	4.8	5.9	6.3	110.2	77.3
Chloride (Cl-)		42.5	50.9	88.0	35.1	40.5	47.0	31.6	21.8	39.0	-	-
Cadmium (Cd), mg/kg											4.5	7.1
Potassium (K), mg/kg											987.0	694.0
Lead (Pb), mg/kg											1.4	1.1
Zinc (Zn), mg/kg											73.6	73.6
Hexavalent chromium (Cr6+), mg/kg											0	0
Arsenic (As)											6.3	3.5
Total mercury (Hg), mg/kg											1.1	1.3
Copper (Cu), mg/kg											58.6	22.1
Iron (Fe), mg/kg											13.8	85.7
Total manganese (Mn), mg/kg											54.1	48.1
Nickel (Ni), mg/kg											2.4	2.0
Apparent Specific Gravity											1.006	1.011
Volatile Solids, kg/kg dry basis											0.666	0.702
Water Content, %											96.7	99.3
Total Solids, mg/L											32,580	9,071
Dissolved Solids, mg/L											8,880	6,421

Source: Study Team

Table 6 - 3 Average Day-Time Concentrations and Removal Rates

Parameter	Influent mg/L	Primary Effluent mg/L	Final Effluent mg/L	Removal Rate, % Primary Treatment	Secondary Treatment	Overall
BOD_5	547	219	113	60.0	48.4	79.4
COD	607	259	137	57.3	47.1	77.4
SS	389	125	45	67.9	64.0	88.4
T-N	71.7	61.1	47.8	14.7	27.8	33.3
T-P	8.7	7.6	5.7	12.6	25.0	34.5

Source : Study Team

6.2.3 Results of the Survey of Facilities

a) Operation and Maintenance

Out of the fourteen (14) facilities surveyed only eight have at least the personnel for O/M. However, none of the facilities could be said to have adequate operation and maintenance. The following are the main reasons for inadequate O/M:

- No responsible organization exists to supervise or to conduct O/M,
- No facilities were available for obtaining data on water quality and quantity,
- The operators do not have sufficient knowledge of the sewage treatment process or of sewage treatment plant operation,
- No equipment or accessories necessary for O/M were available,
- No countermeasures were taken if pipes blocked, became corroded, etc.,
- Generally, no budget was available for replacement or repair, but even when available it was inadequate,
- Access to the treatment facilities was extremely poor, especially to sludge drying beds. For many facilities, (including the sludge drying bed), access for vehicles, and hence the disposal of sludge, is impossible.

b) Structural Conditions

1) Civil Structures

Two types of materials were commonly used, reinforced concrete and concrete blocks. Reinforced concrete was mainly used for channels, circular tanks and small tanks, while the concrete block construction was used mainly for trickling filters and sludge drying beds.

Outside surfaces of reinforced concrete walls were generally in a satisfactory condition, except for minor cracks, and there were no major structural problems.

Concrete block is generally used in the construction of houses in Guatemala and is of lower cost than reinforced concrete. It seems that concrete blocks have been used for facilities which are not subject to water pressure such as trickling filters. However, durability of the blocks is inferior to reinforced concrete and there were some facilities which showed deterioration of the surface appearance.

Most facilities are located on slopes and there were no slope protection measures, therefore at some facilities, erosion has caused damage.

Even though, Guatemala is in an earthquake-prone area, it seems that no consideration of this was made when designing sewage treatment facilities.

2) Pipes

Many of the pipes which connect facilities were blocked and some of them are difficult to clean. In those plants using the trickling filter method, all facilities employ the fixed method of sewage distribution using perforated pipes. In those pipes, blockages, dislocation of joints, corrosion etc. were significant problems.

The main reason for the above was the lack of maintenance, however inappropriate pipe size and materials may also have contributed to the problem. There are a few plants where by replacing the pipes, proper functioning could be recovered.

3) Others

- Access roads

  Access to the treatment plants as well as to individual facilities was incomplete at many plants and especially access by vehicles was not possible in many cases. This was the main reason for sludge disposal not being carried out.

- Fencing

  Almost all facilities were not fenced and may be subject to trespassing.

- Storm Drainage within the Plants

  Storm drainage within the plants was inadequate and in particular the uncontrolled storm water drainage had resulted in slope erosion/failures.

c) Responsible Institutions

- Construction of the plants was carried out by BANVI and private companies.
- Since, BANVI is closing-down, DAVIS has taken-over some of the plants.
- Apart from these, non-governmental organizations (NGO), UNICEF etc. are planning new treatment plants, rehabilitation etc. and are conducting actual operation.
- many institutions are involved in the O/M and the actual situation is not very clear.

d) Possibility of Further Use If Rehabilitated

Out of the fourteen (14) plants surveyed, if rehabilitation is done, it is considered that nine (9) treatment plants can be used further. They are as follows:

- San Cristobal
- Villalobos I
- Villalobos II
- El Mexquital
- Nimajuyu
- USAC
- Canada de San Angel
- Bello Horizonte
- El Roble

However, the extent of rehabilitation recommended is different for each of the treatment plants. In each case the treatment capacity and the area served was estimated from the dimensions of the existing facilities. Even if the plants are rehabilitated, the possibility of overloading exists.

The remaining five (5) plants are considered not to justify rehabilitation. This does not mean abandoning those plants. The reasons why rehabilitation has not been recommended as part of this study are as follows:

Alameda Norte - This plant was initially designed to treat water drained from the adjacent solid waste treatment plant and its capacity is very small. It is not working at present.

		Furthermore, an organization named ARMSA is supposed to be planning to upgrade this plant.
Molino de Las Flores and El Carmen	-	These are both small septic tank facilities and it is difficult to appraise the benefits of rehabilitation.
Lomas de Portugal	-	This is also a septic tank and it has not yet been connected to the influent sewer. The effluent pipe is also damaged. Therefore, before rehabilitating the facility, it is necessary to confirm the sewer connections.
Eureka	-	This is managed by a private company and is under rehabilitation.

6.2.4 Conclusions and Recommendations

Based on the survey and analysis the following conclusions and recommendations are reached:

1) Possible Further Use If Rehabilitated

   Out of those facilities surveyed nine (9) facilities can be used further if rehabilitated.

2) Rehabilitation Cost

   The total estimated rehabilitation cost for the nine plants is Q 6.6 million at 1995 prices.

3) Necessary Conditions for Rehabilitation

   The following are the necessary preconditions, in terms of technical and O/M aspects, for implementing a rehabilitation program.

Technical Aspects

- Preparation of drawings and estimation of the capacity of facilities is necessary.
- Final selection of facilities for rehabilitation should be carried out.
- A rehabilitation plan should be prepared.

Operation and Maintenance Aspects

- The existing O/M structure and responsibilities should be clarified.
- An institutional structure should be established to be responsible for O/M of the facilities after rehabilitation (eg take-over by EMPAGUA or by another single institution i. e. ANAM).
- The O/M technology (treatment, water quality, structural aspects etc.) should be established.
- A sewerage charge collection system should be established.

Table 6-4 shows the details of the plants considered to be of further use if rehabilitated. For details on rehabilitation cost refer Data Book DA, Volume IX.

Table 6-4 Final Results on the Survey of Existing Small-scale Sewage Treatment Plants (1/2)

No.	Name	Owner / responsible institution	Process	Operational State	Flow Rate (Estimated) m3/day	Population (Estimated)	Drainage Area (Estimate)	Rehabilitation Cost (Estimate)
1	San Cristobal	DEINCO	Oxidation ditch-->sedimentation-->infiltration well sludge drying bed	inlet blocked, most of flow by-passed, activated sludge in the ditch was not good, Final Clarifier full of sludge, infiltration well(approx. 2m diameter & 70 m deep) under construction	2,100	10,000	200	Q 975,000
2	Villa Lobos I	DAVIS	Sedimentation-->trickling filterS(I,II,III)-->Final Clarifier, Sludge Digester-->Sludge Drying Bed	distributor pipes are at disconnected state	1,900	28,000	41	Q 1,115,000
3	Villa Lobos II	DAVIS	Sedimentation-->trickling filters(I, II)-->Final Clarifier Sludge drying beds	inlet screen blocked and flow by-passed without any treatment	1,800	25,000	47	Q 1,220,000
4	El Mexquital	DAVIS	Sedimentation-->trickling filter(I, II, III)--> Final Clarifier, Sludge Digester-->Sludge Drying Bed	flow is by-passed because of blockage between sedimentation tank and filter I for last two years	1,300	25,000	47	Q 738,000
5	Nimajuyu	DAVIS	Sedimentation-->trickling filter(I, II)--> Final Clarifier, Sludge Drying Bed	trickling filter distributor pipe blocked	1,200	11,000	26	Q 98,000

Source : Study Team

Table 6-4 Final Results on the Survey of Existing Small-scale Sewage Treatment Plants (2/2)

No.	Name	Owner / responsible institution	Process	Operational State	Flow Rate (Estimated) m3/day	Population (Estimated)	Drainage Area (Estimate)	Rehabilitation Cost (Estimate)
6	USAC	USAC	Sedimentation -->Trickling filter(I, II, III) --> Final Clarifier Digester--> Sludge drying beds		1,700	18,000	123	Q 521,000
7	Eureka	Private	Sedimentation --> Trickling Filter --> Final Clarifier Digester	Trickling filter under rehabilitation, sedimentation tank under construction	200	1,800	3	Q 90,000
8	Ca ña da De San Angel	IHNSA	Imhoff Tank-->Filtration		500	3,200	4	Q 192,000
9	Bello Horizonte	DAVIS	Sedimentation-->trickling filter (I,II) -->final clarifier Sludge Drying beds	Primary sedimentation tank full of scum/sludge, filter distributors and filter I--filter II connection pipe blocked	800	8,800	13	Q 697,000
10	El Roble	IHNSA	Imhoff Tank--> Ground infiltration	not working, covered with soil	100	1,400	4	Q 120,000
11	Alamada Norte	ARMSA	Imhoff tank	Not working	200	500	1	-
12	Molino de Las Flores	MIXCO	Septic tank --> ground infiltration	Water-way has developed along the slope second stage is discharged to Molino River	600	3,000	19	Q 131,000
13	Lomas de Portugal	MIXCO	Septic tank --> ground infiltration	no trace of being used since construction, no influent	100	700	16	Q 639,000
14	El Carmen	Private	Septic Tank -->ground infiltration	covered with soil	-	-	2	-
							TOTAL	Q 6,536,000

Source : Study Team

6.3 EXISTING SANITATION CONDITIONS

The Recent data about the population having access to a toilet in the Study Area was not available, however a survey was conducted by the National Institute of Statistics (INE) in 1992-1993 to estimate coverage of basic services in various municipalities of Guatemala. The results of the survey in Guatemala City, Chinautla, San Pedro Ayampac, Villa Canales, Villa Nueva, Mixco, Santa Catarina Pinula and San Miguel Petapa are described in Table 6 -5.

Table 6 -5 Population Having Access to Toilet Facility

Municipality	Total Population	Population without Toilet	% of Population without Toilet
Guatemala	925,618	60,535	6.54
Chinautla	64,420	14,056	21.82
San Pedro Ayampuc	22,653	4,161	18.37
Villa Canales	64,044	7,800	12.18
Villa Nueva	185,558	7,311	3.94
Mixco	312,772	9,133	2.92
Santa Catarina Pinula	35,856	656	1.83
San Miguel Petapa	37,272	548	1.47

Source : Republica de Guatemala INE
X Censo Nacional de Poblacion Y V de Habitacion, Cobertura de servicios Por Municipio, Julio 1993 (1992-1993)

Results show that about 6.3 % of population do not have access to toilet. The area surveyed probably also includes area outside the Study Area, however the data above gives a rough estimate of the population without a toilet.

Furthermore, to study the basic living conditions in Guatemala City, a survey "Caracterizacion De Las Areas Precarias En La Ciudad De Guatemala", was conducted by UNICEF in 1991. About 232 settlements/colonies with a total population of 801,600 were studied. This survey classified the settlements into four categories based on the type of land, accessibility, community facilities such as water, drainage, electricity, health center, school, culture center etc. These categories are described below.

a) High risk settlements : These are the most disadvantaged settlements and lack public services and community facilities. A population of 178,100 was found to be living in these high risk settlements.

b) Medium risk settlements : These offer higher living conditions than the previous category and are equipped with certain community facilities.

c) Low risk settlements : These have most community facilities and offer better living conditions.

d) No risk settlements : These settlements offer the best living conditions.

Most of the above mentioned settlements lack drainage facilities and wastewater is not being properly collected or treated. This situation has led to an environmental nuisance surrounding these settlements and, can lead to the outbreak of waterborne diseases.

6.3.1 Existing Sanitation Facilities

In the Study Area, the existing sanitation facilities have been developed by private and public developers. They can be grouped into two broad categories; Community sanitation facilities and Individual sanitation facilities and have been constructed to treat both gray water and black water. Septic Tanks are used as the main treatment method with effluent discharged to soil absorption wells. Fig. 6 -5 shows a schematic diagram of such a facility.

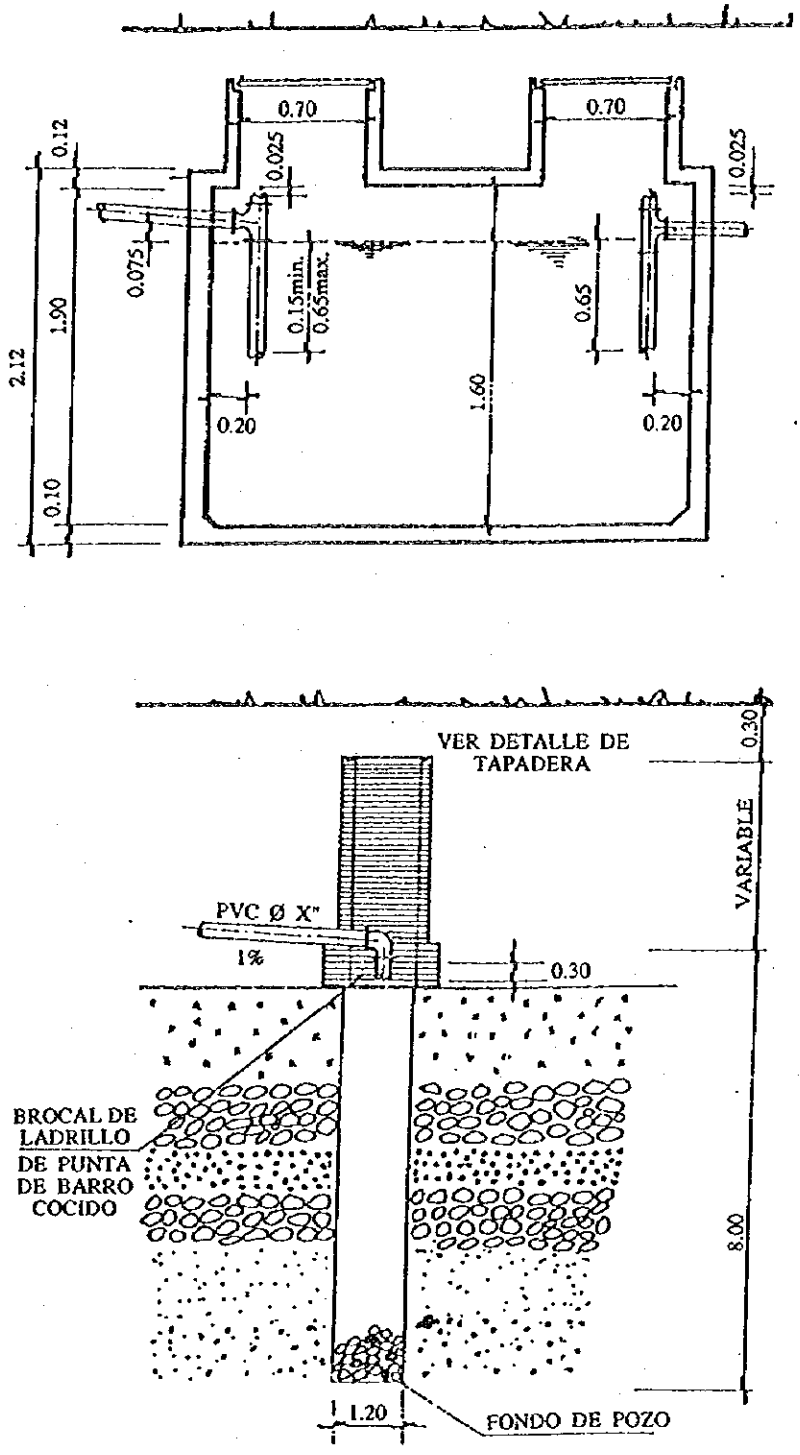
Most of the existing individual on-site systems are uncontrolled and the exact number and location is not known. The list of existing community septic tanks in Guatemala City and Mixco is shown in Table 6-6 and their location is shown in Fig. 6-6. However details of these facilities in other municipalities were not available. Similarly details of existing On-site facilities in the commercial and institutional sector were not available.

Most of the existing septic tank-soil absorption well systems were found to function properly, however in some cases clogging of the soil absorption well was reported. Septic tanks with only one absorption well suffered from more frequent clogging problem. In some cases this clogging resulted in the overflowing of partially treated wastewater to water bodies subsequently causing contamination.

6.3.2 Desludging and Treatment

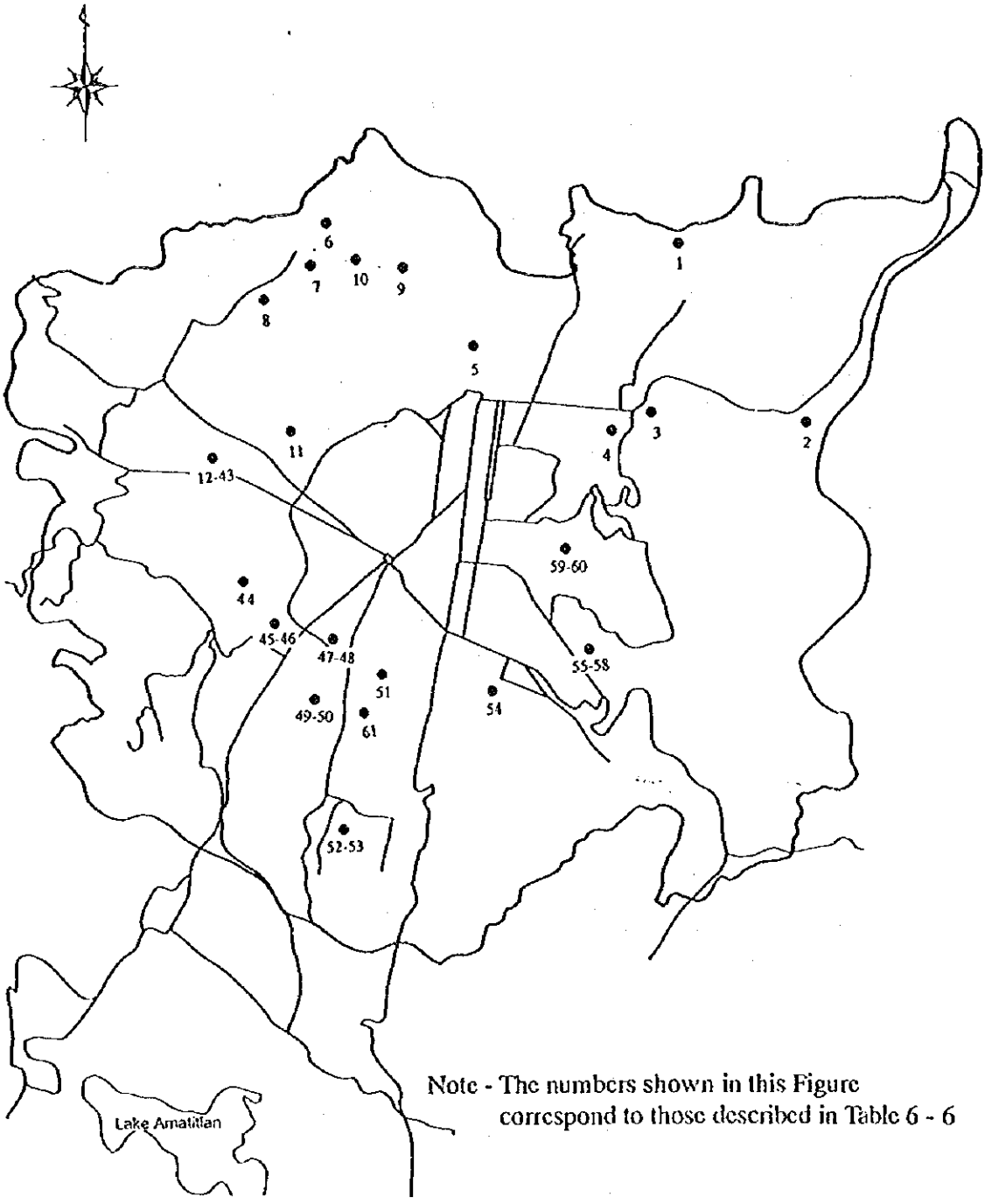
In Guatemala City, an individual/community is responsible for desludging the septic tank unit. Private companies carry out desludging and the subsequent transportation and disposal of septage, utilizing vacuum trucks. At present, septage is being dumped into the collector without any treatment. EMPAGUA is not responsible for desludging or treatment of the septage, however EMPAGUA has allowed private companies to dump septage into the collectors. Hence there is no organized sludge management in Guatemala City.

Fig. 6 - 5



THE REPUBLIC OF GUATEMALA GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)	THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE TYPICAL DRAWING OF SEPTIC TANK WITH SOIL ABSORPTION WELL USED IN STUDY AREA CITY

Fig. 6 - 6



Note - The numbers shown in this Figure correspond to those described in Table 6 - 6

THE REPUBLIC OF GUATEMALA GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)	THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE LOCATION OF EXISTING COMMUNITY SEPTIC TANKS IN GUATEMALA CITY AND MIXCO

Table 6-6 Details of Community Septic Tanks in Guatemala City and Mixco.

No.	Location	Municipality	Population Served	Actual Status
1	VAlle El Encino Z. 18	Guatemala City	1560	E
2	Fraccionamiento San Agustin Zona 17	Guatemala City	1530	UC
3	El Pinito Zona 17	Guatemala City	330	UC
4	Residencial La Sabana Zona 17	Guatemala City	780	E
5	El Zapote Zona 2	Guatemala City	78	E
6	Villas de Minerva	Mixco	250	E
7	Pianos de Minerva	Mixco	200	E
8	Minerva Sur	Mixco	150	E
9	Residenciales El Valle	Mixco	100	E
10	El Condado de lo de Fuentes	Mixco	300	E
11	Valle del Sol	Mixco	1000	E
12	Lomas del Rodeo	Mixco	500	E
13	El Castano	Mixco	200	E
14	Villa Verde I, II and III	Mixco	675	E
15	Sijan	Mixco	100	E
16	Nicajal	Mixco	150	E
17	Kajabal	Mixco	250	E
18	Villa Benecia	Mixco	50	E
19	El Rosario	Mixco	100	E
20	San Ignacio	Mixco	1000	E
21	Paraiso I	Mixco	250	E
22	Paraiso II	Mixco	300	E
23	Hoechst	Mixco	50	E
24	Roosevelt	Mixco	135	E
25	Las Flores	Mixco	100	E
26	Residenciales San Ignacio	Mixco	100	E
27	Nimajay	Mixco	400	E
28	San Carlos	Mixco	150	E
29	Hermano Pedro	Mixco	40	E
30	Palos Altos	Mixco	150	E
31	Mayorca Zone 7 Mixco	Mixco	-	E
32	Molino de Las Flores	Mixco	1500	E
33	Gema	Mixco	100	E
34	Lomas de Portugal	Mixco	750	E
35	Urbanizacion Doraldina	Mixco	200	E
36	Santa Monica I and II Zone 2 Mixco	Mixco	-	E
37	El Periodista Banvi	Mixco	300	E
38	Villas de Santa Rita	Mixco	200	E
39	Santa Rita I	Mixco	350	E
40	Santa Rita II	Mixco	250	E
41	La Ceiba	Mixco	400	E
42	Lomas de san Jacinto I,II, III and IV	Mixco	880	E
43	Berlin	Mixco	600	E
44	Condominio Las Majaditas	Mixco	250	E
45	Condomino Araucarias	Mixco	-	E
46	Condomino El Algodonal	Mixco	-	E
47	Condomino El Bosque Z. 12	Guatemala City	546	E
48	Condomino El Rosario 29 Calle 17-37 Zona 12	Guatemala City	176	E
49	Colonia Villa Sol	Guatemala City	2400	E
50	Villas Florenaa Zona 12	Guatemala City	132	E
51	Colonias Aurora I and II	Guatemala City	2670	E
52	Colonia Morse Z. 12	Guatemala City	2088	E
53	Condomino Renast C/a calley 39 av. Z.2 Vazquez	Guatemala City	584	E
54	La Terronum Zona 14	Guatemala City	2000	E
55	Condomino Chacon	Guatemala City	-	E
56	Residencials Exclusivas de Vista Hermosa Z 15	Guatemala City	204	E
57	Residencials Lafayette Z. 15	Guatemala City	420	E
58	Condomino Los Andes	Guatemala City	-	E
59	Residencials El Valle Z.15	Guatemala City	210	E
60	Condomino Reambrandt Zona 15	Guatemala City	46	E
61	Colonia Santa Eusa Zona 12	Guatemala City	480	UR

Note : E : Existing, UC: Under Construction, UR : Under Rehabilation
Source : EMPAGUA, Mixco Municipality

On the other hand, Mixco municipality provides desludging of septic tank units existing in the Mixco municipality; this is referred to as Public desludging in this report. The frequency of desludging is highly variable ranging from a few months to several years. The average span of desludging for a typical household is about once in two (2) years. Desludged septage is being dumped without any treatment.

Public desludging by Mixco municipality and private desludging by private companies are discussed separately in the subsequent sections.

a) Private Desludging

Private companies provide desludging using vacuum trucks. The Most commonly used vacuum trucks were of 1.1 m^3 (300 gal) capacity and 2.2 m^3 (600 gal) capacity. A driver and assistant are usually assigned to each truck.

The area covered by private companies is mainly Guatemala City and customers are high and middle income residents, hotels and restaurants. The majority of septic tanks are individual ones. However details of customers being provided with desludging services were not available. The request for desludging could be made by telephone and desludging is usually done two (2) days after the request. However in the case of an emergency call, services are provided within 8 to 12 hrs. The frequency of desludging was reported to be once every 18 months. Many private companies were asked about their desludging charges and the average desludging charge was found to be Q 450 for a 1.1 m^3 truck. After desludging, septage is dumped into the collector without treatment which has been permitted by EMPAGUA.

b) Public Desludging

Mixco municipality carries out desludging of septic tanks located within its municipality. Most of these are community septic tanks. Actually the municipality does not provide desludging itself but through private companies.

The request for desludging from a community to Mixco municipality is accepted only by written application. Hence it is necessary for the community representative to make a direct visit to the municipality office. The maximum waiting time until the desludging service is provided is reported to be about 45 days due to the tedious procedure involved. First an application has to be approved by a councilor and then public tender is invited and a private company is selected for providing desludging services. The municipality does not charge the community however the total cost of desludging and transporting was reported as Q 32/m^3

by Mixco municipality. Septage is dumped in open areas without treatment.

c) Comprehensive Evaluation

Private desludging is being carried out for high income individual customers and businesses whereas public desludging is carried out for communities. Public desludging is carried out free of charge as a service by the municipality whereas the desludging charge is as high as Q 410/m^3 in the case of private desludging. Private desludging provides a prompt service and the usual waiting time is 2 days (and in case of emergency only 8-12 hrs), whereas waiting time in the case of public desludging is as long as 45 days.

The most important deficiency of the existing practice of both public and private desludging and disposal is the absence of a sludge treatment plant to ensure an environmentally acceptable means of sludge disposal.

CHAPTER 7

FUNDAMENTALS OF PLANNING FRAMEWORK

7 FUNDAMENTALS OF PLANNING FRAMEWORK

7.1 TARGET YEAR

To carry out the master planning for the development of an economically viable sewerage and sanitation system, the elements of work necessary are forecast and generally defined in successive stages to meet the present and future needs of the Study Area up to the year 2015. The Master Plan should, therefore, be compatible with sound projections of population increase, development programs, water consumption, income growth, and other national and local socio-economic factors affecting the future of the Guatemala Metropolitan Area.

7.2 REGIONS/DISTRICTS

As stated in Section 2.4 above, the Study Area is separated into north, south and east catchments by three major watersheds. For the purpose of planning the staged implementation of sewerage and sanitation works, these three catchments are subdivided into smaller Regions for further consideration. The eastern catchment is divided into East 1 and East 2 Regions, the northern catchment into Central, North 1 and North 2 Regions and the southern catchment into South 1, South 2 and South 3 as shown in Fig 7-1. The boundaries of these Regions were defined based on topographical considerations and administrative boundaries. Table 7-1 shows the planned areas by municipalities and Regions while Table 7-2 shows the land use distribution within and outside the Study Area by Region. The total area for all Regions for sewerage and sanitation implementation is 20,470 ha, excluding green areas and valley's, out of the total Study Area of 34,500 ha.

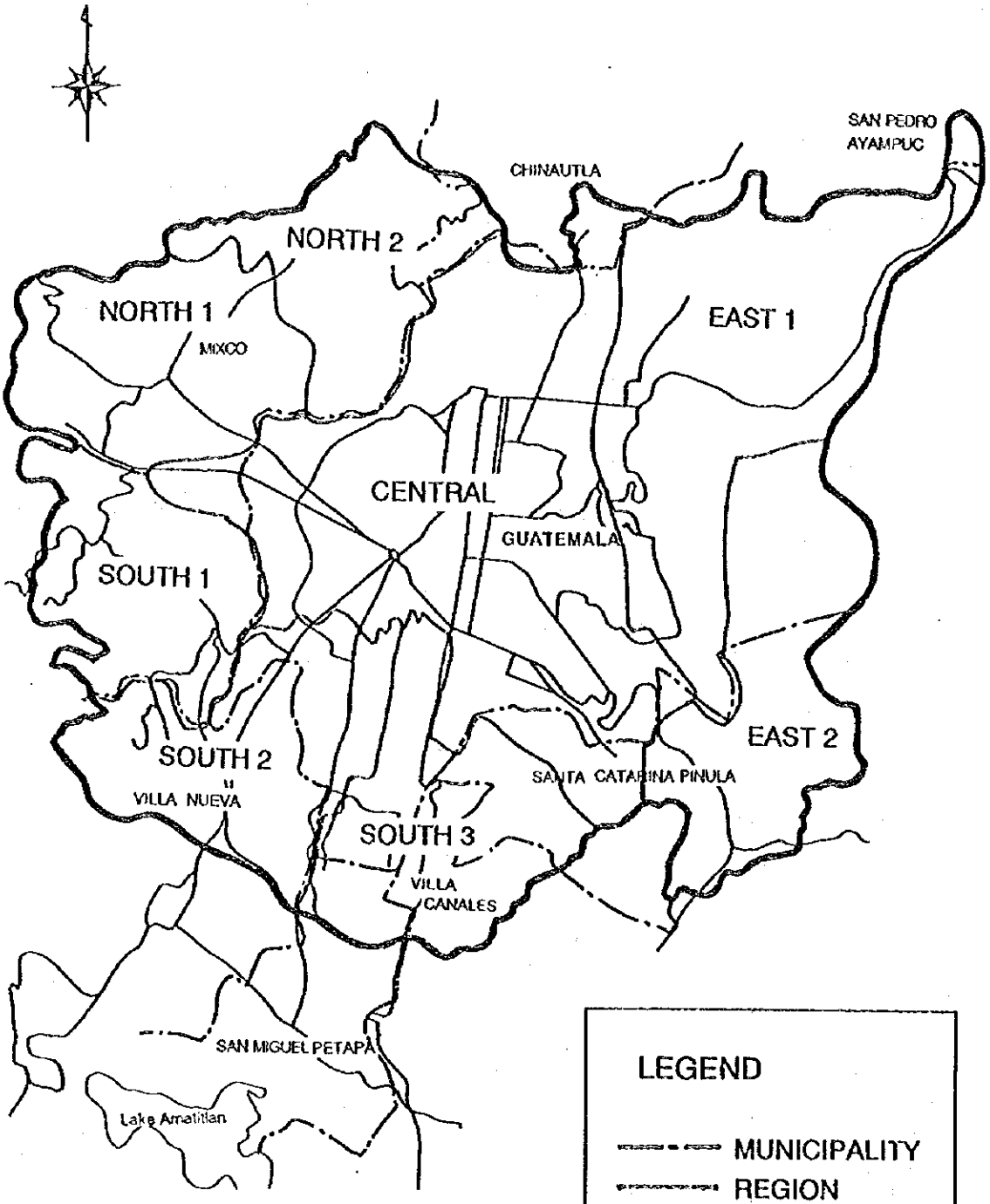
Table 7-1 Planned Area by Municipalities and Regions

<Unit:ha>

Region	Guatemala City	Mixco	Villa Nueva	San Miguel Petapa	Villa Canales	Santa Catarina Pinuala	Chinautla	San Pedro Ayampuc	Total
Central	5,955	235				100	170		6,460
North 1	110	2,080							2,190
North 2		695					45		740
South 1		1,640							1,640
South 2	970		1,250						2,220
South 3	710			370	960	320			2,360
East 1	3,705								3,705
East 2	200					955			1,155
Total	11,650	4,650	1,250	370	960	1,375	215	0	20,470

Source :Study Team

Fig. 7 - 1



THE REPUBLIC OF GUATEMALA GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)	THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE LAYOUT OF SEWERAGE / SANITATION REGIONS

Table 7-2 Land Use Distribution Within and Outside Study Area by Regions

(Unit: ha)

Region	Inside of Planned Area					Outside of Planned Area			Total
	Residential & Commercial	Industrial	Public	Others	Sub Total	Greeneries	Valley & Forest	Sub Total	
Central	5,942	179	118	221	6,460	129	2,796	2,925	9,385
North 1	2,073	65	52		2,190		835	835	3,025
North 2	740				740	220	1,750	1,970	2,710
South 1	1,448	6	0	186	1,640		1,080	1,080	2,720
South 2	1,761	333	106	20	2,220	55	1,215	1,270	3,490
South 3	2,105	85	170		2,360	185	775	960	3,320
East 1	2,395	198	66	1,046	3,705	305	2,050	2,355	6,060
East 2	1,155				1,155		2,635	2,635	3,790
Total	17,619	866	512	1,473	20,470	894	13,136	14,030	34,500

Source : Study Team

7.3 PLANNED POPULATION AND WASTEWATER GENERATION

The total area and estimated current (1994 census) and projected future (2015) population to be served by sewerage/sanitation for each Region are shown in Table 7-3 and in Fig. 7-2. Table 7-4 shows the planned population in 2015 within the Study Area by municipality.

Table 7-3 Population to be Served by Sewerage/Sanitation M/P by Regions

Regions	Area ha	Population				
		Total		Sewerage	Sanitation	
		1994	2015	2015	1994	2015
Central	6,460	508,500	861,400	751,800	109,600	109,600
North 1	2,190	180,000	392,000	379,100	12,900	12,900
North 2*	740	72,000	150,000	-	72,000	150,000
South 1	1,640	40,000	280,000	277,500	2,500	2,500
South 2	2,220	83,000	191,600	183,600	8,000	8,000
South 3	2,360	134,000	279,000	276,100	2,900	2,900
East 1	3,705	251,000	521,000	500,800	20,200	20,200
East 2*	1,155	25,800	40,000	-	25,800	40,000
Total	20,470	1,294,300	2,715,000	2,368,900	253,900	346,100

Note: (*) Only a sanitation system is to be provided.
Source : Study Team

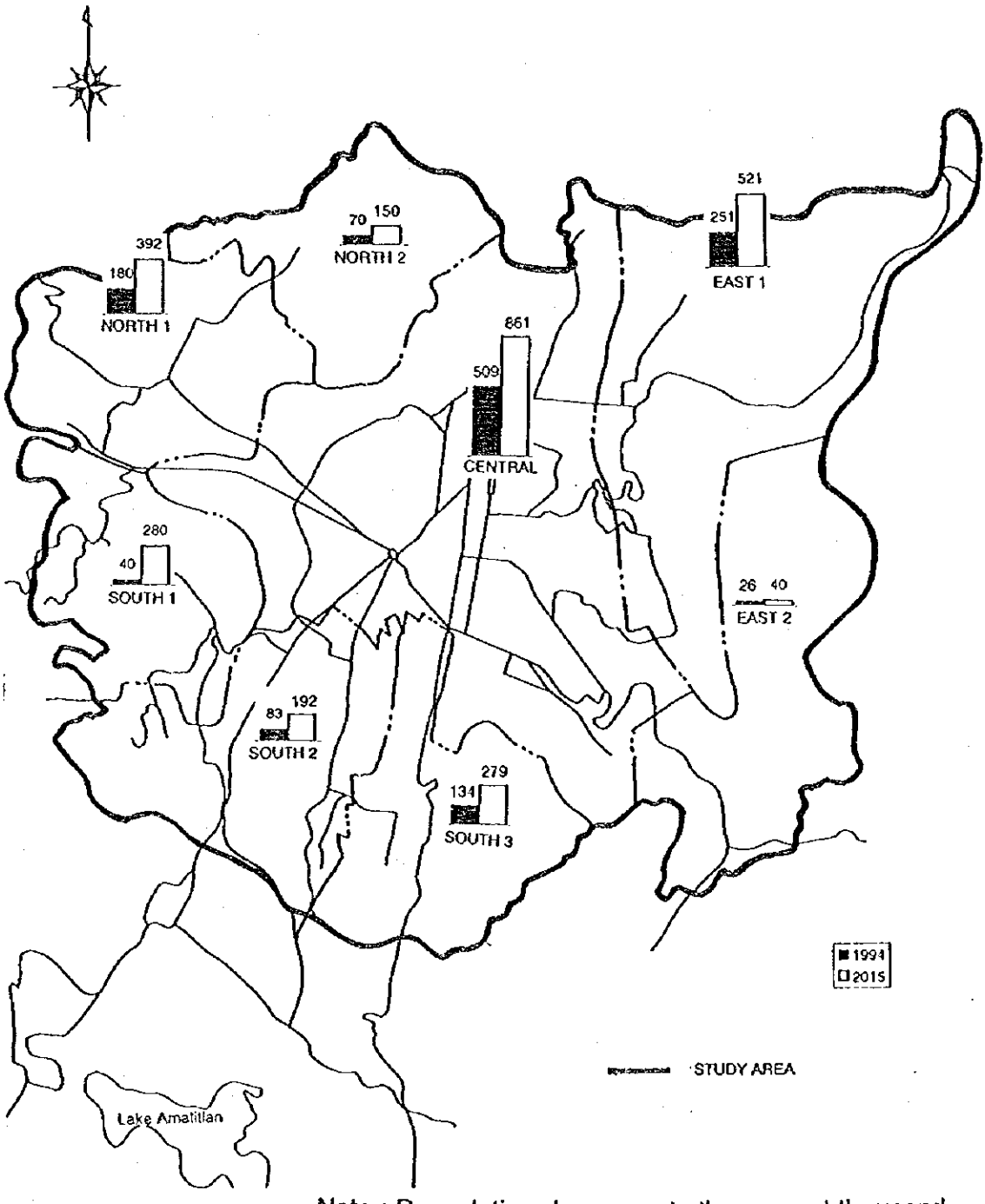
Table 7-4 Planned Population by Municipalities Within Study Area in 2015

Municipality	Population in the Study Area			Others	Total
	Sewerage	Sanitation	Total		
Guatemala City	1,391,200	141,800	1,533,000	9,000	1,542,000
Mixco	662,600	153,400	816,000	25,000	841,000
Villa Nueva	120,400	5,200	125,600	337,400	463,000
San Miguel Petapa	36,600	400	37,000	61,000	98,000
Villa Canales	95,100	900	96,000	81,000	177,000
Santa Catarina Pinula	28,000	30,400	58,400	4,600	63,000
Chinautla	35,000	12,000	47,000	102,000	149,000
San Pedro Ayampuc		2,000	2,000	18,000	20,000
Total	2,368,900	346,100	2,715,000	638,000	3,353,000

Note: Planned population for San Pedro Ayampuc falling within the Study Area (50 ha) was estimated with a population density of 40 person/ha.

Source: Study Team

Fig. 7 - 2



Note : Popuplation shown are to the nearest thousand

THE REPUBLIC OF GUATEMALA GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)	THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE POPULATION TO BE SERVED BY SEWERAGE / SANITATION IN EACH REGION

Table 7-5 shows the projected unit wastewater generation in 2015 (for details see Supporting Report K, Pollutant Load Generation).

Table 7-5 Unit Wastewater Generation in the Year 2015

Area	Domestic	Institutional/ Commercial	Gross Average Per Capita Water Consumption (lpcd)
Central Guatemala & Mixco	200	95	295
Others	200	20	220

Source : Study Team

The design wastewater flowrate is estimated by adding:

a) domestic/institutional wastewater
b) industrial wastewater
c) groundwater infiltration

Industrial wastewater generation is assumed to be 35 m^3/(ha.d) for the industrial land use area excluding the area covered by road (25% of the total).

Groundwater infiltration is assumed to be 5% of the wastewater generated, which is 15 lpcd for Central Guatemala and 10 lpcd for other areas.

Daily wastewater flow variations have been estimated based on water supply data, (refer to Supporting Report K), as follows:

Daily average flow rate : Daily maximum flow rate : Hourly maximum flow rate
= 1.00 : 1.10 : 1.65

Table 7-6 shows the planned wastewater quantity generated for each Region in 2015.

Sanitation facilities are designed for an average water consumption of 150 lpcd at present and assuming a 10% increase, average wastewater generation in the year 2015 will be 165 lpcd.

Table 7-6 Planned Wastewater Quantity for Sewerage System in 2015

Region		Planned Population	Domestic and Commercial Wastewater			Industrial Wastewater		Ground Water	Total			Wet Weather Flow
			Daily Average	Daily Maximum	Hourly Maximum	Daily Average	Hourly Maximum		Daily Average	Daily Maximum	Hourly Maximum	
Central	Separate	80,100	23,630	26,033	39,249			1,202	24,832	27,235	40,451	40,451
	Combined	671,700	198,151	218,302	329,133	4,699	9,398	10,075	212,925	233,076	348,606	1,045,818
	Sub Total	751,800	221,781	244,335	368,382	4,699	9,398	11,277	237,757	260,311	389,057	1,086,269
North 1		379,100	83,402	90,984	136,476	1,706	3,412	3,791	88,899	96,481	143,679	
South 1		277,500	61,050	66,600	99,900	158	316	2,775	63,983	69,533	102,991	
South 2		183,600	40,392	44,064	66,096	8,741	17,482	1,836	50,969	54,641	85,414	
South 3		276,100	60,742	66,264	99,396	2,231	4,462	2,761	65,734	71,256	106,619	
East 1		500,800	110,176	120,192	180,288	5,198	10,396	5,008	120,382	130,398	195,692	
Total		2,368,900	577,543	632,439	950,538	22,733	45,466	27,448	627,724	682,620	1,023,452	

Note: For industrial Wastewater daily average and daily maximum are assumed to be equal. All flows are in m3/d.

Source: Study Team

7.4 WASTEWATER QUALITY

Wastewater quality, in terms of BOD_5 and SS, for planning of wastewater treatment facilities and sanitation systems, has been estimated based on the water quality survey results and reported unit pollutant load generation (Refer Supporting Report K, Pollutant Load Generation). The BOD_5 and SS wastewater concentrations are assumed to be as follows:

(1) Sewerage system 280 mg/L
(2) Sanitation system 330 mg/L

7.5 ADVANTAGES AND DISADVANTAGES OF BYPASSING LAKE AMATITLAN

A preliminary study was carried out on measures to improve the water quality of Lake Amatitlan by alleviating the currently uncontrolled waste load inflows to the lake. Under the present conditions, it is obvious that the inflowing waste loads should be reduced by the provision of wastewater treatment, preferably to the secondary treatment level. Secondary treatment processes can remove 80% to 90% of organic wastes, thereby considerably reducing the inflowing waste load. However, a question still remains as to whether the treated wastewater effluent should be discharged directly to the Lake or should bypass it.

Due to the topography and geography of the area, if the effluent is to bypass the lake, the outfall will need to be laid almost 10 km along the lakeside. Under these conditions, bypassing will be far more costly than the direct discharge of the effluent to the lake. Thus, bypassing appears to be an inappropriate solution in terms of cost effectiveness.

Two alternative plans for disposal of treated effluent are either by:

(i) Bypassing the Lake using an outfall after secondary treatment, or

(ii) Discharging directly to the lake after secondary treatment.

Direct discharge of secondary treatment effluent will be more advantageous than bypassing for the following reasons:

(1) For bypassing, a large size outfall more than 10 km long would need to be laid. This would require a large amount of capital and O/M investment.

(2) At present, an average of 2.33 m^3/sec of contaminated river water flows into the Lake through the Villalobos and other rivers, which comprise the major source of water to the Lake. At the same time, it is a major source of waste load. To minimize the inflow of waste to the Lake, much of the wastewater has to be treated with an appropriate treatment process, preferably to at least secondary treatment level.

(3) If treated wastewater effluent is to be bypassed, the inflow to the Lake will be significantly decreased. The lake water balance is a sensitive issue with respect to hydrological and ecological viewpoints, and the extent of impacts on the environment in and around the Lake, due to bypassing, has to be carefully considered. It is not possible, within the time-frame of this report, to carry out such an appraisal.

(4) The secondary wastewater treatment system may be upgraded and expanded in the future, whenever it becomes mandatory due to more stringent requirements for water quality improvement or for any other reasons. For bypassing, an advanced wastewater treatment would be required from the first stage because Michatoya River water is used directly for bathing and washing by people, and the water quality of the Michatoya River is very much better.

(5) It would be prudent, as a first step, to provide secondary treatment, and then to carefully monitor the water quality improvement of the lake environment to obtain conclusive results, based on which the necessity of bypassing could be accurately assessed at a later stage.

Although more comprehensive and detailed analysis is necessary to identify the degree of influence on the lake environment of wastewater bypassing, it is believed at this stage that the provision of a secondary treatment plant and disposal of treated effluent to the Lake would be the most appropriate solution which would significantly contribute to reducing waste inflows and improving the Lake water quality.

7.6 TREATMENT LEVEL

Existing effluent standards for municipal wastewater discharges (Government Agreement No. 60-89) can be satisfied by primary treatment. Under the circumstances of little or no existing treatment of wastewater, those standards were set as a first step towards requiring at least primary treatment. This type of standard is called a treatment-based standard. They are not based on the requirements of receiving water bodies.

Alternatively, the level of treatment necessary before discharge to a public water body may be determined based on the characteristics and intended utilization of a receiving water body. In other words, to protect the intended utilization of a water body, such as for drinking, irrigation, recreation, aesthetic appearance etc., allowable discharge limits are set. This type of standard is called water quality-based standard.

The development and implementation of effluent standards from treatment-based standards towards water quality-based standards is increasingly complex and requires a long time span, financial investment, technical development etc. Water quality-based standards are more sophisticated and require a through knowledge of the area and the water body. Treatment based standards may be based on primary, secondary or advanced level treatment and issues concerning industrial wastewater treatment are also relevant.

Considering the existing condition of virtually no wastewater treatment, only treatment-based standards are considered in the Master Plan for wastewater management up to 2015. Various possible scenarios of such effluent standards are discussed in the following section.

7.6.1 Scenarios of Effluent Standards

Scenario's of effluent standards are proposed as follows:

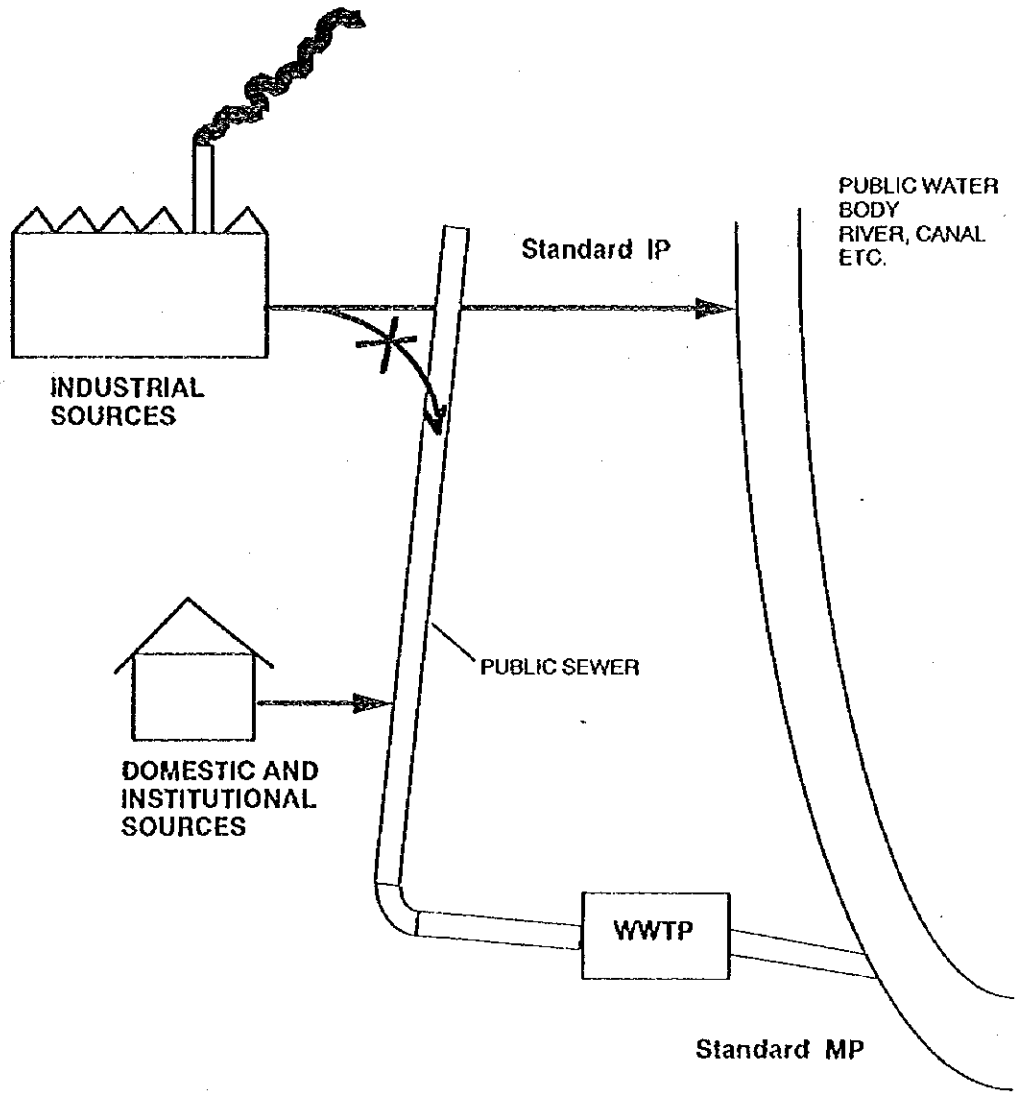
Case I To comply with the existing effluent standards

Industrial wastewater will not be accepted into public sewers (Fig. 7 - 3). Domestic wastewater is to be treated to comply with the existing standard. Industrial wastewater is to be treated by the industries themselves and discharged into the waterways directly. Industries discharging into sewers at present will be allowed to continue to do so except for those discharging heavy metals / hazardous substances but will be required to pay for sewerage services.

Case II Revise Existing Standards

Revise the existing standards such that the existing effluent standards for industries become the standards for discharging into the public sewers (Fig. 7 - 4). Industrial wastewater containing heavy metals and hazardous substances which interferes with operation of the sewage treatment process will not be accepted. Basically industrial wastewater will be accepted into public sewers with some restrictions for large# industries. Effluent standards will be the same for domestic effluent and industries, and the values will be the same as that of domestic wastewater at present. However, it is necessary to add more parameters.

Fig. 7 - 3



Note WWTP - Public Wastewater Treatment Plant
Standard IP - Effluent Standards for Industrial Wastewater into Public Waterbody
Standard MP - Effluent Standards for Municipal Wastewater into Public Waterbody

CASE I
- **NOT ACCEPT INDUSTRIAL WASTEWATERS**
- **EXISTING STANDARDS (60-89)**
- **INDUSTRIES DISCHARGING TO PUBLIC SEWERS AT PRESENT SHALL PAY SEWERAGE CHARGES**

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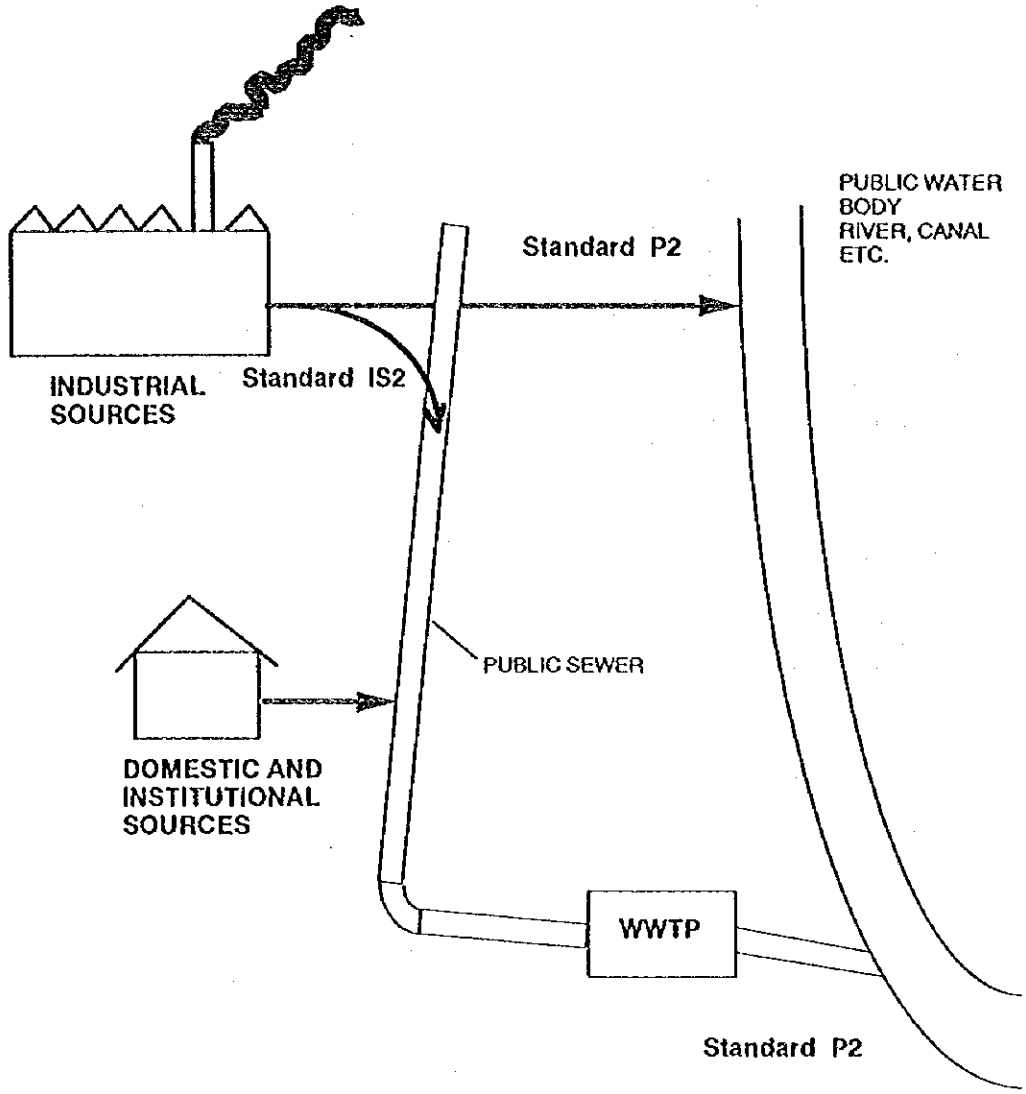
Fig. 7 - 4



Note WWTP - Public Wastewater Treatment Plant
Standard P2 - Effluent Standards for Industrial Wastewater into Public Waterbody
Standard IS2 - Discharge Standards for Industrial Wastewater into Public Sewers
Standard P2 - Effluent Standards for Municipal Wastewater into Public Waterbody

CASE 2
- ACCEPT INDUSTRIAL WASTEWATERS
- REVISE EXISTING STANDARDS (60-89)
- EFFLUENT STANDARDS FOR MUNICIPAL WASTEWATER AND INDUSTRIAL WASTEWATER INTO PUBLIC WATER BODY ARE THE SAME
- DISCHARGE STANDARDS FOR INDUSTRIAL WASTEWATER INTO PUBLIC SEWER REMAINS AT THE SAME LEVEL AS Standard IS2

THE REPUBLIC OF GUATEMALA GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)	THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE SCENARIOS OF EFFLUENT STANDARDS - CASE II

Case III Improved (stricter) Standards

This will be an extension of Case II, in which effluent standards will be improved to the next level (stricter), for example to the secondary treatment level (Fig. 7 - 5). Actual values set for this level will depend on the combined wastewater quality of domestic sewage and industrial wastewater.

Note # Industries discharging large volumes of wastewater and of high concentration compared with domestic sewage, will significantly increase the concentration of wastewater inflow to the sewage treatment works. Those industries can either treat their wastewater themselves or may opt to discharge into public sewers. However, if they would like to discharge into public sewers, they need to pretreat their wastewater to an extent which will depend on the wastewater quality and quantity. This restriction arises from the need for the treatment plant to satisfy the effluent standards.

Table 7 - 7 shows a summary of effluent standards for Cases I, II, and III and Table 7 - 8 shows the example of BOD concentration.

Table 7 - 7 Scenario of Effluent Standards

Source	Case 1	Case 2	Case 3
Effluent Standards for Municipal Wastewater into Public Water Body	Standard MP	Standard P2	Standard P3
Effluent Standards for Industrial Wastewater into Public Water Body	Standard IP		
Discharge Standards for Industrial Wastewater into Public Sewers	_*	Standard IS2	

Note: *Only permitted for those industries with existing discharges.

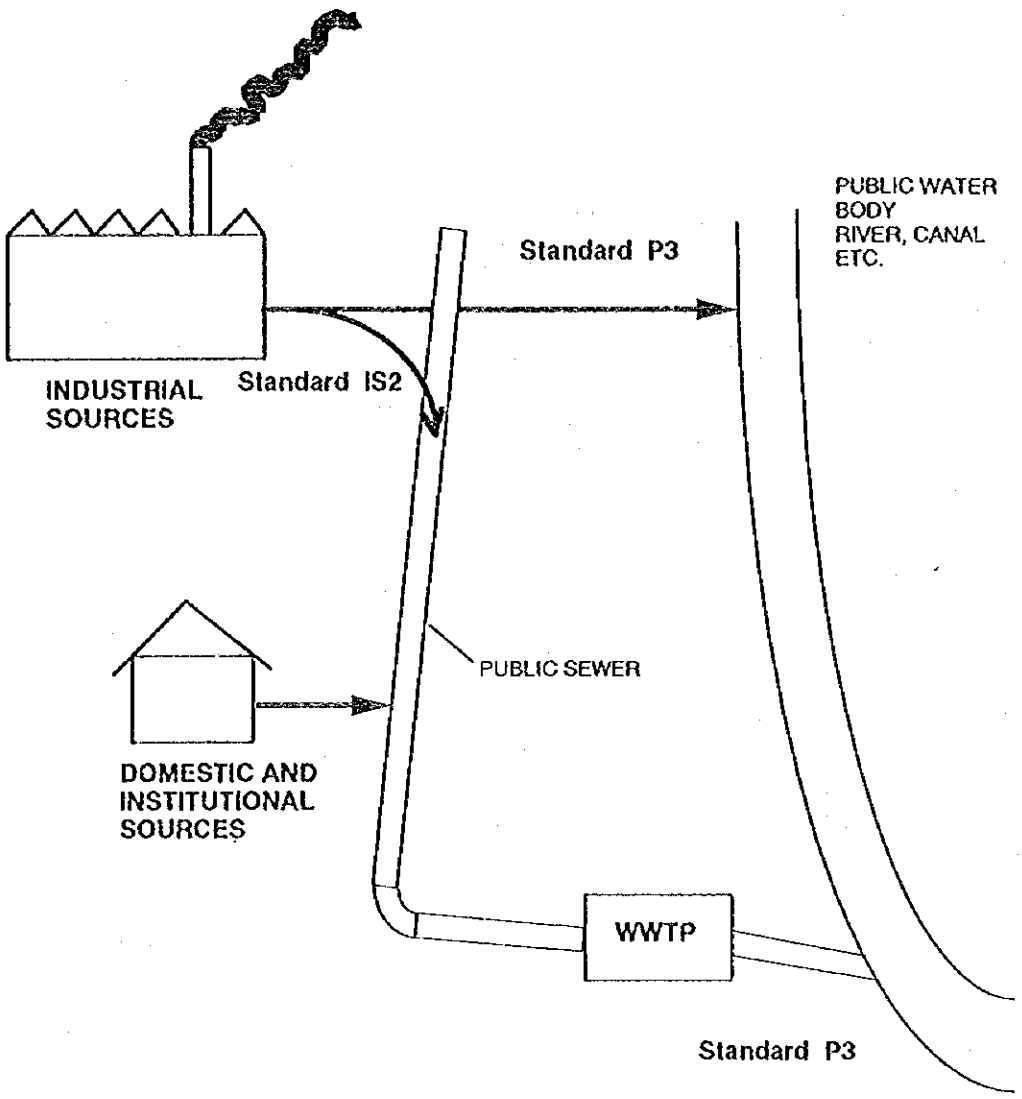
Source : Study Team

Table 7 - 8 Example of Effluent Standards (BOD)

Case	Standard	BOD Concentration mg/L
Case 1	Standard MP	200
	Standard IP (e. g. brewery)	900
Case 2	Standard P2	200
	Standard IS2 (e. g. brewery)	900
Case 3	Standard P3	< 200

Source : Study Team

Fig. 7 - 5



Note
- WWTP - Public Wastewater Treatment Plant
- Standard P3 - Effluent Standards for Industrial Wastewater into Public Waterbody
- Standard IS2 - Discharge Standards for Industrial Wastewater into Public Sewers
- Standard P3 - Effluent Standards for Municipal Wastewater into Public Waterbody

CASE 3

- MORE STRINGENT STANDARDS THAN CASE 2
- ACCEPT INDUSTRIAL WASTEWATERS
- EFFLUENT STANDARDS FOR MUNICIPAL WASTEWATER AND INDUSTRIAL WASTEWATER INTO PUBLIC WATERBODY ARE THE SAME
- DISCHARGE STANDARDS FOR INDUSTRIAL WASTEWATER INTO PUBLIC SEWER REMAINS AT THE SAME LEVEL AS Standard IS2

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7.6.2 Enactment and Implementation of Effluent Standards

As discussed in the previous section, enactment and implementation of effluent standards and discharge standards, (for industrial wastewater), shall be conducted by the respective implementing authorities. As for industrial effluents, necessary procedures shall be taken to provide necessary legal authority for EMPAGUA (or Municipality) to set standards/regulations for accepting industrial wastewater. To ensure safe and reliable functioning of the sewerage system, industries shall provide data on a) flow rate of wastewater and b) characteristics and composition of wastewater to EMPAGUA, to enable EMPAGUA to decide whether or not to accept industrial wastewater into its sewerage system.

CHAPTER 8

STUDY ON WASTEWATER MANAGEMENT FACILITIES

8 STUDY ON WASTEWATER MANAGEMENT FACILITIES

8.1 WASTEWATER COLLECTION SYSTEM

8.1.1 Combined Versus Separate System

The wastewater collection system should be planned as a separate system, which receives wastewater, but not storm water runoff. To select the most suitable collection system for the M/P Area, such various relevant factors as waste disposal methods, rainfall characteristics, topographical features, water uses, and physical planning limitations, have been taken into consideration, as summarized in the following:

(a) A basic considerations influencing the selection of the type of sewerage system for use in Metropolitan Guatemala is the existence of an established sewer collection system. In most of the central and built-up urban area in Guatemala City, an old combined sewerage system is predominantly utilized. However, newly constructed sewer systems adopt the separate collection system. It is obvious that for any urban area where a basic natural flood control system is functional, the concept of a combined sewerage system is hardly justifiable.

(b) The study of the existing water pollution conditions in the Guatemala Metropolitan Area clearly indicates that the rivers and other waterways have been heavily polluted with sanitary and various other wastes, particularly during dry seasons when the rivers and other waterways become, essentially, the trunk and intercepting sewers of the City. These conditions dictate that only with the establishment of a separate system of major trunk and intercepting sewers can sanitary wastes be kept out of the rivers and storm drains, thereby changing the present situation of gross pollution and setting the basis for a progressive cleanup of the City. Thus, the provision of separate sanitary main sewers and interceptors is essential for the City, as a first step in the right direction.

(c) It is recognized, that because of limitations of funds, separate sanitary sewers may not be provided for all of the City area at this time. Hence, it will be necessary to defer construction of sewers in certain areas where problems are less critical, for example, those reasonably well served by septic tanks and leaching beds, or for the time being, those which could be so served. Also, advantage can be taken of the local storm drainage system, on an interim basis, to serve for transporting dry weather sullage flows to main trunk sewers. Similarly, in other areas where house

sewers discharge the wastewaters into the existing local storm drains which in turn flow to the rivers, these drains in some areas may serve to convey the dry weather sullage waste flows to the sanitary trunk sewers/interceptors. In both cases, overflow structures would be provided to prevent overloading of the sanitary trunk sewers/interceptors and treatment facilities during storms.

(d) The basic concept of the strategic plan are therefore i) to delineate the necessary minimum system of sewers and interceptors needed to serve the M/P Area, beginning with the more critical areas within which conditions are serious and the bulk of the population resides, ii) to develop a plan for progressive provision of local sewers, with the interim use of local storm drains where advantageous, and generally giving priority to those areas having the most critical conditions, and iii) to develop a plan of wastewater treatment and disposal which will provide adequate protection of the waterways.

(e) The most significant disadvantage of a combined sewerage system is that, when it rains, the system may causes pollution in the receiving water due to the overflow of untreated waste. However, because of the high intensity of rainfall in Guatemala, sewage discharge to storm sewers or combined sewers will generally be heavily diluted at times of rain. The overflows from combined sewers will therefore be greatly diluted and thus will not have a significant impact on rivers and waterways which receive the overflow, especially considering that these waterways will themselves be at their maximum flow range.

(f) A study(*) on the extent of BOD loading overflows due to from a combined sewer system, calculated for different intercepting sewer capacities, indicates that BOD lost through overflows over a one year period, with the intercepting sewer capacity of one times peak dry weather flow(PDWF), is 2.04 % of the total BOD carried through the sewers, and with a capacity of 10 times PDWF capacity it is 1.40 %. Thus, during times of storm, waste will overflow to the receiving water bodies, irrespective of whether the intercepting sewer capacity of 1 times PDWF and 10 times PDWF. In any case, at such times the overflows will be highly diluted.

(g) Because combined sewers are normally laid deeper than storm channels, excavation costs would be increased. Further, pumping up from greater depths would be required, thus the increased pumping station and power costs to levels would usually exceed the sum of the costs of separate storm and sanitary sewer systems together. The study also indicated that the ratio of the annual cost of separate and combined systems, including capital and operation and maintenance costs, is 1.112/1.341.

(h) Because traffic conditions in Guatemala are often critical, excessive disruption of traffic and normal activities during construction of necessarily deeper and larger sewers, will generally be greater with a combined sewer system.

(i) Guatemala had an average annual precipitation of 1,234.3 mm during the 30 years period (1950 through 1980) much of which was of relatively short duration and high intensity. The 2-year return period for a storm of 15 minutes duration is 100.3 mm. If a combined sewerage system were applied, this rainfall character will significantly increase the cost of the sewerage system.

(j) Other factors to be considered are the immediate need for sewer services in areas of high population density, road conditions, speed of implementation, and availability of funds for the Project, all of which may sometimes be more critical than the cost or pollution problems resulting from selecting one particular type of sewerage system.

(*): "Jakarta Sewerage and Sanitation Project," prepared by NSC for WHO, 1975.

For the above reasons and on the basis of various studies and field surveys of the existing drainage facilities, it is recommended that the new sewerage system for the M/P Area be in principle, a separate system.

8.1.2 Strategy for Stormwater Drainage System

The stormwater drainage network in Metropolitan Guatemala has been gradually expanded to cope with the rapidly expanding Metropolitan Area. The existing drainage is concentrated mainly in the older and most densely populated parts of the Area. Due to the generally steep slopes, stormwater discharge is relatively easy and so far no serious flooding problems have occurred except in limited low lying areas. The stormwater management strategy in this Study is shown in the following table:

Table 8-1 Stormwater management Strategy in Each Region

Region	Sewerage System	Stormwater Management
Central	Combined	Stormwater intercepted will be treated at the wastewater treatment plant with sedimentation process
Other Regions	Separate	Existing stormwater drainage facilities are used. No treatment of stormwater is planned under this Study. Wastewater treatment should be given top priority.

Source : Study Team

8.1.3 Wastewater Treatment Plant Locations

a) Selection Criteria and Constraints

Since it is planned that the collected wastewater will flow by gravity, wastewater treatment plants will generally be located on low lying land close to rivers. Even if a wastewater treatment plant is located in a low lying area, lift pumps may still be required where the incoming sewer is deep and the level of the receiving water course is high. In selecting a wastewater treatment plant site, therefore, the most important factor to be considered is to ensure that collected wastewater can reach the plant by gravity i. e. without using pumps. In addition to eliminating pumping needs, the site should ideally:

i) Be located as near as possible to the treatment district so that construction and O/M costs for the intake sewer can be minimized.
ii) Be located close to the receiving water for discharging the treated effluent to minimize the outfall cost.
iii) Have sufficient area available for the proposed treatment facilities and be located where land owner(s) and neighboring residents agree to the plant construction.
iv) Be sighted in a scarcely populated area with least adverse environmental impact.
v) Have easy access for construction and O/M of the plant.
vi) Have a topographic condition that is favorable for discharge of the effluent into the receiving water.
vii) Minimize the amount of cut and fill necessary.

Influent wastewater can flow by gravity to each of the treatment plant sites selected. In selecting the sites, the various features listed above were carefully studied.

The invert elevations of the outfall pipe should, in each case, be higher than the high water level (HWL) of the receiving water. Since the HWL has not been defined by the authority, the invert elevations of outfall pipes have been tentatively fixed at least 5 meters above the river bottom.

The rationale for the site selection is summarized Table 8-2 and the selected locations are illustrated in Figure 8-1.

Fig. 8 - 1

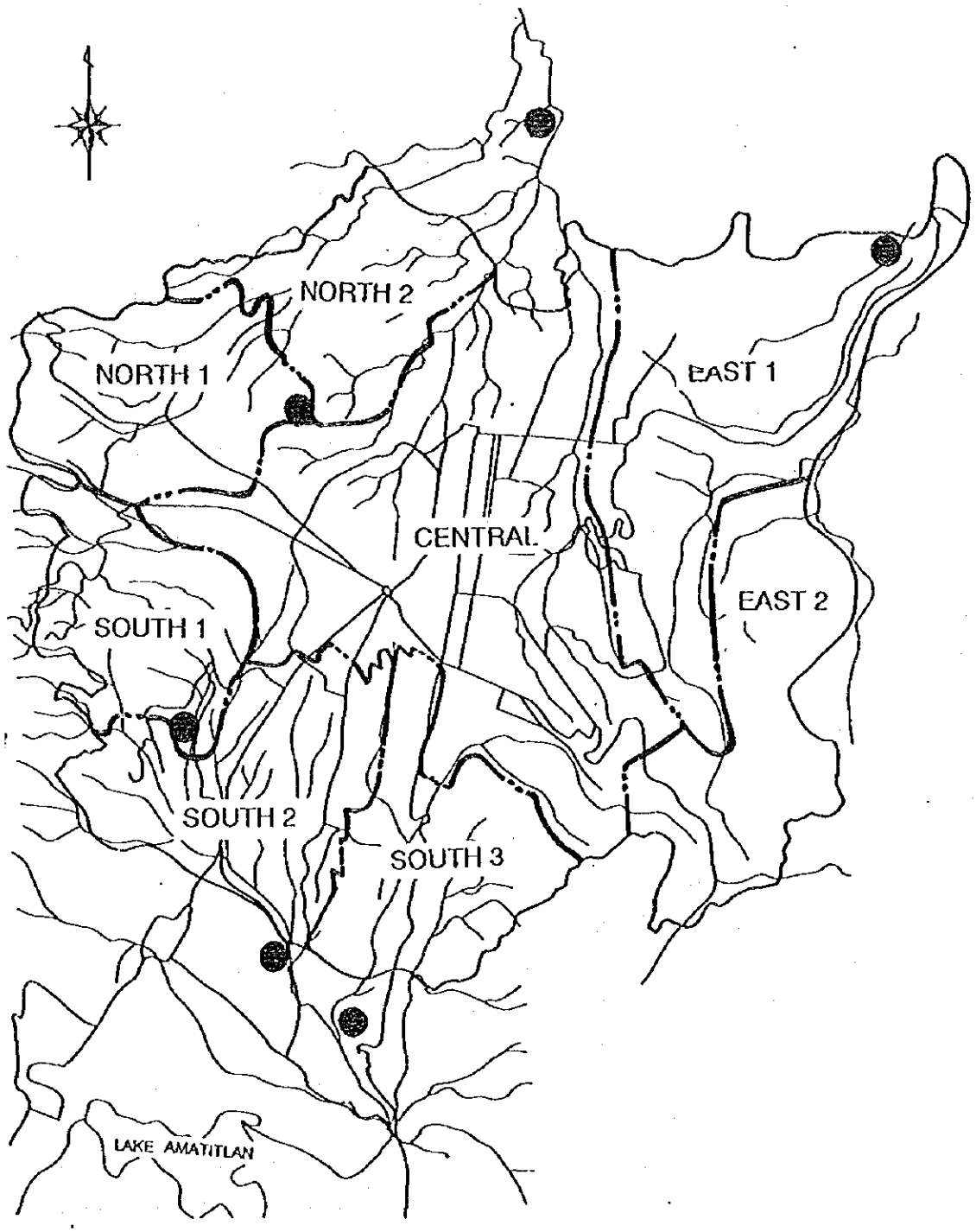

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Table 8-2 Rationale for Wastewater Treatment Plant Site Selection

Region	Rationale for Selection
Central	Located close to the treatment district. Sufficient area available.
North 1	Located close to the treatment district. The site is presently forest and agricultural land.
South 1	Gravity trunk sewers can be installed following the ground surface elevations in the southern part of the Region.
South 2	Suitable land area is available where no significant excavation and filling is required (land elevation will be determined based on the receiving river bed elevation). The land is presently used for abstracting soil.
South 3	Appropriate land is available which needs no significant excavation and filling (actual land elevation will be determined based on the receiving river bed elevation). The land, which gradually slopes toward the river, may be easy to acquire.
East 1	Sufficient area is available. No drinking water intakes are located down stream and the plant effluent discharge should not have an adverse impact on the river water use.

Source : Study Team

8.1.4 Sewer Design Criteria

a) Sewer Layout Planning

Sewer layout is planned considering the following;

1) Sewers will be designed to flow under gravity
2) Sewers will be designed based on maximum hourly wastewater flow with a factor of safety to have additional capacity
3) Sewers will be underground
4) Layout of the sewer will take account of roads, topography, rivers, railroad, soil conditions, other underground facilities etc.
5) Cross section, shape and slope of the sewer will be such that to have adequate flow velocity and self cleansing capacity to avoid accumulation of settled solids and septic conditions.
6) Sewers shall be such that there is minimum leakage and infiltration of stormwater and groundwater.

The convention adopted here in the Study complies with Guatemalan practice. The largest sewers are referred to as main collectors instead of trunk sewers.

Flows are calculated on the basis of the projected domestic and institutional wastewater for the year 2015, plus the industrial wastewater contributions and extraneous flows, including groundwater infiltration.

Because the new sewerage system is to fully utilize the potential energy of wastewater, no pumping station will be considered to lift the wastewater, and both the outfall pipe invert and river bottom elevations should be carefully examined to confirm that the facilities are planned in a hydraulically appropriate manner.

River crossings of collectors also need to be carefully examined with respect to river bed and sewer crown elevations. It should be noted that the level of the top of the sewer is constrained by the river bed elevation, and once a sewer pipe elevation has been fixed, all downstream pipe elevations through to the treatment plant will be governed by this elevation. For this reason, the selected main collector routes to the treatment plants may not necessarily be the shortest one. An explanatory sketch of this condition is shown in Figure 8-2.

b) Sewer Pipe Design

In determining sewer capacities, the Manning equation is used for pipes and conduits, flowing full or partially full, with 'n' values of 0.013 to 0.015 depending on the pipe surface conditions.

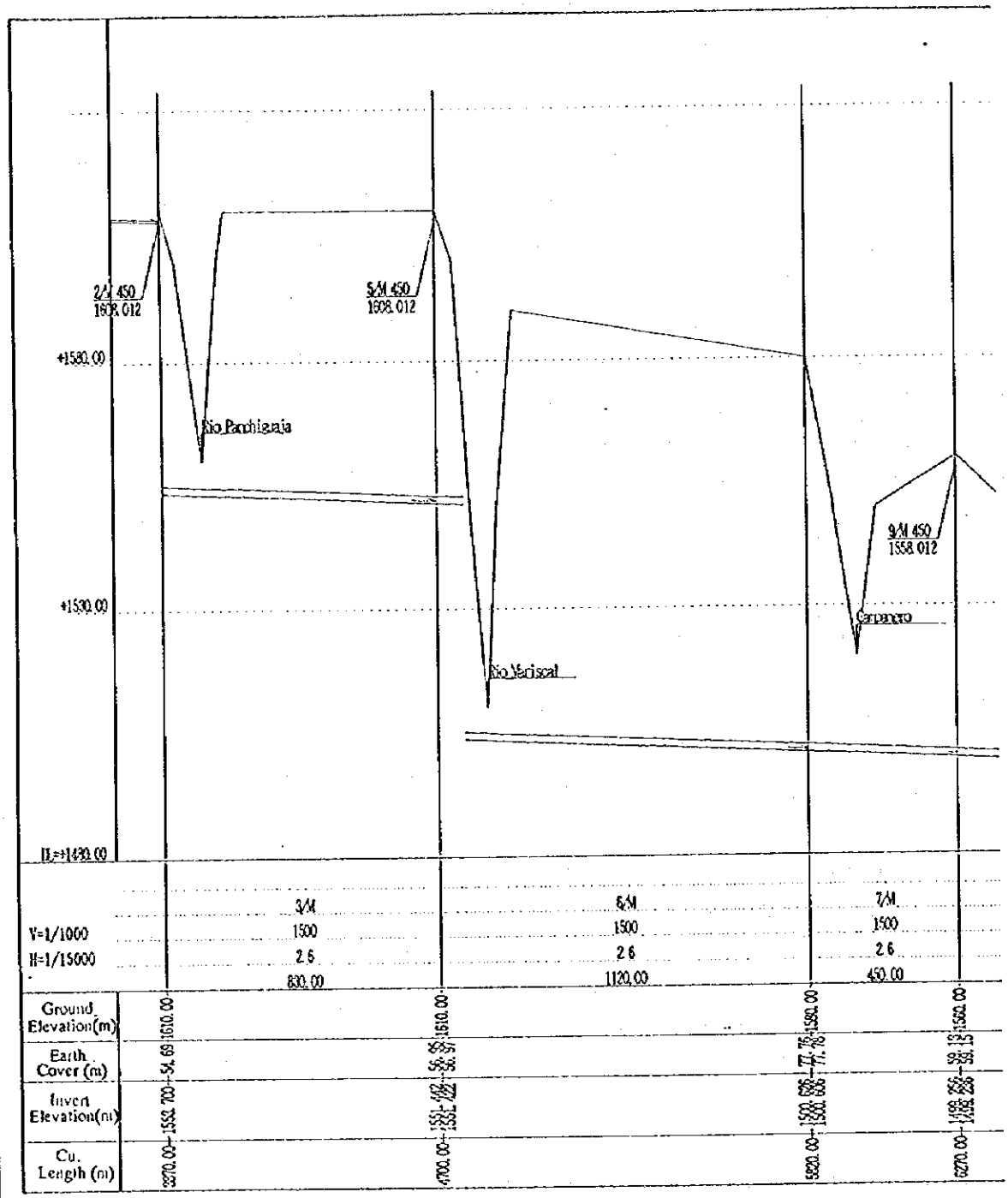
All reinforced concrete (RCP) sewers are designed to maintain a mean flow velocity, when flowing full or half full, using an 'n' value of 0.013, of not less than 60 cm/sec.

All sewers are designed not to exceed a flow velocity of 3 m/sec to protect against erosion. When the ground slope is particularly steep and a velocity may exceed more than 3 m/sec, special provision is to be made to protect against displacement due to erosion and shock.

c) Safety Factor for Design Flowrate

Sewers are designed to convey wastewater under partially-filled condition under gravity. Further, a safety factor for the design flowrate (maximum hourly flowrate) is applied to obtain greater capacity of sewers to incorporate any uncertainties in flow estimation, short-term variation, etc.. Safety factor depends on the pipe diameter and is shown in Table 8-3.

Fig. 8 - 2



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For combined system, safety factor is not applied in general.

Table 8-3 Safety Factor for Design Flowrate

Diameter, mm	Safety Factor for Design Flowrate
200 - 600	2.0
700 - 1,500	1.5 - 2.0
1,650 - 3,000 *	1.25 - 1.5

Note: * Exception when cross-sectional area is decided, based on the excavation method. (For example, minimum diameter for tunneling in 1,500 mm even though the required area is less.)

Source: Guidelines for Sewerage Facility Design, Japan Sewage Works Agency, 1994.

d) Minimum Diameter

A minimum diameter of 200 mm is adopted for sewers, but for house connection pipes 150 mm may be used. When tunneling method is necessary due to topographical conditions, minimum diameter is set at 1,500 mm based on previous experience.

When a smaller sewer is connected to a large one, the crown of both sewers are to be placed at the same elevation.

e) Cover Depth

Sufficient cover is left between the top of the sewer and the road surface to protect sewers from traffic loads and to avoid undue interference with other underground services. A minimum of one meter cover will be provided, except in specific situations where a shallower depth is feasible.

f) Sewer Type and Materials

Sewer pipes currently available in Guatemala are limited in size and material. The collector, main and submain sewers of 1,500 mm diameter or larger are designed on the basis of reinforced concrete tunnel conduits.

g) Manholes

Manholes are indicated on the plans and profiles of the sewers but they should be provided at each change in direction, change in grade, and change in sewer diameter, and should generally not exceed the maximum spacing shown in Table 8-4.

Table 8 -4 Maximum Manhole Spacing

Sewer Diameter (mm)	Maximum Manhole Spacing (m)
300 or less	50
600 or less	75
1,000 or less	100
1,500 or less	150
1,650 or less	200

Source : Study Team

Except for very shallow sewers, all manholes are planned to be large enough for entry and for operation of cleaning equipment. The minimum internal size of manholes is 150 cm. Manholes are also designed to accommodate the future extension of sewers.

h) House Connections

Individual households or communities within areas provided with a public sewer service may be connected with public sewers to enable them to discharge their domestic wastewater to the sewerage system. These pipes are designed to be not less than 150 mm in diameter, preferably with a slope of more than 2 %. Materials, joints, and workmanship should be of a similar type and equal to those of the public sewers to minimize infiltration and root penetration. Although the layout and profiles for these pipes are not prepared for master planning purposes, an average house connection pipe length for an individual household may be 10 to 15 meters.

8.2 WASTEWATER TREATMENT SYSTEM

8.2.1 Design Conditions

a) Flow Rate

The planned wastewater flow rate for each Region in 2015 as defined in Section 7.3 is as shown in Table 8-5.

Table 8-5 Planned Wastewater Flow Rate

Region	Wastewater Flow Rate, m^3/d			Wet Weather Flow rate, m^3/d
	Daily Average	Daily Maximum	Hourly Maximum	
Central	237,757	260,311	389,057	1,086,269
North 1	88,899	96,481	143,679	—
South 1	63,983	69,533	102,991	—
South 2	50,969	54,641	85,414	—
South 3	65,734	71,256	106,619	—
East 1	120,382	130,398	195,692	—

Source : Study Team

For design of wastewater treatment plants, planned flow rates are rounded up to the nearest thousand; the wastewater flow rates used for design are as shown in Table 8-6.

Table 8-6 Design Flow Rates for Wastewater Treatment Plants

Region	Wastewater Flow Rate, m^3/d			Wet Weather Flow Rate, m^3/d
	Daily Average	Daily Maximum	Hourly Maximum	
Central	238,000	261,000	390,000	1,087,000
North 1	89,000	97,000	144,000	—
South 1	64,000	70,000	103,000	—
South 2	51,000	55,000	86,000	—
South 3	66,000	72,000	107,000	—
East 1	121,000	131,000	196,000	—

Source : Study Team

b) Water Quality

As discussed in Section 7.4, influent wastewater quality to WWTP's is 280 mg/L in terms of both BOD_5 and SS.

The high-rate trickling filter process for wastewater treatment is selected for the reasons described in Supporting Report J. The removal rates and effluent quality shown in Table 8-7 and Table 8-8 can be achieved using this process.

Table 8-7 Removal Rates for High-rate Trickling Filter Process

Parameter	Removal Rate (%)			
	Primary Treatment	Secondary Treatment		Overall
	PST	TF(I) IC+(I)	TF(II) FC+(II)	
BOD_5	35	50/68	38/80	80
SS	55	56/80		80

Note: 1. Removal rate A/B indicates removal rate in the individual facility (A) and the overall removal rate (B) including the facility.

2. Detailed discussion is included in Supporting Report J, Annex JB.

Source : Study Team

Table 8-8 Treated Water Quality

Parameter	Concentration, (mg/L)		
	Influent	Effluent	
		Primary	Secondary
BOD_5	280	182	56
SS	280	126	56

Note : Detailed discussion is included in Supporting Report J. Annex JB

Source : Study Team

c) Septage

It is planned to treat septage collected from newly constructed sanitation facilities, (septic tanks), in each Region, at the respective wastewater treatment plant of that Region as described in Section 8.3.

Table 8-9 shows the septage quantity in each Region and the wastewater treatment plant where it will be treated.

Table 8-9 Quantity of Septage to be Collected in Each Region and Wastewater Treatment Plant at which it will be Treated

Region	Quantity of Septage		Dry Sludge, ton/d	WWTP Treating Septage
	Annual, m³/year	Daily, m³/d		
Central	4,384	12.0	0.84	Central
North 1	516	1.4	0.10	North 1
North 2	6,000	16.4	1.15	North 1
South 1	100	0.3	0.02	South 1
South 2	320	0.9	0.06	South 2
South 3	116	0.3	0.02	South 3
East 1	808	2.2	0.15	East 1
East 2	1,600	4.4	0.31	East 1

Source : Study Team

8.2.2 Treatment Process and Flow

a) Liquid Treatment Process

As already Discussed in Section 7.6 the wastewater treatment plants are to achieve the removal efficiencies of at least a secondary treatment level. In view of this, all possible secondary treatment processes have been evaluated with respect to efficiency and performance. Those not meeting the necessary requirements have been screened out from further study. Finally the following four candidate treatment processes are selected for more detailed analysis:

1) Conventional activated sludge,
2) Oxidation ditch,
3) Aerated lagoon,
4) High rate trickling filter.

The above treatment processes have then been evaluated in the light of the following important factors:

1) Water quality and its variations,
2) Quality and quantity of sludge generated,
3) Construction and O/M costs,

4) Personnel requirements for O/M,
5) Extent of impact on the surrounding environment,
6) Topography, geology and climate,
7) Treatment processes applied and O/M situation at existing plants in the Study Area.

From the results of the analysis of alternatives as discussed in Supporting Report J - Selection of Treatment Process, it is concluded that the high rate trickling filter process should be adopted as the treatment system in the Study Area. The Major reasons for this selection are:

1) The wastewater treatment facilities will be located on slopes and the trickling filter process is suitable for utilizing potential energy. External energy input requirement is minimum among the altemative processes.

2) Because of such energy savings, O/M costs will mainly comprise of labor costs making the process more economical than other processes. This is extremely important in Guatemala to ensure sustainability of the facilities.

3) The trickling filter process is being used in the existing facilities within the Study Area and local experience and knowledge of the operation of this process has been accumulated.

4) O/M requirements are simple day to day care as the process does not have any mechanical parts which require maintenance.

5) Sludge generation is relatively low.

6) Although the land area required for the process is higher than for the activated sludge process, it is less than for other processes.

b) Sludge Treatment Process

Sludge generated from the liquid treatment process will be treated without the use of mechanical or electrical facilities. Based on the climatic conditions in the Study Area, the most suitable sludge treatment process is as follows:

Unheated Anaerobic Digestion ----------> Sludge Drying Bed

There are a few existing facilities which employ the above process.

c) **Treatment Process Flow**

- Based on the discussion in preceding sections 1) and 2), treatment process flow will be as shown in Fig 8-3. The following are the main points related to the process flow.
- The treatment process is high-rate trickling filters and consists of two stages with an intermediate clarifier (see Supporting Report J, Annex JB)
- Existing sewers in the Central Region are combined and some storm-water intercepted will enter the WWTP. During wet weather, only primary treatment will be provided for the flow exceeding the maximum hourly flow rate, before it is discharged to receiving water.

8.2.3 Design Criteria

a) Wastewater Flowrates for Design of Process Units

Wastewater flow rates assumed for the design of each wastewater treatment unit are as shown in Table 8-10.

Table 8-10 Design Criteria for Process Units

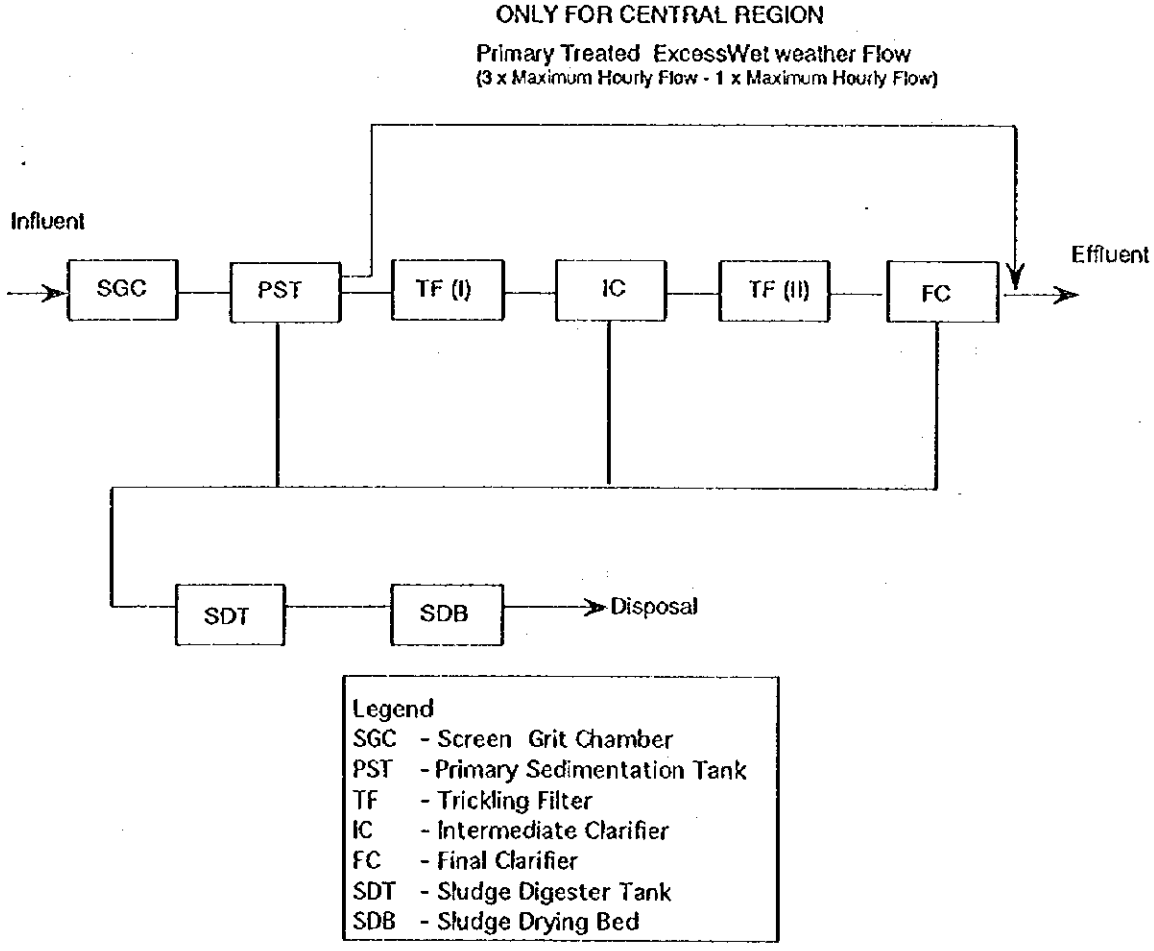
Facility	Treatment Capacity	Hydraulic Capacity
Liquid Treatment	Daily Maximum Flow rate	Hourly Maximum Flow rate
Sludge Treatment	Planned Sludge Quantity (Based on daily average wastewater flow rate)	Same as for Treatment Capacity

Source : Study Team

The basic principles for using the flow rates shown are as follows:

- Hydraulic retention times in liquid treatment facilities is generally short and so these units will frequently become overloaded if designed for daily average flow

Fig. 8 - 3



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- Hourly maximum flow rate occurs during peak hours and for a short duration and is not suitable for the design of treatment capacity. However, to prevent overflowing during peak hours, the hydraulic capacity of the facilities shall be based on hourly maximum flow rate.
- For sludge treatment facilities, the retention time is of the order of several days and therefore facility design is based on the quantity of sludge generated derived from daily average flow.

For Central Region WWTP, as discussed in the previous section, a maximum hourly wet weather flow of about three times the hourly maximum flow rate, (dry weather), will enter the treatment plant. All of the wet weather flow entering the treatment plant will be treated by primary sedimentation but only the hourly maximum flow rate (dry weather) will be passed to the secondary treatment facilities while any excess flow will be discharged directly to the receiving water body (refer to Fig 8-3.).

b) Process Design Criteria

For the treatment process flow shown in Section 8.2.2, design criteria for each facility shown in Table 8-11 are set based on information from many references.

Table 8 -11 Criteria for Trickling Filter Treatment Facility Design

Facility	Item	Unit	Design Range	Applies
Primary	Over flow rate	$m^3/m^2/d$	30-60	50
Sedimentation	Depth	m	-	3.0
Tank	Retention time	hr	1.5-2.5	within the range
Trickling	BOD loading	$kg.BOD/m^3.d$	0.32-1.0	1.0
filter	Hydraulic Loading	m/d	10-40	within the range
Final	Overflow rate	$m^3/m^2/d$	20-30	25
clarifier	Depth	m	-	3.0
	Retention time	hr	3-4	within the range
Sludge	Detention time	day	-	47
digester				
Sludge	Surface loading	$kg.SS/m^2.yr$	100-160	160
drying bed	Sludge thickness	m	0.2-0.3	0.3
	Sludge Concentration			
	- Raw	%		6
	- Digested	%	8-12	10
	- Dried	%		40
	Sludge organic content	%		65
	Volatile Solid Removal Rate	%	50-55	50

Source: Normas de Diseño de Plantas de Tratamiento de Aguas Residuales.
Wastewater Engineering (Third Edition, Metcalf & Eddy 1991).
Sewerage System Design Guidelines (Japan Sewage Works Association 1994).

8.3 SANITATION SYSTEM

8.3.1 Design Conditions

a) Wastewater Quantity

In the year 2015 the unit design wastewater generation is assumed to be 165 lpcd based on the existing unit water consumption of 150 lpcd used for a colony equipped with sanitary facilities.

Daily Flow variation has been assumed to be to be as described below :

Daily Average Flow : Daily Maximum Flow : Hourly Maximum Flow

= 1.00 : 1.10 : 3.00

b) Influent Wastewater Quality

Based on the water quality survey results for existing colonies, influent wastewater quality to treatment facility in terms of BOD is assumed to be 330 mg/L.

8.3.2 Treatment Process and Sludge Disposal

a) Technical Options for Sanitation Facilities

Small community systems are faced with a variety of problems that make the construction and operation of community-wide managed wastewater facilities a difficult undertaking. Some of the related problems are; stringent discharge requirements, high per capita cost, limited finances and limited operation and maintenance budgets. Thus effective low maintenance solutions must be developed to provide wastewater treatment for small communities. In this study, various alternatives for sanitation facilities are evaluated and main selection criteria is to identify the low cost alternative which also requires least operation and maintenance. Various alternatives for sanitation system are described below.

1) Septic Tank: Septic tank is a prefabricated tank that serves as a combined settling and skimming tank and as an unheated unmixed anaerobic digester. Septic tank is used for partial treatment of wastewater and about 55 % of BOD removal efficiency and 70 % of SS removal efficiency can be obtained. Septic tank alone is not recommended as a sanitation treatment system because effluent contains high BOD and can contaminate water bodies significantly.

2) Septic Tank with Soil Absorption Well: This is the most common system which consists of septic tank for partial treatment and soil absorption well for final treatment. With septic tank only, 55 % of BOD removal efficiency is achieved and remaining BOD is removed by means of subsurface soil absorption.

In case of problematic soil conditions such as high soil permeability or sensitive groundwater area, other alternatives of on-site treatment facility should be considered.

3) Septic Tank with Sand Filter: In case of problematic soil conditions or due to limitation of the available area, septic tank with intermittent sand filter could be an appropriate choice. Treatment in the filter is brought about by physical, chemical and biological action. BOD of the effluent could be as low as 10 mg/l and can be discharged to surface waters. However to maintain a high performance level, aerobic conditions should be maintained in the filter or in other words proper venting of the underdrains is necessary. This system needs proper operation and maintenance for proper functioning.

4) Septic Tank with Upflow Anaerobic Filter: In this system partially treated wastewater from septic tank is allowed to pass through the filter which consist of broken stones (size 19-25 mm) in an upflow fashion. Treatment is mainly brought about by biological action in an anaerobic atmosphere. BOD removal efficiency of the system varies 70 - 80 %. The cleansing frequency of upflow filters is considered to be once in 1-2 years, when coarse media is used. Hence low operation and maintenance is required for the system.

5) Johkasou: Johkasou treatment system is a process developed in Japan and literally means "Purification Tank". This system involves a compact tank and design of the tank depends on the process used, such as anaerobic filter, aeration process, separation contact aeration process and separation aeration process etc. This system has been used for individual user as well as for the small community. BOD removal efficiency depends on the type of process used, in general about 90 % of BOD removal efficiency has been obtained.

However Johkasou system not only requires skilled operators, but also demand certain obligations from the user. The user must use the Johkasou system correctly and must maintain and clean it as part of statuary obligations. If the system is not properly managed, the accumulated sludge may exceed the storage capacity, resulting in sludge

flowing out into the effluent.

b) Experiences in Guatemala with Sanitary Treatment System

Septic tank with soil absorption well is being mainly used as sanitary treatment system. Except in few cases the system is functioning well in general. The major problem reported was the clogging of soil absorption well as also described in the previous section. The other problem observed was the unavailability of appropriate soil strata in some zones. As a result depth of digging increases resulting in the higher installation cost.

c) Proposed Sanitation Treatment System

Septic Tank followed by soil absorption well is proposed as sanitation treatment system. Two absorption well with each septic tank are recommended so as to use them alternatively to provide resting to the soil disposal field. During resting period biomat which has developed dries out and cracks exposing the soil surface and results in the restoration of the most of the original infiltration capacity.

In case appropriate soil strata is not available, Septic tank with upflow anaerobic filter is recommended, which also requires low operation and maintenance.

In general, ground water table in the study area is as low as 30m, hence chances of ground water pollution from the effluent of septic tank with soil absorption well/upflow anaerobic filter are quite low. However horizontal distance from the groundwater well should also be studied while locating the position of septic tank.

Septic tank followed by soil absorption well/upflow anaerobic filter is recommended for Sanitation Treatment System. Gravity sewage collection system is proposed for collecting and transporting the wastewater in the colony/settlement to the sanitation treatment system.

d) Desludging and Treatment

Septic tank should be desludged once in a year utilizing vacuum trucks. Desludged septage is proposed to be treated at the sludge treatment facility of the wastewater treatment plant to be constructed in the respective region. Septage from North 2 Region and East 2 Region are proposed to be treated at the sludge treatment facility of the wastewater treatment plant of North 1 and East 1 region respectively.

8.3.3 Process Design Criteria

No standard design criteria for septic tank/upflow filter is existing in Guatemala. The design criteria adopted here for sanitation treatment system, has been also recommended by JICA in Asian Countries. References are listed below :

- John M. Kalbermatten, De Anne S. Julius, D. Duncan Mara and Charles G. Gunnerson; Appropriate Technology for Water Supply and Sanitation : A Planner's Guide, World Bank 1980.
- Duncan Mara; Sewage Treatment in Hot Climates (1976)
- Metcalf & Eddy; Wastewater Engineering; Treatment, Disposal and Reuse (1991)
- Vigneswaran et. al.; Anaerobic Wastewater treatment-Attached growth and sludge Blanket Process, ENSIC, AIT (1986)
- Askinin W.B.; Design Criteria Development of RBC and Anaerobic Filter system for Sewage Treatment, AIT (1983)

a) Septic Tank

The length to width ratio shall be 2-3 : 1. The minimum width shall be 0.75 m.

The allowable minimum and maximum design liquid depths are 1.0 m and 2.1 m respectively. The clearance above liquid level shall be 0.2-0.4 m.

Two compartment septic tank portion, with initial portion covering 2/3 length and final portion 1/3 length will be adopted.

A detention time of 3 days at start up will be provided. The sludge accumulation rate in the tank is assumed as 40 L/capita/year. Desludging frequency which is also the cleansing frequency of upflow filter is considered as once in one year. A maximum sludge accumulation of 1/3 the volume of septic tank is considered as the maximum allowed between consecutive desludging operation.

b) Upflow Anaerobic Filter

Media adopted is generally broken stones of size 19 mm - 25 mm for which void ratio is 0.45. In most cases maximum height adopted is in the range of 0.9 - 1.5 m.

For 20-25 mm broken stone filter media treating domestic wastewater, the recommended

hydraulic loading and hydraulic detention time to obtain a BOD removal of 70-80 % are as follows:

Maximum hydraulic loading :	3.4 $m^3/d/m^2$
Hydraulic detention time :	6 - 9 hrs