3.2 PRESENT WATER USE

3.2.1 Water Area

As illustrated in Fig. I-3.6, WASA has presently 14 water areas in Trinidad and one water area in Tobago. Four water areas, which are E.M.R.(Eastern Main Road) Communities, Caroni, Rio Claro and Tobago, are further divided into several sub-areas. "Water area" or water service area, has been used in WASA for convenience in describing the existing water supply system, projecting future supplies and demands, future system improvements, etc. For the present study, the above water areas/sub-areas are classified into three types: urban, semiurban and rural areas in terms of population density.

Water area has several towns and villages as shown in Supporting Report G "Population Distribution by Water Area". The 1980 census population and major water sources for such towns and villages are tabulated in the Report.

3.2.2 Water Consumption And Population Served

Present water consumption and population served are estimated and shown in Table I-3.4. The population served by WASA water system is about 95% of the population in its service area taking into account the result of the WASA-JICA Customers Survey. Per capita consumption throughout the country is estimated at 590 lpcd (liter per capita per day) on average, however, serious shortage of water supply can be seen especially in southern part of Trinidad. Water consumption in southern water areas/sub-areas such as Mayaro, Arch Trace, Princes Town, Barrackpore, Palmyra, San Fernando, Siparia/Erin and Point Fortin is almost half of that in northern and central water areas in Trinidad.

Population served for each water source is also studied for future optimum distribution of water throughout the country. For the study, water sources in the country are divided into three groups: Source Group I and Source Group II in Trinidad, and a source group in Tobago.

Source Group I formulates a core water supply system of WASA, which consists of 16 systems: Caroni/Arena, El Socorro, Hollis, Caura, Las Lomas, Tacarigua, Valsayn, Arima #6 Well, New Aripo, Guanapo, North Oropouche, Quare(Valencia), Arouca, Carlsen Field, Navet and Old Aripo which is presently being rehabilitated. Average production capacity of the water sources of the Source Group I is 540,200 m^3/d in 1989, which reaches about 80% of WASA total production. The system covers 28 out of 32 water areas/sub-areas in Trinidad. As shown in Table I-3.5, population served by these sources, in 1990, is estimated at approximately 825,000 and per capita consumption is 655 liters on average.

Source Group II comprises remaining water sources in Trinidad as shown in Table I-3.6. Average production capacity for the sources, in 1989, is 107,900 m^3/day. Population served by the sources, in 1990, is estimated at 254,800 and per capita consumption is 423 liters on average.

Average production capacity for source group in Tobago, in 1989, is 20,500 m^3/day. Population served by the sources, in 1990, is estimated at 53,000 and per capita consumption is 387 liters on average as shown in Table I-3.7.

Since the above three Tables I-3.5, I-3.6 and I-3.7 are mainly prepared according to the information described in Supporting Report G "Population Distribution by Water Area", some supplementary sources for areas are excluded.

Clarification of present condition of WASA water distribution is tentatively made by the Team in the following manner based on the data and information provided by WASA and CSO (Central Statistical Office). Amount of water production by each system is disaggregated for each town/village to which the water is supplied, taking into consideration the population served. The 1990 population by town/village is estimated in the same manner discussed in 2.1.1 "Population" of Part Two. As for town/village which has plural water sources of supply, the amount of water is allocated taking supply capacity and area of pertinent sources into consideration. "Water consumption", which is including unaccounted-for water (UFW), is calculated accordingly. The water consumption by water area/sub-area is summarized and tabulated in Table I-3.4.

3.2.3 Customers Survey

In December 1989, the JICA Study Team conducted a customers survey on present water use by way of interviews, in collaboration with WASA and CSO in order to determine the adequacy and quality of water supply to households as well as to public, commercial and industrial establishments. For the customers survey, 1,200 households throughout the country were selected by random sampling and 600 commercial and industrial establishments were selected taking into consideration sectors, sizes and areas. Two questionnaire forms, one for domestic and the other for public, commercial and industrial customers were used for the survey. The forms are attached in Supporting Report C and D respectively.

Eventually 917 forms of questionnaires on domestic water use and 271 forms of questionnaires on public, commercial and industrial water use were used as active data. The survey results are summarized in Supporting Report E "Results of Customers Survey". The summary tables are composed of following three kinds of sheets.

- Domestic (1): Results of the survey for households connected to the water system.
- Domestic (2): Results of the survey for households not connected to the water system.
- Industrial : Results of the survey for public, commercial and industrial establishments.

As revealed in the customers survey, WASA's water supply is still unreliable. According to the results of the questionnaire for household connected to the water system, about 40% of 676 households enjoy 24 hours water supply, however, 25% of households receive water on days less than half of the week. As seen in Table I-3.8, about 50% of customers in northern area in Trinidad enjoy 24 hours supply but only 20% of customers in Tobago and southern area of Trinidad can enjoy it. A similar tendency can be seen in the table for weekly supply. Therefore, it can be said that there is much difference in supply condition among the above three areas.

Table I-3.9 presents water quality determined by customers, in terms of odor and color. More than 70% of the customers tell "clear" or "odorless", however, it seems customers in south Trinidad suffer from more problems in color. This may be because treatment for removal of iron and humic substance is not sufficient in that area (Refer to Supporting Report B "Water Source").

Table I-3.10 presents possession of private water storage facility by household. Percentages of possession of storage facility are 54%, 71% and 92% in north Trinidad, south Trinidad and Tobago respectively. It can be said that the figures are closely related to the poor condition of water supply especially in south Trinidad and Tobago.

Customers mind/consciousness for WASA water supply can be seen in Table I-3.11 in the aspects of water pressure, water quality and supply condition. 53% of the customers are satisfied with WASA water supply, however, difference among areas is also seen in the table.

3.2.4 Water Consumption Survey

As for domestic water use, per capita consumption in 1988 was estimated at 230 liters on average for 161 metered customers based on the data supplied by the Commercial Department of WASA.

On the other hand, WASA-JICA Consumption Survey for the present study has been conducted since late January, 1990 in order to investigate actual water consumption by household. Each water meter brought by the Study Team was installed on the premises of 53 selected customers in Diego Martin, Port of Spain, E.M.R. Communities and Arima, and its meter reading has been made continually as shown in Supporting Report F "Data on Water Consumption". Water consumption for the 53 domestic customers resulted in 329 lpcd on average.

As for the data on water consumption of the 53 customers, the consumption amount has been fluctuating, however, no seasonal changes of water use can be seen.

3.2.5 Pilot Leakage Survey

A leakage locating and quantification/estimation survey was made under the present study as presented in Supporting Report H "Pilot Leakage Survey". The primary purpose of this survey was to find the present features and characteristics of the distribution system leakage of the WASA water supply system in Trinidad and Tobago. For this purpose, ten small isolated areas of 24 hours water supply in distribution system were selected and the pilot leakage survey was conducted.

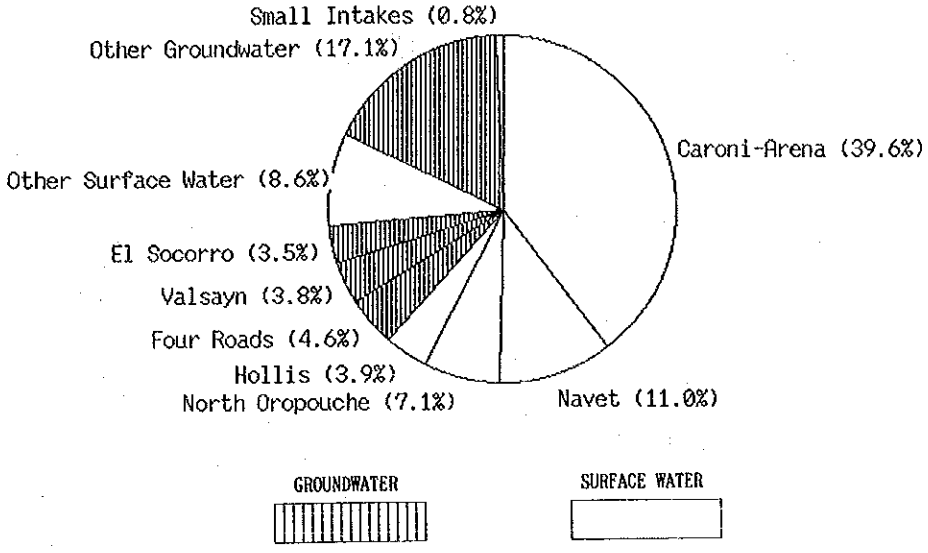
Leakage losses cannot be directly investigated and accurately determined. Since it is difficult to make a detailed survey for the entire water service area in the country under the present study, the 10 representative residential areas where the area could be hydraulically isolated were selected for the survey.

A master meter was installed at inlet water main of each area and hourly readings were taken and recorded to determine the daily demand patterns. The respective night time minimum-flow in the selected service blocks was measured through 24 hours meter reading. The midnight minimum flow rate, when the distribution system has a stable water pressure in higher level while no water usage, could be considered as a leakage loss amount in that service block.

Major findings are presented in Table I-3.12. The estimated leakage losses/amounts in the respective service blocks are ranging from 30% to 80% of the total supplied amount. The leakage losses vary depending on the characteristics of the total length of pipeline, number of house connections and the aging status of facilities in the service area.

Generally, in the nighttime, from midnight to 4 a.m., the system water pressure is rather stable in the high level. The flow rate decreases to the lower level and also becomes stable.

On the other hand, in the daytime, after domestic water use is started in the morning, the system water pressure goes down. The flow rate also varies heavily in accordance with the water pressure variation.



NOTE:
- Capacities of small intakes ranges from less than 50 m3/d to 500 m3/d.
- Water purchased, 1) Texaco to Point Fortin 51 m3/d,
  2) Trintoc to Techer 161 m3/d, and
  3) Texaco to Guayaguayare 194 m3/d,
  are not included in this figure.

Fig. I-3.1 PRODUCTIONS OF MAJOR WATER SOURCES, 1988

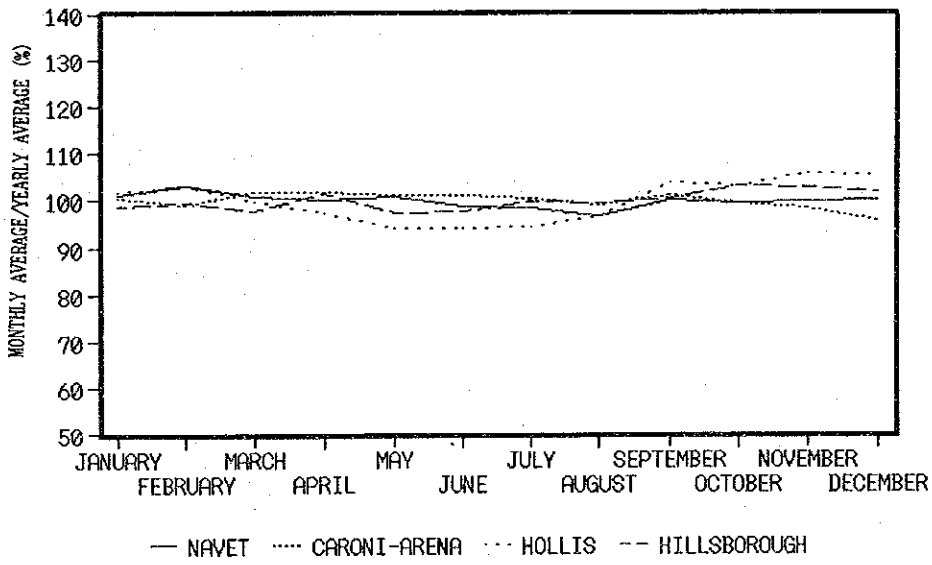
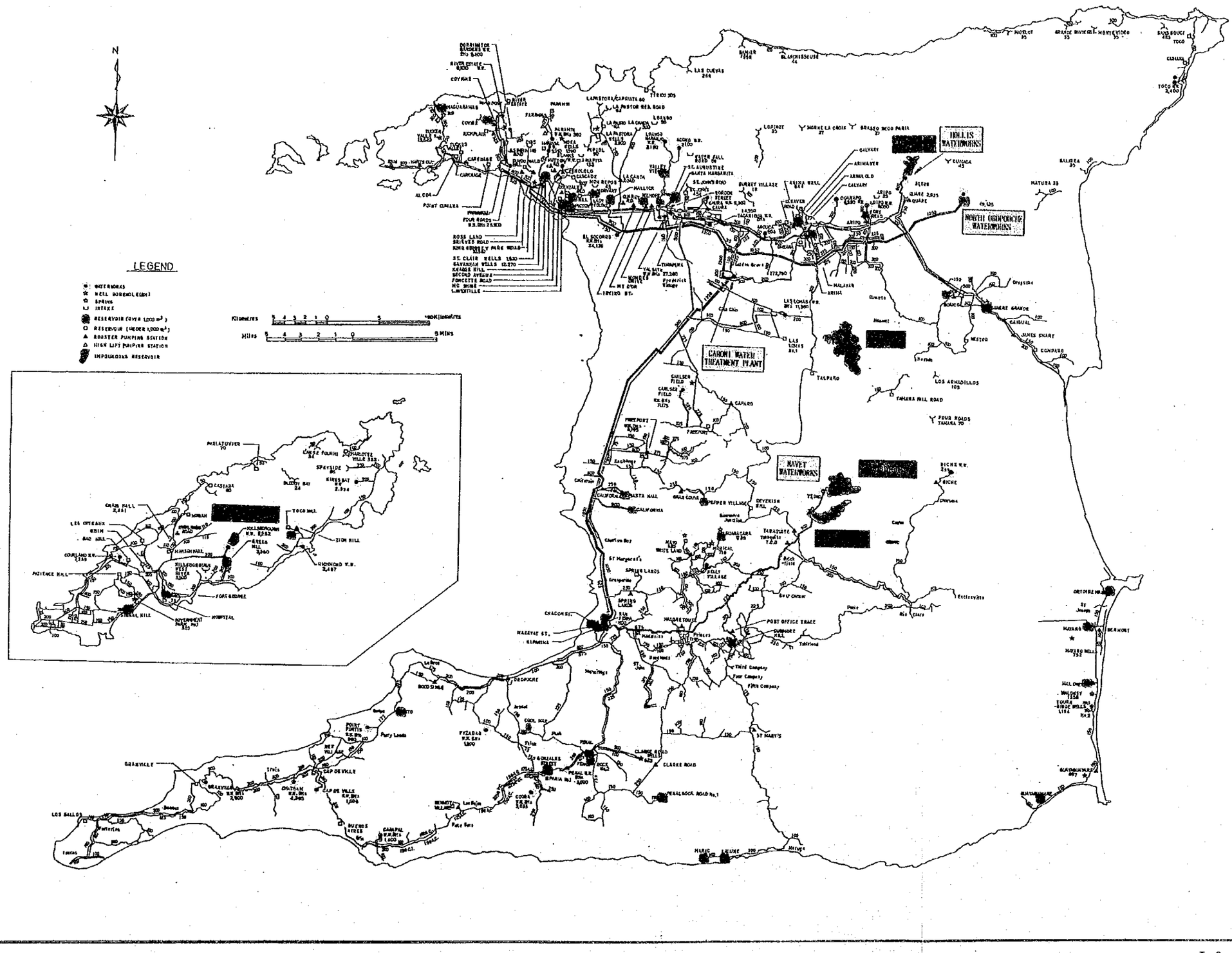


Fig. I-3.3 SEASONAL VARIATION OF PRODUCTIONS FROM IMPOUNDING RESERVIOR SOURCES

Fig.I-3.2 COMPREHENSIVE MAP OF EXISTING WATER SYSTEM



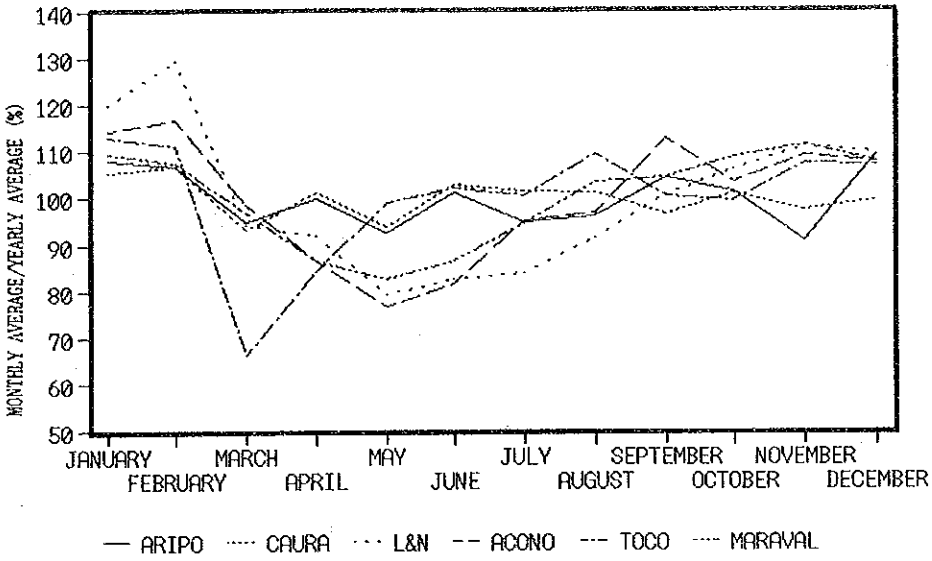


Fig. I-3.4 SEASONAL VARIATION OF PRODUCTIONS FROM RIVER INTAKE SOURCES

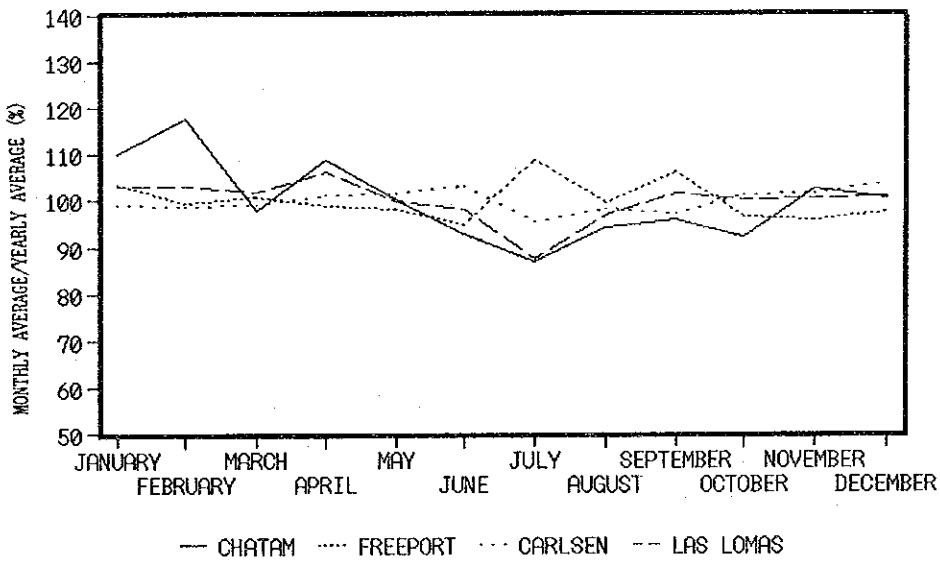


Fig. I-3.5 SEASONAL VARIATION OF PRODUCTIONS FROM GROUNDWATER SOURCES

Fig. I-3.6 MAP SHOWING WASA WATER AREA

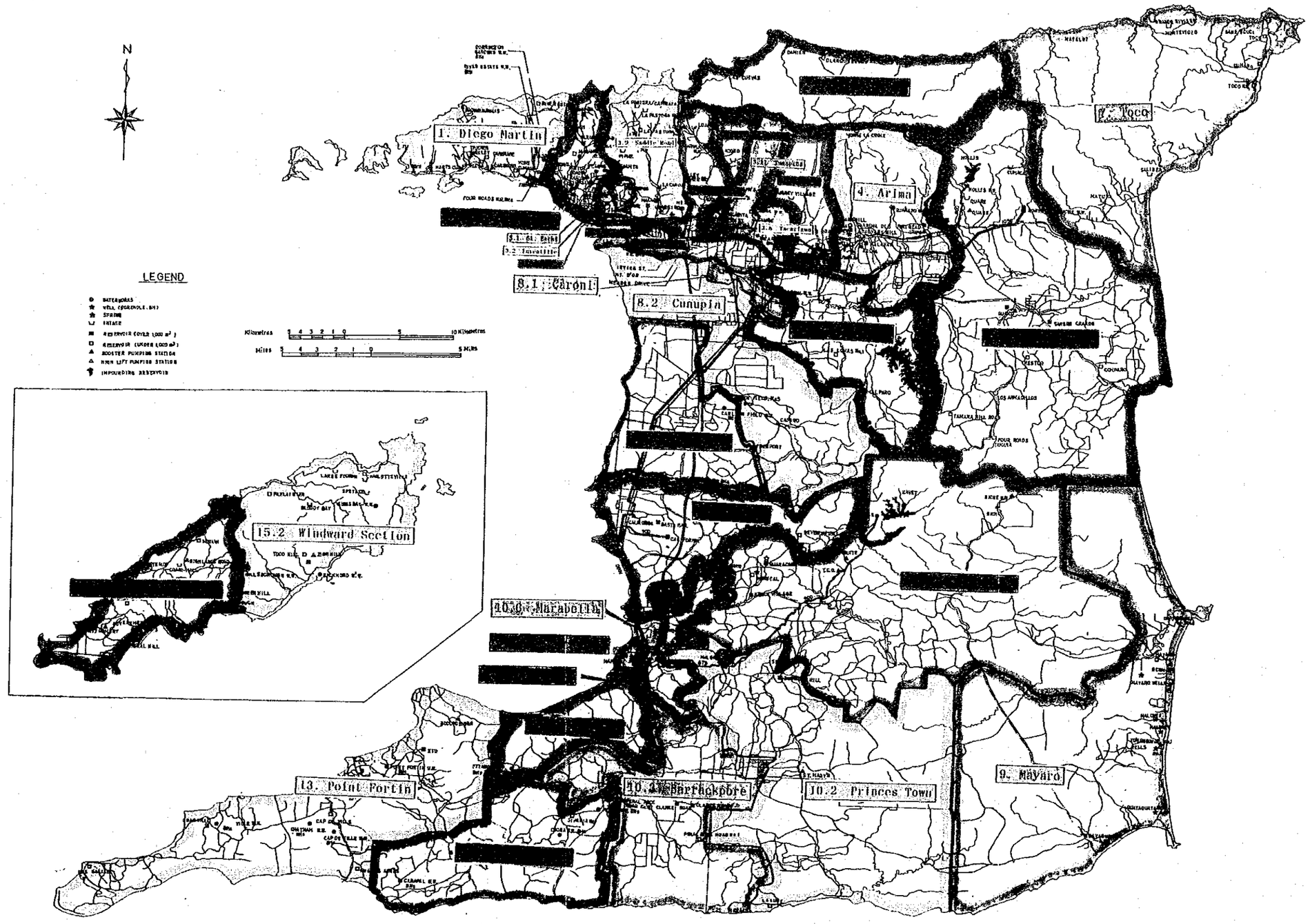


Table I-3.1 LIST OF EXISTING LARGE AND MEDIUM SCALE PRODUCTION FACILITIES (1)

NO.	NAME OF PRODUCTION FACILITY (WATERWORKS/WATER TREATMENT PLANT, INTAKES AND WELLS)	NAME OF SOURCE AND AQUIFER	DESIGN PRODUCTION CAPACITY (M3/D)	1988's AVERAGE DAILY PRODUCTION (M3/D)	INSTALL FLOW METER	NUMBER OF WELLS	TREATMENT PROCESSES							KIND OF CHEMICAL USE	DISTRICT OF WASA
							Aer.	Coa.	Sed.	Fil.	Chl.	pH	A.C.		
	=SURFACE WATER SOURCE= [LARGE SCALE] TRINIDAD														
1	CARONI/ARENA TREATMENT PLANT	ARENA RESERVOIR & CARONI RIVER	272,760	259,781	0	--		*	*	*	*	*	*	AL, LM, CL, AC	N.C.
2	NAVET WATERWORKS	NAVET RESERVOIR	77,280	72,100	0	--		*	*	*	*	*	*	AL, LM, CL	S.E.
3	NORTH OROPOUCHE WATERWORKS	NORTH OROPOUCHE RIVER	90,920	46,728	0	--		*	*	*	*			AL, CL	N.E.
4	HOLLIS WATERWORKS	HOLLIS RESERVOIR	31,826	25,722	X	--				*	*	*		AL, LM, CL	N.E.
	SUB-TOTAL		472,786	404,331 (63.5 %)	(0-3, X-1)										
	[MEDIUM SCALE] TRINIDAD														
1	CAURA WATERWORKS	CAURA RIVER	11,360	9,932	0	--		*	*	*	*			AL, LM, CL	N.C.
2	ARIPO (NEW) WATERWORKS	ARIPO RIVER	15,900	8,365	0	--		*	*	*	*			AL, CL	N.E.
3	GUANAPO WATERWORKS	GUANAPO RIVER	11,360	5,776	0	--		*	*	*	*			AL, CL	N.E.
4	MARAVAL WATERWORKS	MARAVAL RIVER	5,910	4,304	X	--		*	*	*	*			AL, LM, CL	P.O.S.
5	QUARE INTAKE (VALENCIA)	QUARE RIVER	6,818	3,295	X	--					*			CL	N.E.
6	LOANGO/NARANJO WATERWORKS	LOANGO & NARANJO RIVERS	3,180	2,488	0	--		*	*	*	*			AL, CL	N.C.
7	TOCO WATERWORKS	TOMPIRE RIVER	4,546	1,851	X	--		*	*	*	*			AL, CL	N.E.
8	ACONO WATERWORKS	ACONO RIVER	2,100	1,699	0	--		*	*	*	*			AL, CL	N.W.
	SUB-TOTAL		61,174	37,710 (5.9 %)	(0-5, X-3)										
	TOBAGO														
9	HILLSBOROUGH WATERWORKS	HILLSBOROUGH RESERVOIR	8,582	7,111	0	--		*	*	*	*	*		AL, LM, CL	TOBAGO
10	COURLAND WATERWORKS	COURLAND RIVER	7,368	6,186	0	--		*	*	*	*			AL, POLY, CL	TOBAGO
11	RICHMOND WATERWORKS	RICHMOND RIVER	2,467	1,749	0	--	*			*	*			CL	TOBAGO
12	KING'S BAY WATERWORKS	KING'S BAY RIVER	2,994	1,483	0	--		*	*	*	*			AL, LM, CL	TOBAGO
13	CRAIG HALL INTAKE	RIVER	2,461	1,367	0	--					*			CL	TOBAGO
14	GREEN HILL INTAKE	RIVER	3,360	1,189	0	--					*			CL	TOBAGO
	SUB-TOTAL		27,232	19,085 (95.2 %)	(0-6)										
	TOTAL (M3/D) (SURFACE WATER SOURCE)		561,192	461,126 (70.2 %)	(0-14, X-4)										
	=GROUNDWATER SOURCE (WELL)= [MEDIUM SCALE] TRINIDAD														
1	FOUR ROADS WATERWORKS	NORTH-WEST PENINSULA GRAVELS	28,900	29,890	X	12					*			CL	N.W.
2	VALSAYN WATERWORKS	NORTHERN GRAVELS	27,280	25,094	X	9					*			CL	N.C.
3	EL SOCORRO WATERWORKS	NORTHERN GRAVELS	27,270	23,146	X	9					*			CL	N.W.

Table I-3.1 LIST OF EXISTING LARGE AND MEDIUM SCALE PRODUCTION FACILITIES (2)

NO.	NAME OF PRODUCTION FACILITY (WATERWORKS/WATER TREATMENT PLANT, INTAKES AND WELLS)	NAME OF SOURCE AND AQUIFER	DESIGN PRODUCTION CAPACITY (M3/D)	1988's AVERAGE DAILY PRODUCTION (M3/D)	INSTALL FLOW METER	NUMBER OF WELLS	TREATMENT PROCESSES							KIND OF CHEMICAL USE	DISTRICT OF WASA
							Aer.	Coa.	Sed.	Fil.	Chl.	pH	A.C.		
4	TACARIGUA WATERWORKS	NORTHERN GRAVELS	14,550	15,887	X	10					*			CL	N.C.
5	CARLSEN FIELD WATERWORKS	CENTRAL SANDS	18,180	10,604	O	5	*		*	*	*	*		LM,CL	S.F.& S.C.
6	LAS LOMAS WATERWORKS	CENTRAL SANDS	11,360	10,330	O	5	*			*	*	*		LM,CL	N.C.
7	SAVANNAH WELLS	NORTH-WEST PENINSULA GRAVELS	12,270	9,501	X	6					*			CL	P.O.S.
8	TUCKER VALLEY WELLS	NORTH-WEST PENINSULA GRAVELS	7,971	8,425	X	8					*			CL	N.W.
9	RIVER ESTATE WATERWORKS	NORTH-WEST PENINSULA GRAVELS	6,820	7,173	X	5					*			CL	N.W.
10	CHAGUARAMAS WELLS	NORTH-WEST PENINSULA GRAVELS	-	5,669	X	2					*			CL	N.W.
11	KING GEORGE V PARK WELLS	NORTH-WEST PENINSULA GRAVELS	10,340	5,551	X	3					*			CL	P.O.S.
12	FREEPORT WATERWORKS	CENTRAL SANDS	11,360	5,236	O	3	*		*	*	*	*		LM,CL	S.F.& S.C.
13	CHATHAM WATERWORKS	SOUTHERN SANDS	11,360	4,665	O	5	*	*	*	*	*			AL,CL	S.W.
14	PENAL WATERWORKS	SOUTHERN SANDS	3,500	3,009	O	8	*	*	*	*	*			LM,CL	S.W.
15	SIPARIA (COORA) WATERWORKS	SOUTHERN SANDS	3,033	2,954	O	8	*			*	*			CL	S.W.
16	GRANVILLE WATERWORKS	SOUTHERN SANDS	2,800	2,800	O	7	*			*	*			LM,CL	S.W.
17	DORRINGTON GARDEN WATERWORKS	NORTH-WEST PENINSULA GRAVELS	5,400	2,404	X	1					*			CL	N.W.
18	MOKA WELLS	NORTH-WEST PENINSULA GRAVELS	1,590	2,090	X	2					*			CL	P.O.S.
19	ST. CLAIR WELL	NORTH-WEST PENINSULA GRAVELS	1,820	1,885	X	1					*			CL	P.O.S.
20	FYZABAD WATERWORKS	SOUTHERN SANDS	1,500	1,701	O	5			*	*				CL	S.W.
21	LA PASTORA WELLS	NORTHERN GRAVELS	2,900	1,451	X	2					*			CL	N.W.
22	CARAPAL WATERWORKS	SOUTHERN SANDS	1,400	1,333	O	2				*	*			LM,CL	S.W.
23	MALONEY WELLS	SOUTHERN SANDS	1,358	1,294	O	2				*	*			CL	S.E.
24	AMOCO TOURNEBRIDGE WELLS	SOUTHERN SANDS	1,194	1,221	O	3				*	*			CL	S.E.
	TOTAL (M3/D) (GROUNDWATER SOURCE)		214,156	183,313 [27.9 %] (28.8 %)	(O-11, X-13)	123									
	GRAND TOTAL (M3/D)		775,348	644,439 [98.1 %]	(O-25, X-17)	123									
	[LARGE SCALE]		472,786	404,331 [61.6 %]	(O-3, X-1)										
	[MEDIUM SCALE]		302,562	240,108 [36.6 %]	(O-22, X-16)										

NOTE: - P.O.S. ; PORT OF SPAIN, N.W. ; NORTH WEST, N.E. ; NORTH EAST, N.C. ; NORTH CENTRAL, S.F.& S.C. ; SAN FERNANDO & SOUTH CENTRAL, S.E. ; SOUTH EAST, S.W. : SOUTH WEST,
- Aer. ; AERATION, Coa. ; COAGULATION, Sed. ; SEDIMENTATION, Fil. ; FILTRATION, Chl. ; CHLORINATION, pH ; PH CORECTION, A.C. ; ACTIVATED CARBON,
- AL ; ALUMINIUM SULFATE, LM ; HYDRATED LIME, CL ; CHLORINE (both gaseous and powder), POLY ; POLYMER, AC ; ACTIVATED CARBON,
- EACH DESIGN PRODUCTION CAPACITIES ARE QUOTED FROM "THE WATER SYSTEM BALANCE IN TRINIDAD, JUNE 1985" AND "INFORMATION FROM WASA'S REGIONAL OFFICE IN TOBAGO".
- " O " AND " X " MEAN EXISTING AND WITHOUT FLOW METER AT EACH PRODUCTION FACILITYN RESPECTIVELY.
- FIGURES IN [ ] ARE RATIO (%) TO TOTAL AVERAGE DAILY PRODUCTION CAPACITY IN 1988 (656,854 M3/D).
- FIGURES IN ( ) ARE RATIO (%) TO EACH TOTAL AVERAGE DAILY PRODUCTION CAPACITY IN 1988 OF TRINIDAD AND TOBAGO.

Table I-3.2 LIST OF EXISTING SMALL SCALE PRODUCTION FACILITIES

NO.	NAME OF PRODUCTION FACILITY (WATERWORKS, INTAKE, WELL, SPRING AND PURCHASED WATER)	DESIGN PRODUCTION CAPACITY (M3/D)	1988's AVERAGE DAILY PRODUCTION (M3/D)	INSTALL FLOW METER	TREAT-MENT PROCESS Chl	KIND OF CHEMICAL USE	DISTRICT OF WASA
	=SURFACE WATER SOURCE=						
	TRINIDAD						
1	ST. ANN'S WATERWORKS	840	510	X	*	CL	P.O.S.
2	SANS SOUCI	-	501	X	*	CL	N.E.
3	ST. JOHN'S INTAKE	451	454	X	*	CL	N.C.
4	DAMIER INTAKE	143	355	X	*	CL	N.W.
5	TYRICO INTAKE	900	284	X	*	CL	N.W.
6	BICHE WATERWORKS	400	272	0	*	CL	S.E.
7	GUAICO TAMANA/LAS CUEVAS INTAKE	120	241	X	*	CL	N.W.
8	CASCADE INTAKE	-	193	X	*	CL	P.O.S.
9	ARIAPITA INTAKE	327	142	X	*	CL	P.O.S.
10	LA CANOA INTAKE	200	106	X	*	CL	N.W.
11	DIBE INTAKE	-	100	X	*	CL	P.O.S.
12	LA PASTORA RES. ROAD	-	94	X	*	CL	N.W.
13	Mt. D'OR INTAKE	-	88	X	*	CL	N.C.
14	PIPIOL INTAKE	90	88	X	*	CL	N.W.
15	LOS ARMADILLOS INTAKE	105	77	X	*	CL	N.E.
16	FOUR ROADS/TAMANA INTAKE	70	74	X	*	CL	N.E.
17	LA PASTORA/CAPRIATA INTAKE	-	63	0	*	CL	N.W.
18	LOANGO INTAKE	-	59	X	*	CL	N.C.
19	WATERFALL ROAD INTAKE	-	59	X	*	CL	N.C.
20	BLANCHISSEUSE INTAKE	61	44	X	*	CL	N.W.
21	MON REPOS INTAKE	90	44	X	*	CL	N.W.
22	GRAND RIVIERE INTAKE	45	35	X	*	CL	N.E.
23	LOPINOT INTAKE	145	35	X	*	CL	N.C.
24	MATELOT INTAKE	105	35	X	*	CL	N.E.
25	MATURA INTAKE	49	35	X	*	CL	N.E.
26	MONTEVIDEO INTAKE	45	35	X	*	CL	N.E.
27	SALIBEA INTAKE	45	35	X	*	CL	N.E.
28	ARIPO INTAKE	-	34	X	*	CL	N.E.
29	BRASSO SECO-PARIA INTAKE	-	27	X	*	CL	N.E.
30	MORNE LA CROIX INTAKE	-	27	X	*	CL	N.E.
31	CUMACA INTAKE	45	24	X	*	CL	N.E.
32	SURREY VILLAGE INTAKE	45	18	X	*	CL	N.C.
	SUB-TOTAL	4,321	4,188 (0.64 %)	(0-2, X-30)			
	TOBAGO						
33	CHARLOTTEVILLE INTAKE	600	418	0	*	CL	TOBAGO
34	SPEYSIDE INTAKE	86	321	X	*	CL	TOBAGO
35	CASTARA INTAKE	80	161	0	*	CL	TOBAGO
36	L'ANSE FOURMI INTAKE	34	27	X	*	CL	TOBAGO
37	PARATUVIER INTAKE	70	18	X	*	CL	TOBAGO
38	BLOODY BAY INTAKE	24	10	X	*	CL	TOBAGO
	SUB-TOTAL	894	955 (0.15 %)	(0-2, X-4)			
	TOTAL (M3/D)	5,215	5,143 (0.78 %)	(0-4, X-34)			

NO.	NAME OF PRODUCTION FACILITY (WATERWORKS, INTAKE, WELL, SPRING AND PURCHASED WATER)	DESIGN PRODUCTION CAPACITY (M3/D)	1988's AVERAGE DAILY PRODUCTION (M3/D)	INSTALL FLOW METER	TREATMENT PROCESS Are	Fil	Chl	KIND OF CHEMICAL USE	DISTRICT OF WASA	NUMBER OF WELLS
	=GROUNDWATER SOURCE=									
	WELL									
	TRINIDAD									
1	CAP DE VILLE WATERWORKS	1,006	938	0	*	*	*	CL	S.W.	1
2	MAYARO WELLS	1,477	866	0	*		*	CL	S.E.	6
3	GUAYAGUAYARE #1 WELL	-	841	0	*	*	*	CL	S.E.	1
4	ARIMA #6 WELL	3,000	644	X			*	CL	N.E.	1
5	ARQUCA WATERWORKS	1,863	577	X			*	CL	N.C.	2
6	CLARKE ROAD WELLS	623	482	0			*	CL	S.W.	1
7	POINT FORTIN WATERWORKS	980	393	0	*	*	*	LM, CL	S.W.	3
8	PARAMIN WATERWORKS	1,178	366	X			*	CL	P.O.S.	2
	SUB-TOTAL	10,127	5,107 (0.78 %)	(0-5, X-3)						17
	TOBAGO									
9	GOVERNMENT FARM #3 WELL	335	0	X					TOBAGO	1
	SUB-TOTAL	335	0 (0.00 %)	(X-1)						1
	SPRING									
1	GUARACARA SPRING	1,136	725	0			*	CL	S.E.	--
2	MAYO SPRING	630	613	0					S.E.	--
3	MORICAL SPRING	718	521	0			*	CL	S.E.	--
	SUB-TOTAL	2,484	1,859 (0.28 %)	(0-3)						--
	TOTAL (GOUNDWATER SOURCE)	12,946	6,966 (1.06 %)	(0-8, X-4)						18
	PURCHASED									
1	TRINTOC TO TECHIER	-	161	X						--
2	TEXACO TO POINT FORTIN	180	94	X						--
3	TRINTOC TO POINT FORTIN	-	51	0						--
	TOTAL (M3/D) (PURCHASED WATER)	180	306 (0.05 %)	(0-1, X-2)						--
	GRAND TOTAL (M3/D)	18,341	12,415 (1.9 %)	(0-13, X-40)						18

NOTE:
- P.O.S.; PORT OF SPAIN, N.W.; NORTH WEST, N.E.; NORTH EAST, N.C.; NORTH CENTRAL, S.E.; SOUTH EAST, S.F.& S.C.; SAN FERNANDO & SOUTH CENTRAL, S.W.; SOUTH WEST.
- EACH DESIGN PRODUCTION CAPACITIES ARE QUOTED FROM "THE WATER SYSTEM BALANCE IN TRINIDAD, AND "INFORMATION FROM WASA'S REGIONAL OFFICES IN TOBAGO.
- CL ; CHLORINE, LM : HYDRATED LIME, Chl ; CHLORINATION, Are ; AERATION, Fil ; FILTRATION.
- " 0 " AND " X " MEAN INSTALLATION OF AND WITHOUT FLOW METER AT EACH PRODUCTION FACILITY RESPECTIVELY.
- FIGURES IN PARENTHESES ARE RATIO (%) TO TOTAL AVERAGE DAILY PRODUCTION CAPACITY IN 1988 (656,854 M3/D).

Table I-3.3 DAILY AVERAGE WATER PRODUCTION

(unit: m3/day)

YEAR	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	YEARLY AVERAGE
1976	303,574	302,624	307,278	306,119	303,920	307,242	306,883	324,440	321,277	325,972	316,514	315,200	311,792
	97	97	99	98	97	99	98	104	103	105	102	101	100
1977	325,917	320,250	320,082	310,305	311,360	301,474	305,051	324,613	317,209	315,896	326,272	327,076	317,136
	103	101	101	98	98	95	96	102	100	100	103	103	100
1978	321,481	302,433	298,084	297,520	296,552	301,079	296,057	306,951	316,432	317,732	328,876	350,819	311,242
	103	97	96	96	95	97	95	99	102	102	106	113	100
1979	353,574	342,520	340,339	338,198	326,422	327,004	327,926	323,068	322,904	330,235	330,426	337,434	333,303
	106	103	102	101	98	98	98	97	97	99	99	101	100
1980	365,336	368,500	378,958	379,617	384,248	402,623	415,213	404,119	442,029	424,953	404,946	427,657	399,940
	91	92	95	95	96	101	104	101	111	106	101	107	100
1981	426,848	430,934	433,575	440,174	474,762	480,734	482,647	447,092	461,254	486,210	487,174	500,754	462,890
	92	93	94	95	103	104	104	97	100	105	105	108	100
1982	549,731	550,371	558,821	538,617	519,471	538,841	526,879	510,398	508,418	514,398	500,784	555,933	530,999
	104	104	105	101	98	101	99	96	96	97	94	105	100
1983	567,245	577,351	531,406	555,837	536,323	546,098	553,531	559,736	593,625	573,013	604,328	592,655	565,736
	100	102	94	98	95	97	98	99	105	101	107	105	100
1984	596,139	604,458	623,517	596,158	571,195	604,755	610,701	607,881	614,257	602,880	590,240	574,839	599,708
	99	101	104	99	95	101	102	101	102	101	98	96	100
1985	602,073	612,345	616,583	629,791	630,895	641,611	590,970	619,760	640,648	636,597	652,528	637,229	625,864
	96	98	99	101	101	103	94	99	102	102	104	102	100
1986	654,726	677,883	646,026	659,817	650,391	653,954	654,953	632,885	629,738	643,560	646,972	635,261	648,622
	101	105	100	102	100	101	101	98	97	99	100	98	100
1987	655,835	674,570	646,626	642,476	638,325	648,811	633,603	645,026	657,343	646,662	645,453	643,197	647,940
	101	104	100	99	99	100	98	100	101	100	100	99	100
1988	675,080	667,228	665,944	656,671	635,209	633,884	630,199	638,869	668,839	647,966	684,528	664,157	655,594
	103	102	102	100	97	97	96	97	102	99	104	101	100
1989	679,377	676,759	653,074	691,505	668,050	691,483	687,621	686,029	698,579	646,263	n.a.	n.a.	677,727
	100	100	96	102	99	102	101	101	103	95	-	-	100

Note: Figure above in the column shows average daily production, and figure below shows index against the yearly average.
n.a.: not available

Table I-3.4 PRESENT WATER USE BY WATER AREA

WATER AREA	POPULATION AREA (km2)	POPULATION DENSITY (/km2)	*	POPULATION Total	Service Area	Served	Served by Sources I	Served by Sources II	CONSUMPTION (m3/d) Source Group I	Source Group II	Total	PER CAPITA CONSUMPTION (lpcd) Source Group I	Source Group II	Total
1. DIEGO MARTIN	105	666	S	70,161	69,231	65,769	240	65,529	185	45,545	45,731	774	695	695
2. PORT OF SPAIN	56	1,473	U	82,530	81,691	77,607	39,610	37,996	30,555	24,783	55,338	771	652	713
3. E.M.R. COMMUNITIES	302	922		278,073	270,402	256,882	239,562	17,320	172,904	7,757	180,661	722	448	703
3.1 St. Barbs	2	3,523	U	6,342	6,342	6,025	5,803	223	4,475	283	4,759	771	1,274	790
3.2 Laventille	2	4,112	U	6,496	6,496	6,172	6,172		4,610		4,610	747		747
3.3 Morvant	7	2,912	U	19,658	19,658	18,676	18,613	62	14,388	47	14,435	773	753	773
3.4 Picton	9	3,082	U	27,058	27,058	25,705	25,705		19,895		19,895	774		774
3.5 Barataria	13	2,504	U	33,259	33,259	31,596	31,596		23,871		23,871	755		755
3.6 St. Joseph	58	605	S	34,868	31,563	29,985	23,477	6,508	16,323	3,625	19,948	695	557	665
3.7 Arouca	68	355	S	24,269	24,269	23,056	21,578	1,477	14,584	53	14,637	676	36	635
3.8 Tacarigua	13	1,594	U	20,447	19,196	18,236	18,236		12,368		12,368	678		678
3.9 Saddle Road	76	730	S	55,215	54,769	52,031	48,256	3,775	36,475	1,684	38,159	756	446	733
3.10 St. Augustine	29	813	S	23,601	23,573	22,394	17,120	5,275	11,574	2,065	13,639	676	391	609
3.11 Tunapuna	26	1,033	U	26,859	24,218	23,007	23,007		14,342		14,342	623		623
4. ARIMA	141	414	S	61,487	58,180	55,271	55,271		43,435		43,435	786		786
5. SANGRE GRANDE	584	85	R	55,755	49,614	47,133	43,037	4,096	27,418	182	27,599	637	44	586
6. WALLERFIELD	175	143	R	27,365	24,960	23,712	23,712		15,868		15,868	669		669
7. TOCO	370	21	R	8,761	7,821	7,430		7,430		2,611	2,611		351	351
8. CARONI	542	330		186,144	178,931	169,985	147,466	22,518	109,925	4,432	114,357	745	197	673
8.1 Caroni	13	648	S	8,461	8,461	8,038	8,038		5,889		5,889	733		733
8.2 Cunupia	201	265	S	55,597	53,426	50,754	49,724	1,030	37,724	203	37,927	759	197	747
8.3 Chaguanas	153	400	S	63,264	61,403	58,333	43,298	15,035	32,410	2,959	35,369	749	197	606
8.4 Couva	174	320	S	58,823	55,642	52,860	46,406	6,453	33,901	1,270	35,171	731	197	665
9. MAYARO	478	21	R	10,022	9,752	9,265		9,265		2,950	2,950		318	318
10. RIO CLARO	1,382	199		274,591	271,709	258,123	234,054	24,069	116,528	4,419	120,946	498	184	469
10.1 Arch Trace	592	80	R	47,531	44,649	42,416	38,413	4,003	14,691	1,027	15,718	382	256	371
10.2 Princes Town	416	122	R	50,765	50,765	48,227	48,227		18,444		18,444	382		382
10.3 Barrackpore	218	234	R	50,995	50,995	48,445	35,912	12,533	15,604	1,878	17,482	435	150	361
10.4 Fyzabad	93	642	S	59,523	59,523	56,547	49,924	6,623	36,164	1,281	37,445	724	193	662
10.5 Palmyra	58	782	S	45,050	45,050	42,798	41,887	911	16,733	233	16,966	399	256	396
10.6 Marabella	6	3,681	U	20,726	20,726	19,690	19,690		14,892		14,892	756		756
11. SAN FERNANDO	8	3,787	U	29,842	29,842	28,350	28,350		12,800		12,800	452		452
12. SIPARIA/ERIN	195	175	R	34,125	32,716	31,080		31,080		5,751	5,751		185	185
13. POINT FORTIN	297	173	R	51,368	50,018	47,517	13,727	33,790	10,626	8,714	19,340	774	258	407
14. NORTH COAST	194	12	R	2,360	1,842	1,749		1,749		718	718		410	410
TOTAL (TRINIDAD)	4,827	243		1,172,586	1,136,708	1,079,872	825,028	254,844	540,244	107,863	648,107	655	423	600
15. TOBAGO	301	187		56,195	55,784	52,994					20,492			387
15.1 Leeward Sect.	140	311	S	43,689	43,689	41,505					16,594			400
15.2 Windward Sect.	161	78	R	12,505	12,095	11,490					3,898			339
T O T A L	5,128	240		1,228,780	1,192,491	1,132,867	825,028	254,844	540,244	107,863	668,599	655	423	590

Note: * U: Urban, S: Semiurban, R: Rural

Table I-3.5 POPULATION SERVED BY SOURCE GROUP I

SOURCE GROUP I	1980 POPULATION	1990 POPULATION	1990 POPULATION SERVED	(1989) PRODUCTION (m3/day)	(1989) PRODUCTION (lpcd)	INDEX
1 Caroni Arena	327,432	360,148	342,141	264,850	774	118
2 El Socorro	35,713	36,121	34,315	25,633	747	114
3 Hollis	28,231	37,962	36,064	23,452	650	99
4 Caura	13,507	16,669	15,836	9,590	606	92
5 Las Lomas	12,527	16,100	15,295	9,559	625	95
6 Tacarigua	20,776	25,640	24,358	14,516	596	91
7 Valsayn	37,138	41,150	39,093	28,331	725	111
8 Arima Well #6	860	2,020	1,919	644	336	51
9 Aripo Intake	-	-	-			
10 Aripo New	6,062	8,417	7,996	8,997	1,125	172
11 Guanapo	8,113	10,347	9,830	8,625	877	134
12 North Oropouche	54,282	81,941	77,844	57,334	737	112
13 Quare	6,201	8,945	8,498	2,586	304	46
14 Arouca	1,060	1,308	1,243	797	641	98
15 Carlsen Field	13,861	17,905	17,010	11,293	664	101
16 Navet	185,511	203,778	193,589	74,037	382	58
T O T A L	751,273	868,451	825,028	540,244	655	100

Table I-3.7 POPULATION SERVED BY SOURCES IN TOBAGO

SOURCES IN TOBAGO	1980 POPULATION	1990 POPULATION	1990 POPULATION SERVED	(1989) PRODUCTION (m3/day)	(1989) PRODUCTION (lpcd)	INDEX
1 Green Hill	2,145	3,082	2,928	1,653	565	146
2 Hillsborough	9,384	13,406	12,735	7,070	555	144
3 Craig Hall	4,465	5,808	5,517	1,428	259	67
4 Courland	13,323	20,786	19,746	6,406	324	84
5 Castara	463	608	578	37	64	17
6 Richmond	4,501	5,960	5,662	1,800	318	82
7 Kings Bay	3,121	3,895	3,700	1,702	460	119
8 Parlatuvier	283	353	336	18	54	14
9 Bloody Bay	100	125	119	10	84	22
10 L'anse Fourmi	222	277	263	18	68	18
11 Charlotteville	1,188	1,484	1,410	350	248	64
T O T A L	39,195	55,784	52,994	20,492	387	100

Table I-3.6 POPULATION SERVED BY SOURCE GROUP II

SOURCE GROUP II	1980 POPULATION	1990 POPULATION	1990 POPULATION SERVED	(1989) PRODUCTION (m3/day)	(1989) PRODUCTION (lpcd)	INDEX
1 Tucker Valley Wells	10,296	11,799	11,209	8,338	744	176
2 Four Roads Wells	36,122	41,394	39,324	28,786	732	173
3 Dorrington Gardens	7,310	8,376	7,957	2,844	357	84
4 River Estate Wells	7,691	8,813	8,372	6,054	723	171
5 Savannah Wells	8,667	6,947	6,600	8,406	1,274	301
6 King George Wells	7,889	6,310	5,995	6,307	1,052	249
7 Moka Wells	3,521	4,035	3,833	1,441	376	89
8 Maraval	13,959	15,996	15,196	4,850	319	75
9 St. Clair Wells	2,833	2,995	2,845	2,201	774	183
10 St. Anns	958	984	935	695	743	176
11 Dibe Intake	350	401	381	148	389	92
12 Paramin Wells	842	965	917	346	377	89
13 Cascade	189	194	184	196	1,063	251
14 Mon Repos Intake	64	66	63	47	750	177
15 Lluengo Naranjo	4,811	5,937	5,640	3,171	562	133
16 Acono	3,207	3,958	3,760	2,065	549	130
17 Surrey	685	846	804	18	22	5
18 Lopinot	575	710	675	35	52	12
19 Pipiol	1,060	1,089	1,035	81	78	18
20 La Pastora Wells	2,623	2,695	2,560	1,515	592	140
21 La Canoa	186	191	181	88	485	115
22 St. John's Intake	2,032	2,509	2,384	454	190	45
23 Cumaca Intake	822	1,402	1,332	68	51	12
24 Four Roads Tamana Intake	2,686	3,346	3,179	91	29	7
25 Biche	1,085	987	938	253	270	64
26 Freeport	20,012	23,703	22,518	4,432	197	47
27 Matura Intake	1,032	1,326	1,260	35	28	7
28 Salybia Intake	423	549	522	35	67	16
29 Toco	2,508	3,301	3,136	1,896	605	143
30 Matelot Intake	402	530	504	35	70	16
31 Grand Riviere Intake	371	489	465	35	75	18
32 San Souci Intake	573	756	718	509	709	167
33 Monte Video Intake	168	222	211	35	166	39
34 Mayaro	4,964	5,254	4,991	876	176	41
35 Guayaguayare	1,477	1,694	1,609	953	592	140
36 Amoco	2,444	2,803	2,663	1,121	421	99
37 Morichal Spring	2,543	2,951	2,803	718	256	61
38 Guaracara Spring	1,244	1,444	1,372	343	250	59
39 Penal	19,251	22,166	21,058	3,156	150	35
40 Fyzabad	7,422	8,546	8,119	1,570	193	46
41 Siparia	11,229	12,951	12,303	2,859	232	55
42 Carapal	7,942	9,217	8,756	1,325	151	36
43 Cap-de-Ville	5,977	6,760	6,422	1,157	180	43
44 Granville	5,776	6,884	6,540	2,780	425	100
45 Chatham	14,377	16,288	15,474	4,387	284	67
46 Point Fortin	4,885	5,636	5,354	390	73	17
47 Las Cuevas Intake	402	556	528	287	543	128
48 Brasso Paria Intake	324	448	426	27	63	15
49 Blanchisseuse W/W, Intake	605	837	795	404	508	120
T O T A L	236,812	268,256	254,843	107,863	423	100

Table I-3.8 WASA'S DAILY AND WEEKLY WATER SUPPLY

(DAILY WATER SUPPLY)

AREA	24hours	17-23	12-16	1-11	NONE	NOT STATED	TOTAL
PORT OF SPAIN	32	2	1	7	0	0	42
ARIMA BOROUGH	1	1	3	11	0	0	16
DIEGO MARTIN	23	2	0	11	1	2	39
ST. ANNS	59	11	8	22	1	0	101
TACARIGUA	69	3	7	19	0	0	98
ARIMA WARD	2	0	1	14	0	0	17
BLANCHISSEUSE	3	0	1	3	0	0	7
CARONI	1	0	2	4	0	0	7
CHAGUANAS	12	0	6	24	1	1	44
CUNUPIA	3	1	0	1	0	0	5
COUVA	0	2	2	7	0	0	11
CHARUMA	1	0	0	3	2	0	6
TOCO	1	0	0	2	0	0	3
MANZANILLA	1	2	3	4	0	0	10
TAMANA	1	1	3	3	0	0	8
TURURE	4	0	0	4	0	0	8
NORTH(TOTAL)	213	25	37	139	5	3	422
PERCENTAGE	50.5	5.9	8.8	32.9	1.2	0.7	100.0
SAN FERNANDO	2	0	2	21	0	0	25
GUAYAGUAYARE	1	1	0	1	0	0	3
ORTOIRE	7	0	2	2	0	0	11
NAPARIMA	9	4	6	52	1	0	72
POINTE-A-PIERRE	3	0	3	7	1	0	14
MORGA	0	0	1	4	0	0	5
SAVANNA GRANDE	12	3	2	9	1	0	27
POINT FORTIN BOROUGH	3	1	2	6	0	0	12
SIPARIA	3	1	2	21	3	0	30
ERIN	0	0	1	3	1	0	5
LA BREA	3	0	1	8	4	0	16
CEDROS	4	0	0	4	0	0	8
SOUTH(TOTAL)	47	10	22	138	11	0	228
PERCENTAGE	20.6	4.4	9.6	60.5	4.8	0.0	100.0
ST. GEORGE	0	1	1	1	0	0	3
ST. ANDREW	1	0	1	5	0	0	7
ST. PATRICK	0	0	1	5	0	0	6
ST. DAVID	0	1	0	1	0	0	2
ST. PAUL	3	0	1	0	0	0	4
ST. JOHN	1	1	0	2	0	0	4
TOBAGO(TOTAL)	5	3	4	14	0	0	26
PERCENTAGE	19.2	11.5	15.4	53.8	0.0	0.0	100.0
TOTAL	265	38	63	291	16	3	676
PERCENTAGE	39.2	5.6	9.3	43.0	2.4	0.4	100.0

(WEEKLY WATER SUPPLY)

AREA	7DAYS	4-6	1-3	NONE	NOT STATED	TOTAL
PORT OF SPAIN	36	2	4	0	0	42
ARIMA BOROUGH	6	5	5	0	0	16
DIEGO MARTIN	20	7	10	0	2	39
ST. ANNS	84	7	10	0	0	101
TACARIGUA	84	12	2	0	0	98
ARIMA WARD	9	2	6	0	0	17
BLANCHISSEUSE	4	1	2	0	0	7
CARONI	3	2	2	0	0	7
CHAGUANAS	35	4	2	1	2	44
CUNUPIA	4	0	1	0	0	5
COUVA	0	7	4	0	0	11
CHARUMA	0	0	4	2	0	6
TOCO	1	0	2	0	0	3
MANZANILLA	5	1	4	0	0	10
TAMANA	3	1	4	0	0	8
TURURE	3	1	4	0	0	8
NORTH(TOTAL)	297	52	66	3	4	422
PERCENTAGE	70.4	12.3	15.6	0.7	0.9	100.0
SAN FERNANDO	16	7	2	0	0	25
GUAYAGUAYARE	2	0	1	0	0	3
ORTOIRE	4	7	0	0	0	11
NAPARIMA	26	21	24	1	0	72
POINTE-A-PIERRE	2	3	8	1	0	14
MORGA	0	1	4	0	0	5
SAVANNA GRANDE	15	6	5	1	0	27
POINT FORTIN BOROUGH	7	2	3	0	0	12
SIPARIA	1	3	23	3	0	30
ERIN	0	0	4	1	0	5
LA BREA	1	4	7	4	0	16
CEDROS	7	0	1	0	0	8
SOUTH(TOTAL)	81	54	82	11	0	228
PERCENTAGE	35.5	23.7	36.0	4.8	0.0	100.0
ST. GEORGE	0	2	1	0	0	3
ST. ANDREW	2	1	4	0	0	7
ST. PATRICK	2	1	3	0	0	6
ST. DAVID	1	0	1	0	0	2
ST. PAUL	2	2	0	0	0	4
ST. JOHN	1	2	1	0	0	4
TOBAGO(TOTAL)	8	8	10	0	0	26
PERCENTAGE	30.8	30.8	38.5	0.0	0.0	100.0
TOTAL	386	114	158	14	4	676
PERCENTAGE	57.1	16.9	23.4	2.1	0.6	100.0

Table I-3.9 WATER QUALITY BY CUSTOMERS

AREA	(COLOR) CLEAR	DISCOLORED	NA	NOT STATED	TOTAL	(ODOR) ODOR	ODORLESS	NA	NOT STATED	TOTAL
PORT OF SPAIN	39	3	0	0	42	1	12	0	29	42
ARIMA BOROUGH	15	1	0	0	16	0	16	0	0	16
DIEGO MARTIN	36	3	0	0	39	1	37	0	1	39
ST. ANNS	84	16	0	1	101	12	43	0	46	101
TACARIGUA	94	4	0	0	98	3	91	0	4	98
ARIMA WARD	12	5	0	0	17	0	16	0	1	17
BLANCHISSEUSE	6	1	0	0	7	2	5	0	0	7
CARONI	5	2	0	0	7	0	7	0	0	7
CHAGUANAS	39	5	0	0	44	8	34	0	2	44
CUNUPIA	3	2	0	0	5	1	4	0	0	5
COUVA	8	2	0	1	11	2	8	0	1	11
CHARUMA	3	1	2	0	6	1	3	2	0	6
TOCO	2	1	0	0	3	0	3	0	0	3
MANZANILLA	10	0	0	0	10	0	10	0	0	10
TAMANA	7	1	0	0	8	1	7	0	0	8
TURURE	7	1	0	0	8	2	6	0	0	8
NORTH(TOTAL)	370	48	2	2	422	34	302	2	84	422
PERCENTAGE	87.7	11.4	0.5	0.5	100	8.1	71.6	0.5	19.9	100
SAN FERNANDO	12	13	0	0	25	4	12	0	9	25
GUAYAGUAYARE	0	3	0	0	3	0	3	0	0	3
ORTOIRE	4	7	0	0	11	1	9	0	1	11
NAPARIMA	41	30	1	0	72	12	39	1	20	72
POINTE-A-PIERRE	8	5	1	0	14	1	12	1	0	14
MORGA	3	2	0	0	5	0	5	0	0	5
SAVANNA GRANDE	14	12	1	0	27	3	20	1	3	27
POINT FORTIN BOROUGH	8	4	0	0	12	2	10	0	0	12
SIPARIA	15	12	2	1	30	3	23	2	2	30
ERIN	2	2	1	0	5	0	4	1	0	5
LA BREA	11	1	4	0	16	1	11	4	0	16
CEDROS	8	0	0	0	8	0	8	0	0	8
SOUTH(TOTAL)	126	91	10	1	228	27	156	10	35	228
PERCENTAGE	55.3	39.9	4.4	0.4	100	11.8	68.4	4.4	15.4	100
ST. GEORGE	2	1	0	0	3	0	3	0	0	3
ST. ANDREW	6	1	0	0	7	0	7	0	0	7
ST. PATRICK	5	1	0	0	6	0	6	0	0	6
ST. DAVID	2	0	0	0	2	0	2	0	0	2
ST. PAUL	4	0	0	0	4	0	4	0	0	4
ST. JOHN	0	3	0	1	4	1	2	0	1	4
TOBAGO(TOTAL)	19	6	0	1	26	1	24	0	1	26
PERCENTAGE	73.1	23.1	0.0	3.8	100	3.8	92.3	0.0	3.8	100
TOTAL	515	145	12	4	676	62	482	12	120	676
PERCENTAGE	76.2	21.4	1.8	0.6	100	9.2	71.3	1.8	17.8	100

NOTE: NA: Not Applicable

Table I-3.10 STORAGE FACILITY

AREA	YES	NO	TOTAL
PORT OF SPAIN	13	29	42
ARIMA BOROUGH	12	4	16
DIEGO MARTIN	23	16	39
ST. ANNS	57	44	101
TACARIGUA	38	60	98
ARIMA WARD	13	4	17
BLANCHISSEUSE	3	4	7
CARONI	7	0	7
CHAGUANAS	28	16	44
CUNUPIA	3	2	5
COUVA	10	1	11
CHARUMA	5	1	6
TOCO	1	2	3
MANZANILLA	7	3	10
TAMANA	6	2	8
TURURE	2	6	8
NORTH(TOTAL)	228	194	422
PERCENTAGE	54.0	46.0	100.0
SAN FERNANDO	13	12	25
GUAYAGUAYARE	0	3	3
ORTOIRE	7	4	11
NAPARIMA	42	30	72
POINTE-A-PIERRE	12	2	14
MORGA	5	0	5
SAVANNA GRANDE	22	5	27
POINT FORTIN BOROUGH	9	3	12
SIPARIA	27	3	30
ERIN	5	0	5
LA BREA	15	1	16
CEDROS	5	3	8
SOUTH(TOTAL)	162	66	228
PERCENTAGE	71.1	28.9	100.0
ST. GEORGE	3	0	3
ST. ANDREW	7	0	7
ST. PATRICK	5	1	6
ST. DAVID	2	0	2
ST. PAUL	3	1	4
ST. JOHN	4	0	4
TOBAGO(TOTAL)	24	2	26
PERCENTAGE	92.3	7.7	100.0
TOTAL	414	262	676
PERCENTAGE	61.2	38.8	100.0

Table I-3.11 CUSTOMERS MIND/CONSCIOUSNESS FOR WASA WATER SUPPLY

AREA	SATISFIED	UNSATISFIED	NA	NOT STATED	TOTAL
PORT OF SPAIN	31	11	0	0	42
ARIMA BOROUGH	5	11	0	0	16
DIEGO MARTIN	24	15	0	0	39
ST. ANNS	64	35	1	1	101
TACARIGUA	78	20	0	0	98
ARIMA WARD	4	13	0	0	17
BLANCHISSEUSE	4	3	0	0	7
CARONI	1	5	1	0	7
CHAGUANAS	20	23	0	1	44
CUNUPIA	4	1	0	0	5
COUVA	1	10	0	0	11
CHARUMA	2	4	0	0	6
TOCO	2	1	0	0	3
MANZANILLA	6	4	0	0	10
TAMANA	5	3	0	0	8
TURURE	5	3	0	0	8
NORTH(TOTAL)	256	162	2	2	422
PERCENTAGE	60.7	38.4	0.5	0.5	100.0
SAN FERNANDO	9	16	0	0	25
GUAYAGUAYARE	2	1	0	0	3
ORTOIRE	5	6	0	0	11
NAPARIMA	26	46	0	0	72
POINTE-A-PIERRE	4	10	0	0	14
MORGA	0	5	0	0	5
SAVANNA GRANDE	13	14	0	0	27
POINT FORTIN BOROUGH	6	6	0	0	12
SIPARIA	13	17	0	0	30
ERIN	3	2	0	0	5
LA BREA	6	10	0	0	16
CEDROS	6	2	0	0	8
SOUTH(TOTAL)	93	135	0	0	228
PERCENTAGE	40.8	59.2	0.0	0.0	100.0
ST. GEORGE	0	3	0	0	3
ST. ANDREW	1	6	0	0	7
ST. PATRICK	3	3	0	0	6
ST. DAVID	1	1	0	0	2
ST. PAUL	4	0	0	0	4
ST. JOHN	0	3	0	1	4
TOBAGO(TOTAL)	9	16	0	1	26
PERCENTAGE	34.6	61.5	0.0	3.8	100.0
TOTAL	358	313	2	3	676
PERCENTAGE	53.0	46.3	0.3	0.4	100.0

NOTE: NA: Not Applicable

PRESSURE	SATISFIED	UNSATISFIED	NA	NOT STATED	TOTAL
VERY GOOD	46	16	1	0	63
GOOD	180	100	0	0	280
FAIR	92	76	1	1	170
POOR	38	107	0	1	146
NOT APPLICABLE	0	12	0	0	12
NOT STATED	2	2	0	1	5
TOTAL	358	313	2	3	676

COLOR	SATISFIED	UNSATISFIED	NA	NOT STATED	TOTAL
CLEAR	309	202	2	2	515
DISCOLORED	49	96	0	0	145
NOT APPLICABLE	0	12	0	0	12
NOT STATED	0	3	0	1	4
TOTAL	358	313	2	3	676

ODOR	SATISFIED	UNSATISFIED	NA	NOT STATED	TOTAL
ODOR	21	41	0	0	62
ODORLESS	270	209	1	2	482
NOT APPLICABLE	0	12	0	0	12
NOT STATED	67	51	1	1	120
TOTAL	358	313	2	3	676

HOURS	SATISFIED	UNSATISFIED	NA	NOT STATED	TOTAL
24 HOURS	218	44	2	1	265
17-23 HOURS	22	15	0	1	38
12-16 HOURS	29	34	0	0	63
1-11 HOURS	86	204	0	1	291
NONE	1	15	0	0	16
NOT STATED	2	1	0	0	3
TOTAL	358	313	2	3	676

DAYS	SATISFIED	UNSATISFIED	NA	NOT STATED	TOTAL
7 DAYS	269	113	2	2	386
4-6 DAYS	42	71	0	1	114
1-3 DAYS	45	113	0	0	158
NONE	0	14	0	0	14
NOT STATED	2	2	0	0	4
TOTAL	358	313	2	3	676

Table I-3.12 RESULT OF PILOT LEAKAGE SURVEY

No.	Town	Area	[1] Number of House	[2] No. of Persons a House	[3] No. of Persons	[4] Isolated Block (Km2)	[5] Total Flow (m3/day)	[6] Minimum Flow (m3/h)	[7] Night Pressure (Kg/cm2)	[8] Leakage (m3/day)	[9] [5]-[8] Water Consumption (m3/day)	[10] [8]/[5] Leakage (%)	[11] [9]/[5] Water Consumption (%)	[12] [9]/[3] Per Capita Consumption (lpcd)
1	DIEGO MARTIN	DIAMOND VALE	69	4.4	304	0.57	91.554	2.51	3.40	50.268	40.749	54.91	45.09	135.99
2	DIEGO MARTIN	VICTORIA GARDEN	91	4.4	400	0.94	605.137	27.12	2.60	453.331	151.825	74.91	25.09	379.18
3	DIEGO MARTIN	VICTOTIA GARDEN	91	4.4	400	0.94	254.373	8.92	3.70	161.764	92.609	63.59	34.41	231.29
4	DIEGO MARTIN	DIAMOND VALE	58	4.4	255	0.54	144.450	3.81	2.40	79.438	65.012	54.99	45.01	254.75
5	St JOSEPH	TRINCITY	43	4.3	185	0.40	73.908	1.25	2.60	23.415	50.493	31.68	68.32	273.08
6	St JOSEPH	VALSAYN	80	4.3	344	2.20	333.125	11.70	0.40	280.346	52.779	84.16	15.84	153.43
7	TOBAGO	PLYMOUTH	280	4.7	1316	2.80	342.924	4.70	4.70	178.571	164.353	52.07	47.93	124.89
8	ARIMA	NETTOVILLE	91	4.4	400	1.58	140.192	3.49	2.80	80.028	57.163	59.22	40.78	142.77
9	ARIMA	TUMPUNA	102	4.4	449	0.87	130.967	3.73	4.20	260.256	149.289	50.34	57.36	332.64
10	PORT OF SPAIN	ST. JAMES	116	3.1	360	1.18	-	-	-	-	-	-	-	-

Note: [2] Source: Households Budgetary Survey 1989, CSO

4. EXISTING WATER SUPPLY SUPERVISORY SYSTEM

4.1 OVERVIEW OF WATER SUPPLY SYSTEM

4.1.1 History

The history of water supply in Trinidad and Tobago started with the Maraval Waterworks which was established in 1853 with a water production of approximately 4,500 m^3/d. This was the first public water supply system in the country.

It was in 1902 that the River Estate Waterworks was developed to provide water for the western part of Port of Spain area. The development of the country water resources continued in the 1920's in order to improve the supply in the urban centers namely: Port of Spain, San Fernando, Arima in Trinidad and Scarborough in Tobago.

Between 1933 and 1939, the first island-wide project and major surface water source, the Hollis Waterworks, was developed. The present production is 32,000 m^3/d. Water from that source was piped to Port of Spain and remote area in East and South Trinidad.

In addition, the country's groundwater resources were also developed, and by 1949, the total water production was raised to 68,000 m^3/d (about 10% of the current total production in 1989).

In 1950, the Government of Trinidad and Tobago issued a Council Paper, aiming at urgent formulation of a comprehensive program for the developing water resources in the country. In line with this policy, completed in 1962 are Hillsborough Waterworks (Tobago) and the Navet Waterworks (Trinidad) with production of 8,600 m^3/d and 27,000 m^3/d respectively. Further, borehole fields were established in Diego Martin, Valsayn, Tacarigua, Wallerfield, Penal, Granville, El Socorro, Port of Spain and Carlsen Field. Despite such efforts for enhancing water supply system development, a supply deficiency began to develop with the emergence of the Government's industrialization program in the late 1950's.

It was in 1965 that the Water and Sewerage Authority (WASA) was established as the sole agency responsible for the development and control of the water and waste water systems in the country.

Due to financial constraints in the 1960's, WASA was unable to develop large scale surface water sources. It was in and after the 1970's that WASA and the Ministry of Finance embarked several water supply development projects in order to meet the increasing water demand of the country. They are construction of Navet waterworks (with a production 77,280 m^3/d) completed in 1976, North Oropouche waterworks (with a production 90,920 m^3/d) in 1979, package treatment plants in Northern Range Valleys in 1980 and a large scale Caroni-Arena Project (with a production 272,760 m^3/d) in 1983. Newly increased water production during this period reached to about 60% of the total. The area served by these waterworks are illustrated in Fig. I-3.2 and also the existing water supply facilities are presented in Supporting Report I "Existing Water Supply Facilities".

4.1.2 Production Facilities

1) Water Production

As already described in the forgoing section, the existing production facilities are classified into three in terms of magnitude of production: a) large scale, b) medium scale and c) small scale water supply system as referred to Tables I-3.1 and I-3.2.

a) Large Scale Water Supply System

The large scale system with a design production capacity in excess of 30,000 m^3/d is exemplified by Caroni-Arena, North Oropouche, Navet and Hollis Systems in Trinidad. The system generally consists of intake, treatment facilities, transmission/distribution pipes, service storage reservoirs.

The above four systems have the annual average daily production capacity of 404,331 m^3/d in total as of 1988, equivalent to 63.5% of that in

Trinidad. Thus, these systems are contributing significantly to the public as potable water supply in Trinidad.

b) Medium Scale System

The medium scale system focussed herein has a production capacity between 1,000 m^3/d and 30,000 m^3/d. The number of the systems is 38 in total as of 1988, out of which 14 systems extract river water and the 24 groundwater.

River Water Source (14) (8 in Trinidad and 6 in Tobago)

The production capacity of the above is 56,795 m^3/d in total as of 1988, out of which 37,710 m^3/d or 5.9% are production capacity in Trinidad and 19,085 m^3/d or 95.2% in Tobago. Hence, most of the production facilities in Tobago are categorized into medium scale systems that treat surface water.

Groundwater Sources (24) (all in Trinidad)

The production capacity, 183,313 m^3/d are summed up in 1988, or 28.9% in Trinidad. These systems supply hygienic water to each demand zone dispersed in the island.

c) Small Scale System

The small scale system with a production less than 1,000 m^3/d totals 50 in number in 1988. There are 38 surface water treatment systems: 32 in Trinidad and six in Tobago. The remaining 12 are all groundwater/spring water supply including 11 in Trinidad and one in Tobago. They are located mostly in the rural area, supplying consumers nearby waterworks. They are also contributing greatly to the establishment of potable water supply to such remote and small villages regardless of the scale of the facilities.

The total production capacity of the small scale systems is only 12,109 m^3/d as of 1988, of which 11,154 m^3/d is produced in Trinidad and 4.8% in Tobago.

2) Treatment Process/Method

The existing production facilities apply various combination of treatment processes reflecting variation of raw water quality, and are grouped largely into two in terms of the processes/methods applied. They are a) plants which apply only chlorination and b) plants employ full treatment process such as aeration, coagulation, sedimentation, filtration, chlorination and other special treatment methods as referred to Tables I-3.1 and I-3.2. Followings are salient features of the production facilities:

a) Among the total 56 production facilities which treat surface water, 15 large and medium scale facilities apply combination of coagulation, sedimentation, filtration processes before chlorination. Generally, they produce water of satisfactory quality in accordance with WHO guidelines, regardless of any conditions of raw water turbidity,

b) A number of small and medium scale systems that treat surface water by applying only chlorination suffer from seasonal fluctuation in raw water turbidity.

c) In Trinidad, the existing 32 production facilities take raw water from boreholes, out of which the 16 abstract rather clean groundwater from North-West Peninsula Gravels and Northern Gravels aquifers. The remaining 16 obtain iron-bearing groundwater from Central Sands and Southern Sands aquifers, all requiring a combination of aeration, coagulation, sedimentation, filtration before chlorination.

4.1.3 Transmission/Distribution Facilities

Transmission/distribution facilities consist of service storage reservoirs, booster pumping stations/high lift pumping stations and pipelines. The pipelines link numerous 99 service storage reservoirs and 52 booster and 6 high lift pumping stations as referred to Table I-4.1 and Fig. I-3.2.

1) Service Storage Reservoirs

The storage capacity of the reservoirs varies much from a low less than 45 m^3 up to 45,500 m^3. Most of the reservoirs have rather small capacity.

They are generally located on higher elevation near water demand zone to serve hydraulically to a possible extent. Their location generally meets the requirements of an economic water distribution.

Most existing service storage reservoirs apply combined inlet-outlet piping system which does not require frequent valve control.

WASA presently utilizes 76 service storage reservoirs in the distribution system out of total 99. Namely, 22 in Trinidad and one in Tobago are not in use.

The total storage capacity of these reservoirs which are functioning reaches to 365,298 m^3 in Trinidad and 9,449 m^3 in Tobago. The retention time of these storage capacities are equivalent to 13.8 hours of water production in Trinidad and 11.3 hours in Tobago in 1988.

There are 22 non-working service storage reservoirs in Trinidad, of which storage capacity sums up to 17,571 m^3. This may be attributable to the fact that the treated water from waterworks does not reach the reservoirs, especially in South West Region. In view of a) a decreasing carrying capacity of pipelines, b) difficulty in financing the implementation of comprehensive schemes for rehabilitating/upgrading and pumping equipment, c) a large amount of leakage prevailing on the transmission/distribution pipelines, and e) the chronic raw water shortage, this situation might be well explained.

2) Booster Pumping Station/High Lift Pumping Station

There are 52 booster pumping stations and six high lift pumping stations in Trinidad and Tobago. Out of them, 48 booster and six high lift pumping stations are located in Trinidad and four booster pumping stations in Tobago.

A relatively reliable and low cost electric power supply has bolster the construction throughout the country.

Pumping stations currently in operation are 51 booster and five high lift pumping stations: 52 in Trinidad and four in Tobago.

On the other hand, both one booster and one high lift pumping stations in Trinidad are not in operation, because of insufficiency of the water in terms of pressure and quantity.

3) Transmission/Distribution Pipelines

Transmission/distribution pipelines, most of which are substantially aged, have been installed since commissioning Maraval Waterworks in 1853. A variety of pipe materials is used, namely, steel, cast iron, prestressed concrete, ductile iron, PVC, asbestos cement and galvanized steel pipes. The ductile iron and PVC pipes were installed rather recently. The present pipeline conditions vary to a large extent reflecting their ages, materials, soil conditions, maintenance, etc.

Among others, the cast iron pipes, asbestos cement pipes and galvanized steel pipes, all installed more than twenty years ago, are seriously deteriorated and causing the following problems:

a) The cast iron and galvanized steel pipes are already deteriorated by corrosion due to an absence of coating and/or lining.

b) The existing pipelines, accordingly, have reduced their conveyance capacity, and

c) The asbestos cement pipes, rather brittle and vulnerable against the heavy loads, have been installed on less pipe covering depth under public roads. In addition, they usually decrease the wall thickness in the longer use due to the asbestos soluble in water. These might be attributable to the frequent pipe breakage and a large amount of water leakage.

It is observed in some area that waterworks development has not coincided with the expansion of the transmission/distribution mains. There are existing mains in use with a rather limited conveyance capacity as compared to the water demand of the planned supply zone. Leaks are frequently observed on such old deteriorated pipelines.

In addition, the existing transmission/distribution pipelines have the following specific features:

a) Principally, the existing piping systems are not clearly and/or exactly identified as the transmission and distribution purpose at the same manner.

b) Rehabilitation and replacement covering substantial area of the old distribution pipe network have not been conducted so far. Consequently, the utilization of such deteriorated pipelines are causing significant decrease of the transportation capability.

c) Many gate valves installed as flow control valves are usually found on the water mains and branched pipelines. On the other hand, flow meters installed on the pipelines and at waterworks are very few in number and even if found, mostly inoperative and not utilized due to lack of proper maintenance. This means that the operator(s) of production facilities can not monitor and identify actual system flow, water demands or even water production amounts.

4.2 MONITORING

Flow Meters

A variety of types such as orifice plate, partial flume, annubar, propeller and venturi tube has been installed as flow meters. They are found mostly at waterworks but rarely at booster pumping stations. As referred to Table I-4.2, 38 meters are installed on raw water transmission and header mains of total 95 waterworks in Trinidad and Tobago, or 73% of total water production are actually measured in 1988. The remainder is principally

estimates from pump operation records.

Level Meters

Level sensing meters installed at reservoirs and tanks are air purge, gauging staff and pressure differential types. The most typical one is the pressure differential type. Rather complex air purge meters that usually require routine maintenance are mainly defective and left under unworking conditions.

Pressure Gauges

As is often used as pressure gauge, a Bourdon-tube type dominates the waterworks. They are usually installed at raw water intake facilities, backwashing facilities and pumping stations. Some of them are not functioning because of the worn-out elastic elements and appurtenances. It was also found that measurable range of some pressure gauges is inconsistent with the actual water pressure. The measurable range might be incorrectly selected when designed or repaired.

Operation Report

Although a large number of monitoring equipment mostly outlive their design life and are malfunctioning as stated above, flow conditions at the selected points in the water supply system are periodically measured and recorded at site. The daily and hourly records thus obtained are compiled monthly operation reports to WASA head office.

Accuracy of Data

Accurate and reliable data on ground elevation near reservoirs and intake pump facilities are indispensable for effective operation and maintenance of the system. However, data available in WASA are not necessarily accurate as indicated in the WASA's leveling survey conducted under this study. Major facilities' data obtained in the present Study are given in Table I-4.3. Lack of reliable data may be a set back for WASA to carry out intended data processing, analyses and evaluation of the designed water distribution.

Hence, it is strongly recommended that WASA carries out topographical/leveling surveys and inventory of actual equipment specifications at major water supply facilities in Trinidad and Tobago.

Meanwhile, the CSS has been malfunctioning since January 1990, despite WASA's intention of monitoring and recording automatically water level, pressure and flow rate at the designated points in the water supply system. As regards the existing conditions of the CSS, the present report discusses in more detail in Section 4.5 which follows.

4.3 OPERATION/CONTROL

Production Facilities and Reservoirs

The existing production facilities are practicing constant flow rate operation. No hourly fluctuation is observed in raw water intake, filtration, chemical dosing and production rates. Hence, WASA expects the storage capacity of reservoirs may mitigate the hourly variation in water demand. It was, however, confirmed at the several service storage reservoirs positioned in rather high elevation that the treated water does not reach the reservoirs because of the considerable leakage and consumption on its way from the waterworks. In addition, many altitude valves installed for controlling water level are malfunctioning, presumably because of an absence of the proper maintenance. Although this issue is further discussed in Section 4.4, it can be concluded that most storage reservoirs are not properly operated according to water demand fluctuation or any other specific objectives.

At Hollis waterworks, there exists no clear water reservoirs. Whole treatment process and operation are under serious influence in the absence of the reservoirs, resulting in less efficiency of filtration and chlorination and wide fluctuation of water production during backwashing.

Pumping Station

With regard to pumping facilities, the WASA's systems use rather high pump head for the purpose of supplying more water to the consumers because the

water distribution systems are not sufficiently zoned. Hence, in a situation where the real time demands of many consumers can not be satisfied the water supply system and because of the general pump characteristics in many cases pumps are operated far behind or beyond the rated design capacity in terms of pressure and discharge, with decreased efficiency increased power consumption or more leakage from the pipe network.

Transmission and Distribution Mains

To evaluate the conveyance capacity of the transmission and distribution mains, field measurement surveys were conducted under the present Study as referred to Supporting Report J "Field Flow Measurement of Transmission/ Distribution Mains". The surveys conclude that most pipelines have experienced reduced carrying capacity, far less than the original design capacity due mainly to encrustation and deterioration. Numerous number of the off-takes to supply water to the consumers branch from the transmission mains as well as from the distribution. Therefore, water supplies from waterworks are decreasing rapidly its flow rate before reaching the major demand zone because of substantial amount of leakage and water consumption.

Under such circumstances, WASA is inevitably rationing water supply by manual control of the existing gate valves. To this end, each regional office has developed turncock schedules through long term experience by try and error method. There are many turncock staff (80 personnel in total as of August, 1990) stationed in the regional offices and most consumers, 66.2% according to the customer survey, retain storage tanks to store WASA's water to satisfy their daily consumption.

As described above, gate valves installed at off-takes are frequently used to control flow rate. It is, however, broadly accepted criteria that the gate valves are merely effective for shutting/opening function. If the gate valves are used for flow rate control in wider range, valve operation cause possible problems of cavitation inside pipes. In fact, the cavitation noise resulting from these controllers is audible at the existing pumps/valves in Las Lomas and Valsayn waterworks.

Operation Report

Apart from the system control, the district offices and waterworks prepare monthly operation reports in the specified format. They are submitted monthly to the WASA head office. Major items highlighted in the reports are water production, water distribution, cost, staff performance, etc., all related to water supply system operation and maintenance.

Measures and Actions

To seek a comprehensive solution to the above, WASA is recommended to take the following immediate measures and action;

1) To install flow meters, pressure gauges and controllers at off-takes for data acquisition and effective water distribution,

2) To install flow meters on the raw water main and clear water transmission main of the waterworks,

3) To apply universal metering system to charge water tariff to consumers based on their actual water consumption, aiming at reduction of enormous amount of water wastes and losses,

4) To replace and rehabilitate the deteriorated pipelines to restore the original design capacity, and

5) To refurbish and calibrate the malfunctioning pumps, meters, pressure gauges, valves, etc.

4.4 MAINTENANCE

Outstanding Features

Many mechanical and electrical equipment are malfunctioning and left without proper maintenance, although WASA has been making all efforts to cope with this issue. According to WASA officials, this is due mainly to the

severe cash flow situation of WASA and the central government in the past several years, due partly to the limited spares and which in many cases are not locally available. Following are the outstanding features of the system maintenance.

1) After years of operation, some artesian wells are no longer yielding sufficient amount of groundwater. Further, treatment facilities at Chatham waterworks, which consists of the following processes of aeration, sedimentation and filtration are not functioning properly because maintenance has been untimely practiced.

2) In Guanapo waterworks, a decreased rate of the raw water extraction due to deposits accumulated on the river base is causing a substantial cutback in water production.

3) As to water quality control, WASA manages to carry out water sampling and testing of the separately located 95 water sources under the sole organization of the Central Laboratory. In general, bacteriological quality of finished water is satisfactorily maintained safe to the consumers by practicing chlorination at respective sources of supply.

4) The raw water for Caroni waterworks is currently exposed to the possible pollution from industry and farms. This issue was formerly highlighted in the report titled "Water Pollution Control, 1988". WASA, according to the recommendation made in the report, is taking necessary actions to establish a licensing system to control the effluence discharged into the Caroni tributaries.

5) The fact that various types of pump equipment, meters and gauges installed so far have been malfunctioning may be a burden of providing an appropriate number of standby and spares for timely repair of equipment.

6) Because of inadequate inventory of spares, it is a practice to overhaul and cannibalize the defective pumps. To obtain the desirable pump lift, WASA has reshaped even pump impellers. Despite these efforts, many malfunctioning pumps are still left at site with the worn-out appurtenances.

7) Rather high pump head designed by WASA is causing an increased occurrence of valve cavitation and more leakage from the distribution network.

8) Malfunctioning altitude valves due to the worn-out accessories are found at the several major service storage reservoirs in Mt. Hope, Picton No.3, Malick, California and San Fernando, and left without maintenance.

9) Visible leaks are easily found at the various points in the distribution network and even on the premises of WASA. Vast amount of leakage also observed at the major service storage reservoirs in St. Augustine and Mt. Hope.

Necessary Measures

As suggested above, WASA is consistently seeking to cope with these problems although facing to the severe shortage of capital reserves. To strengthen further WASA's capability of the system maintenance, followings are considered essential:

1) To carry out review study on the function and capability of the existing laboratory system for future expansion;

2) To make organizational arrangement in WASA aiming specifically at systematical leak abatement and wastage control;

3) To prepare a comprehensive maintenance program of the entire water supply system including the boreholes, intake facilities, treatment facilities, reservoirs, booster pumping stations and distribution pipelines, and to conduct periodical inspection, calibration and lubrication for maintenance, and to repair and replace the defective equipment and facilities where required; and

4) To employ uniform type of mechanical and electrical equipment as far as possible for ease of maintenance.

4.5 EXISTING CENTRAL SUPERVISORY SYSTEM (CSS)

4.5.1 Background

The existing CSS was introduced in 1980 as a part of Caroni-Arena water supply project. According to the "Final Design Report on Caroni-Arena Water Supply Project, August 1977", this introduction was a first step to develop the CSS throughout the country. The area covered by the CSS, therefore, was limited to the major waterworks, booster pumping stations and reservoirs located in Caroni-Arena system as shown on Fig. I-4.1.

Further, the purposes of this CSS was to effectively operate and control, under a single operation and management system, the complicated WASA's water supply system which has the aforementioned numerous water sources, production facilities and transmission/distribution sub-systems. The Report also suggests the necessity of detailed study of the distribution systems and establishment of metering systems on all consumers as early as possible.

The objectives of the existing CSS as detailed in the "Project Proposal for Japanese Development Program" prepared by WASA are especially on the following points:

a) to improve the flow of information for quicker decision making, thus to enhance the management of the water supply system,
b) to effectively monitor plant operation, the transmission, and distribution systems,
c) to optimize the use of resources like manpower, electricity, chemicals, and water itself,
d) to provide a more efficient service to the customers, and to improve the overall performance of WASA, and
e) to enhance planning functions through storage and retrieval of data.

During the period of two years from its start in November 1980 to November 1982, the system was merely effective in data acquisition and part of alarm notification. Remote control system originally planned did not function well during the said period because of delay in the completion of Tumpuna Storage Lift Pumping Station. Since the whole maintenance was entrusted to the local

agent under system maintenance contract during the said period, and in additional critical troubles on the system WASA's itself were seldom included.

During the period from 1983 to the end of 1986, the CSS was not normally operated due to repair of the two computer systems and RTUs (remote terminal units) which had troubles, and difficulty in procuring spares of CRT (cathode tube ray) display and RTUs from abroad.

After repairing them and expansion of RTUs, the CSS operation with remote control system was resumed in 1987 and was still merely effective in function of water supply supervisory as originally planned, although WASA had been making all efforts to cope with this issue.

The malfunctioning RTUs, however, had to be cannibalized by replacing with normally functioning RTU instruments. This was inevitably made because of difficulty in obtaining necessary spare parts and also the severe cash flow situation of WASA and the central government. The CSS thus reduced its operating units.

The CSS was stopped in operation after January, 1990 mainly due to the problems of devices and spare parts supply for the main computer system. Continuous use of the existing CSS equipment was found almost impracticable because of difficulties for obtaining its spare parts. WASA made a judgment that a repair of the computer peripherals was not economical, which required a large amount of investment.

Conclusively, the CSS did not function as planned. This can be attributable to the fact that 1) very few number of monitoring equipment on the distribution/transmission mains were installed for the CSS, 2) accurate information and data on the water supply system were not available in WASA, 3) metering system was not adopted for all consumers and 4) inadequate training of operations and maintenance was also a problem. This will be further discussed in 4.5.4 and 4.5.5 which follow.

4.5.2 CSS Facilities

The CSS of Caroni-Arena System was composed of the following equipment for real-time monitoring and for historical data acquisition and processing. The historical data were planned to be utilized both for long and short-term planning.

a) Two(2) central computers located at CSS building (WASA's head office), including one standby.
b) Two(2) data radio two-way communication repeaters located at Pepper Hill, Central Trinidad, including one standby.
c) Twelve(12) RTUs, each of which includes a data two-way communication radio at strategic locations in Caroni-Arena.
d) Field instruments and relay contacts for controlling.

Despite the short period when the CSS was functioned, the following items were automatically data collected and recorded by the CSS:

a) river water level in Caroni, clear water levels, flow and pressure at eight waterworks,
b) suction and discharge pressure and flow rate of the four booster pumping stations,
c) water level of the 10 service storage reservoirs,
d) flow rate and pressure of the flow control station.

The Tumpuna Storage Lift Pumping Station after its completion started remote control from the Caroni Water Treatment Plant based on the information of water level telemetered by CSS.

The central computer was equipped with the following basic software for the purposes of system maintenance and historical data processing:

a) input/output to RTU,
b) alarm processing,
c) process control,
d) historical data base,
e) supervisory on running conditions of CPU (central processing unit),

f) message facility for data processing,

g) man/machine interface.

Detailed contents of the existing CSS is covered in the Supporting Report M "Existing CSS Facilities".

4.5.3 Operation and Maintenance

While additional staff members were employed there was no reform or reorganization of WASA specifically for CSS. It was engineer(s) and staff in Operation and Maintenance division, WASA that took care of the CSS operation and maintenance (after expiration of the maintenance contract in 1983). To print out computer data and operate voice radio communication system, they were assigned on the basis of normal daytime shift.

As of November 1989, out of the existing 22 RTU, 10 are in operation, and out of 87 data items to be collected, only 35 are actually counted for data acquisition and processing.

The reason why only a half of the installed RTU were operated was that WASA had to supplement parts for troubled RTUs by replacing with other normal RTUs (especially transducers). WASA was unable to repair the troubled parts due to shortage of electronic spare parts. The RTUs of which parts were dismantled were left without maintenance and operation.

The reason why the CSS stopped in operation in January, 1990, was that WASA concluded to be not economical to repair the drive head units and disk drive units which are input and output equipment of the central computer.

According to the Operation and Maintenance (O/M) Annual Report 1988 approximately 2,500 screen pictures (equivalent to one month operation) have been produced out from the CSS, but any explanatory notes are not provided in what way they were utilized for implementing and planning of the water supply management.

This annual report further describes that one computer system then operated was obliged to stop for maintenance, resulting in failure of the whole on-line operation of the system. This was due to shortage of spare parts retained in both WASA and the local agent. To be worse, somewhat obsolete system equipment is no longer produced by manufacturers 10 years after installation. Conclusively it states that it is becoming difficult to obtain the spare parts, which require much time and cost.

4.5.4 Problems

Problems found in the course of the surveys and in the WASA's reports are as follows:

a) The existing CSS was originally planned for efficient maintenance of the Caroni-Arena System. However, the data collected were not sufficient in numbers. Even data on operation status of the waterworks, the booster pumping stations and water levels in service storage reservoirs were not accurate and limited in numbers. To achieve predetermined targets, it seems minimum requirements to substantially increase measuring equipment such as flow rate controllers, pressure gauges and flow meters on off-takes of transmission and distribution mains.

b) Due to the short period when the CSS was continuously operated, there has been insufficient historical data accumulation. This has caused difficulty in developing a comprehensive water supply management plan.

c) As for maintenance of the CSS equipment, a local agent undertook that, for two years after installation. After expiration of the maintenance contract, WASA took over the whole work exclusive of that for the main computer equipment. Since all spare parts initially supplied were used up in a year after CSS operation, WASA had a very hard time in carrying out the CSS operation and maintenance.

   Especially RTU, instrument indispensable for data collection, have met difficulty from initial operation stage. Inevitably the cannibalization

of the RTU by WASA has reduced the amount of data collected, down to 40% of the originally planned as of November 1989.

d) The CSS hardware and its system software for operation were introduced, however, the necessary application software of water supply system simulation and analysis was not provide from the initial stage. Therefore, the original objectives of the CSS could not be fulfilled.

e) Somewhat weak organizational structure for CSS resulted in insufficient back-up activities for developing the water supply management plan and O/M for equipment.

4.5.5 Evaluation

Evaluation made herein is only for the current study on the Improvement of Water Supply Supervisory System. Based on description made in the foregoing paragraphs, the existing CSS can be concluded as follows:

a) The existing CSS did not function effectively for optimization of water supply management by status monitoring and data processing of the planned system. To attain the original purposes, it is of primary importance to install monitoring equipment and to obtain a large amount of data from both transmission and distribution pipes. This will be duly considered in improvement/development of the CSS.

b) Continued use of the existing CSS equipment seems almost impracticable, because of the difficulty in procuring the spare parts. It is considered most appropriate to replace the old system by the latest one. In the past 10 years, computer related equipment has seen a growing body of technology development in terms of stability, reliability, cost effectiveness, etc.

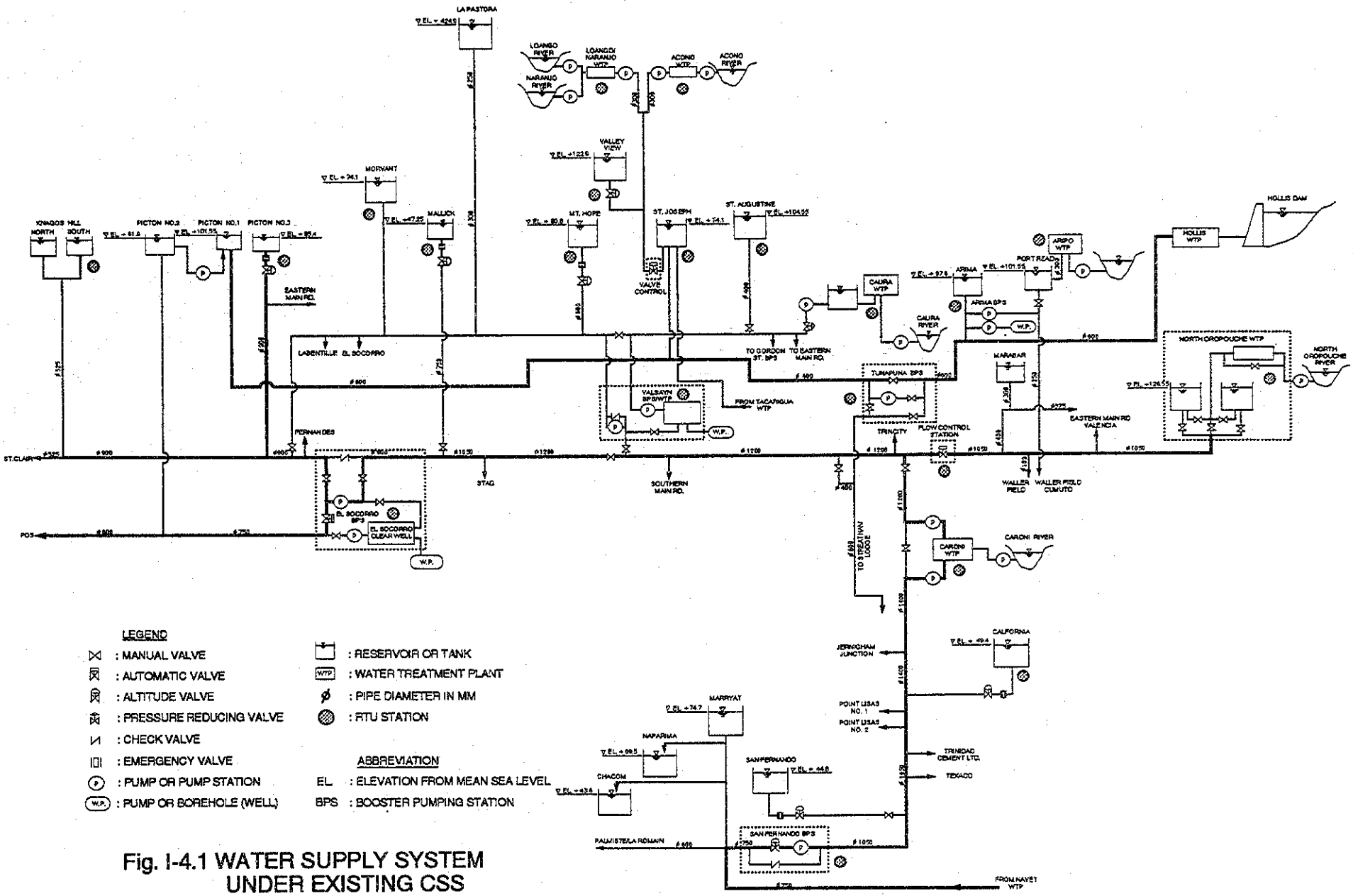


Fig. I-4.1 WATER SUPPLY SYSTEM UNDER EXISTING CSS

Table I-4.1 SUMMARY OF SERVICE STORAGE RESERVOIR, BOOSTER AND HIGH LIFT PUMPING STATION

DISTRICT OF WASA	SERVICE STORAGE RESERVOIR								BOOSTER PUMPING STATION			HIGH LIFT PUMPING STATION		
	NUMBER OF FACILITIES			STORAGE CAPACITY (M3)			MAJOR RESERVOIR EXCEED 5,000 M3		NUMBER OF FACILITIES			NUMBER OF FACILITIES		
	WORKING	NO USE	TOTAL	WORKING	NO USE	TOTAL	NAME	CAPACITY	WORKING	NO USE	TOTAL	WORKING	NO USE	TOTAL
TRINIDAD														
N.C.	8	0	8	54,850	---	54,850	MT. HOPE	22,750	5	0	5	---	---	---
							ST. AUGUSTINE	16,835						
							ST. JOSEPH	13,650						
							Sub-Total	53,235						
N.E.	11	5	16	62,581	596	63,177	NORTH OROPOUCHE	45,500	6	1	7	---	---	---
							FORT READ	7,599						
							Sub-Total	53,099						
N.W.	7	5	12	35,477	4,822	40,299	MALLIC	22,700	11	0	11	2	0	2
							COVIGNE	9,100						
							Sub-Total	31,800						
P.O.S.	13	1	14	121,645	900	122,545	PICTON NO.1	45,500	6	0	6	3	1	4
							KNAGGA HILL	27,300						
							PICTON NO.2	22,750						
							PICTON NO.3	13,650						
							LAVENTILLE	5,915						
							Sub-Total	115,115						
S.F./S.C.	7	2	9	80,535	4,550	85,085	CALIFORNIA	22,750	5	0	5	---	---	---
							SAN FERNANDO	22,750						
							MARRYAT STREET	13,423						
							NAPARIMA	9,100						
							CHACON STREET	7,280						
							Sub-Total	75,303						
S.E.	10	2	12	6,844	173	7,017		---	10	0	10	---	---	---
S.W.	6	7	13	3,366	6,530	9,896		---	4	0	4	---	---	---
SUB-TOTAL	62	22	84	365,298 (13.8 HR)	17,571	382,869 (14.4 HR)	SUB-TOTAL (TRINIDAD)	328,552 (85.8 %)	47	1	48	5	1	6
TOBAGO	14	1	15	9,449 (11.3 HR)	9	9,458 (11.3 HR)		---	4	0	4	---	---	---
TOTAL	76	23	99	374,747	17,580	392,327	TOTAL	328,552	51	1	52	5	1	6

NOTE: - N.C.; NORTH CENTRAL, N.E.; NORTH EAST, N.W.; NORTH WEST, P.O.S.; PORT OF SPAIN, S.F./S.C.; SAN FERNANDO & SOUTH CENTRAL, S.E.; SOUTH EAST, S.W.; SOUTH WEST.

- FIGURES IN PARENTHESES ARE (1) RETENTION TIME (HOURS) TO TOTAL AVERAGE DAILY PRODUCTION CAPACITY IN 1988 OF TRINIDAD (636,814 M3/D) & TOBAGO (20,040 M3/D) AND (2) RATIO (%) TO TOTAL CAPACITY OF SERVICE STORAGE CAPACITY IN TRINIDAD RESPECTIVELY.

Table I-4.2 LIST OF METERED AND ESTIMATED AVERAGE DAILY PRODUCTION CAPACITY AT EXISTING PRODUCTION FACILITIES

WASA'S DISTRICT	TYPE OF SCALE	SURFACE WATER SOURCE				* GROUNDWATER SOURCE				TOTAL					
		METERED		ESTIMATED		METERED		ESTIMATED		METERED		ESTIMATED		TOTAL	
		1988'S AVG. DAILY PRODUCTION (M3/D)	NUMBER OF FACIL (PLACE)	1988'S AVG. DAILY PRODUCTION (M3/D)	NUMBER OF FACIL (PLACE)	1988'S AVG. DAILY PRODUCTION (M3/D)	NUMBER OF FACIL (PLACE)	1988'S AVG. DAILY PRODUCTION (M3/D)	NUMBER OF FACIL (PLACE)	1988'S AVG. DAILY PRODUCTION (M3/D)	NUMBER OF FACIL (PLACE)	1988'S AVG. DAILY PRODUCTION (M3/D)	NUMBER OF FACIL (PLACE)	1988'S AVG. DAILY PRODUCTION (M3/D)	NUMBER OF FACIL (PLACE)
TRINIDAD															
N.C.	LARGE	259,781	1	----	---	----	---	----	---	259,781	1	0	0	259,781	1
	MEDIUM	12,420	2	----	---	10,330	1	40,981	2	22,750	3	40,981	2	63,731	5
	SMALL	----	---	713	6	----	---	577	1	0	0	1,290	7	1,290	7
SUB-TOTAL		272,201	3	713	6	10,330	1	41,558	3	282,531	4	42,271	9	324,802	13
N.E.	LARGE	46,728	1	25,722	1	----	---	----	---	46,728	1	25,722	1	72,450	2
	MEDIUM	14,141	2	5,146	2	----	---	----	---	14,141	2	5,146	2	19,287	4
	SMALL	----	---	939	12	----	---	644	1	0	0	1,583	13	1,583	13
SUB-TOTAL		60,869	3	31,807	15	0	0	644	1	60,869	3	32,451	16	93,320	19
N.W.	MEDIUM	1,699	1	----	---	----	---	78,158	7	1,699	1	78,158	7	79,857	8
	SMALL	63	1	1,256	8	----	---	----	---	63	1	1,256	8	1,319	9
SUB-TOTAL		1,762	2	1,256	8	0	0	78,158	7	1,762	2	79,414	15	81,176	17
P.O.S.	MEDIUM	----	---	4,304	1	----	---	19,027	4	0	0	23,331	5	23,331	5
	SMALL	----	---	945	4	----	---	366	1	0	0	1,311	5	1,311	5
SUB-TOTAL		0	0	5,249	5	0	0	19,393	5	0	0	24,642	10	24,642	10
SF/S.C.	MEDIUM	----	---	----	---	15,840	2	----	---	15,840	2	0	0	15,840	2
	SMALL	----	---	----	---	----	---	----	---	0	0	0	0	0	0
SUB-TOTAL		0	0	0	0	15,840	2	0	0	15,840	2	0	0	15,840	2
S.E.	LARGE	72,100	1	----	---	----	---	----	---	72,100	1	0	0	72,100	1
	MEDIUM	----	---	----	---	2,515	2	----	---	2,515	2	0	0	2,515	2
	SMALL	272	1	----	---	3,566	5	----	---	3,838	6	0	0	3,838	6
SUB-TOTAL		72,372	2	0	0	6,081	7	0	0	78,453	9	0	0	78,453	9
S.W.	MEDIUM	----	---	----	---	16,462	6	----	---	16,462	6	0	0	16,462	6
	SMALL	----	---	----	---	1,864	4	255	2	1,864	4	255	2	2,119	6
SUB-TOTAL		0	0	0	0	18,326	10	255	2	18,326	10	255	2	18,581	12
TOTAL		407,204	10	39,025	34	50,577	20	140,008	18	457,781	30	179,033	52	636,814	82
= LARGE =		378,609	3	25,722	1	0	0	0	0	378,609	3	25,722	1	404,331	4
= MEDIUM =		28,260	5	9,450	3	45,147	11	138,166	13	73,407	16	147,616	16	221,023	32
= SMALL =		335	2	3,853	30	5,430	9	1,842	5	5,765	11	5,695	35	11,460	46
TOBAGO															
	MEDIUM	19,085	6	----	---	----	---	----	---	19,085	6	0	0	19,085	6
	SMALL	579	2	376	4	----	---	0	1	579	2	376	5	955	7
TOTAL		19,664	8	376	4	0	0	0	1	19,664	8	376	5	20,040	13
= MEDIUM =		19,085	6	----	---	----	---	----	---	19,085	6	0	0	19,085	6
= SMALL =		579	2	376	4	----	---	0	1	579	2	376	5	955	7
GRAND-TOTAL		426,868	18	39,401	38	50,577	20	140,008	19	477,445	38	179,409	57	656,854	95
= LARGE =		378,609	3	25,722	1	0	0	0	0	378,609	3	25,722	1	404,331	4
= MEDIUM =		47,345	11	9,450	3	45,147	11	138,166	13	92,492	22	147,616	16	240,108	38
= SMALL =		914	4	4,229	34	5,430	9	1,842	6	6,344	13	6,071	40	12,415	53

NOTE - N.C. : NORTH CENTRAL, N.E. : NORTH EAST, N.W. : NORTH WEST, P.O.S. : PORT OF SPAIN,
SF/S.C. : SAN FERNANDO AND SOUTH CENTRAL, S.E. : SOUTH EAST, S.W. : SOUTH WEST
- " * " IS INCLUDED IN SPRING AND PURCHASED WATER.

Table I-4.3 STATUS OF CSS RELATED FACILITIES (1)

NAME OF FACILITY		PUMP SPECIFICATIONS				WORKING CONDITION					EL OF PUMP CENTER	RESERVOIR/CLEAR WELL			WKG CONDITION OF LEVEL METER			WORKING CONDITION OF FLOW METER				
		CAP (CMM)	HEAD (M)	POWER (KW)	UNIT (NO)	PUMP WKG	PUMP MAL	PRESSURE GAUGE EXT	PRESSURE GAUGE WKG	PRESSURE GAUGE MAL		WATER ELEVATION HIGH	WATER ELEVATION LOW	CAPACITY (CUM)	EXT	WKG	MAL	EXT	WKG	MAL	LOCT	TYPE
INTAKE/WATERWORKS/WELL																						
Arima Well	#6 Well Pump	0.8	54.9	11.2	1	1	-	0	0	-	52.59	---	---	-----	-	-	-	X	-	-	---	-----
Aripo W.W.	Intake Pump (Old)	3.2	91.4	0.0	1	1	-	?	?	?	65.77	---	---	-----	-	-	-	X	-	-	---	-----
	Intake Pump (New)	7.9	59.4	93.2	2	1	1	0	0	-	67.24	---	---	-----	-	-	-	0	0	-	RAW	ORIFICE PLATE
	Fort Read Reservoir	--	--	---	--	-	-	-	-	-	---	98.96	94.24	7,599	0	0	-	X	-	-	---	-----
Arouca W.W.	Clear Water Reservoir	--	--	---	--	-	-	-	-	-	---	35.73	33.54	150	X	-	-	-	-	-	---	-----
	Distribution Pump	3.2	123.4	55.9	1	1	-	0	0	-	34.79	---	---	-----	-	-	-	X	-	-	---	-----
	Distribution Pump	2.3	80.8	55.9	1	1	-	0	0	-	34.67	---	---	-----	-	-	-	-	-	-	---	-----
Carlsen Field W.W.	Clear Water Reservoir	--	--	---	--	-	-	-	-	-	---	24.04	20.93	6,825	X	-	-	-	-	-	---	-----
	Distribution Pump	?	36.6	44.7	3	1	2	0	0	0	22.98	---	---	-----	-	-	-	0	-	0	DISTRIB	PROPELLER
	Distribution Pump	?	57.9	93.2	1	1	-	0	0	-	0.00	---	---	-----	-	-	-	-	-	-	---	-----
	Distribution Pump	?	?	74.6	1	1	-	0	0	-	24.89	---	---	-----	-	-	-	0	0	-	DISTRIB	PROPELLER
Caroni W.T.P.	Intake Pump	* 37.9	18.3	149.1	6	4	2	0	0	-	11.87	---	---	-----	X	-	-	0	0	-	RAW	PARTIAL FLUME
	Intake Pump	* 18.9	18.3	93.2	2	2	-	-	-	-	11.87	---	---	-----	-	-	-	-	-	-	---	-----
	Clear Water Reservoir	--	--	---	--	-	-	-	-	-	---	11.21	5.76	7,400	0	0	-	-	-	-	---	-----
	Transmission Pump	* 26.5	79.2	596.6	2	1	1	-	-	-	11.60	---	---	-----	-	-	-	-	-	-	---	-----
	Transmission Pump	* 37.9	79.2	596.6	4	2	2	0	0	-	11.60	---	---	-----	-	-	-	0	0-Sth	-	TRANSM	ANNUBAL
	Transmission Pump	* 37.9	61.0	522.0	3	3	-	0	0	-	11.60	---	---	-----	-	-	-	0	-	0-Nth	TRANSM	ANNUBAL
Caura W.W.	Intake Pump	6.4	101.5	55.9	1	1	-	0	0	-	38.09	---	---	-----	-	-	-	X	-	-	---	-----
	Intake Pump	4.7	45.7	74.6	1	1	-	-	-	-	38.09	---	---	-----	-	-	-	-	-	-	---	-----
	Clear Water Reservoir	--	--	---	--	-	-	-	-	-	---	53.33	49.85	164	X	-	-	-	-	-	---	-----
	Distribution Pump	2.7	94.5	55.9	4	3	1	0	0	-	54.35	---	---	-----	-	-	-	X	-	-	---	-----
El Socorro W.W.	Clear Water Reservoir	--	--	---	--	-	-	-	-	-	---	4.11	0.71	2,200	0	0	-	-	-	-	---	-----
	Pump to Picton #2	* 10.4	76.2	186.4	4	4	-	0	0	-	5.25	---	---	-----	-	-	-	0	-	0	DISTRIB	VENTURI TUBE
Guanapo W.W.	Intake Pump	6.8	30.5	55.9	1	1	-	0	0	-	60.08	---	---	-----	-	-	-	0	0	-	RAW	PROPELLER
	Intake Pump	2.0	45.7	29.8	1	1	-	0	0	-	60.08	---	---	-----	-	-	-	-	-	-	---	-----
	Clear Water Reservoir	--	--	---	--	-	-	-	-	-	---	70.60	68.69	91	X	-	-	-	-	-	---	-----
	Distribution Pump	8.1	93.3	186.4	2	1	1	0	0	-	67.73	---	---	-----	-	-	-	0	-	0	DISTRIB	PROPELLER
Hollis W.W.		--	--	---	--	-	-	0	0	-	---	Apx. 129 m after Filter			-	-	-	0	-	0	DISTRIB	VENTURI TUBE
Las Lomas W.W.	Clear Water Reservoir	--	--	---	--	-	-	-	-	-	---	34.06	29.75	0	0	0	-	0	0	-	RAW	ORIFICE PLATE
	Distribution Pump	5.5	55.8	74.6	5	2	3	0	0	-	31.04	---	---	-----	-	-	-	0	-	0	DISTRIB	VENTURI TUBE
Navet W.W.	Intake Pump	10.7	81.7	186.4	7	6	1	0	0	-	50.16	---	---	-----	-	-	-	0	-	0	RAW	VENTURI TUBE
	Clear Water Reservoir	--	--	---	--	-	-	-	-	-	---	118.29	113.79	13,650	0	0	-	0	-	0	DISTRIB	VENTURI TUBE
North Oropouche W.W.	Intake Pump	15.8	111.3	372.9	5	5	-	0	0	-	48.33	---	---	-----	-	-	-	0	0	-	RAW	PARTIAL FLUME
	Clear Water Reservoir	--	--	--	--	-	-	-	-	-	---	136.48	125.76	45,500	0	0	-	X	-	-	---	-----
Quare Intake	Clear Water Reservoir	--	--	--	--	-	-	-	-	-	---	62.49	60.36	0	X	-	-	-	-	-	---	-----
	Distribution Pump	2.3	61.0	29.8	3	3	-	0	0	-	59.95	---	---	-----	-	-	-	0	0	-	DISTRIB	VENTURI TUBE

Table I-4.3 STATUS OF CSS RELATED FACILITIES (2)

NAME OF FACILITY		PUMP SPECIFICATIONS				WORKING CONDITION					EL OF PUMP CENTER	RESERVOIR/CLEAR WELL			WKG CONDITION OF LEVEL METER			WORKING CONDITION OF FLOW METER				
		CAP (CMM)	HEAD (M)	POWER (KW)	UNIT (NO)	PUMP		PRESSURE GAUGE				WATER ELEVATION		CAPACITY								
						WKG	MAL	EXT	WKG	MAL		HIGH	LOW	(CUM)	EXT	WKG	MAL	EXT	WKG	MAL	LOCT	TYPE
Tacarigua W.W.	Clear Water Reservoir	--	--	---	--	-	-	-	-	-	---	23.72	18.32	640	0	0	-	-	-	-	---	-----
	Distribution Pump	3.2	50.0	111.9	3	3	-	0	0	-	19.62	---	---	----	-	-	-	X	-	-	---	-----
Valsayn W.W.	Clear Water Reservoir	--	--	---	--	-	-	-	-	-	---	19.57	16.97	2,800	0	0	-	-	-	-	---	-----
	Distribution Pump	6.4	10.1	149.1	4	4	-	0	0	-	17.78	---	---	----	-	-	-	0	0	-	DISTRIB	VENTURI TUBE
BOOSTER PUMP STATION																	-					
Arima	Booster Pump	3.2	54.9	37.3	2	2	-	?	?	?	43.34	---	---	----	-	-	-	?	?	?	?	?
Aripo	Booster Pump	3.2	54.3	111.9	2	1	1	0	0	-	55.00	---	---	----	-	-	-	0	-	0	DISTRIB	VENTURI TUBE
El Socorro	To Picton #3	* 31.5	64.0	447.4	3	2	1	0	0	-	2.18	---	---	----	-	-	-	0	-	0	DISTRIB	ANNUBAL
Malgretoute	Booster Pump	15.5	38.1	149.1	5	4	1	0	0	-	59.72	---	---	----	-	-	-	0	-	0	DISTRIB	VENTURI TUBE
Navet	To navet High Dam	15.7	32.3	111.9	2	2	-	0	0	-	50.16	---	---	----	-	-	-	X	-	-	---	-----
Storage Lift	To navet High Dam	31.6	32.3	223.7	4	1	3	-	-	-	50.16	---	---	----	-	-	-	-	-	-	---	-----
San Fernando	Booster Pump	23.7	45.7	261.0	3	3	-	0	0	-	29.90	---	---	----	-	-	-	0	0	-	DISTRIB	ANNUBAL
T.C.O.	Booster Pump	13.4	57.9	559.3	6	4	2	0	0	-	73.25	---	---	----	-	-	-	0	-	0	DISTRIB	VENTURI TUBE
Tumpuna St.Lift	To Arena Dam	44.7	20.7	223.7	6	6	-	0	0	-	21.52	---	---	----	-	-	-	0	0	-	DISCHAR	VENTURI TUBE
Tunapuna	Booster Pump	5.3	106.7	149.1	3	2	1	0	0	-	22.13	---	---	----	-	-	-	X	-	-	---	-----
Valsayn	Booster Pump	* 12.6	54.9	149.1	3	2	1	0	0	-	18.94	---	---	----	-	-	-	0	0	-	DISTRIB	ANNUBAL
STORAGE RESERVOIR																	-					
Arima New		--	--	---	--	-	-	-	-	-	---	103.70	99.12	2,275	0	0	-	-	-	-	---	-----
Arima Old		--	--	---	--	-	-	-	-	-	---	100.61	97.56	819	0	0	-	-	-	-	---	-----
California		--	--	---	--	-	-	-	-	-	---	59.84	49.38	22,750	0	-	0	-	-	-	---	-----
Knaggs Hill		--	--	---	--	-	-	-	-	-	---	71.64	61.89	27,300	0	0	-	-	-	-	---	-----
Malabar	Not in Use	--	--	---	--	-	-	-	-	-	---	62.05	57.06	1,820	NOT USED			-	-	-	---	-----
Mallic		--	--	---	--	-	-	-	-	-	---	54.41	47.24	22,750	0	-	0	-	-	-	---	-----
Marryat St.		--	--	---	--	-	-	-	-	-	---	79.27	74.85	13,423	0	0	-	-	-	-	---	-----
Mt. Hope		--	--	---	--	-	-	-	-	-	---	91.52	82.91	22,750	0	0	-	-	-	-	---	-----
Naparima		--	--	---	--	-	-	-	-	-	---	74.09	69.52	9,100	0	0	-	-	-	-	---	-----
Picton No.1		--	--	---	--	-	-	-	-	-	---	108.23	101.52	13,650	0	0	-	-	-	-	---	-----
Picton No.2		--	--	---	--	-	-	-	-	-	---	69.82	60.98	22,750	0	0	-	-	-	-	---	-----
Picton No.3		--	--	---	--	-	-	-	-	-	---	94.49	83.81	45,500	0	0	-	-	-	-	---	-----
San Fernando		--	--	---	--	-	-	-	-	-	---	54.95	44.20	22,750	0	0	-	-	-	-	---	-----
St. Augustine		--	--	---	--	-	-	-	-	-	---	110.67	104.57	16,835	0	0	-	-	-	-	---	-----
St. Joseph		--	--	---	--	-	-	-	-	-	---	78.66	74.09	13,650	0	0	-	-	-	-	---	-----

NOTE: EL; ELEVATION, M; METER, EXT; EXIST, TRANSM; TRANSMISSION, W.W.; WATERWORKS, "X"; NO,
St.; STORAGE, KW; KILO WATT, CUM; CUBIC METER, DISCHAR; DISCHARGE, W.T.P.; WATER TREATMENT PLANT, "?"; COLLECTED NO DATA,
CAP; CAPACITY, NO; NUMBER, LOCT; LOCATION, Sth; SOUTH, "*"; CLLECTED PUMP PERFORMANCE CURVE,
CMM; CUBIC METER PER MINUTE, MAL; MALFUNCTION, DISTRIB; DISTRIBUTION Nth; NORTH, "0"; YES,

5. INSTITUTION AND MANAGEMENT

5.1 JURISDICTION OF WASA

The Water and Sewerage Authority (WASA) was established as a body corporate based on the Water and Sewerage Act in 1965. WASA was vested with all the properties of the State (under the Waterworks and Water Conservation Act), the Central Water Distribution Authority and the Port-of-Spain Corporation. The duty of WASA was defined as to carry out the policy of the Government in relation to water and sewerage and to exercise such functions, powers and duties as are conferred on it by the said Act.

Accordingly, WASA is responsible for maintaining and developing the waterworks and other properties relating thereto and promoting the conservation of the water resources of Trinidad and Tobago. At the same time, WASA may authorize through granting a license any person or industry (water purveyor) to supply water to public. At the present time, only TORINTOC (Trinidad and Tobago Oil Company) is selling a portion of its produced water to WASA who supplies it to public through its own distribution networks.

WASA is also responsible for developing and maintaining the sewerage system in Trinidad and Tobago.

The National Housing Authority and private developers are also involved in construction of water distribution and sewerage collection networks and waste treatment plants. Therefore, coordination between these parties and WASA is being required. The Ministry of Public Health is responsible for setting water quality and waste water effluent standards.

5.2 ORGANIZATION OF WASA

Administratively, WASA is under the control of the Ministry of Settlements and Public Utilities. WASA is managed by a nine member Board of Commissioners appointed by the President of the Republic. The overall organization chart of WASA is shown in Fig.I-5.1 in which some positions including Directors of Administration and Information System are not assigned yet. WASA organization

is being comprehensively reviewed through the IDB's Institutional Strengthening Study of WASA (Ref. sub-section 5.5.4).

WASA has a total staff of 4,963 (Ref. Self Sufficiency WASA-1991, January 1989) of which some 2,800 are estimated to be monthly-paid workers and the rest to be daily-paid workers. Out of the total staff, the majority (2,600) work in operations and maintenance.

Major Divisions

In the proposed organization structure shown in Fig.I-5.1, the Executive Director is vested with the highest responsibility for the management being supported by the Deputy Executive Director who controls the line organization of five Divisions including Technical Division, Administrative Division, Water Resources Division, Financial and Accounting Division and Information System Division. Under the Executive Director, there are three staff organizations including Internal Audit Unit, Corporate Planning and Corporate Secretary.

The Deputy Executive Director is responsible directly for the daily operation and maintenance through administering the above-mentioned five Divisions. Under the Technical Director, there are two Chief Engineers responsible for Projects and Waste Water, one Chief Chemist for Quality Control and one Operation Manager responsible for Operations.

The Fig.I-5.2 shows the organization of the Technical Division. The four regional offices including the North, South, Cano and Tobago are under the control of the Operations Manager. The five water works including Caroni-Arena, Navet, Hollis, North Oropouche and Hillsborough (in Tobago) are administered by the respective regional offices. The Central Supervisory System (CSS) and the Major Maintenance and Transport Department are administered by the Operation Manager as well.

5.3 FINANCIAL STATUS OF PUBLIC UTILITIES

The public enterprises in the Republic of Trinidad and Tobago consists of five public utilities including WASA and 67 national companies in which the Government is either sole owner or majority shareholder.

The public utilities have traditionally provided their services at prices below cost of production being subsidized by transfer from the Government to finance both operating deficit and capital investment. This has been possible during the oil boom of 1970's. However, since 1982, economy of Trinidad and Tobago has been depressed as a consequence of a remarkable decline in oil export earnings caused by the effects of both a sharp drop in international oil prices and the falling of the oil production. The Government has experienced a difficulty in providing the public utilities with financial assistance for their operating deficit and for their capital investment. The decreasing trend of the Government's transfer can be observed in Table I-5.2 for the case of WASA.

The financial operations of the five public utilities for 1989 (preliminary basis) are presented in Table I-5.1. The two big public enterprises of TTEC (Trinidad and Tobago Electric Commission) and TELCO (Trinidad and Tobago Telephone Company) have operated 1989 with surplus operating balances. Especially, TTEC gained an overall balance surplus in 1989 without any transfer from the Government for two years since 1988. TELCO attained the more operating revenue than its operating expenditure first time in these several years.

As shown in the table, the three public utilities including PATT (Port Authority of Trinidad and Tobago), PTSC (Public Transport Service Corporation) and WASA had deficit in operation balance in 1989. However, in the case of PTSC, the current account balance changed into surplus due to the big amount of current transfer from the Government. In the case of WASA, the deficit in overall balance was, though it was still deficit, comparatively small due to the capital transfer from the Government which was the biggest among the five public utilities in 1989.

5.4 FINANCIAL STATUS OF WASA

5.4.1 Income Statement

The financial operations of WASA has been improved recently as presented in Table I-5.2. The operating revenue most of which is the water rate revenue has increased three times during these five years. This revenue increase was brought about by both the increase in water volume for sale and the effort for water charge collection. While the operating expenditure decreased to about 80% of the amount five years ago. This decrease was brought about by the reduction of expenditure for wages and salaries which was resulted by the decrease in number of employees from about 6,000 in 1985 to about 5,000 in 1989. Thus, though it is still deficit, the operating balance in 1989 was reduced to one third that in 1985. It is to be noted that this improvement has been achieved under the conditions that the Government's financial assistance to WASA has decreased drastically from TT$ 234 million in 1985 to TT$ 44 million in 1989.

5.4.2 Water Tariff

Most of the operating revenue of WASA is being raised by water rates. The previous water tariff has long been unchanged since 1937, as there was no cause for WASA to amend the tariff due to the sufficient transfer from the Government. The water tariff was amended in 1986, which included a 25% increases of the tariff in 1987.

The water rates of WASA currently effective are shown in Table I-5.3. The water rates very by four categories of:

1) Industrial, Commercial, Public Buildings and Water for Resale,
2) Agriculture,
3) Churches and
4) Domestic.

Except for the water use in churches, the water rates are classified for the unmetered use and the metered use. And for the unmetered water use, the

annual taxable value (ATV) which is the value of a building assessed by the tax office is adopted as the base of billing. For domestic water use, the water rates are set for two categories of users e.g. standpipe users and premises users. The premises users are further divided into those served by a single yard tap and those with internal plumbing.

The revaluation of ATV is made only in the city areas. Therefore, there is, in some cases, disparity between the market value and the book value (=tax base) of the assets.

The water charges are tax-deductible, i.e. the expenditures for water and wastewater can be deducted from the tax base for income tax like a portion of educational cost for children.

According to WASA, the amendment of water rates is now under preparation and will be submitted to PUC (Public Utilities Commission) in 1991. It is said that the amendment will cover both the metered and unmetered customers.

5.4.3 Balance Sheet

The balance sheet of WASA as of the end of 1989 and 1985 is shown in Tables I-5.4 and I-5.5 respectively. During these four years, the total value of fixed assets was reduced due to the decrease in the value of the fixed assets. As a matter of course, the value of fixed assets decreases as it is depreciated every year but in the case of WASA, it was accelerated by the decrease of capital investment in these several years. As already shown in Table I-5.2, WASA's capital expenditure has been decreasing since 1985 due to the decrease of capital transfer of the Government. The capital investment in 1990, however, recovered so much that it amounted to the equivalent to the total capital investment of these five years ahead. This was based on the worry that the facilities and equipment of WASA would be deteriorated if the decreasing trend of capital investment will continue further. For this purpose, the first commercial loan in the history of WASA of TT$ 55 million was introduced. The scheduled investment includes pipeline projects, booster pumping station, service storage reservoirs, metering of non-domestic customers, sewage elements and rehabilitation of Port of Spain sewage.

The capital fund increased more than two times during these four years; this is due to the accounting treatment that the Government agreed to capitalize its loans to WASA accumulated in the period from 1971 to 1986 amounting to TT$ 1,761 million in July 1989.

5.5 STRUCTURAL REFORM OF WASA

Under this heading, ongoing relevant projects or studies being undertaken by WASA and/or IDB are introduced to depict the WASA's exerted efforts for strengthening managerial aspects and to picture future step toward targets.

5.5.1 Background

After the end of the oil boom, as mentioned in the preceding section 5.3, the financial support of the Government to WASA has become difficult. The review of the total management of WASA including reduction of its overstaffed employees has started by this serious situation. In August 1988, a Task Force was appointed by the Executive Director to conduct a manpower audit and review the operations of WASA aiming at recommending measures which enables WASA to achieve the self-sufficiency by 1991. The result of the Task Force's effort was compiled in the "Report on Self Sufficiency; WASA-1991" in January 1989. The report proposed a two-phased reduction of nearly 2,000 employees from the current total of 4,963 to 2,970 by the end of 1991. At the same time, a new organization of WASA including the strengthening of the Office of the Executive Director was proposed.

In May 1989, WASA publicized a "Strategic Plan 1989-1991" which constituted both a blue print for immediate action and a comprehensive framework to be used to guide WASA's activities in the years ahead. The vision stipulated in this Strategic Plan comprises five items: 1) financial self sufficiency by 1991, 2) improved service delivery level, 3) human resources development, 4) water resources management and 5) enhancement of corporate image.

In October 1989, a report "Moving WASA to Financial Self Sufficiency"

prepared by an IDB consultant was submitted to WASA. It is pointed out in this report that WASA cannot be self-sufficient without taking measures to increase its revenue and reduce expenditures. And it recommends to start as soon as possible the five studies including the institutional strengthening, leakage detection and universal metering studies to be financed under an IDB pre-investment program approved by IDB in August 1988.

5.5.2 SAL and Performance Targets

In September 1989, the negotiations were held between the Government team and the World Bank on the WASA component of the Structural Adjustment Loan (SAL). The TOR (Terms of Reference) of the Institutional Strengthening Study of the IDB Global Pre-investment Program was amended to accommodate the two World Bank studies of WASA reorganization and the commercial metering.

In November 1989, the SAL in an amount equivalent to US$ 40 million was signed between the Government and the World Bank. The performance targets imposed to WASA as conditionalities comprised the followings:

1) Reduction of the ratio of employees per 1,000 water connections from the current 31 to no more than 21 by 1991;

2) Reduction of outstanding receivables to 6.0 months by the end of 1991 and 4.0 months by the end of 1993; and

3) Reduction of the working ratio (the ratio of operating expenditures less depreciation to operating income) from current 1.58 to 1.05 by the end of 1991 and 0.95 by the end of 1993.

These management efficiency indices are listed in Table I-5.6 for five Latin American municipal water companies. The ratio of employees per 1,000 water connections is currently estimated at 31 in WASA while the same ratio in some Latin American countries ranges from 3.5 to 6.8. The outstanding receivables of WASA is currently estimated at about 10 months in 1989 while it ranges 1.3 to 3.9 months in Latin American countries. The working ratio of

WASA is currently estimated at 1.58 while the same ratio ranges from 0.53 to 0.87 in Latin American countries.

The targets of 1) and 3) of the above are, according to the Ministry of Settlements and Public Utilities (Ref. Trinidad and Tobago World Bank Structural Adjustment Programme-WASA), to be achieved principally by the followings:

1) Staff reduction of 1,150 (accumulated in 1990 and 1991) by the end of 1991 and 1,800 (accumulated from 1990 to 1993) by the end of 1993; and

2) An increase in house connections from 160,000 in 1988 to 187,000 in 1991 or by 17% over the 1988 base.

The performance targets, WASA is now facing, is addressed in the above mentioned "Strategic Plan 1989-1991" and the recommendations in the "Task Force Report".

5.5.3 Voluntary Retirement Program

The overstaffing has been one of the biggest problems of WASA. Among the five public utilities of Trinidad and Tobago, WASA has the largest number of the employees. The historical statistics of the employees of the public utilities are as shown below:

Number of Employees of Public Utilities

	1985	1986	1987	1988	1989
WASA	6,095	6,095	5,975	5,225	5,052
TTEC	3,071	3,077	3,089	3,059	2,963
PTSC	3,419	3,348	3,311	3,363	3,082
PATT	3,611	2,780	3,347	2,907	1,900
TELCO	2,715	2,608	2,499	2,499	2,343

Source: Ministry of Finance (Ref. Trinidad and Tobago, Recent Economic Development, IMF, April 1990)

Notes : TTEC ; Trinidad and Tobago Electricity Commission
PATT ; Port Authority of Trinidad and Tobago
PTSC ; Public Transport Service Corporation
TELCO; Trinidad and Tobago Telephone Company
WASA ; Water and Sewerage Authority

An effort to reduce the employees has been observed for these several years. The number of employees, however, is still excessive comparing to the supply capacity. As stated in the preceding section, the ratio of employees per 1,000 water connections is now 31 in WASA and is being targeted to be reduced to no more than 21 by 1991. And at the same time, the reduction of nearly 3,000 employees (1,150 by 1991 and 1,800 by 1993) by the end of 1993 is also targeted as the conditionality of SAL.

As a measures of the reduction of employees, WASA advertises two plans of the voluntary retirement: VTEP (Voluntary Termination of Employment Plan) and VESP (Voluntary Early Separation Plan).

The VTEP started in June 1989 for the scheduled period of three years up to June 1992. This is administered by the Government and the beneficiaries are qualified as monthly paid employees. It is pointed out that this program is not so attractive because the retirement allowance is not paid at one time but in three times in three years. The VTEP is summarized hereunder:

1) Voluntary Termination of Employment Plan (VTEP)
   Promoter: The Government of T&T, the Office of the Prime Minister
   Eligible Applicants: Monthly-paid employees in the public services
   Benefits: A premium gratuity payable added to the normal entitlement
   Period : Starting from 1989

The VESP started from July 1990 and will terminate on December 31, 1990. This is administered internally by WASA for the daily-paid workers in WASA. The retirement allowance will be paid at one time with a full amount. About 300 to 400 volunteers are anticipated to apply for this plan. The VESP is summarized hereunder:

2) Voluntary Early Separation Plan (VESP)
   Eligible Applicants: Daily-paid employees of WASA
   Benefits: Enhanced severance benefits shown in the Collective Agreement signed between WASA and the National Union of Government and Federal Workers
   Period : July 15 1990-October 15 1990

As of December 11, 1990, the number of applicants for VTEP is registered at 207 and that for VESP is registered at 320 in WASA. The beneficiaries of both VTEP and VESP can get more retirement allowance than what they could get if they retired at the age of compulsory retirement age.

5.5.4 IDB Studies

The five IDB studies mentioned above comprises the followings:

1) Institutional Strengthening of WASA
2) Cost/benefit Analysis of Universal Metering
3) Feasibility Studies for Leak Detection
4) Integrations of Separate Sewerage System in Trinidad
5) Feasibility Studies for the Collection, Treatment and Disposal of Wastewater in Tobago.

Of these five studies, the first three studies are considered to be priorities by their order according to an IDB staff in Port of Spain. The major frameworks of the three studies including objectives, scope of the study and the present status are shown as follows:

1) Institutional Strengthening

Objectives

Restructuring of WASA, including the strengthening of the planning, technical, financial and administrative capabilities, so as to increase efficiency and effectiveness in implementing and managing the required programs and activities of WASA.

Scope of the Study

The Study involves a review of the structure and operations of WASA to include:

Phase I	Phase II
a. Reorganization	a. Research Planning and Programming
i) Operation and Maintenance	b. Project Management
ii) Management Information Systems	c. Human Resources Development
	d. Public Education and Information
b. Financing Matters	
i) Budgeting and Accounting	
ii) Commercial Operations	

Present Status

- The Study had started from November 1990, planned to complete in August 1991
- Consultant: Black and Veatch (USA)
- Cost : TT$ 3.4 million

2) Cost Benefit Analysis of Universal Metering

Objectives

- To define the optimum level of metering to be implemented, taking into account the socio-economic characteristics of users;
- To develop detailed cost effective program for large consumers that account for about 50% of consumption;
- To develop cost estimates for medium and other consumers;
- To redesign tariff structure to make it more responsive to the ability to pay the cost of service consistent with WASA financial goals.

Scope of the Study

- Cost-benefit analysis to determine the optimum macro metering coverage levels. Evaluation of benefits due to lower operating costs and postponement of new works brought about by reduced consumption due to metering program. Determination of costs of metering program including on-going operational costs and initial investment costs.

- Identification of large customers by category and location, and the transmission and distribution systems to which macro metering should be installed.
- Assessment of types of meters and assessment of cost effectiveness of alternative systems and equipment.
- Analysis of factors that affect the installation of service connections and ownership of meters.
- Design of public education campaign to educate consumers and minimize resistance to use of meters.
- Review and update of existing tariff structure to make it more effective and equitable when meters are introduced.

Present Status

- Draft contract has been reached to IDB on November 22, 1990
- Consultant: DELCAN (Canada)
- Study will start from January 1991 to be completed within four months.
- Cost: TT$ 0.4 million

3) Feasibility Studies for Leak Detection

Objectives

The primary objective of the Study is to determine cost-effective methods, to be integrated into the management of the distribution systems, to enable WASA to reduce distribution losses from the now-estimated 40% to a more acceptable level of approximately 20%.

Scope of the Study

- Review the leak detection method and equipment currently in use
- Review the present administrative framework for leak detection and repair
- Examine the application of telemetry among others in the distribution systems

- Review the use of WASA's present Central Supervisory System (CSS) with respect to the use of telemetry. The CSS incorporated in the water system monitors various hydraulic parameters through a central computer and remote terminal units
- Investigate the state of existing district meters and make suitable recommendations to aid in leakage monitoring and control
- Recommend appropriate leakage management systems, methods and equipment for a leak detection and control program taking into consideration social, technical and economic aspects
- Propose training program for the implementation of the leak detection exercise
- Develop an implementation strategy for the systematic control of leakage and provide a detailed program of activities for the carrying out of the program
- Provide cost estimate and time frame for implementation of all elements for the detailed program of activities

Present Status

- Draft contract will be reached to IDB within January 1991
- Study will start from February or March 1991 to be completed within four months
- Consultant: Thames Water International (UK)
- Cost : TT$ 0.36 million

The Institutional Strengthening Study, among others, has started in November 1990 and is planned to complete in August 1991. This study aims at the restructuring of WASA including the strengthening of the planning, technical, financial and administrative capabilities.

5.6 RECOMMENDATIONS

As already pointed out in the foregoing subsections, SAL agreement sets up targets to be achieved by WASA. They are a) reduction of the ratio of employees per 1,000 water connections from the current 31 to no more than 21 by 1991, b) reduction of the ratio of outstanding accounts receivables to 6.0

months by the end of 1991 and 4.0 months by the end of 1993, and c) reduction of the working ratio from current 1.58 to 1.05 by the end of 1993. Highlighted in this subsection are necessary measures to be exerted for attaining these three targets.

1) Institutional and Management Aspects

Regarding the target a); the reduction of the workforce should be accompanied by the raising of labor productivity. For this purpose, the retraining of workforce which is being done in an inhouse training facilities should be strengthened. At the same time, the computerization of daily work should be pursued as far as possible to raise its efficiency. The organizational structure should also be reviewed including the study of possibilities of merging some sections and streamlining of routine works.

Regarding the target b); the public relations activities should be strengthened to improve customer relations. There seems to be little communication between customers and WASA at present. Basically, the leak of faith of consumers toward the accuracy of billing is deemed to be the cause of delay of paying bills. In this regard, the installation of water meters and the detection of water leakage would be the preconditions for the reduction of outstanding account receivables of WASA.

Regarding the target c); the reduction of salaries and wages is most effective is improving the working ratio since they are the biggest share items in the recurrent expenditures being 68% of the total expenditures of WASA in 1989. This means that, if the target a) can be attained, the target c) can be attained to a large extent simultaneously. The expenditure on chemicals and other materials sometimes changes according to the movement of foreign exchange rate and the expenditure on utilities like electricity and telephone is difficult to be reduced because of the rationalization which has been exercised in past years.

2) Financial Aspects

The increase of the operating revenue would also contribute to the target c) namely the improvement of the working ratio. In this regard, the amendment of water rates which is now under study by WASA should be implemented as soon as possible.

In principle, the operating expenditures are to be covered by the operating revenue in a public water corporation. In the case of WASA, it seems that there remains the room to raise the water rates. Actually, the percentage of expenditure for water to the total monthly household expenditure was estimated at as low as 1.3% in 1988 as shown below:

-Monthly household expenditure in 1988 :$ 1,872 (1)
-Estimated expenditure for water in 1988
Family size in 1988 :4.1 persons
Per capita per day consumption :220 lpcd (2)
Water consumption for a quarter :81.2 m^3
Water rates for a quarter :$ 70.52 (3)
-Ratio of payment for water to household expenditure
=($70.52/3)/$1,872=1.256%

Notes;
(1):"Household Budgetary Survey 1988", Central Statistics Office, the Republic of Trinidad and Tobago
(2):Based on the estimate of JICA Study Team
(3):Based on the Water Tariff of WASA

The above percentage is rather low comparing to the corresponding rate of about 3-5% in average in developing countries. Moreover, the Government offices including firefighting and police do not pay any water charge for their water consumptions. These facts indicate that there is some possibilities for WASA to increase its revenue through raising the water rates and through collecting the charge from the government's users.

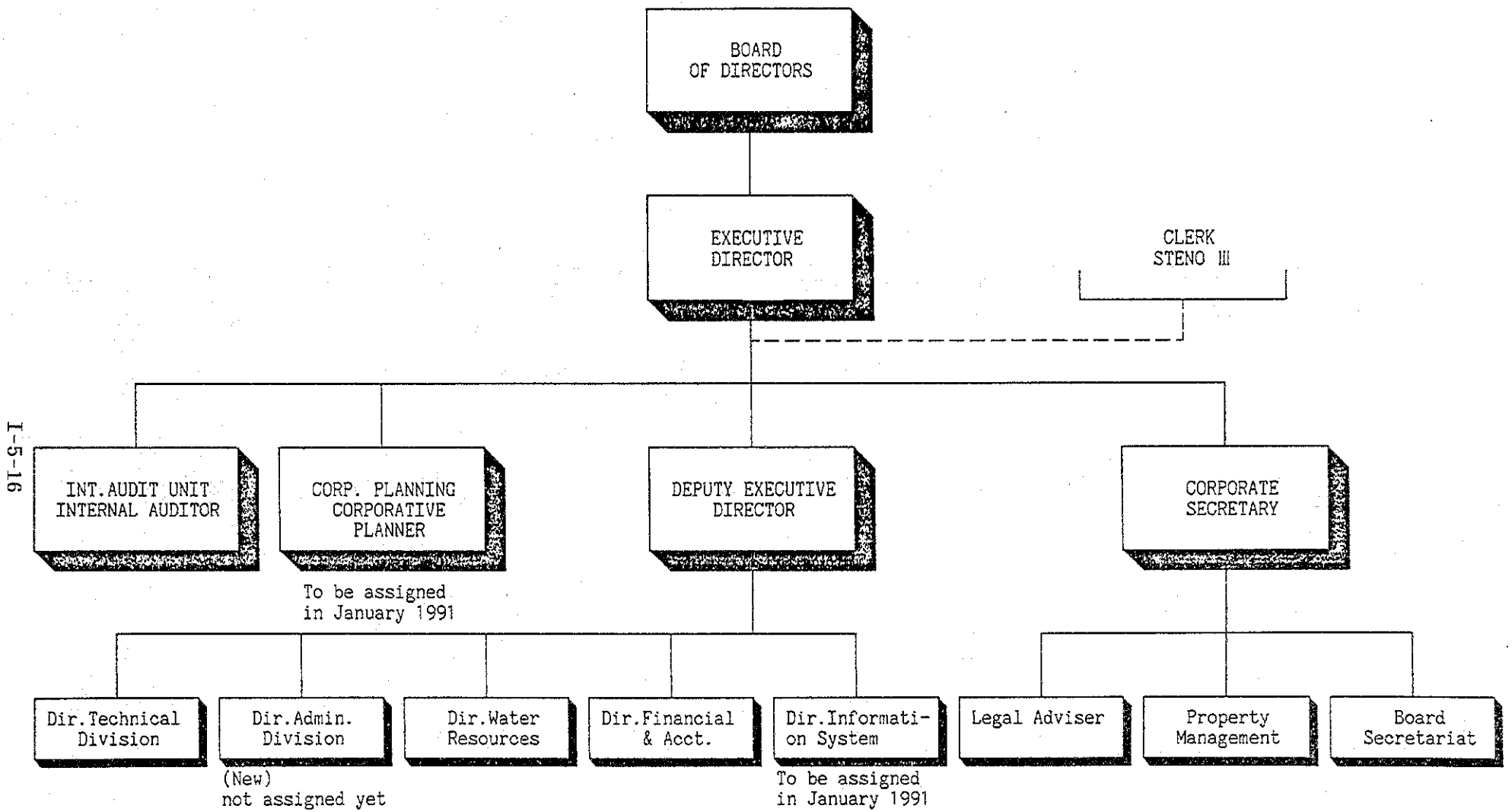


Fig. I-5.1 ORGANIZATION STRUCTURE OF WASA, DECEMBER 1990

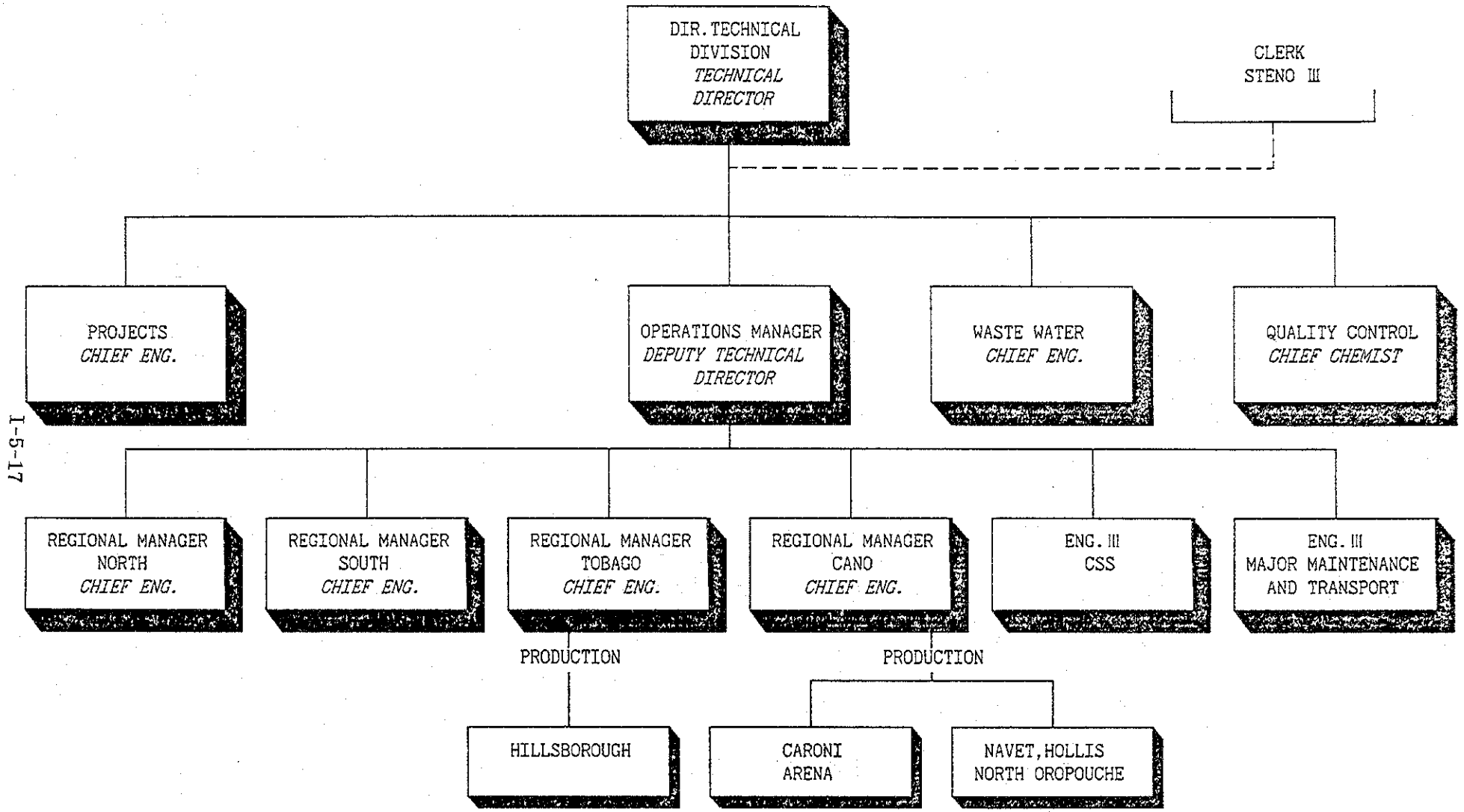


Fig. I-5.2 ORGANIZATION STRUCTURE OF WASA, TECHNICAL DIVISION, DECEMBER 1990

Table I-5.1 FINANCIAL OPERATIONS OF PUBLIC UTILITIES
(PRELIMINARY 1989)

(TT$ 1,000,000)

DESCRIPTION	TTEC	PATT	PTSC	TELCO	WASA
Operating Revenue	379.8	41.9	17.2	490.7	121.8
Operating Expenditure	358.7	146.2	124.3	399.5	197.8
Wages & Salaries	163.9	79.0	86.5	116.1	134.1
Contribution to NIB	2.8	1.7	1.9	2.2	2.1
Pensions & Others	--	41.9	--	2.1	4.9
Interest Payment	32.5	4.2	0.1	154.2	0.3
Goods & Services	159.5	19.4	35.8	124.9	56.4
Operating Balance	21.1	-104.3	-107.1	91.2	-76.0
Current Transfers from Central Administration	--	36.5	109.5	--	43.5
Current A/C Balance	21.1	-67.8	2.4	91.2	-32.5
Capital Transfers from Central Administration	--	2.0	2.0	6.4	22.8
Capital Contributions	--	--	--	--	1.5
Capital Expenditure	18.3	7.0	--	7.2	13.2
Capital A/C Balance	-18.3	-5.0	2.0	-0.8	11.1
Overall Balance	2.8	-72.8	4.4	90.4	-21.4
Number of Employees (1989)	2,963	1,900	3,082	2,343	5,052

SOURCE: "TRINIDAD AND TOBAGO; RECENT ECONOMIC DEVELOPMENTS", IMF, APRIL 1990.
NOTES : TTEC ; TRINIDAD AND TOBABO ELECTRICITY COMMISSION
PATT ; PORT AUTHORITY OF TRINIDAD AND TOBAGO
PTSC ; PUBLIC TRANSPORT SERVICE CORPORATION
TELCO; TRINIDAD AND TOBAGO TELEPHONE COMPANY
WASA ; WATER AND SEWERAGE AUTHORITY
NIB ; NATIONAL INSURANCE BOARD

Table I-5.2 FINANCIAL OPERATIONS OF WASA (1985-1989)

(TT$ 1,000,000)

DESCRIPTION	1985	1986	1987	1988	1989
Operating Revenue	31.5	43.3	110.1	114.4	121.8
Operating Expenditure	255.8	247.7	244.8	219.3	197.8
Wages & Salaries	191.0	183.3	160.4	152.4	134.1
Contribution to NIB	3.4	3.8	3.3	3.3	2.1
Pensions & Gratuities (*)	--	--	--	--	4.9
Interest Payments	--	0.1	0.2	0.2	0.3
Goods & Services	61.4	60.5	80.9	63.4	56.4
Operating Balance	-224.3	-204.4	-134.7	-104.9	-76.0
Current Transfers from Central Administration	233.8	168.0	134.2	62.8	43.5
Current A/C Balance	9.5	-36.4	-0.5	-42.1	-32.5
Capital Transfers from Central Administration	28.1	2.5	5.0	--	22.8
Capital Contributions	4.0	--	0.9	1.8	1.5
Capital Expenditure	60.0	--	13.5	7.9	13.2
Capital A/C Balance	-27.9	2.5	-7.6	-6.1	11.1
Overall Balance	-18.4	-33.9	-8.1	-48.2	-21.4
Number of Employees (1989)	6,095	6,095	5,975	5,225	5,052

SOURCE: "TRINIDAD AND TOBAGO, RECENT ECONOMIC DEVELOPMENTS", IMF, APRIL 1990.
NOTE : (*) INCLUDES SEVERANCE AND PENSION PAYMENTS RESULTING FROM VOLUNTARY SEPARATION AND RETIREMENT PROGRAMS.

Table I-5.4 SUMMARY BALANCE SHEET OF WASA (AS OF END 1989)

(TT$1,000)

DEBIT		CREDIT	
1. Current Assets	161,494	1. Current Liabilities	124,954
2. Investments	3,637	2. Capital Funds	3,108,137
3. Fixed Assets	911,713	3. General Reserve	113,561
		4. Long Term Loans	130
		5. Accumulated Operating Deficit	-2,269,937
TOTAL	1,076,844	TOTAL	1,076,844

Table I-5.5 SUMMARY BALANCE SHEET OF WASA (AS OF END 1985)

(TT$1,000)

DEBIT		CREDIT	
1. Current Assets	97,978	1. Current Liabilities	24,693
2. Investments	2,146	2. Capital Funds	1,064,278
3. Fixed Assets	1,027,824	3. General Reserve	113,561
		4. Long Term Loans	153
		5. Accumulated Operating Deficit	-1,666,863
		6. Operating Deficit Advances	1,592,127
TOTAL	1,127,948	TOTAL	1,127,949

NOTE: PROCESSED FROM THE FINANCIAL STATEMENTS OF WASA.

Table I-5.6 MANAGEMENT INDICATORS OF MUNICIPAL WATER COMPANIES IN LATIN AMERICA IN 1987

COMPANY	TOTAL STAFF	STAFF/ 1000WC (a)	WORKING RATIO (b)	ACCOUNTS RECEIVABLES MONTHS
A	6,799	5.4	0.72	3.9
B	2,628	3.5	0.53	3.0
C	2,326	6.8	0.86	1.3
D	1,770	4.1	0.62	2.8
E	411	6.8	0.87	n.a.

NOTES : (a); 1,000 WATER CONNECTIONS.
(b); OPERATING COSTS LESS DEPRECIATION/OPERATING REVENUE.
SOURCE: "MANAGEMENT AND OPERATIONAL PRACTICES OF MUNICIPAL AND REGIONAL WATER AND SEWERAGE COMPANIES IN LATIN AMERICA AND THE CARIBBEAN" WORLD BANK, JUNE 1989.

Table I-5.3 WATER AND WASTE WATER RATES OF WASA
(EFFECTIVE FROM JULY 1ST 1987)

WATER

Industrial, Commercial, Public Buildings and water for re-sale

Unmetered

12.5% of ATV (Annual Taxable Value)
Minimum bill per quarter: $425

Metered

Up to 500 cu metres	$3.50 per cu metre
Next 19,500 cu metres	$2.30 per cu metre
Next 180,000 cu metres	$1.75 per cu metre
Over 200,000 cu metres	$1.20 per cu metre

Minimum bill per quarter. $425

Agricultural

Unmetered

10% of ATV (Annual Taxable Value)
Minimum bill per quarter: $210

Metered

$1.20 per cubic metre
Minimum bill per quarter: $210

Churches

and Registered Charitable Organizations $80 per quarter

Domestic A1
(Standpipe users)

Unmetered

Consumers without a service connection but whose premises are within 400m radius of a standpipe. $25 per quarter

Domestic A2

Unmetered

Premises served by a single yard tap $50 per quarter

Domestic A3
Premises with internal plumbing

Unmetered

ATV (Annual Taxable Value)	%	Minimum
up to $500	70	$80.00
from $501 to $1,000	60	$87.50
from $1,001 to $2,000	40	$150.00
over $2,000	35	$200.00

Maximum bill per quarter: $225.00

Metered

per quarter
Up to 10 cu metres $20.00

Next 40 cu metres	$0.60 per cu metre
Next 50 cu metres	$0.85 per cu metre
Next 50 cu metres	$1.15 per cu metre
All over 150 cu metres	$1.30 per cu metre

(SEWERAGE)

WASTEWATER

Domestic

Applicable only to internally serviced premises within 45 metres of a street or collecting sewer.

Water bill of less than $150 per quarter $56 per quarter

Water bill of $150 per quarter or more $69 per quarter

Non-Domestic

Metered

Applicable to all premises within 45 metres of a street or collecting sewer.

12.5% of water bill
Minimum bill per quarter: $212.50

Agricultural

Metered

12.5% of water bill
Minimum bill per quarter: $105

Unmetered Water Service:

50% of water bill

Other Charges

Water Connection

Domestic:	$187.50
Non-Domestic:	Actual Cost
Reconnection after Disconnection:	$312.00
Sewerage Connection:	Actual Cost
Swimming Pool *(Unmetered)*:	$160.00 per quarter
Domestic Building Tap *(Metered)*:	Actual Cost
Non-Domestic Building Tap *(Metered)*:	Actual Cost
All other services not specifically provided for:	Actual Cost

Note: **Actual Cost** refers to **Direct Cost** plus **Overheads.**

6. PREREQUISITE FOR CSS

The role of municipal water supply is to operate and manage a continuous-uninterrupted supply of potable water to all consumers at all times, with satisfactory quality, in adequate quantity, and at sufficient pressure, regardless of any conditions.

In order to fulfill the above purposes, the routine maintenance of water supply facilities including leakage control and rehabilitation of existing facilities should be of most concern to WASA. In addition, WASA must have long and medium term water supply master plan including development of water resources and implement the projects at the same time. The plan must be revised periodically to meet a current need or requirement.

The actual circumstances of WASA's system unfortunately does not meet with the above basic requirements due to the existing various problems as described in the former section. The situation of balancing water demand vs supply will become more serious in near future, since no comprehensive water supply master plan is existing to cover programs of water resources development and reduction of wastes and leakage.

On the other hand, the objective of this study is to formulate a master plan of water supply supervisory system. The proposed master plan is based on the condition that the WASA's system will satisfy the above basic conditions. Therefore, the water demand projection in this study is formulated on the assumption that the leakage reduction program would be implemented simultaneously and unaccounted-for water ratio would be decreased to 20% by 2005.

In other words, the present study might result in unfeasible projects formulation if the above mentioned basic requirements could not be met.

The prerequisites for this study on the water supply supervisory system, among others, are the following basic matters:

a) Update of data and drawings

- To develop water supply plan based on accurate data and drawings.
- To facilitate the most appropriate operation and control of the water supply system.

b) Implementation of leakage reduction program

- To increase revenue by reducing waste of potable water.
- To defer developing of new water resources.
- To restore function and capability of existing transmission/ distribution facilities.
- To control system pressure on pipelines.

c) Rehabilitation/replacement of existing deteriorated pipelines

- To recover function and capability of existing transmission/ distribution facilities.
- To reduce the system leakage and create the same benefits as the above item b).

d) Calibration/overhaul/replacement of mechanical/electrical equipment

- To normalize the capability and function of mechanical/ electrical facilities.
- To strengthen the safety and reliability of facilities.

e) Introduction of metering system including service connection meters

- To compile and analyze data on water demand in each water service area.
- To formulate the planning of water supply operation.
- To restrain customers from water wastage/excessive use.
- To establish adequate tariff system based on water consumption within affordability of consumers.

f) Formulation of the long and medium term water supply master plan

- To implement the development projects according to the master plan.
- To formulate future strategy for development of water supply system including water sources and supervisory system.

g) Establishment of self-sufficiency of WASA

- To strengthen the financial capability of WASA by reducing rather outstanding figures of accounts receivables and the working ratio and by improving the WASA's work efficiency to satisfactory levels as discussed in the subsection 5.5.2.
- To improve water supply service to the customers by implementing rehabilitation, leak repair and expansion work and by organizing public campaign.

h) Intensive public campaign by WASA through media such as TV, radio, daily papers, posters, etc.

- To inform of the outlined WASA's activities, policies, and future planning to obtain public supports and understanding.
- To provide opportunities to understand that clear water is being produced through various treatment processes and supplied through costly and lengthy pipelines.
- To let them know how to use piped water in order to reduce wasteful and unsanitary water use.
- To establish communication routes between the public and WASA through telephone and daily papers to obtain their free opinions and complaints against WASA.

In view of the current study objectives, all the above are considered as the scope of an Immediate Project. Therefore, the immediate project should be executed before or at least simultaneously with the Phase I project, of which scope, content and schedule will be described in Parts II, III and IV.

PART TWO: MASTER PLAN

1. TARGET YEAR AND STUDY AREA

1.1 TARGET YEAR

The present study's purposes is formulate a comprehensive master plan (M/P) for the Water Supply Supervisory System (WSSS) in Trinidad and Tobago, which will facilitate a long range planning of the public utility of water supply.

The National Physical Development Plan for Trinidad and Tobago, 1984, provides an overall view of the physical development plan of the country, including water supply, up to the year 2000. For the current Master Plan, it is considered appropriate to adopt a target year of 2005, instead of 2000 because of:

1) The WSSS composed of mechanical equipment and electronic instruments has usual design life of about 10 years.

2) Time requirements for the proposed project formation and implementation are about five years at least, including those for administrative procedures for loan application, detailed design and construction/installation.

Accordingly, a planning period (Master Plan period) will require 15 years at least (or 2005 as target year). Under the current circumstances, it seems impractical to extend farther beyond 2005.

Further, the planning period of the master plan is divided into two stage, namely Phase I (1991-1995) for improvement and expansion of the existing CSS and Phase II (1996-2005) for development of water supply supervisory system throughout the country, in consideration of the durable life of installed equipment, period required for operation, size of projects and WASA's presetting targets for early establishment of the central supervisory system.

In the meantime, possible options for the Phase I Project implementation are studied in Part IV Comparative Study which suggests more feasible solution for the Phase I Project implementation. The recommended option, which

requires a much longer project period of nine years, divides the Phase I Project into three steps: 1) installation of monitoring equipment with recorders at the first step (1992-1995), 2) data acquisition and analyses on water supply conditions (1996-1997), and 3) CSS instrumentation and control equipment installation (1997-2000). This option is evaluated further in Section 2 "Evaluation of Option-A", Part IV.

1.2 STUDY AREA

In accordance with the Scope of Work agreed between the GRTT and JICA, the study area, for which the Master Plan of Water Supply Supervisory System is conducted, is identical to the entire WASA water supply area in Trinidad and Tobago. The present water supply system of WASA covers almost all area of Trinidad and Tobago, presently separated into 34 water areas/sub-areas. In the water areas of 5,128 sq. km in total, 1,133,000 population or 95% of total 1,192,000 population served in its service area are supplied with potable water as of 1990. Major water sources, waterworks and transmission/ distribution mains are shown on Fig. I-3.2 given in Section 3 "Water Source and Present Water Use", Part I.

In proposing a project area for Phase I Project, duly considered are a) the area covered by the existing CSS, b) existing pipeline alignment, especially of transmission/distribution mains, c) population by water area, d) magnitude of water production at waterworks and e) layout and storage capacity of service storage reservoirs. After comprehensive review of the existing water supply system, the area containing four major waterworks (Caroni, North Oroupoche, Hollis and Navet) including 16 raw water sources is finally proposed as Phase I project area which is shown on Fig. III-1.1, Section 1, Part III.

Within the Phase I project area thus determined, 825,000 (population served) or 69% of total population served in its service area are residing, consuming approximately 70-80% of total water production in Trinidad and Tobago in 1990.

2. WATER DEMAND AND BALANCE

2.1 POPULATION AND WATER DEMAND

2.1.1 Population

For future water demand projection in the present study, population by water area/sub-area covering the design period (1990-2005) are estimated based on the data and information mainly supplied by the Central Statistical Office (CSO) as shown in Table II-2.1.

As shown in Table I-2.1 of Part I, census population for the year 1960, 1970 and 1980 are 827,957, 931,071 and 1,055,763 respectively. The growth rates are 1.18% and 1.26% per annum for the periods of 1960-1970 and 1970-1980 respectively.

Table II-2.2 shows the population growth for the past ten years. The rate of population increase has fluctuated continuously as shown in the table. The growth can be associated with changing patterns of external migration, natural increase and economic and social climate. The rates of natural increase ranged between 1.65% and 2.27% for the ten years and the average rate was 2.06% per annum. On the other hand, the rates of net migration varied between -3.51 and +0.20%.

Population for the year 1989 is estimated at 1,208,515, as shown in Table II-2.3, based on the latest data of CSO including the outcome of the Household Budgetary Survey which was conducted in late 1988 by CSO. The growth rate for the period 1980-1989 is 1.51% per annum, an increase of 0.25% from the 1.26% per annum attained between 1970-1980.

Population growth rate attained between 1980-1989 for each water area is shown in Table II-2.1. The table also shows the projected populations for the years 1990, 1995, 2000 and 2005. Population for the year 1990 was projected by the growth rate for each water area attained between 1980-1989. The growth rates for each area for 1990-2000 and 2000-2005 were employed taking into consideration the previous studies of WASA, past trend of population growth and future strategy of the Government. The average yearly growth rates are

1.75%, 1.84% and 1.63% for the periods 1990-1995, 1995-2000 and 2000-2005 respectively.

Fig. II-2.1 graphically shows the past trend of the population from the year 1970 to 1988 and also the population projection made by the Team up to the year 2005. For reference, the CSO projection made in 1980 is also shown in the figure.

2.1.2 Unit Water Demand

Taking into consideration socio-economic features of the country, unit water demand in the present report consists of two categories: per capita water demand for all water areas and special industrial water demand for five specified water areas.

The per capita water demand is composed of domestic, industrial/ agricultural, commercial/public and unaccounted-for water (UFW) as shown in Table II-2.4. Then, the per capita water demand is analyzed for three types of water areas/sub-areas: urban, semiurban and rural. Considering the present condition of water use discussed in Part I, each use components of net water demand are proposed as shown in Table II-2.4. It is assumed that UFW in the year 1990 is 50% of the total per capita water demand considering the result of the pilot leakage survey.

The per capita water demand is projected for the years 1995, 2000 and 2005 based on the condition that UFW could be decreased by years. It is assumed that the amounts of UFW are 40% for 1995, 30% for 2000 and 20% for the year 2005 by the leakage reduction program.

In addition to the above per capita water demand, as shown in Table II-2.5, special industrial water demand is considered for five major industrial water areas: Port of Spain, Barataria, St. Joseph, Arouca and Couva. The special industrial water demand is allocated for the above five areas in a similar way discussed in the report of "The Water System Balance in Trinidad, June 1985". In the report, 90.40% of the total industrial demand in Trinidad was allocated for the five water areas and the rest 9.60% was allocated for

the other water areas. In the present report, however, 10% of the total industrial demand is included in the per capita water demand and the rest 90% of the total industrial demand, which is named as special industrial water demand, is additionally distributed to the above five areas.

Industrial water demand for the year 1990 is assumed as 70 lpcd (liters per capita per day) excluding UFW because the amount is considered in the above study for the year 1982, which stands the highest value of Gross Domestic Product in the past. It is also assumed that UFW in the year 1990 is 50% of the special industrial water demand.

Then, the special industrial water demand is projected for the years 1995, 2000 and 2005 on the basis of the assumptions that rate of increase of the demand is 2% per annum and proportions of UFW are 40%, 30% and 20% for the years 1995, 2000 and 2005 respectively. As a result, the special industrial water demands are 126 lpcd in 1990, 116 lpcd in 1995, 110 lpcd in 2000 and 106 lpcd in 2005 as shown in Table II-2.5.

2.1.3 Summary of Water Demand

Based on the unit water demand discussed above, as shown in Table II-2.6, total water demand of 666,300 m^3/day for the year 1990 inclusive of UFW is calculated as the sum of 511,400 m^3/day of per capita water demand and 154,800 m^3/day of special industrial water demand. For the year 1990, the water demand in Trinidad is 642,500 m^3/day, while that in Tobago is 23,800 m^3/day. Water demand by water area/sub-area is also summarized and tabulated in the same table. Further, the demands of the area supplied by the sources of the source groups I and II are seen in the columns of "Area I" and "Area II" respectively. Projected water demands for the years 1995, 2000 and 2005 are tabulated in a similar way.

The projected water demand for Trinidad and Tobago up to the year 2005 is summarized as shown in Table II-2.7 and is graphically shown in Fig. II-2.2.