Average per capita water demands including UFW for the areas of the source groups I and II, and Tobago for the years 1990, 1995, 2000 and 2005 are summed up and tabulated below.

AVERAGE PER CAPITA WATER DEMAND

(Unit: lpcd)

YEAR	AREA OF SOURCE GROUP I	AREA OF SOURCE GROUP II	TOBAGO
1990	644	436	449
1995	572	379	394
2000	521	342	355
2005	485	308	326

2.2 WATER BALANCE

Production capabilities of the existing water sources are both limited by the capacity of facilities and the amount taken at the sources. Upon estimating dependable yields from existing sources, if available raw water is in excess of the stipulated amount, the production capacities of existing facilities restrict the yields. In contrast, during period of drought when water at sources is insufficient, the dependable yields are estimated from the river discharge, impounding reservoir storage and aquifer's storage.

The production capacities listed by WASA, cited from the report titled "The Water System Balance in Trinidad, June 1985", are compared to past production records and the seasonal production capabilities are investigated. Then, the dependable yields are estimated for respective sources as shown in Table II-2.8.

Upon estimating the dependable yields from the existing sources, expansion of the existing production facilities is not considered. The dependable yields are limited to the present production capabilities of the existing facilities. Potential water production by exploiting new sources or by expanding the existing facilities is not considered, but recovering the present production levels to the original levels is taken into account.

The total dependable yields of existing 96 waterworks in Trinidad and Tobago (including Hillsborough West in Tobago to be constructed) are estimated at 771,300 m^3/day at the rainy season and 711,100 m^3/day at the dry season.

Water balance in Trinidad and Tobago for the years 1990, 1995, 2000 and 2005 is summarized as follows.

WATER BALANCE IN TRINIDAD AND TOBAGO
(DRY SEASON)

(Unit: m^3/day)

	Year	Demand			Supply* Capability	Balance
		Net	UFW	Total**		
Trinidad	1990	321,250	321,250	642,500	679,400	+ 36,900
	1995	370,400	246,700	617,100	679,400	+ 62,300
	2000	427,400	183,100	610,500	679,400	+ 68,900
	2005	489,000	122,600	611,600	679,400	+ 67,800
Tobago	1990	11,900	11,900	23,800	31,700	+ 7,900
	1995	14,900	9,900	24,800	31,700	+ 6,900
	2000	18,600	8,000	26,600	31,700	+ 5,100
	2005	22,300	5,600	27,900	31,700	+ 3,800

*.... Supply amounts in Tobago include that of Hillsborough West.
**.... Total Demand = Net Demand/(1-UFW Ratio)

As shown in Table II-2.9, the dependable yields of the source group I, which totals 545,600 m^3/day for dry season, are disaggregated for water areas supplied by the 16 water sources including four major sources. Water demand of the area supplied by the source group I in 1990 is estimated at 531,400 m^3/day including the special industrial demand so that the supply can meet the demand throughout the area. As shown in the table, water supply exceeds the demand in the area of the source group I up to the year 2005. Water balance of the area of the source group I for the years 1990, 1995, 2000 and 2005 is summarized as follows.

WATER BALANCE OF THE AREA OF SOURCE GROUP I
(DRY SEASON)

(Unit: m^3/day)

Year	Demand			Supply Capability	Balance
	Net	UFW	Total		
1990	256,700	256,700	531,400	545,600	+ 14,200
1995	307,700	205,100	512,800	545,600	+ 32,800
2000	356,800	152,900	509,700	545,600	+ 35,900
2005	410,800	102,700	513,500	545,600	+ 32,100

The water area allocation of the dependable yields shown in Table II-2.9 is just a trial for the present study, however, when flow rates at offtakes are measured by meters and population of the area supplied from the offtake is determined, the allocation will be modified accordingly.

The dependable yields of the source group II are totaled in 133,700 m^3/day for dry season. As shown below, for the area supplied by the sources, the supply exceeds the demand of the area as a whole.

WATER BALANCE OF THE AREA OF SOURCE GROUP II (DRY SEASON)

(Unit: m^3/day)

Year	Demand			Supply Capability	Balance
	Net	UFW	Total		
1990	55,550	55,550	111,100	133,700	+ 22,600
1995	62,600	41,700	104,300	133,700	+ 29,400
2000	70,550	30,250	100,800	133,700	+ 32,900
2005	78,500	19,600	98,100	133,700	+ 35,600

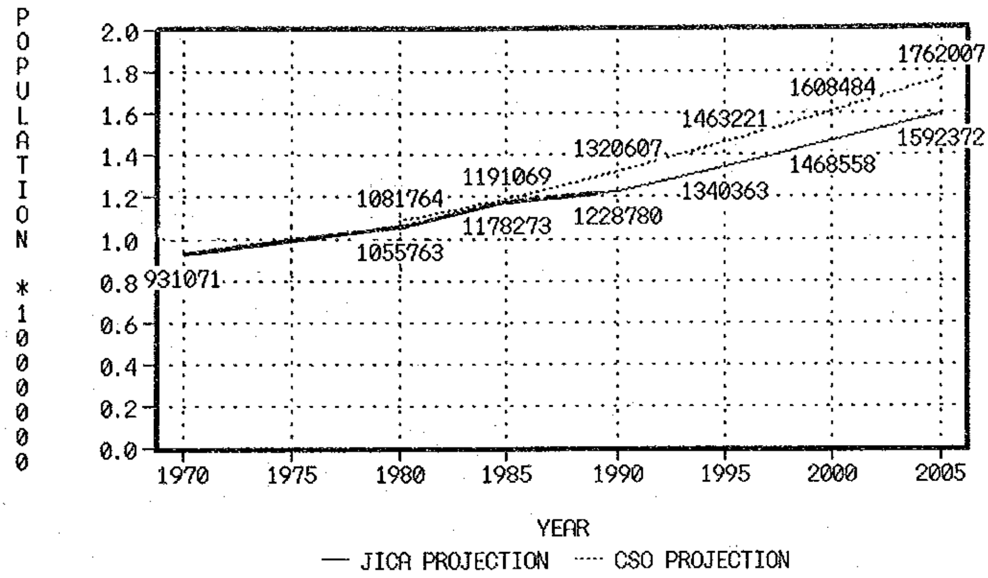


Fig. II-2.1 POPULATION PROJECTION

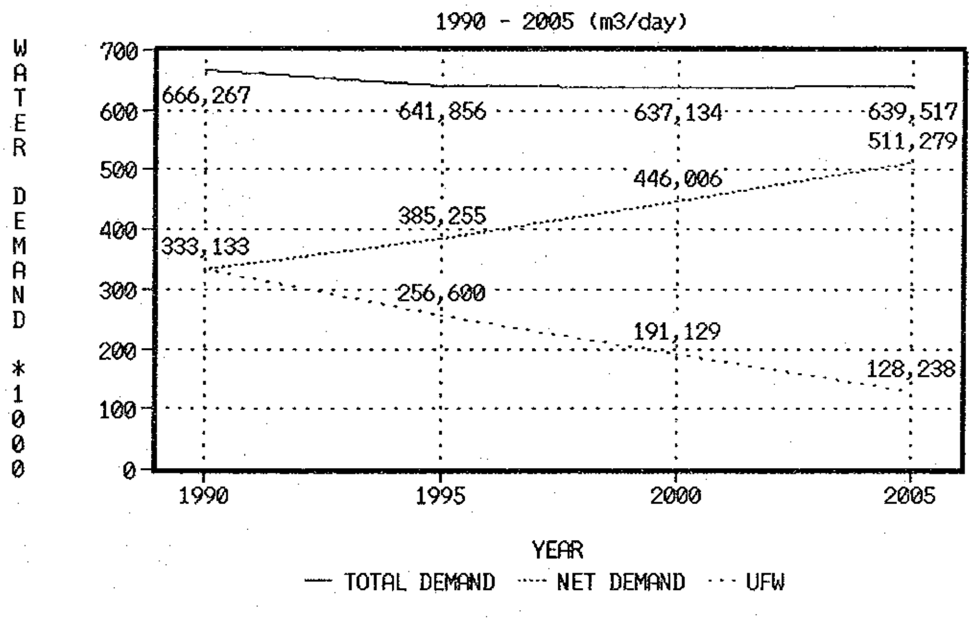


Fig. II-2.2 WATER DEMAND PROJECTION

Table II-2.1 POPULATION PROJECTION BY WATER AREA (1)

WATER AREA	CENSUS POPULATION 1980	Annual Rate of Growth Over 9 Years (%)	ESTIMATED POPULATION 1989	ESTIMATED POPULATION 1990	Annual Rate of Growth (%) 1990-2000	PROJECTED POPULATION 1995	PROJECTED POPULATION 2000	Annual Rate of Growth (%) 2000-2005	PROJECTED POPULATION 2005
1. DIEGO MARTIN	61,226	1.37	69,212	70,161	1.50	75,583	81,425	1.00	85,578
2. PORT OF SPAIN	90,302	-0.91	83,156	82,530	0.13	82,928	83,622	0.03	83,733
Municipality	55,800	-2.39	44,894	43,822	-1.00	41,674	39,632	-1.00	37,690
Diego Martin	27,526	1.37	31,116	31,543	1.50	33,981	36,607	1.00	38,474
St. Anns	6,976	0.27	7,146	7,165	0.30	7,273	7,383	0.50	7,569
3. E.M.R. COMMUNITIES	246,917	1.18	274,508	278,073	1.43	297,995	320,646	1.32	342,305
3.1 St. Barbs	6,175	0.27	6,325	6,342	0.30	6,438	6,535	0.50	6,700
3.2 Laventille	6,325	0.27	6,479	6,496	0.30	6,594	6,694	0.50	6,863
3.3 Morvant	19,140	0.27	19,606	19,658	0.30	19,955	20,256	0.50	20,768
3.4 Picton	26,344	0.27	26,985	27,058	0.30	27,466	27,880	0.50	28,584
3.5 Barataria	32,382	0.27	33,170	33,259	0.30	33,761	34,270	0.50	35,136
3.6 St. Joseph	29,365	1.73	34,265	34,868	2.10	38,658	42,934	1.76	46,850
St. Anns	6,628	0.27	6,789	6,808	0.30	6,910	7,015	0.50	7,192
Tacarigua	22,737	2.13	27,476	28,060	2.50	31,748	35,919	2.00	39,658
3.7 Arouca	15,971	4.22	23,177	24,269	3.55	28,849	34,414	2.46	38,859
Tacarigua	11,888	2.13	14,366	14,671	2.50	16,599	18,780	2.00	20,735
Arima	4,083	8.92	8,812	9,598	5.00	12,250	15,634	3.00	18,124
3.8 Tacarigua	16,568	2.13	20,021	20,447	2.50	23,134	26,174	2.00	28,898
3.9 Saddle Road	53,759	0.27	55,068	55,215	0.30	56,048	56,894	0.50	58,331
3.10 St. Augustine	19,124	2.13	23,110	23,601	2.50	26,703	30,212	2.00	33,356
3.11 Tunapuna	21,764	2.13	26,300	26,859	2.50	30,389	34,382	2.00	37,961
4. ARIMA	37,302	5.07	58,241	61,487	3.19	71,608	84,175	2.22	93,937
Borough	24,112	2.37	29,775	30,481	1.00	32,036	33,670	1.00	35,388
Arima Ward	13,190	8.92	28,466	31,006	5.00	39,572	50,505	3.00	58,549
5. SANGRE GRANDE	43,633	2.47	54,358	55,755	2.68	63,611	72,647	2.08	80,536
Valencia	1,604	8.59	3,367	3,656	5.00	4,666	5,955	3.00	6,904
Manzanilla	21,395	2.06	25,697	26,225	2.50	29,672	33,571	2.00	37,065
Tamana	7,629	2.13	9,219	9,415	2.50	10,652	12,052	2.00	13,306
Turure	12,862	2.38	15,897	16,276	2.50	18,414	20,834	2.00	23,003
San Raphael	143	2.49	178	183	2.50	207	234	2.00	258
6. WALLERFIELD	18,888	3.74	26,293	27,365	3.40	32,311	38,243	2.51	43,285
Tacarigua	2,585	2.13	3,124	3,190	2.50	3,609	4,084	2.00	4,509
Arima Ward	3,021	8.92	6,520	7,101	5.00	9,063	11,568	3.00	13,410
San Rafael	4,328	2.49	5,399	5,533	2.50	6,260	7,083	2.00	7,820
Cunupia	8,954	2.57	11,251	11,540	3.00	13,378	15,509	2.50	17,547
7. TOCO	6,681	2.75	8,527	8,761	3.00	10,157	11,775	2.50	13,322
Matura	1,513	2.54	1,896	1,944	3.00	2,254	2,613	2.50	2,956
Toco	5,168	2.81	6,631	6,817	3.00	7,903	9,162	2.50	10,366
8. CARONI	150,684	2.13	182,229	186,144	2.57	211,233	239,840	2.39	269,840
8.1 Caroni	6,690	2.38	8,264	8,461	2.79	9,707	11,138	2.29	12,474
Tacarigua	2,954	2.13	3,570	3,646	2.50	4,125	4,667	2.00	5,152
Cunupia	3,736	2.57	4,694	4,815	3.00	5,582	6,471	2.50	7,321
8.2 Cunupia	43,142	2.57	54,204	55,597	2.95	64,294	74,358	2.48	84,034
Cunupia	4,903	2.57	6,161	6,319	3.00	7,325	8,492	2.50	9,608
Chaguanas	35,783	2.63	45,209	46,399	3.00	53,789	62,356	2.50	70,550
Montserrat	2,456	1.60	2,834	2,879	2.00	3,179	3,510	2.00	3,875
8.3 Chaguanas	50,396	2.30	61,835	63,264	2.71	72,288	82,639	2.44	93,230
Chaguanas	34,087	2.63	43,066	44,200	3.00	51,240	59,401	2.50	67,206
Couva	9,419	1.55	10,818	10,986	2.00	12,130	13,392	2.50	15,152
Montserrat	6,890	1.60	7,950	8,078	2.00	8,919	9,847	2.00	10,872
8.4 Couva	50,456	1.55	57,927	58,823	2.00	64,945	71,704	2.24	80,102
Couva	24,062	1.55	27,637	28,065	2.00	30,986	34,211	2.50	38,707
Montserrat	10,095	1.60	11,649	11,835	2.00	13,067	14,427	2.00	15,929
Pointe-a-Pierre	16,299	1.50	18,642	18,922	2.00	20,891	23,066	2.00	25,466
9. MAYARO	9,354	0.68	9,942	10,022	0.98	10,500	11,054	1.23	11,752
Guayaguayare	7,420	1.38	8,397	8,513	1.50	9,171	9,880	1.50	10,643
Trinity	469	-5.38	285	270	-5.00	209	161	-2.00	146
Cocal	1,465	-1.66	1,260	1,239	-2.00	1,120	1,012	-1.00	963

Table II-2.1 POPULATION PROJECTION BY WATER AREA (2)

WATER AREA	CENSUS POPULATION 1980	Annual Rate of Growth Over 9 Years (%)	ESTIMATED POPULATION 1989	ESTIMATED POPULATION 1990	Annual Rate of Growth (%) 1990-2000	PROJECTED POPULATION 1995	PROJECTED POPULATION 2000	Annual Rate of Growth (%) 2000-2005	PROJECTED POPULATION 2005
10. RIO CLARO	241,876	1.27	271,062	274,591	1.40	294,215	315,688	1.48	339,695
10.1 Arch Trace	45,918	0.34	47,325	47,531	0.60	48,829	50,464	0.98	52,992
Cocal	8,879	-1.66	7,636	7,509	-2.00	6,788	6,136	-1.00	5,835
Charuma	12,650	-0.93	11,634	11,526	-1.00	10,961	10,424	-0.50	10,166
Pointe-a-Pierre	5,511	1.50	6,303	6,398	2.00	7,064	7,799	2.00	8,611
Ortoire	6,498	1.94	7,724	7,873	2.00	8,693	9,598	2.00	10,597
Savanna Grande	12,380	1.40	14,028	14,224	1.50	15,323	16,508	1.50	17,783
10.2 Princes Town	43,373	1.59	49,971	50,765	1.73	55,310	60,282	1.74	65,722
Naparima	4,369	1.45	4,975	5,047	1.50	5,437	5,858	1.50	6,310
Moruga	5,788	2.06	6,952	7,095	2.50	8,028	9,083	2.50	10,276
Ortoire	7,317	1.94	8,697	8,866	2.00	9,789	10,807	2.00	11,932
Savanna Grande	25,899	1.40	29,347	29,757	1.50	32,057	34,534	1.50	37,203
10.3 Barrackpore	44,114	1.46	50,261	50,995	1.56	55,092	59,527	1.56	64,327
Naparima	7,890	1.45	8,984	9,115	1.50	9,819	10,578	1.50	11,396
Moruga	2,355	2.06	2,829	2,887	2.50	3,266	3,695	2.50	4,181
Savanna Grande	2,606	1.40	2,953	2,994	1.50	3,226	3,475	1.50	3,743
Siparia	31,263	1.42	35,495	35,999	1.50	38,781	41,778	1.50	45,007
10.4 Fyzabad	51,584	1.44	58,677	59,523	1.50	64,123	69,079	1.50	74,418
Naparima	33,210	1.45	37,816	38,366	1.50	41,331	44,525	1.50	47,966
Siparia	18,374	1.42	20,861	21,157	1.50	22,792	24,554	1.50	26,452
10.5 Palmyra	38,946	1.47	44,399	45,050	1.50	48,532	52,283	1.50	56,324
Pointe-a-Pierre	13,075	1.50	14,954	15,179	1.50	16,352	17,616	1.50	18,977
Naparima	23,327	1.45	26,562	26,948	1.50	29,031	31,275	1.50	33,692
Savanna Grande	2,544	1.40	2,883	2,923	1.50	3,149	3,392	1.50	3,654
10.6 Marabella	17,941	1.45	20,429	20,726	1.50	22,328	24,054	1.50	25,913
11. SAN FERNANDO	33,395	-1.12	30,180	29,842	-1.00	28,380	26,989	-0.50	26,321
12. SIPARIA/ERIN	29,556	1.45	33,638	34,125	1.50	36,763	39,604	1.50	42,665
Siparia	19,152	1.42	21,744	22,053	1.50	23,758	25,594	1.50	27,572
Erin	10,404	1.50	11,894	12,072	1.50	13,005	14,010	1.50	15,093
13. POINT FORTIN	44,719	1.40	50,660	51,368	1.61	55,636	60,265	1.61	65,285
Borough	16,710	1.13	18,493	18,703	1.50	20,148	21,705	1.50	23,382
Erin	384	1.50	439	446	1.50	480	517	1.50	557
Cedros	9,320	1.77	10,916	11,109	2.00	12,266	13,542	2.00	14,952
La Brea	18,305	1.44	20,812	21,111	1.50	22,742	24,500	1.50	26,394
14. NORTH COAST	1,706	3.30	2,285	2,360	3.00	2,736	3,172	2.00	3,502
15. TOBAGO	39,524	3.58	54,223	56,195	3.52	66,707	79,415	2.67	90,616
15.1 Leeward Section	29,780	3.90	42,027	43,689	3.85	52,723	63,771	2.89	73,530
St. George	4,580	2.42	5,678	5,815	2.50	6,579	7,444	2.00	8,219
St. Andrew	10,935	4.11	15,707	16,352	4.00	19,895	24,205	3.00	28,060
St. Patrick	7,859	5.25	12,455	13,109	5.00	16,731	21,353	3.50	25,361
St. David	6,406	2.76	8,187	8,413	2.50	9,519	10,770	2.00	11,891
15.2 Windward Section	9,744	2.53	12,196	12,505	2.26	13,984	15,644	1.78	17,086
St. Mary's	2,291	3.41	3,097	3,202	3.00	3,713	4,304	2.50	4,869
St. Paul	4,637	2.24	5,659	5,786	2.00	6,388	7,053	1.50	7,598
St. John	2,816	2.25	3,440	3,517	2.00	3,883	4,288	1.50	4,619
TOTAL	1,055,763	1.51	1,208,515	1,228,780	1.80	1,340,363	1,468,558	1.63	1,592,372

Table II-2.2 POPULATION GROWTH

YEAR	LIVE BIRTHS (A)	DEATHS (B)	NATURAL INCREASE (C) (A)-(B)	ARRIVALS (D)	DEPARTURES (E)	NET MIGRATION (F) (D)-(E)	CSO MID-YEAR POPULATION ESTIMATE (G)	RATE OF NATURAL INCREASE (C)/(G)*100 (%)	RATE OF NET MIGRATION (F)/(G)*100 (%)	TOTAL INCREASE (H) (C)+(F)	ANNUAL GROWTH RATE (I) (H)/(G)*100 (%)
1979	29,698	7,060	22,638	576,120	585,380	-9,260	NA	-	-	13,378	-
1980	29,869	7,506	22,363	567,870	571,850	-3,980	1,079,791 *	2.07	-0.37	18,383	1.70
1981	32,177	7,355	24,822	536,902	540,070	-3,168	1,093,940	2.27	-0.29	21,654	1.98
1982	32,537	7,641	24,896	533,862	531,612	2,250	1,115,701	2.23	0.20	27,146	2.43
1983	33,208	7,546	25,662	532,026	530,973	1,053	1,138,542	2.25	0.09	26,715	2.35
1984	31,599	7,819	23,780	560,174	572,004	-11,830	1,169,628	2.03	-1.01	11,950	1.02
1985	33,735	8,026	25,709	567,468	574,856	-7,388	1,178,273	2.18	-0.63	18,321	1.55
1986	32,027	7,699	24,328	578,093	593,470	-15,377	1,196,401	2.03	-1.29	8,951	0.75
1987	30,000	8,100	21,900	609,779	620,819	-11,040	1,211,753	1.81	-0.91	10,860	0.90
1988	28,000	8,036	19,964	600,017	642,507	-42,490	1,211,539	1.65	-3.51	-22,526	-1.86
1989	NA	NA	-	577,701	596,917	-19,216	NA	-	-	-	-

Note: * Census Population including Institutional Population
NA : Not Available

Sources: Population and Housing Census 1980
Population and Vital Statistical Report 1984
Population and Births Report 1985
Death Reports 1986, 1988
International Travel Report 1988
Travel Statistics - Jan 89, Aug 89, Dec 89, Jun 90
Annual Statistical Digest 1988

Table II-2.3 ESTIMATED 1989 POPULATION

Area	Number of Households as of 1980 Census	Population Census 1980	Estimated Number of Households as of Oct 1989	Average Size of Household	Estimated Population 1989	Annual Population Growth Rate (%)
1. Port of Spain	15,083	55,800	14,482	3.1	44,894	-2.39
2. San Fernando	7,930	33,395	7,942	3.8	30,180	-1.12
3. Arima Borough	5,128	24,112	6,767	4.4	29,775	2.37
4. Point Fortin Borough	4,083	16,710	5,137	3.6	18,493	1.13
5. Diego Martin	20,722	88,752	25,725	3.9	100,328	1.37
6. St. Ann's	37,649	157,729	41,428	3.9	161,569	0.27
7. Tacarigua	21,672	97,620	30,248	3.9	117,967	2.13
8. Rest of St. George						
Arima Ward	4,326	20,294	11,230	3.9	43,797	8.92
Blanchisseuse	466	1,706	586	3.9	2,285	3.30
San Rafael	962	4,471	1,430	3.9	5,577	2.49
9. Caroni						
Montserrat	3,969	19,441	5,217	4.3	22,433	1.60
Chaguanas	14,147	69,870	20,529	4.3	88,275	2.63
Cunupia	3,476	17,593	5,141	4.3	22,106	2.57
Couva	6,771	33,481	8,943	4.3	38,455	1.55
10. Nariva/Mayaro						
Cocal	2,151	10,344	2,281	3.9	8,896	-1.66
Charuma	2,539	12,650	2,983	3.9	11,634	-0.93
Guayaguayare	1,936	7,420	2,153	3.9	8,397	1.38
Trinity	139	469	73	3.9	285	-5.40
11. St. Andrew/St. David						
Toco	1,383	5,168	1,542	4.3	6,631	2.81
Valencia	365	1,604	783	4.3	3,367	8.59
Matura	379	1,513	441	4.3	1,896	2.54
Manzanilla	4,639	21,395	5,976	4.3	25,697	2.06
Tamana	1,573	7,629	2,144	4.3	9,219	2.13
Turure	2,715	12,862	3,697	4.3	15,897	2.38
12. Victoria						
Ortoire	2,788	13,815	3,732	4.4	16,421	1.94
Naparima	18,453	86,737	22,447	4.4	98,767	1.45
Pointe-a-Pierre	7,214	34,885	9,068	4.4	39,899	1.50
Moruga	1,775	8,143	2,223	4.4	9,781	2.06
Savanna Grande	8,769	43,429	11,184	4.4	49,210	1.40
13. St. Patrick						
Siparia	14,047	68,789	17,750	4.4	78,100	1.42
Erin	2,338	10,788	2,803	4.4	12,333	1.50
La Brea	4,264	18,305	4,730	4.4	20,812	1.44
Cedros	2,044	9,320	2,481	4.4	10,916	1.77
14. Tobago						
St. George	964	4,580	1,208	4.7	5,678	2.42
St. Mary's	500	2,291	659	4.7	3,097	3.41
St. Andrew	2,562	10,935	3,342	4.7	15,707	4.11
St. Patrick	1,842	7,859	2,650	4.7	12,455	5.25
St. David	1,384	6,406	1,742	4.7	8,187	2.76
St. Paul	943	4,637	1,204	4.7	5,659	2.24
St. John	637	2,816	732	4.7	3,440	2.25
TOTAL	234,727	1,055,763	294,833	4.1	1,208,515	1.51

Table II-2.4 PER CAPITA WATER DEMAND

PER CAPITA WATER DEMAND 1990/1995

(lpcd)

	1990			1995		
	URBAN	SEMIURBAN	RURAL	URBAN	SEMIURBAN	RURAL
DOMESTIC	240	220	180	250	230	185
INDUSTRIAL/AGRICULTURAL	10	10	4	12	12	4
COMMERCIAL/PUBLIC	5	5	2	6	6	2
SUB-TOTAL(NET)	255	235	186	268	248	191
UNACCOUNTED-FOR WATER	255	235	186	179	165	127
TOTAL	510	470	372	447	413	318

Note: Percentage of UFW: 50%(1990), 40%(1995)
Agricultural demand includes water for livestocks but not for irrigation.
Total Demand = Net Demand/(1-UFW Ratio)

PER CAPITA WATER DEMAND 2000/2005

(lpcd)

	2000			2005		
	URBAN	SEMIURBAN	RURAL	URBAN	SEMIURBAN	RURAL
DOMESTIC	260	240	190	270	250	195
INDUSTRIAL/AGRICULTURAL	14	14	4	16	16	4
COMMERCIAL/PUBLIC	7	7	2	8	8	2
SUB-TOTAL(NET)	281	261	196	294	274	201
UNACCOUNTED-FOR WATER	120	112	84	74	69	50
TOTAL	401	373	280	368	343	251

Note: Percentage of UFW: 30%(2000), 20%(2005)
Agricultural demand includes water for livestocks but not for irrigation.
Total Demand = Net Demand/(1-UFW Ratio)

Table II-2.5 SPECIAL INDUSTRIAL WATER DEMAND

(lpcd)

YEAR	SPECIAL INDUSTRIAL (NET)	UFW	TOTAL
1990	63	63	126
1995	70	46	116
2000	77	33	110
2005	85	21	106

Allocation for five water areas:

Port of Spain	6.14%
Barataria	6.35%
St. Joseph	13.51%
Arouca	5.71%
Couva	68.30%

Note: Percentage of UFW: 50%(1990), 40%(1995), 30%(2000) and 20%(2005)
Total Demand = Net Demand/(1-UFW Ratio)

Table II-2.6 POPULATION AND WATER DEMAND PROJECTION 1990-2005 (1)

YEAR 1990

WATER AREA	POPULATION Total	POPULATION Service Area	POPULATION Served	POPULATION Served by Sources I	POPULATION Served by Sources II	WATER DEMAND (m3/d) Area I	WATER DEMAND (m3/d) Area II	WATER DEMAND (m3/d) General	WATER DEMAND (m3/d) Special	WATER DEMAND (m3/d) Total
1. DIEGO MARTIN	70,161	69,231	65,769	240	65,529	113	30,799	30,911		30,911
2. PORT OF SPAIN	82,530	81,691	77,607	39,610	37,996	29,707	19,378	39,579	9,505	49,085
3. E.M.R. COMMUNITIES	278,073	270,402	256,882	239,562	17,320	157,339	8,152	125,911	39,580	165,491
3.1 St. Barbs	6,342	6,342	6,025	5,803	223	2,959	113	3,073		3,073
3.2 Laventille	6,496	6,496	6,172	6,172		3,147		3,147		3,147
3.3 Morvant	19,658	19,658	18,676	18,613	62	9,493	32	9,525		9,525
3.4 Picton	27,058	27,058	25,705	25,705		13,109		13,109		13,109
3.5 Barataria	33,259	33,259	31,596	31,596		25,945		16,114	9,831	25,945
3.6 St. Joseph	34,868	31,563	29,985	23,477	6,508	31,946	3,059	14,093	20,912	35,005
3.7 Arouca	24,269	24,269	23,056	21,578	1,477	18,979	694	10,836	8,837	19,674
3.8 Tacarigua	20,447	19,196	18,236	18,236		9,300		9,300		9,300
3.9 Saddle Road	55,215	54,769	52,031	48,256	3,775	22,680	1,774	24,455		24,455
3.10 St. Augustine	23,601	23,573	22,394	17,120	5,275	8,046	2,479	10,525		10,525
3.11 Tunapuna	26,859	24,218	23,007	23,007		11,734		11,734		11,734
4. ARIMA	61,487	58,180	55,271	55,271		25,977		25,977		25,977
5. SANGRE GRANDE	55,755	49,614	47,133	43,037	4,096	16,010	1,524	17,533		17,533
6. WALLERFIELD	27,365	24,960	23,712	23,712		8,821		8,821		8,821
7. TOCO	8,761	7,821	7,430		7,430		2,764	2,764		2,764
8. CARONI	186,144	178,931	169,985	147,466	22,518	175,050	10,584	79,893	105,741	185,634
8.1 Caroni	8,461	8,461	8,038	8,038		3,778		3,778		3,778
8.2 Cunupia	55,597	53,426	50,754	49,724	1,030	23,370	484	23,855		23,855
8.3 Chaguanas	63,264	61,403	58,333	43,298	15,035	20,350	7,066	27,417		27,417
8.4 Couva	58,823	55,642	52,860	46,406	6,453	127,552	3,033	24,844	105,741	130,585
9. MAYARO	10,022	9,752	9,265		9,265		3,446	3,446		3,446
10. RIO CLARO	274,590	271,709	258,123	234,054	24,069	98,783	9,692	108,475		108,475
10.1 Arch Trace	47,531	44,649	42,416	38,413	4,003	14,290	1,489	15,779		15,779
10.2 Princes Town	50,765	50,765	48,227	48,227		17,940		17,940		17,940
10.3 Barrackpore	50,994	50,995	48,445	35,912	12,533	13,359	4,662	18,022		18,022
10.4 Fyzabad	59,523	59,523	56,547	49,924	6,623	23,464	3,113	26,577		26,577
10.5 Palmyra	45,050	45,050	42,798	41,887	911	19,687	428	20,115		20,115
10.6 Marabella	20,726	20,726	19,690	19,690		10,042		10,042		10,042
11. SAN FERNANDO	29,842	29,842	28,350	28,350		14,459		14,459		14,459
12. SIPARIA/ERIN	34,125	32,716	31,080		31,080		11,562	11,562		11,562
13. POINT FORTIN	51,368	50,018	47,517	13,727	33,790	5,106	12,570	17,676		17,676
14. NORTH COAST	2,360	1,842	1,749		1,749		651	651		651
TOTAL (TRINIDAD)	1,172,585	1,136,708	1,079,872	825,028	254,844	531,364	111,121	487,659	154,826	642,485
15. TOBAGO	56,195	55,784	52,994					23,781		23,781
15.1 Leeward Sect.	43,689	43,689	41,505					19,507		19,507
15.2 Windward Sect.	12,505	12,095	11,490					4,274		4,274
TOTAL	1,228,780	1,192,491	1,132,867	825,028	254,844	531,364	111,121	511,440	154,826	666,267

YEAR 1995

WATER AREA	POPULATION Total	POPULATION Service Area	POPULATION Served	POPULATION Served by Sources I	POPULATION Served by Sources II	WATER DEMAND (m3/d) Area I	WATER DEMAND (m3/d) Area II	WATER DEMAND (m3/d) General	WATER DEMAND (m3/d) Special	WATER DEMAND (m3/d) Total
1. DIEGO MARTIN	75,583	74,581	70,851	258	70,593	107	29,155	29,261		29,261
2. PORT OF SPAIN	82,928	82,025	77,923	38,612	39,311	26,860	17,572	34,832	9,601	44,432
3. E.M.R. COMMUNITIES	297,995	289,375	274,906	255,775	19,131	150,231	7,911	118,166	39,976	158,142
3.1 St. Barbs	6,438	6,438	6,116	5,890	226	2,633	101	2,734		2,734
3.2 Laventille	6,594	6,594	6,265	6,264		2,800		2,800		2,800
3.3 Morvant	19,955	19,955	18,957	18,894	64	8,445	28	8,474		8,474
3.4 Picton	27,466	27,466	26,093	26,093		11,663		11,663		11,663
3.5 Barataria	33,761	33,761	32,073	32,073		24,266		14,337	9,929	24,266
3.6 St. Joseph	38,658	34,922	33,176	25,810	7,366	31,780	3,042	13,702	21,121	34,823
3.7 Arouca	28,849	28,849	27,406	25,735	1,672	19,554	691	11,319	8,926	20,245
3.8 Tacarigua	23,134	21,718	20,632	20,632		9,223		9,223		9,223
3.9 Saddle Road	56,048	55,597	52,817	48,984	3,833	20,230	1,583	21,813		21,813
3.10 St. Augustine	26,703	26,674	25,340	19,371	5,970	8,000	2,466	10,466		10,466
3.11 Tunapuna	30,389	27,401	26,031	26,031		11,636		11,636		11,636
4. ARIMA	71,608	66,587	63,258	63,258		26,125		26,125		26,125
5. SANGRE GRANDE	63,611	56,664	53,831	49,091	4,740	15,611	1,507	17,118		17,118
6. WALLERFIELD	32,311	29,523	28,047	28,047		8,919		8,919		8,919
7. TOCO	10,157	9,068	8,614		8,615		2,739	2,739		2,739
8. CARONI	211,233	203,213	193,052	168,039	25,014	176,199	10,331	79,731	106,799	186,530
8.1 Caroni	9,707	9,707	9,221	9,222		3,809		3,808		3,808
8.2 Cunupia	64,294	61,840	58,748	57,610	1,137	23,793	470	24,263		24,263
8.3 Chaguanas	72,288	70,234	66,722	49,971	16,751	20,638	6,918	27,556		27,556
8.4 Couva	64,945	61,433	58,361	51,236	7,125	127,960	2,943	24,103	106,799	130,902
9. MAYARO	10,500	10,288	9,773		9,774		3,108	3,108		3,108
10. RIO CLARO	294,215	291,609	277,028	251,139	25,887	91,995	9,003	100,998		100,998
10.1 Arch Trace	48,829	46,223	43,912	39,641	4,271	12,606	1,358	13,964		13,964
10.2 Princes Town	55,310	55,310	52,545	52,545		16,709		16,709		16,709
10.3 Barrackpore	55,092	55,092	52,338	38,836	13,500	12,350	4,293	16,643		16,643
10.4 Fyzabad	64,123	64,123	60,917	53,782	7,134	22,212	2,946	25,159		25,159
10.5 Palmyra	48,532	48,532	46,106	45,124	981	18,636	405	19,042		19,042
10.6 Marabella	22,328	22,328	21,212	21,212		9,482		9,482		9,482
11. SAN FERNANDO	28,380	28,380	26,961	26,961		12,052		12,052		12,052
12. SIPARIA/ERIN	36,763	35,246	33,483		33,484		10,648	10,648		10,648
13. POINT FORTIN	55,636	54,171	51,463	14,788	36,675	4,702	11,663	16,365		16,365
14. NORTH COAST	2,736	2,135	2,028		2,028		645	645		645
TOTAL (TRINIDAD)	1,273,656	1,232,862	1,171,217	895,967	275,250	512,801	104,282	460,707	156,376	617,083
15. TOBAGO	66,707	66,253	62,941					24,773		24,773
15.1 Leeward Sect.	52,723	52,723	50,087					20,686		20,686
15.2 Windward Sect.	13,984	13,530	12,854					4,087		4,087
TOTAL	1,340,363	1,299,116	1,234,158	895,967	275,250	512,801	104,282	485,480	156,376	641,856

Table II-2. 6 POPULATION AND WATER DEMAND PROJECTION 1990-2005 (2)

2000

YEAR / WATER AREA	POPULATION Total	POPULATION Service Area	POPULATION Served	POPULATION Served by Sources I	POPULATION Served by Sources II	WATER DEMAND (m3/d) Area I	WATER DEMAND (m3/d) Area II	WATER DEMAND (m3/d) General	WATER DEMAND (m3/d) Special	WATER DEMAND (m3/d) Total
1. DIEGO MARTIN	81,425	80,345	76,328	278	76,049	104	28,366	28,470		28,470
2. PORT OF SPAIN	83,622	82,648	78,516	37,713	40,803	25,041	16,362	31,485	9,918	41,402
3. E.M.R. COMMUNITIES	320,646	310,946	295,399	274,235	21,165	147,600	7,903	114,206	41,297	155,503
3.1 St. Barbs	6,535	6,535	6,208	5,979	229	2,398	92	2,490		2,490
3.2 Laventille	6,694	6,694	6,359	6,359		2,550		2,550		2,550
3.3 Morvant	20,256	20,256	19,243	19,180	65	7,691	26	7,717		7,717
3.4 Picton	27,880	27,880	26,486	26,486		10,621		10,621		10,621
3.5 Barataria	34,270	34,270	32,557	32,557		23,312		13,055	10,257	23,313
3.6 St. Joseph	42,934	38,707	36,772	28,437	8,334	32,426	3,109	13,716	21,819	35,535
3.7 Arouca	34,414	34,414	32,694	30,803	1,891	20,710	706	12,195	9,221	21,415
3.8 Tacarigua	26,174	24,572	23,343	23,343		9,361		9,361		9,361
3.9 Saddle Road	56,894	56,436	53,614	49,723	3,891	18,547	1,451	19,998		19,998
3.10 St. Augustine	30,212	30,179	28,670	21,916	6,755	8,175	2,519	10,694		10,694
3.11 Tunapuna	34,382	31,002	29,452	29,452		11,810		11,810		11,810
4. ARIMA	84,175	76,926	73,080	73,080		27,259		27,259		27,259
5. SANGRE GRANDE	72,647	64,786	61,547	56,052	5,495	15,695	1,539	17,233		17,233
6. WALLERFIELD	38,243	35,011	33,260	33,260		9,313		9,313		9,313
7. TOCO	11,775	10,512	9,986		9,986		2,796	2,796		2,796
8. CARONI	239,840	230,921	219,375	191,581	27,794	181,787	10,367	81,827	110,327	192,154
8.1 Caroni	11,138	11,138	10,581	10,581		3,947		3,947		3,947
8.2 Cunupia	74,358	71,584	68,005	66,749	1,256	24,897	468	25,366		25,366
8.3 Chaguanas	82,639	80,372	76,353	57,682	18,671	21,515	6,964	28,480		28,480
8.4 Couva	71,704	67,827	64,436	56,569	7,867	131,427	2,934	24,034	110,327	134,362
9. MAYARO	11,054	10,889	10,345		10,345		2,896	2,896		2,896
10. RIO CLARO	315,688	313,332	297,665	269,796	27,869	88,217	8,616	96,834		96,834
10.1 Arch Trace	50,464	48,108	45,703	41,121	4,582	11,514	1,283	12,797		12,797
10.2 Princes Town	60,282	60,282	57,268	57,268		16,035		16,035		16,035
10.3 Barrackpore	59,527	59,527	56,550	42,005	14,545	11,761	4,072	15,834		15,834
10.4 Fyzabad	69,079	69,079	65,625	57,940	7,686	21,611	2,867	24,478		24,478
10.5 Palmyra	52,283	52,283	49,669	48,612	1,057	18,132	394	18,526		18,526
10.6 Marabella	24,054	24,054	22,851	22,851		9,163		9,163		9,163
11. SAN FERNANDO	26,989	26,989	25,640	25,640		10,281		10,281		10,281
12. SIPARIA/ERIN	39,604	37,969	36,071		36,071		10,100	10,100		10,100
13. POINT FORTIN	60,265	58,681	55,747	15,931	39,816	4,461	11,149	15,609		15,609
14. NORTH COAST	3,172	2,475	2,351		2,351		658	658		658
TOTAL (TRINIDAD)	1,389,143	1,342,430	1,275,308	977,565	297,744	509,757	100,753	448,967	161,541	610,509
15. TOBAGO	79,415	78,914	74,969					26,625		26,625
15.1 Leeward Sect.	63,771	63,771	60,583					22,597		22,597
15.2 Windward Sect.	15,644	15,143	14,386					4,028		4,028
TOTAL	1,468,558	1,421,344	1,350,277	977,565	297,744	509,757	100,753	475,593	161,541	637,134

2005

YEAR / WATER AREA	POPULATION Total	POPULATION Service Area	POPULATION Served	POPULATION Served by Sources I	POPULATION Served by Sources II	WATER DEMAND (m3/d) Area I	WATER DEMAND (m3/d) Area II	WATER DEMAND (m3/d) General	WATER DEMAND (m3/d) Special	WATER DEMAND (m3/d) Total
1. DIEGO MARTIN	85,578	84,443	80,221	293	79,929	100	27,416	27,516		27,516
2. PORT OF SPAIN	83,733	82,710	78,575	36,832	41,743	23,941	15,361	28,915	10,387	39,303
3. E.M.R. COMMUNITIES	342,306	331,631	315,049	292,012	23,038	147,190	7,909	111,848	43,252	155,100
3.1 St. Barbs	6,700	6,700	6,365	6,130	235	2,256	86	2,342		2,342
3.2 Laventille	6,863	6,863	6,520	6,520		2,399		2,399		2,399
3.3 Morvant	20,768	20,768	19,730	19,663	66	7,236	24	7,260		7,260
3.4 Picton	28,584	28,584	27,155	27,155		9,993		9,993		9,993
3.5 Barataria	35,136	35,136	33,379	33,379		23,026		12,284	10,743	23,026
3.6 St. Joseph	46,850	42,183	40,074	30,872	9,202	33,441	3,156	13,745	22,852	36,597
3.7 Arouca	38,859	38,859	36,916	34,828	2,089	21,603	717	12,662	9,657	22,319
3.8 Tacarigua	28,898	27,129	25,773	25,773		9,484		9,484		9,484
3.9 Saddle Road	58,331	57,861	54,968	50,979	3,989	17,486	1,368	18,854		18,854
3.10 St. Augustine	33,356	33,320	31,654	24,197	7,458	8,299	2,558	10,857		10,857
3.11 Tunapuna	37,961	34,228	32,517	32,517		11,966		11,966		11,966
4. ARIMA	93,937	85,108	80,853	80,853		27,732		27,732		27,732
5. SANGRE GRANDE	80,536	71,858	68,265	62,134	6,130	15,596	1,539	17,135		17,135
6. WALLERFIELD	43,285	39,628	37,647	37,647		9,449		9,449		9,449
7. TOCO	13,322	11,893	11,298		11,298		2,836	2,836		2,836
8. CARONI	269,840	259,892	246,897	215,896	31,001	189,603	10,633	84,686	115,550	200,236
8.1 Caroni	12,474	12,474	11,850	11,850		4,065		4,065		4,065
8.2 Cunupia	84,034	80,933	76,886	75,499	1,387	25,896	476	26,372		26,372
8.3 Chaguanas	93,230	90,664	86,131	65,226	20,905	22,373	7,170	29,543		29,543
8.4 Couva	80,102	75,821	72,030	63,320	8,710	137,269	2,987	24,706	115,550	140,257
9. MAYARO	11,752	11,602	11,022		11,022		2,766	2,766		2,766
10. RIO CLARO	339,696	337,455	320,582	290,527	30,052	86,363	8,410	94,773		94,773
10.1 Arch Trace	52,992	50,751	48,213	43,247	4,967	10,855	1,247	12,102		12,102
10.2 Princes Town	65,722	65,722	62,436	62,436		15,671		15,671		15,671
10.3 Barrackpore	64,327	64,327	61,111	45,441	15,668	11,406	3,933	15,339		15,339
10.4 Fyzabad	74,418	74,418	70,697	62,417	8,279	21,409	2,840	24,249		24,249
10.5 Palmyra	56,324	56,324	53,508	52,369	1,138	17,962	390	18,353		18,353
10.6 Marabella	25,913	25,913	24,617	24,617		9,059		9,059		9,059
11. SAN FERNANDO	26,321	26,321	25,005	25,005		9,202		9,202		9,202
12. SIPARIA/ERIN	42,665	40,904	38,859		38,859		9,754	9,754		9,754
13. POINT FORTIN	65,285	63,573	60,394	17,162	43,233	4,308	10,851	15,159		15,159
14. NORTH COAST	3,502	2,732	2,595		2,595		651	651		651
TOTAL (TRINIDAD)	1,501,756	1,449,750	1,377,263	1,058,359	318,901	513,484	98,127	442,423	169,190	611,612
15. TOBAGO	90,616	90,077	85,573					27,905		27,905
15.1 Leeward Sect.	73,530	73,530	69,854					23,960		23,960
15.2 Windward Sect.	17,086	16,547	15,720					3,946		3,946
TOTAL	1,592,372	1,539,827	1,462,836	1,058,359	318,901	513,484	98,127	470,328	169,190	639,517

Table II-2.7 WATER DEMAND PROJECTION BY WATER AREA

YEAR / WATER AREA	AREA (km2)	POPULATION DENSITY (/km2)		1990 WATER DEMAND (m3/day) Total	Net	UFW	1995 WATER DEMAND (m3/day) Total	Net	UFW	2000 WATER DEMAND (m3/day) Total	Net	UFW	2005 WATER DEMAND (m3/day) Total	Net	UFW
1. DIEGO MARTIN	105	666	S	30,911	15,456	15,456	29,261	17,571	11,690	28,470	19,922	8,549	27,516	21,981	5,535
2. PORT OF SPAIN	56	1,473	U	49,085	24,542	24,542	44,432	26,644	17,788	41,402	29,005	12,397	39,303	31,411	7,892
3. E.M.R. COMMUNITIES	302	922		165,491	82,746	82,746	158,142	94,886	63,256	155,503	108,880	46,623	155,100	123,954	31,146
3.1 St. Barbs	2	3,523	U	3,073	1,536	1,536	2,734	1,639	1,095	2,490	1,745	745	2,342	1,871	471
3.2 Laventille	2	4,112	U	3,147	1,574	1,574	2,800	1,679	1,121	2,550	1,787	763	2,399	1,917	482
3.3 Morvant	7	2,912	U	9,525	4,762	4,762	8,474	5,081	3,393	7,717	5,407	2,309	7,260	5,801	1,460
3.4 Picton	9	3,082	U	13,109	6,555	6,555	11,663	6,993	4,671	10,621	7,443	3,178	9,993	7,984	2,009
3.5 Barataria	13	2,504	U	25,945	12,972	12,972	24,266	14,553	9,713	23,313	16,329	6,984	23,026	18,408	4,619
3.6 St. Joseph	58	605	S	35,005	17,502	17,502	34,823	20,900	13,922	35,535	24,871	10,664	36,597	29,262	7,335
3.7 Arouca	68	355	S	19,674	9,837	9,837	20,245	12,152	8,092	21,415	14,988	6,428	22,319	17,841	4,479
3.8 Tacarigua	13	1,594	U	9,300	4,650	4,650	9,223	5,529	3,693	9,361	6,559	2,801	9,484	7,577	1,907
3.9 Saddle Road	76	730	S	24,455	12,227	12,227	21,813	13,099	8,715	19,998	13,993	6,005	18,854	15,061	3,793
3.10 St. Augustine	29	813	S	10,525	5,263	5,263	10,466	6,284	4,181	10,694	7,483	3,211	10,857	8,673	2,184
3.11 Tunapuna	26	1,033	U	11,734	5,867	5,867	11,636	6,976	4,660	11,810	8,276	3,534	11,966	9,560	2,406
4. ARIMA	141	414	S	25,977	12,989	12,989	26,125	15,688	10,438	27,259	19,074	8,185	27,732	22,154	5,579
5. SANGRE GRANDE	584	85	R	17,533	8,767	8,767	17,118	10,282	6,836	17,233	12,063	5,170	17,135	13,721	3,413
6. WALLERFIELD	175	143	R	8,821	4,410	4,410	8,919	5,357	3,562	9,313	6,519	2,794	9,449	7,567	1,882
7. TOCO	370	21	R	2,764	1,382	1,382	2,739	1,645	1,094	2,796	1,957	839	2,836	2,271	565
8. CARONI	542	330		185,634	92,817	92,817	186,530	111,956	74,573	192,154	134,486	57,668	200,236	160,090	40,146
8.1 Caroni	13	648	S	3,778	1,889	1,889	3,808	2,287	1,522	3,947	2,762	1,185	4,065	3,247	818
8.2 Cunupia	201	265	S	23,855	11,927	11,927	24,263	14,569	9,693	25,366	17,749	7,617	26,372	21,067	5,305
8.3 Chaguanas	153	400	S	27,417	13,708	13,708	27,556	16,547	11,009	28,480	19,928	8,552	29,543	23,600	5,943
8.4 Couva	174	320	S	130,585	65,292	65,292	130,902	78,553	52,349	134,362	94,047	40,315	140,257	112,177	28,080
9. MAYARO	478	21	R	3,446	1,723	1,723	3,108	1,867	1,241	2,896	2,028	869	2,766	2,215	551
10. RIO CLARO	1,382	199		108,475	54,237	54,237	100,998	60,646	40,352	96,834	67,779	29,055	94,773	75,793	18,980
10.1 Arch Trace	592	80	R	15,779	7,889	7,889	13,964	8,387	5,577	12,797	8,958	3,839	12,102	9,691	2,411
10.2 Princes Town	416	122	R	17,940	8,970	8,970	16,709	10,036	6,673	16,035	11,224	4,810	15,671	12,550	3,122
10.3 Barrackpore	218	234	R	18,022	9,011	9,011	16,643	9,996	6,647	15,834	11,084	4,750	15,339	12,283	3,056
10.4 Fyzabad	93	642	S	26,577	13,289	13,289	25,159	15,107	10,051	24,478	17,128	7,350	24,249	19,371	4,878
10.5 Palmyra	58	782	S	20,115	10,058	10,058	19,042	11,434	7,607	18,526	12,964	5,563	18,353	14,661	3,692
10.6 Marabella	6	3,681	U	10,042	5,021	5,021	9,482	5,685	3,797	9,163	6,421	2,742	9,059	7,238	1,822
11. SAN FERNANDO	8	3,787	U	14,459	7,229	7,229	12,052	7,226	4,826	10,281	7,205	3,077	9,202	7,351	1,850
12. SIPARIA/ERIN	195	175	R	11,562	5,781	5,781	10,648	6,395	4,252	10,100	7,070	3,030	9,754	7,811	1,943
13. POINT FORTIN	297	173	R	17,676	8,838	8,838	16,365	9,829	6,536	15,609	10,926	4,683	15,159	12,139	3,020
14. NORTH COAST	194	12	R	651	325	325	645	387	258	658	461	198	651	522	130
TOTAL (TRINIDAD)	4,827	243		642,485	321,243	321,243	617,083	370,379	246,704	610,509	427,374	183,135	611,612	488,980	122,632
15. TOBAGO	301	187		23,781	11,891	11,891	24,773	14,877	9,897	26,625	18,632	7,994	27,905	22,300	5,606
15.1 Leeward Sect.	140	311	S	19,507	9,754	9,754	20,686	12,422	8,264	22,597	15,812	6,785	23,960	19,140	4,820
15.2 Windward Sect.	161	78	R	4,274	2,137	2,137	4,087	2,455	1,632	4,028	2,820	1,208	3,946	3,160	786
TOTAL	5,128	240		666,267	333,133	333,133	641,856	385,255	256,600	637,134	446,006	191,129	639,517	511,279	128,238

N.B. U:Urban, S:Semiurban, R:Rural
UFW(Unaccounted-for Water): 50% in 1990, 40% in 1995, 30% in 2000, 20% in 2005

Table II-2.8 ESTIMATED DEPENDABLE YIELDS (1)

* Estimated

DISTRICT OF WASA	No.	NAME OF PRODUCTION FACILITIES WATERWORKS/TREATMENT PLANTS INTAKES, WELLS AND SPRINGS	KIND OF SCALE	SURFACE WATER RAINY (m3/d)	SURFACE WATER DRY (m3/d)	GROUNDWATER RAINY (m3/d)	GROUNDWATER DRY (m3/d)	TOTAL RAINY (m3/d)	TOTAL DRY (m3/d)
NORTH CENTRAL	1	CARONI/ARENA TREATMENT PLANT	LARGE-S	272,760	272,760	----	----	272,760	272,760
	2	* VALSAYN WATERWORKS	MEDIUM-G	----	----	27,280	27,280	27,280	27,280
	3	* TACARIGUA WATERWORKS	MEDIUM-G	----	----	14,550	14,550	14,550	14,550
	4	LAS LOMAS WATERWORKS	MEDIUM-G	----	----	11,360	11,360	11,360	11,360
	5	CAURA WATERWORKS	MEDIUM-S	11,360	9,094	----	----	11,360	9,094
	6	LOANGO/NARANJO WATERWORKS	MEDIUM-S	3,180	2,214	----	----	3,180	2,214
	7	* AROUCA WATERWORKS	SMALL-G	----	----	653	653	653	653
	8	* ST. JOHN'S INTAKE	SMALL-S	454	454	----	----	454	454
	9	* Mt. D'OR INTAKE	SMALL-S	88	88	----	----	88	88
	10	* WATERFALL ROAD INTAKE	SMALL-S	59	59	----	----	59	59
	11	* LOANGO INTAKE	SMALL-S	59	59	----	----	59	59
	12	* LOPINOT INTAKE	SMALL-S	35	35	----	----	35	35
	13	* SURREY INTAKE	SMALL-S	18	18	----	----	18	18
		LARGE-S		272,760	272,760	0	0	272,760	272,760
		MEDIUM-G		0	0	53,190	53,190	53,190	53,190
		MEDIUM-S		14,540	11,308	0	0	14,540	11,308
		SMALL-G		0	0	653	653	653	653
		SMALL-S		713	713	0	0	713	713
		SUB-TOTAL		**288,013**	**284,781**	**53,843**	**53,843**	**341,856**	**338,624**
NORTH EAST	14	NORTH OROPOUCHE WATERWORKS	LARGE-S	90,125	44,825	----	----	90,125	44,825
	15	* HOLLIS WATERWORKS	LARGE-S	31,826	25,000	----	----	31,826	25,000
	16	GUANAPO WATERWORKS	MEDIUM-S	11,360	11,360	----	----	11,360	11,360
	17	ARIPO NEW WATERWORKS	MEDIUM-S	10,530	8,059	----	----	10,530	8,059
	18	* ARIPO INTAKE	MEDIUM-S	4,535	4,535	----	----	4,535	4,535
	19	* QUARE INTAKE (VALENCIA)	MEDIUM-S	2,935	2,935	----	----	2,935	2,935
	20	* TOCO WATERWORKS	MEDIUM-S	2,162	1,525	----	----	2,162	1,525
	21	* ARIMA WELL #6	SMALL-G	----	----	644	644	644	644
	22	* SANS SOUCI INTAKE	SMALL-S	493	493	----	----	493	493
	23	* LOS ARMADILLOS INTAKE	SMALL-S	105	105	----	----	105	105
	24	* FOUR ROAD/TAMANA INTAKE	SMALL-S	70	70	----	----	70	70
	25	* CUMACA INTAKE	SMALL-S	45	45	----	----	45	45
	26	* MATURA INTAKE	SMALL-S	35	35	----	----	35	35
	27	* MATELOT INTAKE	SMALL-S	35	35	----	----	35	35
	28	* GRAND RIVIERE INTAKE	SMALL-S	35	35	----	----	35	35
	29	* SALIBEA INTAKE	SMALL-S	35	35	----	----	35	35
	30	* MONTEVIDEO INTAKE	SMALL-S	35	35	----	----	35	35
	31	* MORNE LA CROIX INTAKE	SMALL-S	27	27	----	----	27	27
	32	* BRASSO SECO-PARIA INTAKE	SMALL-S	27	27	----	----	27	27
		LARGE-S		121,951	69,825	0	0	121,951	69,825
		MEDIUM-S		31,522	28,414	0	0	31,522	28,414
		SMALL-G		0	0	644	644	644	644
		SMALL-S		942	942	0	0	942	942
		SUB-TOTAL		**154,415**	**99,181**	**644**	**644**	**155,059**	**99,825**
NORTH WEST	33	* FOUR ROADS WATERWORKS	MEDIUM-G	----	----	28,900	28,900	28,900	28,900
	34	* EL SOCORRO WATERWORKS	MEDIUM-G	----	----	24,126	24,126	24,126	24,126
	35	* TUCKER VALLEY WELLS	MEDIUM-G	----	----	7,971	7,971	7,971	7,971
	36	* RIVER ESTATE WATERWORKS	MEDIUM-G	----	----	6,820	6,820	6,820	6,820
	37	* CHAGUARAMAS WELLS	MEDIUM-G	----	----	5,669	5,669	5,669	5,669
	38	* DORRINGTON GARDEN WATERWORKS	MEDIUM-G	----	----	5,400	5,400	5,400	5,400
	39	* LA PASTORA WELLS	MEDIUM-G	----	----	2,900	2,900	2,900	2,900
	40	ACONO WATERWORKS	MEDIUM-S	2,100	1,543	----	----	2,100	1,543
	41	* DAMIER INTAKE	SMALL-S	358	358	----	----	358	358
	42	* TYRICO INTAKE	SMALL-S	305	305	----	----	305	305
	43	* GUAICO TAMANA/LAS CUEVAS INTAKE	SMALL-S	266	266	----	----	266	266
	44	* LA CANOA INTAKE	SMALL-S	200	200	----	----	200	200
	45	* LA PASTORA RES. ROAD	SMALL-S	94	94	----	----	94	94
	46	* PIPIOL INTAKE	SMALL-S	90	90	----	----	90	90
	47	LA PASTORA/CAPRIATA INTAKE	SMALL-S	88	88	----	----	88	88
	48	* MON REPOS INTAKE	SMALL-S	45	45	----	----	45	45
	49	* BLANCHISSEUSE INTAKE	SMALL-S	44	44	----	----	44	44
		MEDIUM-G		0	0	81,786	81,786	81,786	81,786
		MEDIUM-S		2,100	1,543	0	0	2,100	1,543
		SMALL-S		1,490	1,490	0	0	1,490	1,490
		SUB-TOTAL		**3,590**	**3,033**	**81,786**	**81,786**	**85,376**	**84,819**
PORT OF SPAIN	50	* SAVANNAH WELLS	MEDIUM-G	----	----	12,270	12,270	12,270	12,270
	51	* KING GEORGE V PARK WELLS	MEDIUM-G	----	----	10,340	10,340	10,340	10,340
	52	* ST. CLAIR WELL	MEDIUM-G	----	----	1,820	1,820	1,820	1,820
	53	* MOKA WELLS	MEDIUM-G	----	----	1,590	1,590	1,590	1,590
	54	* MARAVAL WATERWORKS	MEDIUM-S	5,910	4,770	----	----	5,910	4,770
	55	* PARAMIN WATERWORKS	SMALL-G	----	----	390	390	390	390
	56	* ST ANN'S WATRWORKS	SMALL-S	840	840	----	----	840	840
	57	* CASCADE INTAKE	SMALL-S	207	207	----	----	207	207
	58	* DIBE INTAKE	SMALL-S	145	145	----	----	145	145

Table II-2.8 ESTIMATED DEPENDABLE YIELDS (2)

* Estimated

DISTRICT OF WASA		NAME OF PRODUCTION FACILITIES WATERWORKS/TREATMENT PLANTS INTAKES, WELLS AND SPRINGS	KIND OF SCALE	SURFACE WATER RAINY (m3/d)	SURFACE WATER DRY (m3/d)	GROUNDWATER RAINY (m3/d)	GROUNDWATER DRY (m3/d)	TOTAL RAINY (m3/d)	TOTAL DRY (m3/d)
	59	* ARIAPITA INTAKE	SMALL-S	138	138	----	----	138	138
		MEDIUM-G		0	0	26,020	26,020	26,020	26,020
		MEDIUM-S		5,910	4,770	0	0	5,910	4,770
		SMALL-G		0	0	390	390	390	390
		SMALL-S		1,330	1,330	0	0	1,330	1,330
		SUB-TOTAL		7,240	6,100	26,410	26,410	33,650	32,510
SAN FERNANDO /SOUTH CENTRAL	60	CARLSEN FIELD WATERWORKS	MEDIUM-G	----	----	11,175	11,175	11,175	11,175
	61	FREEPORT WATERWORKS	MEDIUM-G	----	----	6,165	6,165	6,165	6,165
		MEDIUM-G		0	0	17,340	17,340	17,340	17,340
		SUB-TOTAL		0	0	17,340	17,340	17,340	17,340
SOUTH EAST	62	NAVET WATERWORKS	LARGE-S	77,280	77,280	----	----	77,280	77,280
	63	MALONEY WELLS	MEDIUM-G	----	----	1,358	1,358	1,358	1,358
	64	AMOCO TOURNEBRIDGE WELLS	MEDIUM-G	----	----	1,194	1,194	1,194	1,194
	65	GUARACARA SPRING	SMALL-G	----	----	1,136	1,136	1,136	1,136
	66	GUAYAGUAYARE WELL #1	SMALL-G	----	----	897	897	897	897
	67	MAYARO WELLS	SMALL-G	----	----	792	792	792	792
	68	MORICHAL SPRING	SMALL-G	----	----	718	718	718	718
	69	MAYO SPRINGS	SMALL-G	----	----	630	630	630	630
	70	BICHE WATERWORKS	SMALL-S	259	259	----	----	259	259
		LARGE-S		77,280	77,280	0	0	77,280	77,280
		MEDIUM-G		0	0	2,552	2,552	2,552	2,552
		SMALL-G		0	0	4,173	4,173	4,173	4,173
		SMALL-S		259	259	0	0	259	259
		SUB-TOTAL		77,539	77,539	6,725	6,725	84,264	84,264
SOUTH WEST	71	CHATHAM WATERWORKS	MEDIUM-G	----	----	6,750	6,750	6,750	6,750
	72	PENAL WATERWORKS	MEDIUM-G	----	----	3,500	3,500	3,500	3,500
	73	SIPARIA (COORA) WATERWORKS	MEDIUM-G	----	----	3,033	3,033	3,033	3,033
	74	GRANVILLE WATERWORKS	MEDIUM-G	----	----	2,800	2,800	2,800	2,800
	75	FYZABAD WATERWORKS	MEDIUM-G	----	----	1,500	1,500	1,500	1,500
	76	CARAPAL WATERWORKS	MEDIUM-G	----	----	1,400	1,400	1,400	1,400
	77	CAP DE VILLE WATERWORKS	SMALL-G	----	----	1,006	1,006	1,006	1,006
	78	POINT FORTIN WATERWORKS	SMALL-G	----	----	980	980	980	980
	79	CLARKE ROAD WELLS	SMALL-G	----	----	623	623	623	623
	80	* TEXACO TO GUAYAGUARE	SMALL-G	----	----	180	180	180	180
	81	* TRINTOC TO TECHIER	SMALL-G	----	----	155	155	155	155
	82	TRINTOC TO PT. FORTIN	SMALL-G	----	----	69	69	69	69
		MEDIUM-G		0	0	18,983	18,983	18,983	18,983
		SMALL-G		0	0	3,013	3,013	3,013	3,013
		SUB-TOTAL		0	0	21,996	21,996	21,996	21,996
TRINIDAD		LARGE-S		471,991	419,865	0	0	471,991	419,865
		MEDIUM-G		0	0	199,871	199,871	199,871	199,871
		MEDIUM-S		54,072	46,035	0	0	54,072	46,035
		SMALL-G		0	0	8,873	8,873	8,873	8,873
		SMALL-S		4,734	4,734	0	0	4,734	4,734
		TOTAL		530,797	470,634	208,744	208,744	739,541	679,378
TOBAGO	83	HILLSBOROUGH WATERWORKS	MEDIUM-S	8,582	8,582	----	----	8,582	8,582
	84	COURLAND WATERWORKS	MEDIUM-S	7,368	7,368	----	----	7,368	7,368
	85	HILLSBOROUGH WEST RIVER	MEDIUM-S	3,500	3,500	----	----	3,500	3,500
	86	GREEN HILL INTAKE	MEDIUM-S	3,360	3,360	----	----	3,360	3,360
	87	KINGS BAY WATERWORKS	MEDIUM-S	2,994	2,994	----	----	2,994	2,994
	88	RICHMOND WATERWORKS	MEDIUM-S	2,467	2,467	----	----	2,467	2,467
	89	CRAIG HALL INTAKE	MEDIUM-S	2,461	2,461	----	----	2,461	2,461
	90	GOV'T FARM WELL #3	SMALL-G	----	----	335	335	335	335
	91	CHARLOTTEVILLE	SMALL-S	388	388	----	----	388	388
	92	* SPEYSIDE	SMALL-S	86	86	----	----	86	86
	93	CASTARA	SMALL-S	80	80	----	----	80	80
	94	* PARLATUVIER	SMALL-S	70	70	----	----	70	70
	95	* L'ANSE FOURMI	SMALL-S	34	34	----	----	34	34
	96	* BLOODY BAY	SMALL-S	24	24	----	----	24	24
		MEDIUM-S		30,732	30,732	0	0	30,732	30,732
		SMALL-G		0	0	335	335	335	335
		SMALL-S		682	682	0	0	682	682
		TOTAL		31,414	31,414	335	335	31,749	31,749
TRINIDAD AND TOBAGO		LARGE-S		471,991	419,865	0	0	471,991	419,865
		MEDIUM-G		0	0	199,871	199,871	199,871	199,871
		MEDIUM-S		84,804	76,767	0	0	84,804	76,767
		SMALL-G		0	0	9,208	9,208	9,208	9,208
		SMALL-S		5,416	5,416	0	0	5,416	5,416
		GRAND-TOTAL		562,211	502,048	209,079	209,079	771,290	711,127

NOTE: - " * " MEANS NO INSTALLATION OF FLOW METER AT THE EXISTING PRODUCTION FACILITIES.
- " -S " MEANS OBTAINING RAW WATER FROM SURFACE WATER.
- " -G " MEANS OBTAINING RAW WATER FROM GROUNDWATER.

Table II-2.9 WATER DEMAND PROJECTION

YEAR	1990					1995				2000				2005			
WATER DEMAND	WATER DISTRIBUTION FOR AREA OF SOURCE GROUP I	WATER DEMAND			WATER CONSUMPTION	WATER DISTRIBUTION FOR AREA OF SOURCE GROUP I	WATER DEMAND			WATER DISTRIBUTION FOR AREA OF SOURCE GROUP I	WATER DEMAND			WATER DISTRIBUTION FOR AREA OF SOURCE GROUP I	WATER DEMAND		
WATER AREA		AREA OF SOURCE GROUP I	AREA OF SOURCE GROUP II	TOTAL			AREA OF SOURCE GROUP I	AREA OF SOURCE GROUP II	TOTAL		AREA OF SOURCE GROUP I	AREA OF SOURCE GROUP II	TOTAL		AREA OF SOURCE GROUP I	AREA OF SOURCE GROUP II	TOTAL
1. DIEGO MARTIN	115	113	30,799	30,911	45,731	115	107	29,155	29,262	113	104	28,366	28,470	111	100	27,416	27,516
2. PORT OF SPAIN	28,526	29,707	19,378	49,085	55,338	28,546	26,860	17,572	44,432	28,612	25,041	16,362	41,402	28,709	23,941	15,361	39,303
3. E.M.R. COMMUNITIES	159,271	157,339	8,152	165,491	180,661	159,192	150,231	7,911	158,142	158,931	147,600	7,903	155,503	158,544	147,190	7,909	155,100
4. ARIMA	29,887	25,977		25,977	43,435	29,768	26,125		26,125	29,373	27,259		27,259	28,789	27,732		27,732
5. SANGRE GRANDE	19,742	16,010	1,524	17,533	27,599	19,664	15,611	1,507	17,118	19,403	15,695	1,539	17,233	19,016	15,596	1,539	17,134
6. WALLERFIELD	11,503	8,821		8,821	15,868	11,457	8,919		8,919	11,305	9,313		9,313	11,080	9,449		9,449
7. TOCO			2,764	2,764	2,611			2,739	2,739			2,796	2,796			2,836	2,836
8. CARONI	179,235	175,050	10,584	185,634	114,357	180,002	176,199	10,331	186,530	182,558	181,787	10,367	192,154	186,344	189,603	10,633	200,236
9. MAYARO			3,446	3,446	2,950			3,108	3,108			2,896	2,896			2,766	2,766
10. RIO CLARO	99,038	98,783	9,692	108,475	120,946	98,645	91,995	9,003	100,998	97,336	88,217	8,616	96,834	95,398	86,363	8,410	94,772
11. SAN FERNANDO	11,724	14,459		14,459	12,800	11,678	12,052		12,052	11,523	10,281		10,281	11,293	9,202		9,202
12. SIPARIA/ERIN			11,562	11,562	5,751			10,648	10,648			10,100	10,100			9,754	9,754
13. POINT FORTIN	6,595	5,106	12,570	17,676	19,340	6,569	4,702	11,663	16,365	6,482	4,461	11,149	15,609	6,353	4,308	10,851	15,159
14. NORTH COAST			651	651	718			645	645			658	658			651	651
15. TOBAGO				23,781	20,492				24,773				26,625				27,905
TOTAL	545,636	531,364	111,121	666,267	668,599	545,636	512,801	104,282	641,856	545,636	509,757	100,753	637,134	545,636	513,485	98,127	639,517

(Unit: m3/day)

3. STRATEGIES AND CONCEPTS FOR DEVELOPING WSSS

To develop the Water Supply Supervisory System (WSSS) in Trinidad and Tobago, strategies and concepts are worked out in line with the design objectives of the existing Central Supervisory System (CSS). The design objectives for the existing CSS are presented in Section 4.5 "Existing Central Supervisory System", Part I of this report.

It is convinced that the newly proposed system with various equipment and facilities are to be developed and operated to accomplish the designed functions of WSSS.

WASA has experienced operation and utilization of the existing CSS since its inauguration in early 1980's. Monitoring was the major targeting function of the existing CSS, aiming at gathering and accumulation of information/data regarding the current operational status of entire water supply system. Through these experiences, however, it was found that the originally planned monitoring was not satisfactorily achieved nor fulfilled.

The major reasons for above were a) absence of the very basic information/ data on water supply system necessary for the practical daily operation and control of the system, b) insufficiency of monitoring equipment in number for flow measurements especially at waterworks and transmission/distribution mains, c) inadequate inventory records of the system, particularly of the transmission/distribution mains and d) weak organizational structure for the CSS, especially insufficient back-up activities for developing the water supply management plan and operation/maintenance for equipment.

Taking into account the above experiences, monitoring procedures, integral part of the WSSS, will be established in sections which follow. In addition to the monitoring system improvement and expansion, an applicable system automation, such as possibility of remote operation is discussed and incorporated in the present master plan.

There are many motivations and necessity to monitor or record parameters associated with the water supply supervisory system. In generalized terms, four of the most significant applications of effective data collection are:

1) Optimization of resource use in terms of water, power, fuels, manpower, chemicals such as chlorine, alum sulphate, lime, soda-ash, etc.

2) Short-term planning for preventive maintenance of numerous equipment and instruments, adoptive measures in emergency, inventory control of pipelines, pumping facilities, treatment plants, equipment spare parts, chemicals and system operation for process adjustment and control at waterworks, service storage reservoirs and off-takes,

3) Long-term planning for water source development, expansion of treatment works, transmission facilities, storage and distribution facilities, system modification such as installation of flow meters, pressure gauges, valves, pumps and pipelines, and

4) Enhancement of the water supply system management for quicker decision making, improvement of service level to the customers, internal exchange of accurate and prompt information within WASA.

Apart from the area of data applications, there exist four large-scale production facilities (that exceed water production of 30,000 m^3/d) in Trinidad, namely, North Oropouche, Hollis, Navet, and Caroni. To supply rather sparsely populated rural area, many medium and small scale systems in Trinidad have been established together; 75 systems in 1989. In terms of water production, the former produces 63.5% of total water production in Trinidad in 1988.

Waterworks constructed in Tobago are 13 in number including 6 medium scale and 7 small scale water supply systems. Water production by medium scale water supply system at Hillsborough, Courland, Richmond, Craig Hall, Green Hill, and Kings Bay is dominantly large with 19,000 m^3/d which accounts for 95.2% of total production in Tobago in 1988.

In due consideration of the present water supply conditions in Trinidad and Tobago, water supply supervisory system will be proposed in the sections which follow.

4. PROPOSED WATER SUPPLY SUPERVISORY SYSTEM

The Water Supply Supervisory System (WSSS), targeting the year of 2005, is proposed in the following subsections. Proposed WSSS consistent with the existing CSS is based on the established strategies or concepts which are described in the preceding Section 3.

The proposed WSSS consists of two sub-systems of 1) Central Supervisory System (CSS) and 2) Local Supervisory System (LSS), as currently practiced by WASA.

For master planning WSSS, a stage-wise development in two phases (Phase I: 1991-1995, and Phase II: 1996-2005) is recommended, considering about the present condition of the entire water supply system in Trinidad and Tobago, and also the financial burden of the initial and succeeding investments to the proposed projects in the master plan program.

4.1 TARGET

1) Establishment of an effective water supply supervisory system for optimum water production and distribution in the entire system of WASA by improving and expanding the existing CSS.

   - To increase the efficiency in operation of the water supply system, the operation status data/information on water levels, pressures, flow amounts of raw water, treated water, distributed water are indispensable.

     At present, the measurement equipment for these data/information are inadequately installed. As for the existing CSS improvement in the present study, the necessary equipment for the above system operation status are planned to be installed for the optimum system operation.

   - The current status of water production and distribution will be expected and/or confirmed, with the estimated hourly and seasonal variation using the gathered data for several years.

- After confirmation of the present status of the water production and distribution through WSSS operation and associated studies and analyses, the standard system operation program will be formulated.

- This operation program will be periodically reviewed and improved to reduce operation costs for water production and distribution and to attain optimal usage of water resources.

2) Stabilization of the proper distribution pressure

- To achieve equitable water supply to each consumer, off-take flows and pressures are controlled.

3) Contribution to the leakage control

- After execution of the universal metering program, and completion of the metering system for the service connections, the leakage condition in each water supply area could be obtained by comparing the total flow amount at each off-take and the accumulated water consumption by metering the consumers in the service area. This result may contribute to prompt execution of effective measures for the leakage control.

4) Establishment of information flow for quicker decision-making for the water supply management

- An appropriate instructions to the operators will be given in real time, for normalization of the water supply.

- To find the problems and aspects to be improved on the water supply operation and existing facilities, with analysis of the accumulated data through the CSS, which contributes to quickly establish the next planning step for water supply and the facilities improvement.

4.2 WSSS IN 2005

The final status of the proposed WSSS at the master plan target year 2005 is highlighted hereunder. Fig. II-4.1 illustrates concepts of the WSSS.

4.2.1 CSS and LSS

1) In order to monitor and operate the existing water supply system effectively, the present water supply area of WASA is recommended to be separated into the two groups based on size of the system in water supply amounts and numbers of facilities. Namely, the area which is supplied water from the four major sources of Caroni/Arena, North Oropouche, Navet, and Hollis.

   They also have the many numbers of facilities and the large amount of water to be supplied, and the rest of the areas which have many numbers but smaller size and scattered facilities for smaller amount of water supply. See the preceding Sections 3 and 4, Part I.

   Based on this grouping of the system, the Water Supply Supervisory System (WSSS) for the WASA's entire system operation and management, the Central Supervisory System (CSS) for the first group of the large size system, and the Local Supervisory System (LSS) for the second group of the smaller size system, are formulated considering the most appropriate measures for the operation and management in Trinidad and Tobago.

2) The water supply facilities in the CSS covering area include many numbers of intakes, waterworks/water treatment plants, booster pumping stations, high lift pumping stations, transmission and distribution mains' off-takes with control valves, and service storage reservoirs.

   And this area has an estimated capacity of water supply of more than 70 percent of the total amount of water supply of WASA.

3) The water supply facilities to be covered in the LSS covering area also include many numbers however, the lesser total amount of water is supplied compared to that of CSS.

4) The data on water levels, pressures, flow amounts at the strategic points for the system of CSS are transmitted to the CSS building located in the complex of WASA Head Office for the monitoring at same place and time.

5) The operation status of the LSS covering facilities are reported to each Regional Office from the respective District Offices under them, then transmitted to the CSS building via on-line transmission system with electronically input of its data into the individual computer by optical character reader (OCR).

6) The pumps and control valves in the booster pumping stations including the existing Tumpuna Storage Lift Pumping Station, and the control valves at the transmission and distribution mains' off-takes are remotely-operated from the CSS building or Caroni Treatment Plant.

4.2.2 WSSS Hardware and Data Communication

Utilizing the existing system with facilities at maximum level, the proposed CSS is planned to achieve its design functions as shown on Fig. II-4.2, which presents WSSS hardware and data communication of this proposed WSSS.

<u>CSS</u>

1) The data signals of water levels, pressures, and flow amounts which are measured at strategic monitoring points at raw water storage reservoirs, waterworks and transmission/distribution facilities including off-takes are transmitted to remote terminal unit (RTU) first, then to CSS building by the radio communication system.

2) As for the proposed data communication system, the existing system of radio communication is applied, compared to the other type of the data communication system considering geographically locating situations, WASA's sufficient experience of operation, and reliability with economy.

3) Control valves installed at off-takes on transmission/distribution mains are operated by automatic remote controls, via controller installed at each site by operating valve control panel with mini-graphic display in the CSS building.

4) Pumping units and control valves in booster pumping stations are operated by remote control at the control panel in the CSS building.

5) The pumping units and discharge valves in the existing Tumpuna Storage Lift Pumping Station are operated by remote control by the existing control panel, installed at Caroni Water Treatment Plant. This operation is directed under the CSS information through the main computer in the CSS building.

6) Data signals received at the CSS building are compiled and processed by the main computer system, as they are displayed on the graphic panel as well.

   The display style of the collected information is planned for the combined system of the fixed large graphic panel and the CRT (cathode ray tube) display, based on the following reasons:

   - To display the total system information on a large graphic panel to enable observation of the operation status of the entire system at a same dimension or level base .

   - This aims at easy monitoring of the complicated total system for quicker decision-making.

   - Detailed information which are not indicated on the graphic panel are presented on CRT units more precisely for substantial monitoring.

- The information displayed on CRT are made into hard copies for reporting and for discussion materials.

7) The computer system and radio communication unit for data communication in CSS building, and the radio repeater unit are designed to be installed as dual-system units so that the system can secure the reliability and safety during an emergency.

8) RTUs are installed to receive and transmit the data, measured at respective facilities in the system. RTUs are designed to be installed to cover the distance within 2 km from the system measurement points where instruments are installed, based on the limit of data transmission system by cables.

9) To secure the reliability of operation of the planned equipment, the capacity of uninterrupted power battery units for repeater station equipment are designed to last for over four hours capacity, while that for the CSS building equipment and each RTU units are designed for one hour capacity.

10) Taking into account the present condition of existing facilities or equipment, the newly proposed facilities are designed as new products or materials. Since, the existing facilities and equipment are considered not to be used for the future system.

    However, those equipment which are capable for further usage for the proposed system are considered to be utilized at maximum level so that the project costs could be lowered.

    Such facilities or equipment are the existing stand-by generator in the existing CSS building, the repeater station facilities on Pepper Hills with its antenna tower and building structure, and, the remote operation devices/unit installed at Caroni Treatment Plant, for remote operation of the existing Tumpuna Storage Lift Pumping Station's equipment, are considered to be utilized again with necessary repair works.

LSS

Installation of work stations at these regional offices of South, North, and Tobago is planned. Each of work stations consist of a computer system equipped with the individual computer/CRT unit, OCR unit and the terminal unit of the main computer in CSS building with normal computer functions. Each work station has following three functions:

- Data electronically input by OCR, transmit data to the individual computer on LSS weekly operation status of LSS under the respective Regional Offices.

- Monitoring the water supply operation status of WASA's entire system, communication to the main computer in CSS building, its system status is monitored by the CRT unit installed at each Regional Office.

- Individual computer function; each work station will be installed with the individual computer unit for respective use purposes in Regional Offices.

A list of WSSS hardware with its purposes is presented in Table II-4.1. The equipment in the list is designed to achieve the previously described functions.

Further, lists of the monitoring and control equipment to be installed for WSSS are presented in Tables II-4.2 and II-4.3. These equipment are designed for the previously described supervisory functions of water supply system status.

4.2.3 WSSS Monitoring/Control

CSS

1) Level meters, pressure gauges, and flow meters are installed at each facility to measure the water levels, pressures, and flow amounts.

   The existing monitoring equipment which are in usable conditions now, are put in use continuously for the future system operation.

2) Control valves are designed to be installed at each off-take on the strategic points on transmission and distribution mains, to control water flows and pressures at respective off-takes.

3) The automatic control valves at all service storage reservoirs are designed to be installed to stop excess over flows from the respective reservoirs.

LSS

1) Installation of flow meters with recorder at each outlet pipe of the production facilities.

4.3 STEPWISE DEVELOPMENT

As mentioned in the preceding sub-section, the master plan for WSSS is formulated in two-phase developments (Phase I: 1992-1995 and Phase II: 1996-2005), considering about the present conditions of the water supply system in Trinidad and Tobago, and the financial burden of the proposed projects in the master plan.

The proposed development plan is designed to be implemented in two phases as follows. In phase I, the major equipment of CSS and the necessary equipment for monitoring system with RTUs and control units of valves are designed for installation. Further, this Phase includes the remote operation units for six booster pumping stations and the remote operation devices to control the existing pumping and valving equipment at Tumpuna Pumping Station.

Regarding the control valves for off-takes on the transmission and distribution mains, in Phase I, the valves and its remote operation devices will be installed in Phase I.

In the initial/first step of system operation, automatic valve operation setting is made by manual input at sites for a trial. After valve control operation is practiced, and the actual operation status data are collected and analyzed, the operation target setting will be established to operate remotely from the CSS building in the second step of system operation.

In Phase II, some equipment and devices especially for CSS related instrument and electronic appliances which are installed in Phase I need to be replaced, which have been in use for more than 10 years. Therefore, such equipment and devices are planned to be replaced with new ones. And, the remote operation devices for the control valves, installed at off-takes on the transmission and distribution mains, are planned to be installed. In addition to this in Phase II, work stations at each Regional Offices and flow meters with recorder for the waterworks in LSS are planned to be installed.

Immediate projects are recommended in this Study, as a substantial part of the Master Plan, which require to undertake the ongoing "Universal Metering Program" and the planned "Leakage Reduction Program" in an earliest timing in the initial stage of Master Plan improvement program (1992-1995).

Fig. II-4.1 CONCEPT OF WATER SUPPLY SUPERVISORY SYSTEM (PHASE II)

WATER SUPPLY SUPERVISORY SYSTEM (WSSS)

CENTER

NAME OF SUPERVISORY SYSTEM	LOCAL SUPERVISORY SYSTEM (LSS) IN NORTH	CENTRAL SUPERVISORY SYSTEM (CSS)	LOCAL SUPERVISORY SYSTEM (LSS) IN SOUTH	LOCAL SUPERVISORY SYSTEM (LSS) IN TOBAGO
LOCATION OF CENTER	NORTH REGION	EXISTING CSS BUILDING (EXPANSION)	SOUTH REGION	TOBAGO REGION
SUPERVISORY EQUIPMENT TO BE INSTALLED AT CENTER	WORK STATION	COMPUTER SYSTEM AND GRAPHIC PANEL	WORK STATION	WORK STATION WITH MEMORY
MONITORING ITEMS	FLOW	WATER FLOW, WATER LEVEL, WATER PRESSURE, VALVE & PUMP STATUS AND ALARM	FLOW	FLOW
REMOTE CONTROL AND OPERATION EQUIPMENT	NONE	PUMPS & VALVES AT BOOSTER PUMPING STATION ("*" AS SHOWN ON THE BELOW TABLE) FOR REMOTE OPERATION AND CONTROL VALVES AT OFF-TAKE OF STRATEGIC POINTS	NONE	NONE
Link to CSS	ON-LINE		ON-LINE	ON-LINE
Link to site	WEEKLY REPORT	ON - LINE	WEEKLY REPORT	WEEKLY REPORT

SITE

EQUIPMENT TO BE INSTALLED AT SITE	FLOW METER AT EACH PRODUCTION F'TY	FLOW METER, LEVEL METER, PRESSURE GAUGE, CONTROL VALVE AND RTU AT STRATEGIC POINTS	FLOW METER AT EACH PRODUCTION F'TY	FLOW METER AT EACH PRODUCTION F'TY

FACILITIES TO BE SUPERVISED

LSS in North — PRODUCTION FACILITY (45)

N.C.	(7)	MEDIUM-(1)
		SMALL-(6)
N.E.	(12)	MEDIUM-(1)
		SMALL-(11)
N.W.	(16)	MEDIUM-(7)
		SMALL-(9)
POS	(10)	MEDIUM-(5)
		SMALL-(5)

CSS — PRODUCTION FACILITY

N.C.	1	CARONI/ARENA W.T.P.	LARGE
	2	VALSAYN W.W.	MEDIUM
	3	TACARIGUA W.W.	MEDIUM
	4	LAS LOMAS W.W.	MEDIUM
	5	CAURA W.W.	MEDIUM
	6	AROUCA W.W.	SMALL
N.E.	7	NORTH OROPOUCHE W.W.	LARGE
	8	HOLLIS W.W.	LARGE
	9	GUANAPO W.W.	MEDIUM
	10	ARIPO W.W. (NEW)	MEDIUM
	11	ARIPO INT	MEDIUM
	12	QUARE INT (VALENCIA)	MEDIUM
	13	ARIMA WELL #6	SMALL
N.W.	14	EL SOCORRO W.W.	MEDIUM
SF/SC	15	CARLSEN FIELD W.W.	MEDIUM
S.E.	16	NAVET W.W.	LARGE

CSS — BOOSTER PUMPING STATION

N.C.	1	*TUNAPUNA B. P/S
	2	*VALSAYN B. P/S
N.E.	3	ARIMA B. P/S
	4	ARIPO B. P/S
N.W.	5	*EL SOCORRO B. P/S
SF/SC	6	*SAN FERNANDO B. P/S
S.E.	7	*MALGRETOUTE B. P/S
	8	*T.C.O. B. P/S

CSS — STORAGE LIFT PUMPING STATION

N.C.	1	*TUMPUNA S.L. P/S
S.E.	2	NAVET S.L. P/S

CSS — OFF-TAKE CONTROL VALVES

CSS — SERVICE STORAGE RESERVOIR

N.C.	1	MT. HOPE
	2	ST. AUGUSTINE
	3	ST. JOSEPH
N.E.	4	NORTH OROPOUCHE
	5	FORT READ
	6	ARIMA NEW
	7	ARIMA OLD
N.W.	8	MALLIC
POS	9	KNAGGS HILL
	10	PICTON # 1
	11	PICTON # 2
	12	PICTON # 3
SF/SC	13	CALIFORNIA
	14	SAN FERNANDO
	15	MARRYAT St.
	16	NAPARIMA

LSS in South — PRODUCTION FACILITY (21)

SF/SC	(1)	MEDIUM-(1)
S.E.	(8)	MEDIUM-(2)
		SMALL-(6)
S.W.	(12)	MEDIUM-(6)
		SMALL-(6)

LSS in Tobago — PRODUCTION FACILITY (14)

TOBAGO	(14)	MEDIUM-(7)
		SMALL-(7)

NOTE: N.C.; NORTH CENTRAL, N.E.; NORTH EAST, N.W.; NORTH WEST, POS; PORT OF SPAIN, SF/SC; SAN FERNANDO/SOUTH CENTRAL, S.E.; SOUTH EAST, S.W.; SOUTH WEST, W.T.P.; WATER TRATMENT PLANT, W.W.; WATERWORKS, INT; INTAKE, B. P/S; BOOSTER PUMPING STATION, S.L. P/S; STORAGE LIFT PUMPING STATION, (8); THE NUMBER OF FACILITIES IN EACH DISTRICT, MT.; MOUNT, ST.; SAINT, St.; STREET, F'TY; FACILITIES.

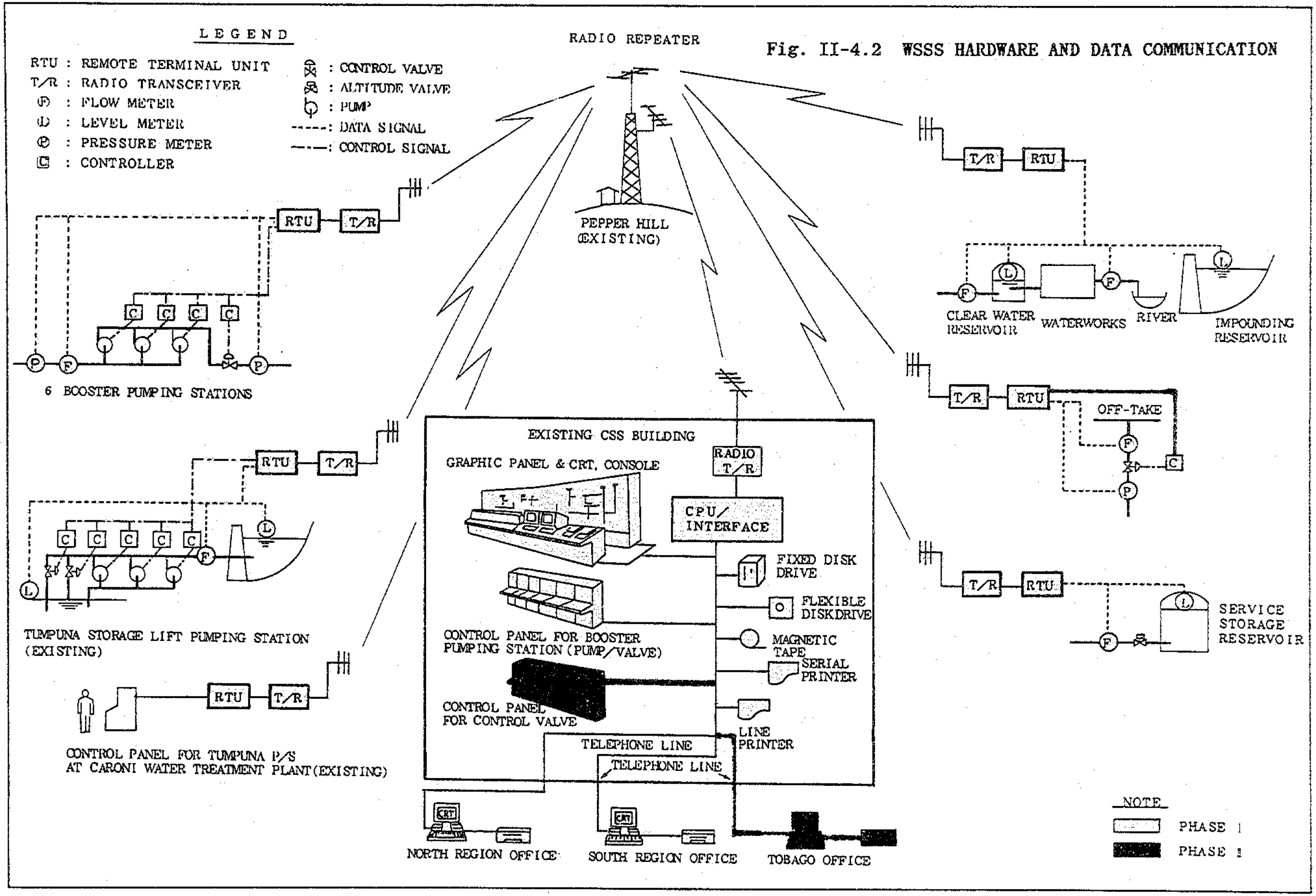


Fig. II-4.2 WSSS HARDWARE AND DATA COMMUNICATION

Table II-4.1 LIST OF WSSS HARDWARE

HARDWARE COMPONENTS	QUANTITY	ROLE OF COMPONENTS
[A] CENTRAL DATA PROCESSING SYSTEM (CDPS)		
(1) CENTRAL PROCESSING UNIT (CPU)	2	DATA PROCESSING, STORAGE AND RETRIEVAL
(2) FIXED DISK DRIVE	2	STORAGE OF OPERATING SYSTEM
(3) FLEXIBLE DISK DRIVE	2	DATA STORAGE
(4) CARTRIDGE TAPE DRIVE	2	DATA STORAGE
(5) COMMUNICATION INTERFACE	2	CONTROL OF CPU AND DATA COMMUNICATION
(6) SERIAL INTERFACE	2	PERIPHERAL CONTROL
(7) SERIAL INPUT/OUTPUT INTERFACE	2	CONTROL OF GRAPHIC PANEL, PUMP REMOTE OPERATION & VALVE REMOTE PANELS
(8) CRT DISPLAY	2	DISPLAY OF GRAPHIC AND ALPHANUMERIC SYMBOLS
(9) HARD COPIER	1	CRT PICTURE COPY
(10) LINE PRINTER	1	DATA PRINTOUT
(11) SERIAL PRINTER	1	OPERATION REPORT PRONTOUT
(12) SYSTEM CONSOLE	1	CONTROL OF COMPUTER SYSTEM
(13) GRAPHIC PANEL	1	DISPLAY OF WATER SUPPLY SYSTEM AND MONITORING DATA
(14) MODEM	2	MODULATION AND DEMODULATION OF SIGNAL
(15) UNINTERRUPTIBLE POWER SUPPLY	1	BACK-UP POWER SUPPLY FOR EQUIPMENT OF CSS BUILDING
[B] REMOTE TERMINAL UNIT (RTU)		
(1) INTERNAL CONTROLLER	48	INTERPRETATION BETWEEN CPU AND FIELD INSTRUMENTS
(2) SERIAL INPUT/OUTPUT INTERFACE	48	INPUT/OUTPUT CONTROL FOR MICROPROCESSOR
(3) PROCESS INPUT/OUTPUT INTERFACE	48	ANALOG AND DISCRETE DATA CONTROL
[C] DATA RADIO COMMUNICATION SYSTEM		
(CSS BUILDING)		
(1) UHF TRANCEIVER	2	DATA COMMUNICATION BETWEEN CSS BUILDING AND REPEATER STATION
(2) COMMUNICATION INTERFACE	2	CONTROL OF DATA COLLECTION
(REPEATER STATION)		
(1) UHF REPEATER	2	COMMUNICATION RELAY FROM/TO VHF
(2) VHF REPEATER	2	COMMUNICATION RELAY FROM/TO UHF
(3) UNINTERRUPTIBLE POWER SUPPLY	1	BACK-UP POWER SUPPLY FOR EQUIPMENT OF REPEATER STATION
(RTU STATION)		
(1) VHF TRANSCEIVER	48	DATA COMMUNICATION BETWEEN RTU AND REPEATER STATION
(2) COMMUNICATION INTERFACE	48	CONTROL OF DATA TRANSMISSION
(3) UNINTERRUPTIBLE POWER SUPPLY	48	BACK-UP POWER SUPPLY FOR EQUIPMENT OF RTU STATION
[D] REGIONAL OFFICE		
(1) WORK STATION (CRT AND COMPUTER)	3	DATA INPUT, DISPLAY AND ANALYSES
(2) OPTICAL CHARACTER READER (OCR)	3	DATA ELECTRONICALLY INPUT INTO THE INDIVIDUAL COMPUTER
(3) HARD COPIER	3	CRT PICTURE COPY

Table II-4.2 LIST OF MONITORING AND CONTROL EQUIPMENT TO BE INSTALLED FOR CENTRAL SUPERVISORY SYSTEM (1)

NOTE: AN; ANNUBAR, AP; AIR PURGE TYPE, AV; ALTITUDE VALVE, B ; BOURDON TUBE, BU; BUTTERFLY VALVE, CV; CONE VALVE, F ; FLOAT TYPE, O ; ORIFICE PLATE, P ; PROPELLAR TYPE, PF; PARSHALL FLUME, V ; VENTURI TUBE, WW; WATERWORKS, BPS; BOOSTER PUMPING STATION, WTP; WATER TREATMENT PLANT, D ; DIFFERENTIAL PRESSURE TYPE, HW ; HIGH WAY, (300); PIPE DIAMETER(MM), "*" ; EXISTINGS TO BE USED, "¥"; EXISTINGS (REPLACEMENT PERIPHERALS), "#"; INSTALLATION OF CONTROL EQUIPMENT,

PHASE I

REMOTE TERMINAL UNIT (RTU)		EQUIPMENT AND NUMBER TO BE INSTALLED				NUMBER OF MONITORING DATA BY CENTRAL SUPERVISORY SYSTEM (CSS)							EQUIPMENT TO BE CONTROLLED			
NO.	LOCATION	LEVEL METER	PRESS GAUGE	FLOW METER	CONTROL VALVE	WATER LEVEL	WATER PRESS	FLOW RATE	VALVE STATUS	PUMP STATUS	ALARM	TOTAL	PUMP NO.	PUMP PLACE	VALVE NO.	VALVE PLACE
1	NORTH OROPOUCHE WW	F 1 *D 2		¥PF 1 AN 1		3		2				5				
2	HOLLIS WW	F 1		AN 2		1		2				3				
3	GILL TRACE	D 1	B 4 ¥B 1	AN 4 ¥V 1	BU 4	1	5	5	4			15			4	SITE
4	ARIPO BPS	D 2	B 3	AN 5 ¥O 1 ¥V 1	BU 3	2	3	7	3			15			3	SITE
5	GUANAPO JUNCTION	D 1	B 3	AN 4	BU 3	1	3	4	3			11			3	SITE
6	DEMERARA JUNCTION		B 2	AN 2	BU 2		2	2	2			6			2	SITE
7	ARIMA OLD RESERVOIR	F 1 D 1	B 4	AN 7	BU 4	2	4	7	4			17			4	SITE
8	MAUSICA JUNCTION		B 6	AN 6	BU 6		6	6	6			18			6	SITE
9	AROUCA WW	D 1	B 2	AN 3	BU 3	1	2	3	3			9			3	SITE
10	CAURA WW	D 1	B 1	AN 2	BU 1	1	1	2	1			5			1	SITE
11	TACARIGUA WW	¥D 1	B 4	AN 4	BU 3	1	4	4	3			12			3	SITE
12	FLOW CONTROL STATION		B 4	AN 2 ¥V 1	BU 2 #CV 2		4	3	4			11			4	SITE
13	ST AUGUSTINE RESERVOIR	F 1	B 4	AN 5	AV 1	1	4	5				10				
14	TUNAPUNA BPS		B 6	AN 6	BU 5		6	6	5	6	25	48	3	CSS	2 3	CSS SITE
15	ST JOSEPH RESERVOIR	F 1	B 4	AN 6	BU 4	1	4	6	4			15			4	SITE
16	VALSAYN WW	¥D 1	¥B 3	AN 1 ¥AN 1 ¥V 2	BU 2	1	3	4	2	6	25	41	3	CSS	1 1	CSS SITE
17	URIAH BUTLER HW JUNCTION		B 1	AN 1	BU 1		1	1	1			3			1	SITE
18	MT. HOPE RESERVOIR	D 1	B 7	AN 8	AV 1 BU 7	1	7	8	7			23			7	SITE
19	MALICK RESERVOIR	D 1	B 3	AN 4	AV 1 BU 3	1	3	4	3			11			3	SITE
20	EL SOCORRO WW	¥AP 1	B 3 ¥B 3	AN 3 ¥AN 2 ¥V 1	BU 5	1	6	6	5	6	25	49	3	CSS	1 4	CSS SITE
21	LAVENTILLE		B 1	AN 1	BU 1		1	1	1			3			1	SITE
22	BLACK RIVER		B 4	AN 4	BU 4		4	4	4			12			4	SITE
23	PICTON NO.3 RESERVOIR	*D 4	B 3	AN 6	AV 4 BU 3	4	3	6	3			16			3	SITE
24	SERVOL LIFE CENTER		B 3	AN 3	BU 3		3	3	3			9			3	SITE

PHASE II

REMOTE TERMINAL UNIT (RTU)		EQUIPMENT AND NUMBER TO BE INSTALLED				NUMBER OF MONITORING DATA BY CENTRAL SUPERVISORY SYSTEM (CSS)							EQUIPMENT TO BE CONTROLLED			
NO.	LOCATION	LEVEL METER	PRESS GAUGE	FLOW METER	CONTROL VALVE	WATER LEVEL	WATER PRESS	FLOW RATE	VALVE STATUS	PUMP STATUS	ALARM	TOTAL	PUMP NO.	PUMP PLACE	VALVE NO.	VALVE PLACE
1	NORTH OROPOUCHE WW	¥F 1 D 2		¥PF 1 ¥AN 1		3		2				5				
2	HOLLIS WW	¥F 1		¥AN 2		1		2				3				
3	GILL TRACE	¥D 1	B 1 ¥B 4	¥AN 4 ¥V 1	#BU 4	1	5	5	4			15			4	CSS
4	ARIPO BPS	¥D 2	¥B 3	¥AN 5 ¥O 1 ¥V 1	#BU 3	2	3	7	3			15			3	CSS
5	GUANAPO JUNCTION	¥D 1	¥B 3	¥AN 4	#BU 3	1	3	4	3			11			1 2	WW CSS
6	DEMERARA JUNCTION		¥B 2	¥AN 2	#BU 2		2	2	2			6			2	CSS
7	ARIMA OLD RESERVOIR	¥F 1 ¥D 1	¥B 4	¥AN 7	#BU 4	2	4	7	4	4	17	38	2	CSS	4	CSS
8	MAUSICA JUNCTION		¥B 6	¥AN 6	#BU 6		6	6	6			18			6	CSS
9	AROUCA WW	¥D 1	¥B 2	¥AN 3	#BU 3	1	2	3	3			9			1 2	WW CSS
10	CAURA WW	¥D 1	¥B 1	¥AN 2	#BU 1	1	1	2	1			5			1	WW
11	TACARIGUA WW	D 1	¥B 4	¥AN 4	BU 1 #BU 3	1	4	4	4			13			2 2	WW CSS
12	FLOW CONTROL STATION		¥B 4	¥AN 2 ¥V 1	#BU 2 #CV 2		4	3	4			11			4	CSS
13	ST AUGUSTINE RESERVOIR	¥F 1	¥B 4	¥AN 5	¥AV 1 BU 4	1	4	5	4			14			4	CSS
14	TUNAPUNA BPS		¥B 6	¥AN 6	#BU 5		6	6	5	6	25	48	3	CSS	5	CSS
15	ST JOSEPH RESERVOIR	¥F 1	¥B 4	¥AN 6	#BU 4	1	4	6	4			15			4	CSS
16	VALSAYN WW	D 1	B 3	¥AN 2 ¥V 2	#BU 2	1	3	4	2	6	25	41	3	CSS	1 1	WW CSS
17	URIAH BUTLER HW JUNCTION		¥B 1	¥AN 1	#BU 1		1	1	1			3			1	CSS
18	MT. HOPE RESERVOIR	¥D 1	B 1 ¥B 7	AN 1 ¥AN 8	¥AV 1 BU 1 #BU 7	1	8	9	8			26			8	CSS
19	MALICK RESERVOIR	¥D 1	¥B 3	¥AN 4	¥AV 1 #BU 3	1	3	4	3			11			3	CSS
20	EL SOCORRO WW	F 1	B 3 ¥B 3	¥AN 5 ¥V 1	#BU 5	1	6	6	5	6	25	49	3	CSS	1 4	WW CSS
21	LAVENTILLE		¥B 1	¥AN 1	#BU 1		1	1	1			3			1	CSS
22	BLACK RIVER		¥B 4	¥AN 4	#BU 4		4	4	4			12			4	CSS
23	PICTON NO.3 RESERVOIR	D 4	¥B 3	¥AN 6	¥AV 4 #BU 3	4	3	6	3			16			3	CSS
24	SERVOL LIFE CENTER		¥B 3	¥AN 3	#BU 3		3	3	3			9			3	CSS

Table II-4.2 LIST OF MONITORING AND CONTROL EQUIPMENT TO BE INSTALLED FOR CENTRAL SUPERVISORY SYSTEM (2)

NOTE: AN; ANNUBAR, AP; AIR PURGE TYPE, AV; ALTITUDE VALVE, B ; BOURDON TUBE, BU; BUTTERFLY VALVE, CV; CONE VALVE, F ; FLOAT TYPE, O ; ORIFICE PLATE, P ; PROPELLAR TYPE, PF; PARSHALL FLUME, V ; VENTURI TUBE, WW; WATERWORKS, BPS; BOOSTER PUMPING STATION, WTP; WATER TREATMENT PLANT, D ; DIFFERENTIAL PRESSURE TYPE, HW ; HIGH WAY, (300): PIPE DIAMETER(MM), "*" ; EXISTINGS TO BE USED, "¥"; EXISTINGS (REPLACEMENT PERIPHERALS), "#": INSTALLATION OF CONTROL EQUIPMENT.

REMOTE TERMINAL UNIT (RTU)		PHASE I															PHASE II														
		EQUIPMENT AND NUMBER TO BE INSTALLED				NUMBER OF MONITORING DATA BY CENTRAL SUPERVISORY SYSTEM (CSS)							EQUIPMENT TO BE CONTROLLED				EQUIPMENT AND NUMBER TO BE INSTALLED				NUMBER OF MONITORING DATA BY CENTRAL SUPERVISORY SYSTEM (CSS)							EQUIPMENT TO BE CONTROLLED			
													PUMP		VALVE													PUMP		VALVE	
NO.	LOCATION	LEVEL METER	PRESS GAUGE	FLOW METER	CONTROL VALVE	WATER LEVEL	WATER PRESS	FLOW RATE	VALVE STATUS	PUMP STATUS	ALARM	TOTAL	NO.	PLACE	NO.	PLACE	LEVEL METER	PRESS GAUGE	FLOW METER	CONTROL VALVE	WATER LEVEL	WATER PRESS	FLOW RATE	VALVE STATUS	PUMP STATUS	ALARM	TOTAL	NO.	PLACE	NO.	PLACE
25	KNAGGS HILL	*D 2	B 6	AN 7	*AV 2 BU 4	2	6	7	4			19			4	SITE	D 2	¥B 6	¥AN 7	¥AV 2 #BU 4	2	6	7	4			19			4	CSS
26	NATIONAL FLOUR MILL		B 1	AN 1	BU 1		1	1	1			3			1	SITE		B 3 ¥B 1	¥AN 1 ¥P 3	#BU 4		4	4	4			12			4	CSS
27	TUMPUNA STORAGE LIFT PS	¥AP 1 F 1		¥V 2	¥BU 2	2		2	2	12	59	77	6	CARONI	2	CARONI	F 1 ¥F 1		¥V 2	#BU 2	2		2	2	12	59	77	6	CARONI	2	CARONI
28	CARONI WTP	¥AP 2	*B 2	¥AN 2 ¥PF 1	¥BU 2	2	2	3	2			9			2	CARONI	¥AP 2	B 2	¥AN 2 ¥PF 1	#BU 2	2	2	3	2			9			2	CARONI
29	KELLY VILLAGE		B 1	AN 1	BU 1		1	1	1			3			1	SITE		¥B 1	¥AN 1	#BU 1		1	1	1			3			1	CSS
30	SCALE YARD		B 2	AN 2	BU 2		2	2	2			6			2	SITE		¥B 2	¥AN 2	#BU 2		2	2	2			6			2	CSS
31	LAS LOMAS WW	D 1	¥B 1	¥O 1 ¥V 1	BU 1	1	1	2	1			5			1	SITE	¥D 1	B 1	¥O 1 ¥V 1	#BU 1	1	1	2	1			5			1	WW
32	JERNINGHAM JUNCTION		B 2	AN 2	BU 1		2	2	1			5			1	SITE		¥B 2	¥AN 2	BU 1 #BU 1		2	2	2			6			2	CSS
33	CHAGUANAS		B 2	AN 2	BU 2		2	2	2			6			2	SITE		¥B 2	¥AN 2	#BU 2		2	2	2			6			2	CSS
34	CARLSEN FIELD WW	F 1	B 2	AN 2	BU 2	1	2	2	2			7			2	SITE	¥F 1	¥B 2	¥AN 2	#BU 2	1	2	2	2			7			2	WW
35	CARAPICHAIMA		B 3	AN 3	BU 1		3	3	1			7			1	SITE		¥B 3	¥AN 3	BU 2 #BU 1		3	3	3			9			3	CSS
36	WARDEN OFFICE		B 3	AN 3	BU 3		3	3	3			9			3	SITE		¥B 3	¥AN 3	#BU 3		3	3	3			9			3	CSS
37	TRINGEN II		B 1	AN 1	BU 1		1	1	1			3			1	SITE		¥B 1	¥AN 1	#BU 1		1	1	1			3			1	CSS
38	CALIFORNIA RESERVOIR	D 1		AN 1	AV 1	1		1				2					¥D 1		¥AN 1	¥AV 1	1		1				2				
39	TCL		B 1	AN 1	BU 1		1	1	1			3			1	SITE		¥B 1	¥AN 1	#BU 1		1	1	1			3			1	CSS
40	MARAVELLA		B 1	AN 1	BU 1		1	1	1			3			1	SITE		¥B 1	¥AN 1	#BU 1		1	1	1			3			1	CSS
41	SAN FERNANDO BPS	¥D 3	B 3 ¥B 2	AN 5 ¥AN 1	AV 1 BU 3 *BU 1	3	5	6	4	6	25	49	3	CSS	1 3	CSS SITE	D 3	B 2 ¥B 3	¥AN 6	¥AV 1 #BU 4	3	5	6	4	6	25	49	3	CSS	4	CSS
42	MOSQUITO CREEK		B 1	AN 1	BU 1		1	1	1			3			1	SITE		¥B 1	¥AN 1	#BU 1		1	1	1			3			1	CSS
43	ST CLEMENT		B 2	AN 2	BU 2		2	2	2			6			2	SITE		¥B 2	¥AN 2	#BU 2		2	2	2			6			2	CSS
44	DAISY		B 1	AN 1	BU 1		1	1	1			3			1	SITE		¥B 1	¥AN 1	#BU 1		1	1	1			3			1	CSS
45	MALGRETOUTE BPS		B 3 ¥B 2	AN 3 ¥V 1	BU 4		5	4	4	10	41	64	5	CSS	1 3	CSS SITE		B 2 ¥B 3	¥AN 3 ¥V 1	#BU 4		5	4	4	10	41	64	5	CSS	4	CSS
46	BROTHER ROAD		B 3	AN 3	BU 3		3	3	3			9			3	SITE		¥B 3	¥AN 3	#BU 3		3	3	3			9			3	CSS
47	TCO BPS		B 1 ¥B 2	AN 1 ¥V 1	BU 2	 3	3	2 6	2	12	49	68 9	6	CSS	1 1	CSS SITE		B 2 ¥B 1	¥AN 1 ¥V 1	#BU 2		3	2	2	12	49	68	6	CSS	2	CSS
48	NAVET WW	F 3		AN 6													¥F 3		¥AN 6		3		6				9				
	TOTAL	38	127	160	124	38	127	160	113	58	249	745	29		113		38	131	164	136	38	131	164	125	62	266	786	31		125	
	= LIST OF EQUIPMENT =	¥AP 4 D 11 *D 8 ¥D 5 F 10	¥B 14 B 111 *B 2	¥AN 6 AN 139 ¥O 2 ¥PF 2 ¥V 11	AV 9 *AV 2 BU 106 *BU 1 ¥BU 4 #CV 2								6 23	CARONI CSS	102 7 4	SITE CSS CARONI	¥AP 2 D 13 ¥D 11 F 2 ¥F 10	B 20 ¥B 111	AN 1 ¥AN 145 ¥O 2 ¥P 3 ¥PF 2 ¥V 11	BU 9 ¥AV 11 #BU 114 #CV 2								6 25	CARONI CSS	4 111 10	CARONI CSS WW

Table II-4.3 LIST OF MONITORING EQUIPMENT AND DATA UNDER LOCAL SUPERVISORY SYSTEM

NO.	FACILITY	PHASE I: NUMBER OF MONITORING FLOW DATA IN M'LY REPORT	PHASE II: FLOW DATA MONITORED IN W'LY REPORT: IN'ED METER	PHASE II: FLOW DATA MONITORED IN W'LY REPORT: NUMBER OF DATA
(NORTH CENTRAL)				
1	LOANGO/NARANJO WW (300)	1	¥ 1	1
2	LOANGO INTAKE (100)	* 1	1	1
3	LOPINOT INTAKE (100)	* 1	1	1
4	MT. D'OR INTAKE (100)	* 1	1	1
5	ST. JOHN'S INTAKE (150)	* 1	1	1
6	SURRY INTAKE (100)	* 1	1	1
7	WATERFALL RD. INTAKE (100)	* 1	1	1
	SUB-TOTAL	[6] 7	[1] 7	7
(NORTH EAST)				
8	BRASO SECO-PARIA INTAKE(100)	* 1	1	1
9	CUMACA INTAKE (100)	* 1	1	1
10	FOUR RD/TAMANA INTAKE (100)	* 1	1	1
11	GRAND RIVIERE INTAKE (100)	* 1	1	1
12	MATELOT INTAKE (100)	* 1	1	1
13	MATURA INTAKE (100)	* 1	1	1
14	MONTEVIDEO INTAKE (100)	* 1	1	1
15	MORNE LA CROIX INTAKE (100)	* 1	1	1
16	SARIBEA INTAKE (100)	* 1	1	1
17	SANS SOUCI WATERWORKS (100)	* 1	1	1
18	TOCO WATERWORKS (250)	* 1	1	1
19	LOS ARMADILLOS INTAKE (100)	* 1	1	1
	SUB-TOTAL	[12] 12	[0] 12	12
(NORTH WEST)				
20	BLANCHISSEUSE INTAKE (100)	* 1	1	1
21	CHAGUARAMAS WELLS (300)	* 2	2	2
22	DAMIER INTAKE (100)	* 1	1	1
23	DORRINGTON GARDEN WW (200)	* 1	1	1
24	FOUR RD. WATERWORKS (200)	* 12	12	12
25	LA CANOA INTAKE (100)	* 1	1	1
26	LA PASTORA RES. RD. (125)	* 1	1	1
27	LA PASTORA WELLS (200)	* 2	2	2
28	GUAICO TAMANA/L. C. IT(100)	* 1	1	1
29	MON REPOS INTAKE (100)	* 1	1	1
30	PIPIOL INTAKE (100)	* 1	1	1
31	RIVER ESTATE WW (200)	* 5	5	5
32	TUCKER VALLEY WELLS (200)	* 8	8	8
33	TYRICO INTAKE (100)	* 1	1	1
34	ACONO WATERWORKS (300)	1	¥ 1	1
35	LA PASTORA/CAPRIATA IT (125)	1	¥ 1	1
	SUB-TOTAL	[14] 40	[2] 40	40
(PORT OF SPAIN)				
36	ARIPITA INTAKE (100)	* 1	1	1
37	CASCADE INTAKE (125)	* 1	1	1
38	DIBE INTAKE (100)	* 1	1	1
39	KING GEORGE V PK. WELLS (300)	* 3	3	3
40	MARAVAL WATERWORKS (675)	* 1	1	1
41	MOKA WELLS (200)	* 2	2	2
42	PARAMIN WATERWORKS (200)	* 2	2	2
43	SAVANNAH WELLS (300)	* 6	6	6
44	ST ANN'S WATERWORKS (200)	* 1	1	1
45	ST CLAIR WELL (300)	* 1	1	1
	SUB-TOTAL	[10] 19	[0] 19	19
(SAN FERNANDO/SOUTH CENTRAL)				
46	FREEPORT WATERWORKS (300)	3	¥ 3	3
	SUB-TOTAL	[0] 3	[3] 3	3
(SOUTH EAST)				
47	MALONEY WELLS (150)	2	¥ 2	2
48	AMOCO TOURNEBRIDGE WELL(100)	3	¥ 3	3
49	GUARACARA SPRING (100)	1	¥ 1	1
50	GUAYAGUAYARE WELL #1 (100)	1	¥ 1	1
51	MAYARO WELLS (100)	6	¥ 6	6
52	MORICHAL SPRING (100)	1	¥ 1	1
53	MAYO SPRINGS (100)	1	¥ 1	1
54	BICHE WATERWORKS (150)	1	¥ 1	1
	SUB-TOTAL	[0] 16	[16] 16	16
(SOUTH WEST)				
55	CHATAM WATERWORKS (400)	5	¥ 5	5
56	PENAL WATERWORKS (250)	8	¥ 8	8
57	SIPARIA (COORA) WW (300)	8	¥ 8	8
58	GRANVILLE WATERWORKS (200)	7	¥ 7	7
59	FYZABAD WWTERWORKS (150)	5	¥ 5	5
60	CARAPAL WATERWORKS (250)	2	¥ 2	2
61	CAP DE VILLE WW (300)	1	¥ 1	1
62	POINT FORTIN WW (200)	3	¥ 3	3
63	CLARK ROAD WELLS (150)	1	¥ 1	1
64	TEXACO TO GUAYAGUARE (100)	* 1	1	1
65	TRINTOC TO TECHIER (100)	* 1	1	1
66	TRINTOC TO P'T FORTIN (100)	1	¥ 1	1
	SUB-TOTAL	[2] 43	[41] 43	43
(TOBAGO)				
67	HILLSBOROUGH WW (400)	1	¥ 1	1
68	COURLAND WATERWORKS (400)	1	¥ 1	1
69	HILLSBOROUGH WEST RV (300)	1	¥ 1	1
70	GREEN HILL INTAKE (300)	1	¥ 1	1
71	KINGS BAY WATERWORKS (200)	1	¥ 1	1
72	RICHMOND WATERWORKS (200)	1	¥ 1	1
73	CRAIG HALL INTAKE (150)	1	¥ 1	1
74	GOV'T FARM WELL #3 (150)	1	¥ 1	1
75	CHARLOTEVILLE INTAKE (100)	1	¥ 1	1
76	SPEYSIDE INTAKE (250)	* 1	1	1
77	CASTARA INTAKE (50)	1	¥ 1	1
78	PARLATUVIER INTAKE (50)	* 1	1	1
79	L'ANSE FOURMI INTAKE (50)	* 1	1	1
80	BLOODY BAY INTAKE (50)	* 1	1	1
	SUB-TOTAL	[4] 14	[10] 14	14
	TOTAL	[48] 154	[73]154	154

NOTE:

WW; WATERWORKS,
IT; INTAKE,
RD.; ROAD,
RES.; RESERVOIR,
L.C.; LAS CUEVAS,
PK.; PARK,
P'T; POINT,
RV.; RIVER,
GOV'T; GOVERNMENT,
M'LY; MONTHLY,
W'LY; WEEKLY,

(200); PIPE DIAMETER (MM),
"*"; NO INSTALLATION OF FLOW METER IN EXISTING FACILITY,
"¥"; EXISTINGS (REPLACEMENT OF PERIPHERALS),
IN'ED; INSTALLED,

5. WSSS OPERATION AND MANAGEMENT

5.1 METHODOLOGY

This section presents the operation and management of the proposed Water Supply Supervisory System (WSSS) which is formulated and proposed in the present study. Since the WSSS is a segment of WASA's water supply operation and management under its organization, the technical aspects of WSSS is focussed in this section.

The fundamental function of WSSS is to monitor the WASA's actual/present operation status of the major four water supply system in the country under the Phase I Project. Further in the next advanced step, the proposed WSSS targets to formulate a practical water supply operation program for all system in the country, based on the analyses of the collected and accumulated operation status data/information. The following depicts operation method of the WSSS at final stage of the project.

<u>CSS</u>

The system operation status of existing water production facilities and service areas for WASA core water supply system including the four major sources, is monitored at CSS building. This monitoring is practiced for 24 hours a day, by real time monitoring system.

The major monitoring items for CSS are:

- Alarm status of each facilities,
- Operating status of pumping units and valves at each booster pumping stations,
- Operating status of control valves at each strategic points,
- Water levels at impounding reservoirs and rivers,
- Water levels at clear water and service storage reservoirs,
- Water flows of raw water, waterworks and transmission/distribution facilities,
- Water flows and pressures at each strategic points, and
- Leakage control related works.

LSS

As for the operation status in LSS covering areas, the system operation reports at weekly basis are planned to be prepared. And the necessary information are telecommunicated by Regional Offices to the main computer system in CSS building through the terminal units of the work stations installed in each Regional Office. The weekly operation status is also compiled into the data files in the CSS building.

The medium and small-scale systems operation are monitored under LSS. The weekly operation reports prepared by each regional office will compile data on water production and distribution records into the each work stations by OCR, which are reviewed and evaluated with the water supply plans provided by the WSSS management in advance.

Major monitoring items for LSS are:

- Distribution records of waterworks, intakes and wells/springs, and
- Operation records of waterworks, intakes and wells/springs.

Water Supply Program Formulation

Regarding the optimum water supply program formulation in the following stage, the efficient water production and distribution program is planned to be formulated. This plan could be effectively performed, utilizing the consumption records which are obtained by the metering system for each service connections under the "Universal Metering Program".

The production and distribution flow records are obtained by flow metres installed under the proposed Phase I Project on the major facilities and strategic points on the existing transmission/distribution mains for the CSS, and other production facilities for the LSS in Phase II Project.

Thus, an optimum efficient water supply planning is formulated based on the locally available amounts of water production in the system and the water demands in the respective service areas.

The water production/distribution and consumption balances for each service area are calculated and reviewed periodically, so that it could be analyzed and interpreted to the system leakage and/or waste of water in each service area, which could finally totals to all system loss of WASA.

Maintenance of the Equipment and Facilities Related to WSSS

To effectively operate the proposed WSSS, the equipment and facilities installed under the Phase I and Phase II Projects are planned to be periodically and sufficiently maintained, by the staff specifically assigned for this purpose. To accomplish the above maintenance works, spare parts with necessary materials for the WSSS related equipment and facilities are planned to be stored in the CSS building. And, it is also planned that they are periodically replaced to maintain the practical life of usage.

5.2 ORGANIZATION

To achieve the objectives and targets of the proposed WSSS described in the preceding sections, an appropriate organization for the WSSS is recommended as presented in Fig. II-5.1. The recommended organization structure for operation and management of WSSS is formulated to coordinate with the present organization of WASA.

The proposed WSSS is composed of two sub-systems of CSS and LSS, following the present practice of WASA. The CSS part organization is newly recommended to operate the improved on-line system, while the LSS part is recommended under the Regional Manager as it is practiced now.

The CSS organization structure consists of three parts of 1) operation status monitoring, 2) water supply planning, and 3) maintenance of CSS equipment and facilities.

This organization is formulated with objectives of the following three major activities in the proposed WSSS: 1) to perform the continuous monitoring of water production and demands' variations for 24 hours, and to improve the preventive measures against accidents occurred on facilities in the system, 2) to review and analyze collected data, and prepare appropriate water production and distribution plans for each sub-system, and 3) to enhance a proper maintenance system of CSS related equipment and facilities, respectively.

Especially, the planning section in the recommended structure is cited as an intensively recommended part. This part is planned to perform an effective utilization of the collected data and to promote the technology development for the optimum level of water supply programming.

The engineers assigned to the newly prepared positions are recommended, those who have sufficient capability to execute the task-roles presented in this report.

Regarding the effective use of manpower, most of the pump operators for booster pumping stations and valve operators for off-takes are efficiently transferred or recruited to other sections.

The major task-roles of each section in the above organization structure are presented below:

Planning Section

- Review and analysis of data collected on water production and consumption trends by water sources and transmission/distribution mains basis,

- Water production/distribution and system with facilities operation planning by seasonal and daily basis,

- Water supply technology development for optimum usage of service storage reservoirs and economical water production and distribution, and

- Existing and future water supply facilities rehabilitation and expansion planning.

Operation Section

- Continuous monitoring for water levels, pressures, flows at major facilities in the system,

- Status monitoring on emergency aspects occurred, operation direction for booster pumping units and valve units, and necessary system operation and control direction to each sites of system operation,

- Remote operation of booster pumping and valve units,

- Remote control of flow control valves at strategic points, and

- Reporting on water supply by daily, monthly and yearly basis.

Maintenance Section

- Maintenance planning for computer system, data communication equipment, local instrument, and CSS related equipment,

- Periodical check and calibration, and its repair works for CSS related equipment, and

- Reporting of maintenance records for CSS related equipment, including information on accidents statistics records.

The task-role of the proposed CSS Manager is recommended to have an important role, therefore his position is recommended identical to the regional managers, under the Deputy Technical Director.

5.3 TRAINING

Regarding the new system of WSSS operation, a training program is recommended to be planned for the newly assigned/recruited staff for the system operation, so that they could practically and efficiently operate the improved and expanded CSS and LSS. This section describes the proposed training program for WSSS operation and management.

Following items are recommended to be included in the training program:

- Through sufficiently learning the operation methods and basic rules for operation of the newly installed equipment/facilities, to confirm the objectives and functions of the WSSS, especially the new CSS is needed. This matter is applied to all staff of WASA as well as the staff assigned to the new CSS operation.

- It is necessary to prepare materials and methods for the above purpose for all WASA's staff training,

- For CSS operation staff, as for the common knowledge of WASA's staff, the entire water supply system of WASA with its detailed functions and components of each facility, is planned to be well informed,

- In addition to the above item, the CSS staff are planned to be well trained for the objectives and functions of the newly improved CSS with each equipment together with facilities,

- To conduct the above training, following materials are required to be prepared: detailed description on each facility with drawings, which are equipped to the operators' office for future operation,

- CSS planning engineers are planned training of the software application for the pipe net-work analysis and the optimum water distribution programming, through the equipment operation test running with substantial training by the system equipment suppliers, since application software sets for pipe-network analysis and economic water distribution programming etc. are planned to be installed to the CSS computer system, and

- CSS operation engineers are planned training of operation and maintenance technology for each facility/equipment installed in the system, to smoothly cope with any requirements for system operation.

5.4 INFORMATION FLOW

Table II-5.1 presents information flows in the proposed WSSS for decision-makers, communication methods, operators, and operation and control methods of each water supply facilities.

The major activities in the information flows are presented below:

- decision-makings for operation and control of CSS related facilities are made by the Chief CSS Operation Engineer, and decision-makings for LSS are done by respective Regional Manager,

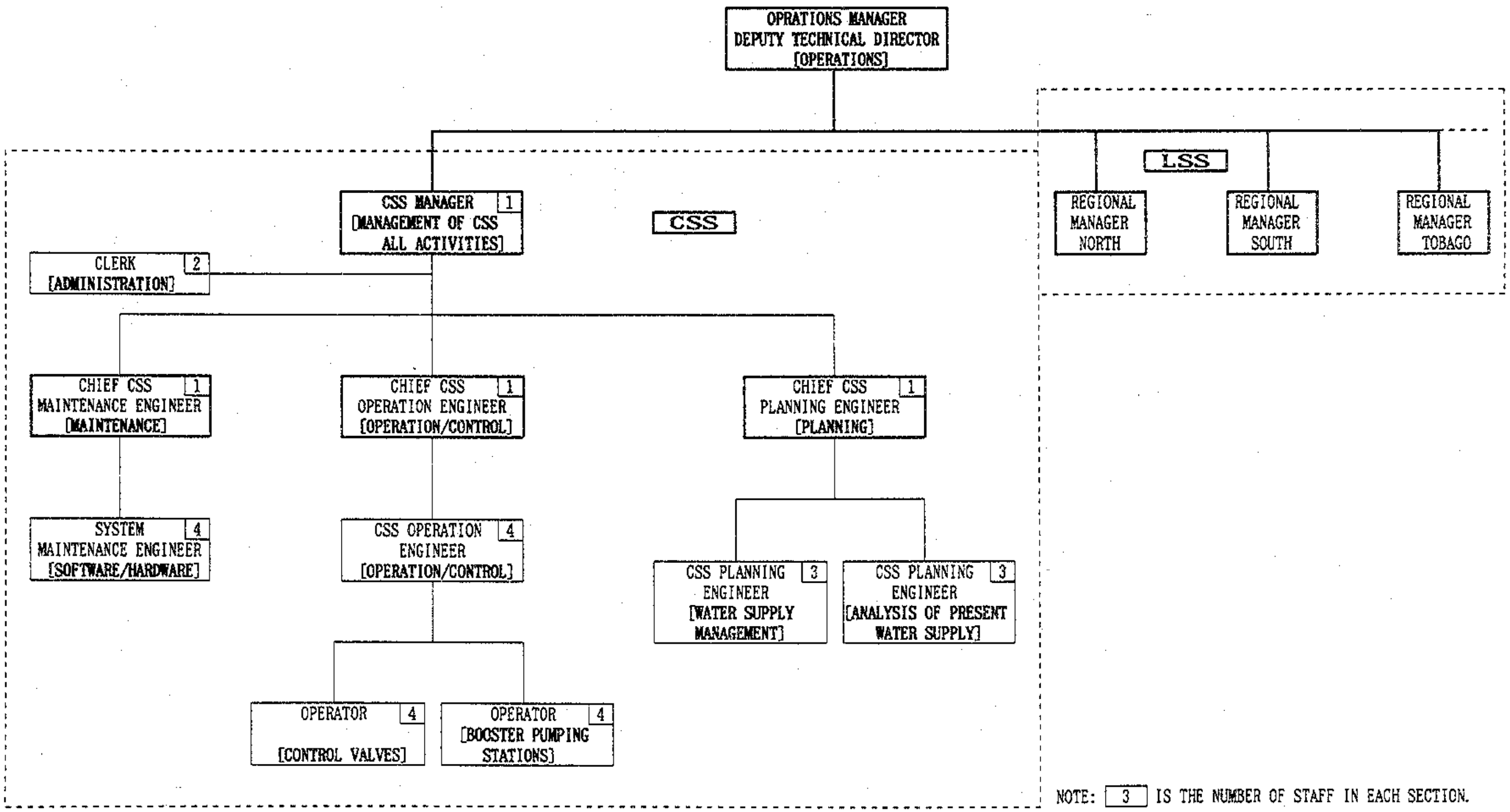
- normal operation of each facility is executed following to the Operation Manual prepared by CSS Operation Manager,

- any emergency modification of the operation status is transmitted directly to the respective operation sites by CSS Operation Engineer through the voice radio communication system,

- remote operation of the pumping and valve units at booster pumping stations and remote control of flow control valves at strategic points are executed by Pump/Valve Operators using the data communication network under direction of Chief CSS Operation Engineer, and

- pumps and release valves at the existing Tumpuna Storage Lift Pumping Station are remotely controlled by Operators in Caroni Water Treatment Plant according to the direction of Chief CSS Operation Engineer.

Fig. II-5.1 PROPOSED ORGANIZATION OF WATER SUPPLY SUPERVISORY SYSTEM (WSSS)



NOTE: [3] IS THE NUMBER OF STAFF IN EACH SECTION.

Table II-5.1 OPERATION AND CONTROL OF WATER SUPPLY SUPERVISORY SYSTEM

CONTROL OBJECTS	DECISION MAKER	COMMUNICATION MEANS	OPERATORS	CONTROL METHOD
C S S				
Raw Water Flow & Distribution/ Transmission Flow at Waterworks	Operation Engineer at CSS Building	Voice Radio Communication System	Operators at Waterworks	**Manual Control** -Selection of Number of Pump Operation -Start/Stop of Pumps -Valve Position Control
Storage Lift Pumps & Reservoir Release Valve at Tumpuna	Ditto	Data Communication System (CSS)	Operators at Caroni Water Treatment Plant	**Remote Manual Control** -Selection of Number of Pump Operation -Start/Stop of Pumps -Open/Close of Valves
Booster Pumps & Control Valves at the Six Booster Pumping Stations	Ditto	Ditto	Pump Operators at CSS Building	**Remote Manual Control** -Selection of Number of Pump Operation -Start/Stop of Pumps -Valve Position Control
Booster Pumps at Aripo and Arima Booster Pumping Stations	Ditto	Voice Radio Communication System	Operators at Aripo Waterworks and North District Office	**Manual Control** -Selection of Number of Pump Operation -Start/Stop of Pumps -Valve Position Control
Flow Rate at Offtakes	Ditto	Data Communication System (CSS)	Control Valve Operators at CSS Building	**Automatic Remote Control by Designated Flow Rate**
Storage Lift Pumps at Navet WW	Ditto	Ditto	Operators at Navet Waterworks	**Manual Control** -Selection of Number of Pump Operation -Start/Stop of Pumps
Water Level at Service Storage Reservoir	Ditto	Voice Radio Communication System	Operators at Related Waterworks & Booster Pumping Stations	**Manual Control** -Selection of Number of Pump Operation at Related Waterworks & Booster P/S -Valve Position Control at the Above Site **Automatic Control by Altitude Valve**
L S S				
Distribution/Transmission Flow Rate at Waterworks	Regional Manager	Voice Radio Communication System	Operators at Waterworks, Intake & Well	**Manual Control** -Selection of Number of Pump Operation and/or Valve Position Control

6. COST ESTIMATES

The cost for the Projects in the Master Plan are estimated based on market prices (March 1991) in Japan and Trinidad and Tobago, and the data/information obtained through the experienced similar projects in developing countries. The cost estimate summary for the Phase I and Phase II Projects in the Master Plan is shown in Table II-6.1, and the cost estimates for the recommended Immediate Projects are presented in Supporting Report N "Data on Cost Estimate".

In estimating projects capital costs, construction, engineering and administration costs are categorized as shown in the figure. The physical contingencies allowance is estimated to be 15 percent of the sum of the costs for construction and engineering. Price contingencies is not included in this figure. Value Added Tax (VAT) is considered 15 percent of the sum of the costs for construction and engineering.

Project cost for Phase I Project is US$ 46,300,000 and that for Phase II is US$ 39,200,000 as summarized below. Total project cost totals in US$ 85,500,000.

SUMMARY OF PROJECT COST

(UNIT: 1,000 US DOLLARS)

ITEM	PHASE I	PHASE II	TOTAL
[1] CONSTRUCTION WORKS	31,600	22,800	54,400
[2] ENGINEERING SERVICE	3,900	7,200	11,100
[1]+[2]	35,500	30,000	65,500
[3] VALUE ADDED TAX	5,300	4,500	9,800
[4] CONTINGENCY	5,300	4,500	9,800
[5] ADMINISTRATION	200	200	400
PROJECT COST	46,300	39,200	85,500

Table II-6.1 SUMMARY OF COST ESTIMATE FOR WATER SUPPLY SUPERVISORY SYSTEM

UNIT: IN x 1,000

ITEM / NAME OF FACILITIES AND EQUIPMENT	PHASE I										PHASE II									
	FOREIGN CURRENCY (US$)			LOCAL CURRENCY (TT$)						TOTAL (US$)	FOREIGN CURRENCY (US$)			LOCAL CURRENCY (TT$)						TOTAL (US$)
	SUPPLY			CIVIL WORKS				SUPPLY			SUPPLY			CIVIL WORKS				SUPPLY		
	PRIMARY EQUIPMENT	INSTRUMENT -ATION	TOTAL (US$)	F-M/C-V CHAMBER	BUILDING WORKS	INSTAL- LATION	SUB-TOTAL (CIVIL)	TRANS- PORTATION	TOTAL (TT$)		PRIMARY EQUIPMENT	INSTRUMENT -ATION	TOTAL (US$)	F-M/C-V CHAMBER	BUILDING WORKS	INSTAL- LATION	SUB-TOTAL (CIVIL)	TRANS- PORTATION	TOTAL (TT$)	
[1] CONSTRUCTION WORKS																				
[CSS]																				
FLOW METER	494.2	1,329.8	1,824.0	1,438.4	---	775.2	2,213.6	155.0	2,368.7	2,381.3	4.4	1,363.0	1,367.4	10.1	---	581.1	591.2	116.2	707.4	1,533.8
CONTROL VALVE	2,156.4	3,779.8	5,936.2	1,396.5	---	2,522.9	3,919.4	504.6	4,424.0	6,977.1	296.2	1,620.7	1,916.9	115.0	---	814.7	929.7	162.9	1,092.6	2,174.0
LEVEL METER	32.5	279.6	312.0	---	---	132.6	132.6	26.5	159.1	349.5	6.5	312.8	319.3	---	---	135.7	135.7	27.1	162.8	357.6
PRESSURE GAUGE	---	566.7	566.7	---	---	240.8	240.8	48.2	289.0	634.7	---	593.9	593.9	---	---	252.4	252.4	50.5	302.9	665.1
CSS's CENTRAL EQUIP	---	5,861.9	5,861.9	---	385.3	1,902.6	2,287.9	380.5	2,668.4	6,489.7	---	3,486.9	3,486.9	---	---	1,481.9	1,481.9	296.4	1,778.3	3,905.3
REGIONAL OFFICE	---	211.6	211.6	---	---	89.9	89.9	18.0	107.9	236.9	---	317.3	317.3	---	---	134.9	134.9	27.0	161.8	355.4
REPEATER STATION	---	219.1	219.1	---	---	93.1	93.1	18.6	111.7	245.4	---	219.1	219.1	---	---	93.1	93.1	18.6	111.7	245.4
RTU STATION	---	11,832.0	11,832.0	---	2,219.5	5,028.6	7,248.1	1,005.7	8,253.8	13,774.1	---	9,973.3	9,973.3	---	---	4,238.7	4,238.7	847.7	5,086.4	11,170.1
BOOSTER P/S	---	226.7	226.7	---	---	96.3	96.3	19.3	115.6	253.9	---	---	---	---	---	---	---	---	---	---
SPARE PARTS	---	249.3	249.3	---	---	---	---	21.2	21.2	254.3	---	249.3	249.3	---	---	---	---	21.2	21.2	254.3
SUB-TOTAL	2,683.1	24,556.3	27,239.4	2,834.9	2,604.9	10,882.1	16,321.9	2,197.6	18,519.5	31,596.9	307.1	18,136.4	18,443.4	125.1	---	7,732.5	7,857.6	1,567.7	9,425.3	20,661.1
[LSS]																				
FLOW METER	---	---	---	---	---	---	---	---	---	---	328.4	1,279.9	1,608.3	1,444.6	---	683.5	2,128.1	136.7	2,264.8	2,141.2
SUB-TOTAL	---	---	---	---	---	---	---	---	---	---	328.4	1,279.9	1,608.3	1,444.6	---	683.5	2,128.1	136.7	2,264.8	2,141.2
TOTAL	2,683.1	24,556.3	27,239.4	2,834.9	2,604.9	10,882.1	16,321.9	2,197.6	18,519.5	31,596.9	635.4	19,416.3	20,051.7	1,569.7	---	8,416.0	9,985.7	1,704.4	11,690.1	22,802.3
[2] ENGINEERING SERVICES	---	---	3,437.0	---	---	---	---	---	2,109.3	3,933.3	---	---	6,311.1	---	---	---	---	---	3,809.3	7,207.4
TOTAL OF ITEMS [1] & [2]	2,683.1	24,556.3	30,676.4	2,834.9	2,604.9	10,882.1	16,321.9	2,197.6	20,628.7	35,530.2	635.4	19,416.3	26,362.8	1,569.7	---	8,416.0	9,985.7	1,704.4	15,499.4	30,009.7
[3] TAX (VAT)	---	---	---	---	---	---	---	---	22,650.5	5,329.5	---	---	---	---	---	---	---	---	19,131.2	4,501.5
[4] CONTINGENCY	---	---	4,601.5	---	---	---	---	---	3,094.3	5,329.5	---	---	3,954.4	---	---	---	---	---	2,324.9	4,501.5
[5] ADMINISTRATION	---	---	---	---	---	---	---	---	755.0	177.7	---	---	---	---	---	---	---	---	637.7	150.0
GRAND-TOTAL	2,683.1	24,556.3	35,277.9	2,834.9	2,604.9	10,882.1	16,321.9	2,197.6	47,128.6	46,367.0	635.4	19,416.3	30,317.2	1,569.7	---	8,416.0	9,985.7	1,704.4	37,593.2	39,162.7

NOTE: EQUIP.; EQUIPMENT, P/S ; PUMPING STATION, F-M/C-V; FLOW METER AND CONTROL VALVE, VAT ; VALUE ADDED TAX, EXCHANGE RATES; 1 US$ = ¥ 135 AND 1 US$ = TT$ 4.25,

7. IMPLEMENTATION SCHEDULE

In accordance with the target year discussed in Sub-section 1.1 "Target Year", and in consideration of works described in Section 4 "Proposed Water Supply Supervisory System", the implementation schedule of the whole project of the Master Plan is worked out and shown in Fig. II-7.1.

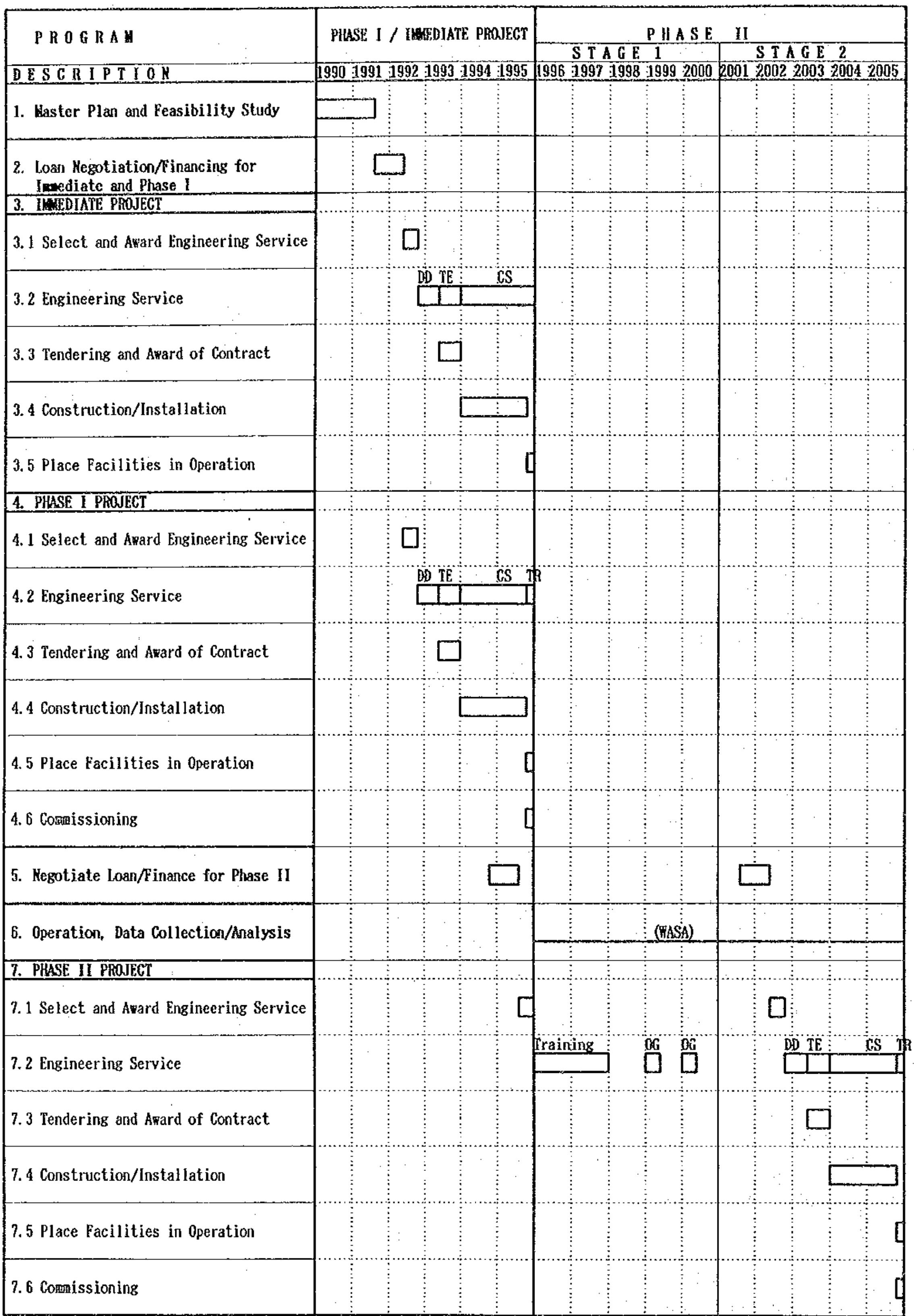
A rather tight implementation schedule has been developed for Phase I Project as well as Immediate Projects. Phase I Project requires about four years period from its initiation in mid 1992 to completion of the construction works, taking into account the work volume, financial constraints and the time required for foreign financing. As far as Phase II Project is concerned, it is essential that a feasibility study be prepared prior to its implementation. It should be noted that Master Plan and implementation schedule is only a general guideline, and is subject to changes/modifications as conditions warrant.

In Phase I Project, water supply supervisory system facilities will be satisfactorily installed in 1995. However, if the newly established WSSS with installed facilities do not properly function as intended and designed, the Phase II Project should be delayed.

Objective of Phase II Project is to manage the WSSS, mostly monitoring system, which is realized in Phase I Project along with Immediate Projects. Further, it aims to accumulate essential information of the water supply system, with relevant analysis, to provide an effective operation and management program of the water supply system in the future. As well as upgrading the level of system operation monitoring in Phase II, a remote operation for selected facilities of the system is exercised, succeeding to the improvement of the level of whole system operation.

For this Phase, a total ten years period, which is divided into two stages as illustrated in the figure, is considered appropriate. It is principally based on a proposed sufficient time for system operation with training and an essential and actual data accumulation through the system operation. In addition to the above, the time for the same procedure for project formation and implementation made in Phase I is incorporated.

Fig. II-7.1 IMPLEMENTATION SCHEDULE



NOTE: DD - Detailed Design
TE - Tender Evaluation
CS - Construction Supervision
TR - Test Run
OG - Water Supply Operation Guideline
(WASA) - Executed by WASA

8. BENEFITS ACCRUED FROM THE PROJECT

The benefits accrued from the Project can be broadly categorized into three aspects: 1) improvement of services to customers, 2) reduction of operational costs while maintaining the services to customers and 3) contribution to planning of water supply systems. It should be noted that most of the benefits will be accrued only when the data and information collected is utilized appropriately and is made available whenever it is needed, as well as that such prerequisites as mentioned before are met.

1) Improvement of Services to Customers

Improvement of services to customers comprises stable water supply to customers, foresight of or prompt reaction to abnormal occurrences, and the monitoring and detection of water leakage.

Stable water supply to customers

With the level of water leakage reduced enough to meet the demand of water, the water supply supervisory system (WSSS) will enable WASA to provide customers with more water in a good pressure and to decrease the areas subject to rationing of water.

In addition, chances could be provided to effectively utilize produced water during dry period.

Foresight of or prompt reaction to abnormal occurrences

When take place disasters, stoppage of electricity, accidents in facilities or others which suspend water supply, prompt reaction and appropriate treatment made possible with the WSSS will contribute to minimizing the areas suffering from the cut-off of water supply. It may be possible to change the courses of water flow and to flexibly utilize treated water among the treatment plants, so that the affected people can secure the "life-line" of water.

Moreover, continuing monitoring of water systems could enable WASA to find signs which indicate occurrences of accidents, and then prevent them.

Monitoring and detection of water leakage

Monitoring of the water system and detection of water leakage will contribute to reducing the leakage. Using the WSSS, the leakage will be detected in a shorter period. In addition, the opportunity could be provided to formulate the most cost effective method for the detection.

Also, the WSSS will get the saved water more effectively distributed to customers. The benefits could not be fully realized if some water is wasted at the level of consumer due to inappropriate distribution.

2) Reduction of Operational Costs

Operational costs include energy, chemicals and personnel costs. Reduction of operational costs with the WSSS can be achieved in three ways: 1) reduction of personnel costs involved with the installation of CSS, 2) production and supply of water which corresponds to the demand and 3) establishment of the minimum cost operating strategy of a given multiple sources through distribution.

With the installation of CSS, manual works will be replaced by its functions: some booster pump operators in Phase II, so that the operation of water supply will be optimized while meeting increased demand.

As a result, the resources required for the production and supply of water, including water, will be reduced for a given level of supply.

The minimum cost operating method could be figured out, probably focusing on pump scheduling and source optimization. For example, costs of treating water could be reduced when precedence is given to higher quality of water in use.

3) Contribution to Planning of Water Supply Systems

In addition to the benefits of ordinary operations, the WSSS will contribute to the planning in future. The storage of data collected with the WSSS will be the base on which the plans of water supply systems such as the expansion and improvement of the systems will be formulated.

This is important since unavailability and/or inaccuracy of data will be negatively affect the validity of the plans.

PART THREE: FEASIBILITY STUDY

1. PROJECT IDENTIFIED IN MASTER PLAN

The Scope of Work agreed between JICA and the Government of Trinidad and Tobago in May, 1989 defines the scope of feasibility study. Basic requirement of the Study is an improvement and expansion of the existing CSS. The Master Plan identifies the most appropriate project area, target year, population, water balance as well as major scope and work of the Phase I Project. Followings are brief summary of Master Plan related to Phase I Project.

Project Area

The area supplied with piped water principally from the four major waterworks (Caroni, North Oropouche, Hollis and Navet) including 16 raw water sources as shown on Fig. III-1.1.

Target Year

The end of 1995, 4 years after the initiation of the project implementation in mid 1992.

Population

Future population is forecast with the net growth rate of 1.8% during Phase I period. Population served in WASA water system will increase from 1,192,000 in 1990 to 1,299,000 in 1995. Population served within the project area will also show an rapid growth in the said period, i.e., from 825,000 in 1990 to 896,000 in 1995.

Water Demand

On assumption that unaccounted-for water ratio would be substantially improved from the present 50% to a rather optimistic ratio of 40% in the target year (1995) by conducting intensive wastage control activities, future net water demand including UFW in the project area will be forecast almost constant with a slight drop from 531,000 m^3/d in 1990 to 513,000 m^3/d in 1995.

Water Balance

Dependable yields of the said 16 water sources and of the existing production facilities in the project area are most critical in dry seasons when the runoff of the rain water is minimum. Estimates from the historical data and information suggest a 10% decrease of the dependable yields from 602,000 m^3/d in rainy seasons to 546,000 m^3/d in dry seasons. This implies a total of dependable yields will suffice well for the water requirement in 1995 (513,000 m^3/d) even in dry seasons.

As discussed in Section 6, Part I, however, urgent implementation of the leakage reduction program to supply treated water effectively is definitely required for the water balancing. Otherwise, the water demand will exceed the dependable yields in the coming several years.

Outline of Phase I Project

Improvement and expansion of the CSS facilities are major scope proposed for the Phase I Project. This mainly aims strengthening to establish on-line monitoring and control system in the project area.

Therefore, this phase includes works to formulate the metering and valving system on the transmission/distribution mains, which aim at not only the indispensable information collection of the main pipelines in the distribution system, but also the basic information collection to effectively mobilize the new CSS, with actual data of operation status from the initial step of its system operation.

Such information enables the CSS to work properly as expected for strategic control of the transmission/distribution system. It is especially noted that acquisition and analysis of such data are quite time consuming. Moreover, such data collection can only be possible with the installation and operation of sensing equipment.

Major facilities and instruments contained in the Project will have following functions:

1) The CSS building will be a center for monitoring and control, equipped with master terminal unit, central processing unit, input/output interface, graphic panel, uninterruptible power supply, remote control panel, etc.

2) The repeater station will perform repeater function of signal and data, which will be equipped with a repeater system and uninterruptible power supply.

3) RTU stations to be newly constructed on site will encase remote terminal units, an instrument panel and uninterruptible power supply to receive and transfer electrical and mechanical signals to the CSS building.

4) Monitoring and control equipment to be installed at the waterworks, pumping stations, service storage reservoirs and water mains are flow meters, pressure gauges, level sensing meters and flow rate controllers.

In the meantime, an early implementation of the Immediate Projects is a prerequisite condition for developing the CSS facilities as described in Parts I and II. Studies on leakage reduction, WASA institution, mapping system, universal metering system and tariff structure are just at initial stage with assistance of several international funding agencies.

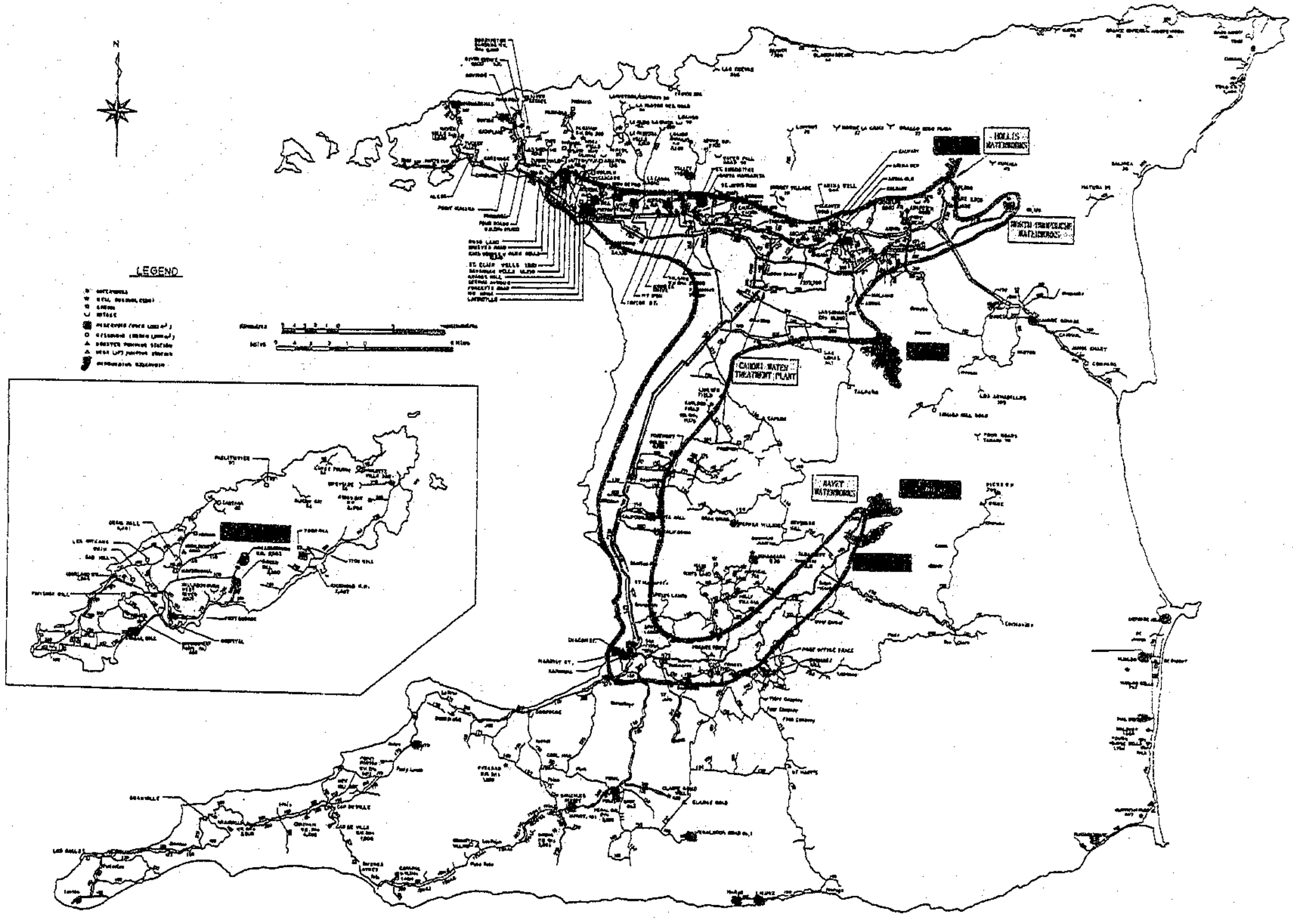
This report does not aim to picture such planning of the Immediate Projects. Any data or information on the Immediate Projects, if found in this Report, are tentative estimates or assumption inevitably made for the present study, which shall be reviewed in the future studies and analyses.

On the other hand, replacement/installation of control valves, flow meters level meters and pressure gauges for CSS operation, which constitute an integral part of the CSS, are considered as the work of the Phase I Project. Preliminary design and cost estimates of such work also carried out in the present study are incorporated in the Part III.

This Part III consists of six sections. Section 2 deals with design concept and criteria for establishing the central supervisory system. In the Sections 3 and 4, preliminary design and cost estimate of the CSS related facilities and equipment will be made reflecting results of review of the existing CSS. Section 5 works out construction and implementation schedule of the Project. Special stresses will be laid on financial and economic evaluation of the proposed Phase I project in Section 6.

The Part III thus compiled is simply materials for future appraisal by international funding agencies whether the project is feasible or not.

Fig. III-1.1 PROJECT AREA



2. DESIGN CONCEPT AND CRITERIA

To determine type and function of the CSS instruments in the succeeding sections, design concept and criteria will further be developed hereunder. As for basic scope and strategies of the Phase I Project, it is recommended to refer to Part II Master Plan of this report. Some of the basic strategies are inevitably reproduced hereunder merely for reference, although redundant and duplicate descriptions are kept minimum. Emphasis is laid on such point that the design criteria may not contradict the aforementioned basic strategies. Fig. III-2.1 illustrates overall concept of the CSS, laying stress on CSS control area of the water supply facilities and relation with the LSS.

2.1 CSS SOFTWARE

CSS to be established is to monitor flow rate, water level and water pressure at the several designated points of water mains, reservoirs, waterworks and pumping stations and to operate/control water production, transmission and distribution from the four major waterworks to achieve the predetermined targets. To this end, CSS hardware and software will be furnished mainly in the CSS building, RTU stations and monitoring/control points. Followings are criteria developed specifically for designing the CSS software.

1) The on-line real time data acquisition system (five-minute interval) as has adopted in the existing CSS is the minimum requirement for effective operation and management.

   Recommended data processing is on hourly and daily bases at least. Acquired data may be an input to pipe network analyses as hourly and daily fluctuation of water demand, pressure and flow rate. Monthly and annual data will be utilized mainly for future planning of water supply system and water source development. Five-minute data, in addition to the processed, are also stored as primary data.

2) Software of the CSS will be composed of system software and application software. The system software is to run the CSS by receiving, processing,

storing and displaying data, and the application software to utilize the CSS for specific purpose of computation and analyses. The former will be easily expanded and open-ended one for easy renewal and replacement. The latter will be effective in conducting pipe network analyses, water hammer analyses, and simulating reservoir operation, pump operation, etc. for the simultaneous use at the CSS building.

3) It is monthly operation reports prepared by district offices that provide the various data on the waterworks and pumping stations which will be monitored under LSS. They may be data on water production, chemical storage and usage, raw water characteristics, etc. Such off-line data regarding LSS will be stored together in the expanded memory to conduct comprehensive analyses on water supply conditions of the whole service area and on inventory management. The CSS will accommodate such data as well.

2.2 CSS HARDWARE

The CSS hardware will consist of at least Central Data Processing System (CDPS), Remote Terminal Unit (RTU), Data Radio System, Field Instruments, and Remote Control Equipment. In designing type and function of the CSS hardware, followings are considered as design criteria.

1) Central data processing system to be furnished for data collection, alarm warning, data processing and data display will have a function similar to or more than that of the latest mini-computer.

2) Remote terminal units to transfer data signal between the CDPS of the CSS building and field instruments will be encased in chambers to be constructed near monitoring points. Rooms that encase RTU instruments will be ventilation free from damped air and high temperature.

3) As like the existing CSS, communication between the CDPS and RTUs will be carried out through the existing Repeater Station at Pepper Hill. For this purpose, all RTUs and CSS building will be provided by radio transceivers.

4) Field instruments will be transducers of flow rate, pressure and water level. Analog signal from primary measuring device (sensor) will be output to the panels equipped in local control panel stands and in RTU stations after conversion into electric signal.

5) The North and South regional offices will be furnished the work station consisting of a computer system with individual computer/CRT display to overview the water supply conditions in the project area. The work station with a function of computer will have beneficial effects on free access to the CSS acquired data and their utilization for analytical purpose.

2.3 CSS BUILDING AND RTU STATIONS

Design criteria for the CSS building and RTU stations in which the CSS hardware will be furnished are worked out as follows:

1) The existing CSS building elaborates dual floor structure to encase cables and lines between the floors. To achieve maximum utilization of the existing, the major CSS equipment and instruments will be installed in the existing building that will play an important role as operation and control center. To accommodate most engineers and staff assigned for CSS, new CSS building will be expanded occupying the WASA's parking lot located in front of the existing building. New building will have similar span and size as the existing one.

2) Minor modification and rearrangement of the existing CSS building will be required to accommodate the proposed CSS instruments.

3) New RTU stations will be a concrete structure. These stations will be located on WASA's premises or government's area as far as possible to avoid time consuming land acquisition. In locating RTU stations, the existing facilities will be utilized to the maximum extent.

2.4 MONITORING AND CONTROL UNITS

2.4.1 Pressure Gauges, Flow Meters and Level Meters

To monitor flow conditions of the water supply system, primary sensors such as pressure gauges, flow meters and level meters for the proposed CSS will be installed at several designated points. Major monitoring items are flow rate and water pressure on water mains, intake and distribution flow rates and pressures at waterworks and water level in impounding, clear water and service storage reservoirs. Followings are design criteria developed for these primary sensors.

<u>Waterworks and Pumping Stations</u>

1) As discussed in Supporting Report L "Comparative Studies", major existing 7 pumping stations (six booster and one storage lift pumping stations: Tunapuna, Valsayn, El Socorro, San Fernando, Malgretoute, TCO and Tumpuna) located within the project area will be monitored for the purpose of remote operation and control from the CSS building.

   On the other hand, operation and control of all waterworks and other minor booster pumping stations within the area will be made locally on the basis of the acquired data. Instruction or directions from the CSS to such waterworks and/or booster pumping stations for routine operation will be generally through voice radio communication system.

2) Monitoring items will cover intake rate, water production at waterworks and water level in impounding and clear water reservoirs and river. In case waterworks treats groundwater, water production rather than intake rate will be simply measured. Another essential factor at waterworks is a distribution pressure. Pressure gauges will be equipped on the pipes wherever distribution pumps are installed.

3) As to the six booster pumping stations in TCO, Malgretoute, San Fernando, El Socorro, Valsayn and Tunapuna, flow rate of either pump discharge or suction will be measured, as water losses in the pumping stations are

considered negligible. Water pressure will be measured at both lines of discharge and suction.

4) Recommended flow meter type is "annubar" in consideration of the cost, head loss, easy installation, simplicity, accuracy and life span. The existing flow meters which are functioning or even malfunctioning because of damaged peripherals, although most of them seemingly required calibration, will be utilized as long as possible. The life of meters can be lengthened by appropriate repair and replacement of the damaged peripherals.

5) The existing level-sensing meters and pressure gauges, although most of them seemingly require calibration, overhaul or repair, will also be utilized as far as they can be assumed to function normally.

Service Storage Reservoirs

1) For effective operation and control of the distribution system, it is desirable to monitor fluctuation of flow and water level in the reservoirs. Hence major service storage and clear water reservoirs that lie within the project area will be equipped with flow and level meters. As for flow rate, it is recommended to measure outflow from the reservoirs rather than inflow.

2) Type of level meters to be newly installed depends on structure of the reservoirs, namely, a float type is for underground structure and a pressure differential type for others.

3) As to flow meters, annubar type is considered most economical and effective with the least head loss. Further, this type has an advantage of monitoring that ensures both inflow and outflow measurement regardless of flow direction.

Off-Takes

1) Off-takes of the transmission/distribution mains from the four major waterworks, i.e., Caroni, North Oropouche, Hollis and Navet waterworks are

proposed monitoring points for flow control. Monitoring items are pressure and flow rate.

2) Recommended flow meters and pressure gauges are annubar type and Bourdon-tube type respectively for ease of installation and cost effectiveness.

3) Proposed site for installing such flow meters and pressure gauges is on the off-takes between the existing gate valves and new flow control valves. Consideration should be given to the need for straight lengths of pipe preceding the meters (minimum allowable lengths: upward eight times of pipe diameter and downward four times).

2.4.2 Control Units

The CSS is to monitor/control effectively water supply systems from the CSS building or by giving directions to each district office or waterworks through voice radio communication system. Flow control aims at supplying sufficient and potable water to all consumers in the service area. To this end, flow control instruments will be equipped at major booster pumping stations and off-takes from the water mains. These instruments will function effectively together with the monitoring devices. Major pumping stations will be controlled from the CSS building, while all off-takes are operated by site operators.

As regards service storage reservoirs, altitude valves are recommended as flow control equipment as currently practiced in WASA. These are effective for maintaining water level within an allowable limit of high water.

Waterworks and Booster Pumping Stations

1) Flow control valves equipped with electric motor drives will be installed on all header mains from waterworks and booster pumping stations that lie within the project area. However, all of them except the seven major pumping stations will be locally controlled. Operators under direction of the waterworks engineers will operate the system by controlling the flow rate and pressure.

The said six major pumping stations will be controlled directly from the CSS building and also the existing Tumpuna Storage Lift Pumping Station will be controlled by the existing control panel installed at Caroni Water Treatment Plant through direction from the CSS building.

2) Since many variations of flow rate controllers are available, selections of the most suitable type shall be based on the flow conditions, pipe characteristics, planned water pressure and water demand. As the reliable data are currently not available, it is tentatively assumed to install butterfly valves as flow controller.

Service Storage Reservoirs

1) An altitude valve is a typical type installed for flow control of the existing service storage reservoirs in the country. This valve functions when the water level exceeds the predetermined maximum in storage reservoirs. For ease of maintenance and operation, same type of altitude valves will be installed at all storage reservoirs where combined inlet/outlet mains (single inlet-outlet piping system) is applied.

2) Other service storage reservoirs that apply separate inlet-outlet piping system will be controlled locally by the site staff. As far as discharges from off-takes to the reservoirs are properly controlled, it will be rare case for them to be involved frequently in manual-flow control at site.

Off-Takes

1) A flow control valve will be installed on selected off-takes of the transmission and distribution mains in the project area where flow meters and pressure gauges are laid. Consideration shall be given to the straight pipe length where flow meters are installed.

2) It is tentatively assumed that a motor-driven butterfly valve is a proposed type for flow control.

3) Direction from the CSS building will be delivered through district offices to the site operators assigned for valve control.

4) The valve equipped with an electric driven motor will be controlled on site without a direct access to the valve. The operator will set flow rates on the valve control panel stand. The valve control will be made, principally according to the direction from the CSS, to meet water demand in the service area.

2.4.3 Valve Chambers, Meter Boxes, etc.

All meters, valves and gauges except level meters are encased in chambers and boxes to protect the equipment from sunshine, humidity, precipitation and any other undesirable conditions. Followings are proposed design criteria for preliminary design of the above facilities:

1) In general, a meter and a valve are separately encased in underground chambers made of concrete. Pressure gauges are installed on the pipeline in the valve chambers.

2) A control panel consists of a controller for valve control, signal indicators and transmitters. The panel shall be encased in a steel-plate stand for easy access. The steel plate shall be coated with proper protection.

3) As previously mentioned, location of flow meters are carefully determined to assure uniform flow through the meters. It is recommended that the meter shall precede the flow control valve.

4) The valve control panel stand is encircled with fencing to avoid human access from disturbance.

Fig. III-2.1 CONCEPT OF CENTRAL SUPERVISORY SYSTEM

CENTRAL SUPERVISORY SYSTEM (CSS)

ON-LINE — NORTH REGION; ON-LINE — SOUTH REGION; MONTHLY REPORT — TOBAGO REGION

CENTER				
LOCATION OF CENTER	NORTH REGION	EXISTING CSS BUILDING (EXPANSION)	SOUTH REGION	TOBAGO REGION
SUPERVISORY EQUIPMENT TO BE INSTALLED AT CENTER	WORK STATION	COMPUTER SYSTEM AND GRAPHIC PANEL	WORK STATION	NONE
MONITORING ITEMS	FLOW	WATER FLOW, WATER LEVEL, WATER PRESSURE, VALVE & PUMP STATUS AND ALARM	FLOW	FLOW
REMOTE CONTROL AND OPERATION EQUIPMENT	NONE	PUMPS & VALVES AT BOOSTER PUMPING STATIONS FOR REMOTE OPERATION (AS SHOWN ON "*" OF THE BELOW TABLE)	NONE	NONE
	MONTHLY REPORT	ON - LINE	MONTHLY REPORT	MONTHLY REPORT

SITE				
EQUIPMENT TO BE INSTALLED AT SITE	NONE (EXISTINGS TO BE USED)	FLOW METER, LEVEL METER, PRESSURE GAUGE, CONTROL VALVE AND RTU AT STRATEGIC POINTS	NONE (EXISTINGS TO BE USED)	NONE (EXISTINGS TO BE USED)
FACILITIES TO BE SUPERVISED	see below	see below	see below	see below

North Region — PRODUCTION FACILITY (45)

N.C.	(7)	MEDIUM-(1)
		SMALL-(6)
N.E.	(12)	MEDIUM-(1)
		SMALL-(11)
N.W.	(16)	MEDIUM-(7)
		SMALL-(9)
POS	(10)	MEDIUM-(5)
		SMALL-(5)

Central — PRODUCTION FACILITY

N.C.	1	CARONI/ARENA W.T.P.	LARGE
	2	VALSAYN W.W.	MEDIUM
	3	TACARIGUA W.W.	MEDIUM
	4	LAS LOMAS W.W.	MEDIUM
	5	CAURA W.W.	MEDIUM
	6	AROUCA W.W.	SMALL
N.E.	7	NORTH OROPOUCHE W.W.	LARGE
	8	HOLLIS W.W.	LARGE
	9	GUANAPO W.W.	MEDIUM
	10	ARIPO W.W. (NEW)	MEDIUM
	11	ARIPO INT	MEDIUM
	12	QUARE INT (VALENCIA)	MEDIUM
	13	ARIMA WELL #6	SMALL
N.W.	14	EL SOCORRO W.W.	MEDIUM
SF/SC	15	CARLSEN FIELD W.W.	MEDIUM
S.E.	16	NAVET W.W.	LARGE

BOOSTER PUMPING STATION

N.C.	1	*TUNAPUNA B. P/S
	2	*VALSAYN B. P/S
N.E.	3	ARIMA B. P/S
	4	ARIPO B. P/S
N.W.	5	*EL SOCORRO B. P/S
SF/SC	6	*SAN FERNANDO B. P/S
S.E.	7	*MALGRETOUTE B. P/S
	8	*T.C.O. B. P/S

STORAGE LIFT PUMPING STATION

N.C.	1	*TUMPUNA S.L. P/S
S.E.	2	NAVET S.L. P/S

OFF-TAKE CONTROL VALVES

SERVICE STORAGE RESERVOIR

N.C.	1	MT. HOPE
	2	ST. AUGUSTINE
	3	ST. JOSEPH
N.E.	4	NORTH OROPOUCHE
	5	FORT READ
	6	ARIMA NEW
	7	ARIMA OLD
N.W.	8	MALLIC
POS	9	KNAGGS HILL
	10	PICTON # 1
	11	PICTON # 2
	12	PICTON # 3
SF/SC	13	CALIFORNIA
	14	SAN FERNANDO
	15	MARRYAT St.
	16	NAPARIMA

South Region — PRODUCTION FACILITY (21)

SF/SC	(1)	MEDIUM-(1)
S.E.	(8)	MEDIUM-(2)
		SMALL-(6)
S.W.	(12)	MEDIUM-(6)
		SMALL-(6)

Tobago Region — PRODUCTION FACILITY (14)

TOBAGO	(14)	MEDIUM-(7)
		SMALL-(7)

NOTE: N.C.; NORTH CENTRAL, N.E.; NORTH EAST, N.W.; NORTH WEST, POS; PORT OF SPAIN, SF/SC; SAN FERNANDO/SOUTH CENTRAL, S.E.; SOUTH EAST, S.W.; SOUTH WEST, W.T.P.; WATER TRATMENT PLANT, W.W.; WATERWORKS, INT; INTAKE, B. P/S: BOOSTER PUMPING STATION, S.L. P/S: STORAGE LIFT PUMPING STATION, (8): THE NUMBER OF FACILITIES IN EACH DISTRICT, MT.: MOUNT, ST.: SAINT, St.: STREET, F'TY: FACILITIES.

3. PRELIMINARY DESIGN AND SPECIFICATIONS

3.1 PRELIMINARY DESIGN

Major facilities to be constructed in Phase I Project are the CSS building, RTU stations, valve control panel stands, valve and meter chambers where monitoring and control equipment is installed. The new CSS building and the existing CSS building accommodate most engineers/staff and various instruments for the CSS respectively. In each RTU station, microprocessor controller with input/output interface will be installed to transfer information from valve control panel stands to the CSS via the repeater station in Pepper Hill. Valve control panel stands that encase signal indicators, transmitters, controller and panels will be constructed at the most appropriate place near off-takes of the water mains. Preliminary design of the CSS related facilities and monitoring and control units are prepared in consideration of the following:

1) Objectives of the project, basic concept and design criteria developed, which are described in the previous sections;

2) Project area, the existing pipe alignment and reservoirs, the existing CSS facilities, system operation and maintenance practiced by WASA;

3) Maximum utilization of indigenous materials and work forces;

4) Operational and institutional aspects of WASA who intends to push urgent implementation of the CSS.

In the succeeding paragraphs, main contexts of the preliminary design are explained further.

CSS Facilities

Fig. III-3.1 illustrates the arrangement of the CSS related facilities and data communication system while Fig. II-4.2 already shown in Part II also illustrates that of Phase II. Major differences of these figures are absence of the valve control panel with mini-graphic display in the CSS building and work station with CRT display at Tobago regional office.

Continuous variables (flow rate, pressure, water level) and discrete states (on/off, open/close) sensed at off-takes, waterworks, pumping stations and reservoirs are transmitted to the RTU stations in the form of electrical signal. After modulation at the RTU stations, radio transceivers emit signal to the repeater station at Pepper Hill where signals are relayed to the CSS building after conversion into the ultra high frequency (UHF). This process takes place according to the request from the CSS building. The water supply conditions thus sensed and transmitted will be displayed on the CRT display and the graphic panel after necessary data processing by central computer.

On the other hand, the direction from the CSS to operate the remote control pumping stations is transferred to the repeater station in the form of electrical signal. The repeater station converts signal into that of very high frequency (VHF). It is the RTU station that transfers signal to an actuator of the controlled equipment which physically moves the valves and pumps. Off-take valves are controlled on site by operators. Feedback control sequence designed for this purpose controls the flow rate in the pipeline.

Table III-3.1 lists the number and type of data monitored, monitoring and control equipment to be installed, while Figs. III-3.2 and III-3.3 show the proposed location of the monitoring and control equipment and RTU stations respectively.

Fig. III-3.4 shows proposed layout of CSS instruments in the CSS buildings. Major stresses are placed on the following three: 1) graphic panel and remote control panel for booster pumping stations are positioned in one room because of their close relation, 2) printers that may be a source of noise is isolated in the nearby repair room, and 3) rooms required for stationing planning and maintenance staff and officials are planned in the new CSS building to be constructed in the existing WASA's parking lot.

Fig. III-3.5(1) shows a process instrument diagram for control valves to be installed on the off-take from water mains. FIC examines the actual flow rate monitored at FI in comparison with the flow rate inputs given beforehand.

After comparison with these figures, FIC will close or open the valve to control flow rate emitting signal to the actuator. This is done repeatedly until the deviation becomes zero.

Fig. III-3.5(2) is also a process instrument diagram for operating booster pumping station from the CSS building. The data signals monitored at suction and discharge of the booster pumps are transferred to the CSS. The pumps and valves are usually operated from the control panel of the CSS building. In emergency case, they are operable on site using control switches mounted locally.

Fig. III-3.5(3) outlines the control circuit diagram for Tumpuna storage lift pumping station. Signals such as water levels in the Arena impounding reservoir and Tumpuna weir, inflow and outflow from the reservoirs are delivered to the CSS and displayed as LI and FI. Based on direction from the CSS, operating staff stationed in the Caroni Water Treatment Plant operates the valves and pumps.

<u>Monitoring and Control Unit</u>

Monitoring points as shown on Fig. III-3.2 are carefully selected through several times of field reconnaissance and interviews with the WASA counterparts and personnels. Off-takes from the major water mains from the four waterworks and the six major booster pumping stations are all considered as monitoring points. The equipment to be installed at the designated points for the CSS operation are summarized in Table III-3.1 which specifies also the number of the monitoring data and control methods and places.

As listed in the Table III-3.1, newly installed equipment are 11 differential type level meters, 10 float type level meters, 111 bourdon-tube type pressure gauges, 139 sets of annubar flow meters, 9 altitude valves, and 106 flow control butterfly valves. Others are the existing equipment to be utilized further after repair or replacement of the damaged peripherals.

3.2 AVAILABILITY OF EQUIPMENT, MATERIALS, ETC.

For preparing a preliminary design of the proposed system, the availability of materials and equipment in Trinidad and Tobago is one of the key factors to be considered. It seems most appropriate to follow the WASA's established practices for procurement in order to minimize time losses anticipated during project implementation.

There are many manufacturers intensively engaged in producing construction materials in Trinidad and Tobago. Construction materials required for constructing the new CSS building, RTU stations and valve chambers are easily procured in the country. Materials and equipment not locally manufactured are mainly the CSS hardware and most of piping materials and fittings. They are usually imported from overseas as have been experienced by WASA through the previous similar projects. Sources of supply and work are presented in the table which follows:

MATERIALS & EQUIPMENT	IMPORTED OR PROCURED LOCALLY
1) Building materials	
-Cement, sand, cobbles and gravel	Procured locally
-Steel bar, roofing materials	Procured locally
-Slate, sash, glass, etc.	Procured locally
2) Valves, meters and gauges	
-PVC & Steel pipes and fittings	Procured locally
-Piping materials (DCIP)	Imported
-Pumps and valves	Imported
-Level and flow meters	Imported
-Pressure gauges	Imported
-Piping equipment and tools	Imported
3) Chambers, boxes and local valve control panel stands	
-Valve chambers	Constructed at site
-Meter chambers	Constructed at site
-Valve control panel stand	Imported
-RTU station	Constructed at site
-CSS building	Constructed at site
4) CSS hardware	
-CSS instruments	Imported
-Graphic panel	Imported
-CRT	Imported
-RTU	Imported
-Uninterruptible power supply	Imported
-Control panel	Imported

The Phase I Project focussed on in this Part III contains following major civil works:

1) Earth work including excavation, backfilling, sheet piling and pavement for building RTU station, valve chambers, etc.,

2) Concrete work for constructing the new CSS building, RTU stations, valve and flow meter chambers,

3) Piping work including cutting, welding, jointing, meter/valve installation on the existing water mains and off-takes,

4) Installation of valve control panel stands to encase electrical instruments including construction of the foundation, landscaping, fencing, etc., and

5) Installation of CSS instruments in the existing CSS center building and RTU stations.

There are many local contractors officially registered, who are intensively involving in various public works, constructing many modern buildings, roads and bridges in the country. They have experienced construction of waterworks facilities and pipe laying works in the past similar water supply projects.

In consideration of the nature of the civil works contained in the present Project, any special skills and expertise are not required for the construction and installation, except the work item 5) above. Most of civil contractors in the country have sufficient capacity and experiences in such field of the civil work. As for the item 5), manufacturers involvement in the work may be indispensable because of their proprietary nature. It is desirable that local contractors install the CSS instruments under technical guidance and directions by manufacturers.