CHAPTER 5 PLAN OF WATER SUPPLY FOR SMALL RURAL AREA

Deep wells were applied for water resources development in small rural areas. Assuming that a deep well is installed in each village with 100 inhabitants by unit supply rate of 70 lit./capita/day, a deep well should supply 7 m³/day of residential water. As expected yield in Sergipe State is estimated to be 40~600m³/day, a deep well has enough water potential. Taking into account of 10% of water loss rate and fresh water rate according to aquifers, the required number of wells and desalinizers in 2020 is estimated by municipalities and shown in Table-5.2.

The plan of water resources development and supply is shown in Table-5.1 and Figure-5.1. Additionally, present water supply facilities is planned to be gradually replaced to private-tap systems, then present water supply capacity will be decreased toward 2020.

Table-5.1 Plan of Water Resources Development and Supply for Small Rural Area

PRESENT WATER SUPPLY SYSTEM						
Name	Water Source			Present Water Supply Capacity		
Small Rural Area (Single Well System)	Deep Well Development			2,333 m³/day		
POPULATION PROJECTION						
Items	1997	2000	2005	2010	2015	2020
Population	144,907	144,750	145,802	148,735	154,000	162,311
WATER DEMAND PROJECTION						
Items	1997	2000	2005	2010	2015	2020
<Municipal Water>						
Unit Consumption Rate (lit/day/capita)	70	70	70	70	70	70
Water Demand (m³/day)	10,143	10,132	10,206	10,411	10,780	11,362
Water Supply Rate (%)	48.4	52.7	59.9	67.3	75.1	83.3
Planned Water Consumption (m³/day)	4,913	5,343	6,119	7,012	8,092	9,468
Water Loss Rate (%)	10	10	10	10	10	10
Necessary Water Supply (m³/day)	5,458	5,936	6,798	7,791	8,991	10,520
Supply Water Shortage (m³/day)	3,125	3,755	4,871	6,117	7,571	9,353
WATER SUPPLY PROGRAM						
Items	1997	2000	2005	2010	2015	2020
Present Supply Capacity (m³/day)	2,333	2,181	1,928	1,674	1,420	1,167
(1) Deep Well Development	0	1,220	3,253	5,286	7,320	9353
Planned Water Supply (m³/day)	2,333	3,401	5,181	6,960	8,740	10,520

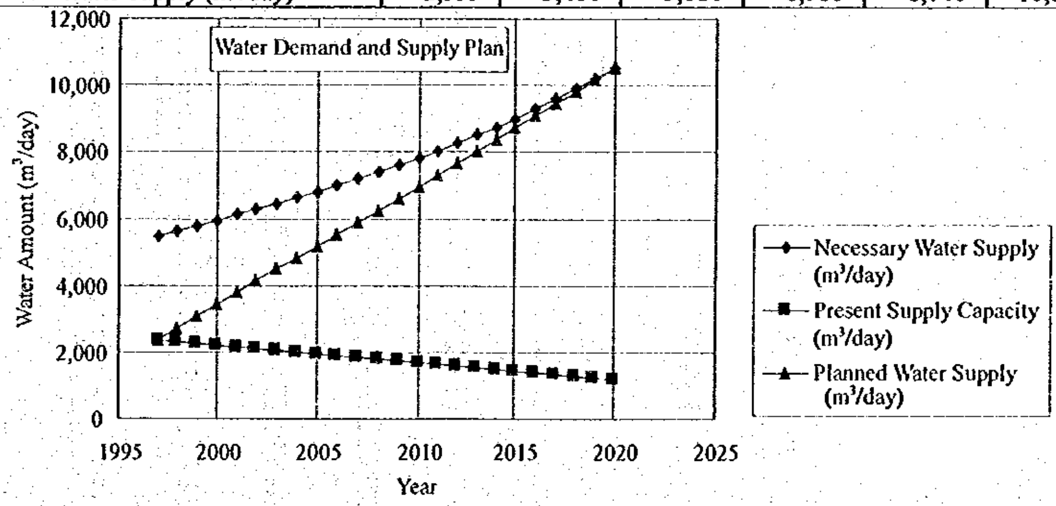


Figure-5.1 Plan of Water Resources Development and Supply for Small Rural Area

Table-5.2 Plan of Small Rural Water Supply in 2020

Region		Population (person)	Beneficiaries (person)	Present Water Supply Capacity (m^3/day)		Necessary Water Supply (m^3/day)	Supply Water Shortage (m^3/day)	Supply Water Shortage Rate (%)	Source Water Shortage (m^3/day)	Number of Deep Well	Number of Desalinizer
				1,997	2,020						
SERGIPE		162,311	120,259	2,333	1,167	10,520	9,353	401	11,689	1,242	566
MICRO-REGION											
01- Sergipana do Sertao do Sao Francisco		14,046	10,419	200	100	910	810	405	1,012	110	99
02- Carira		7,040	4,452	220	110	456	346	157	507	47	36
03- Nossa Senhora das Dores		6,635	4,458	167	83	430	347	208	478	48	40
04- Agreste de Itabaiana		22,320	16,114	387	193	1,447	1,253	324	1,607	165	95
05- Tobias Barreto		10,882	7,012	320	160	705	545	170	784	72	41
06- Agreste de Lagarto		16,715	12,579	210	105	1,083	978	466	1,204	127	64
07- Propria		7,174	5,507	73	37	465	428	584	517	60	31
08- Cotinguiba		5,092	3,922	50	25	330	305	610	367	41	25
09- Japaratuba		7,679	5,457	147	73	498	424	289	553	58	11
10- Baixo Cotinguiba		2,735	1,915	57	28	177	149	263	197	22	9
11- Aracaju		19,223	15,954	10	5	1,246	1,241	12,409	1,384	160	3
12- Boquim		27,663	21,102	303	152	1,793	1,641	541	1,992	216	92
13- Estancia		15,108	11,368	190	95	979	884	465	1,088	116	20
MUNICIPALITY											
01-0120	Caninde do Sao Francisco	2,866	2,002	60	30	186	156	260	206	21	18
01-0220	Feira Nova	230	106	13	7	15	8	62	17	2	2
01-0240	Gararu	1,867	1,384	27	13	121	108	404	134	14	12
01-0260	Gracho Cardoso	743	448	27	13	48	35	131	53	5	5
01-0310	Itabi	488	342	10	5	32	27	266	35	4	4
01-0420	Monte Alegre de Sergipe	1,122	849	13	7	73	66	495	81	9	8
01-0450	Nossa Senhora da Gloria	1,750	1,351	17	8	113	105	631	126	14	12
01-0540	Poco Redondo	1,623	1,224	20	10	105	95	476	117	13	12
01-0560	Porto da Folha	3,358	2,712	13	7	218	211	1,582	242	28	26
02-0140	Carira	2,443	1,864	27	13	158	145	544	176	19	16
02-0230	Frei Paulo	1,712	1,041	60	30	111	81	135	123	11	8
02-0445	Nossa Senhora Aparecida	850	430	43	22	55	33	77	61	5	4
02-0500	Pedra Mole	562	383	13	7	36	30	223	40	4	3
02-0520	Pinhao	504	248	27	13	33	19	72	36	3	2
02-0600	Ribeiropolis	969	486	50	25	63	38	76	70	5	3
03-0020	Aquidaba	2,540	1,838	43	22	165	143	330	183	19	17
03-0190	Cumbe	412	215	20	10	27	17	84	30	3	3
03-0380	Malhada dos Bois	490	408	0	0	32	32	-	35	5	4
03-0430	Muribeca	1,061	777	17	8	69	60	363	76	8	5
03-0460	Nossa Senhora das Dores	1,735	1,060	60	30	112	82	137	125	11	9
03-0700	Sao Miguel do Aleixo	397	160	27	13	26	12	47	29	2	2
04-0050	Areia Branca	5,086	4,002	37	18	330	311	849	366	41	15
04-0100	Campo do Brito	2,111	1,331	67	33	137	104	155	152	14	10
04-0290	Itabaiana	7,513	5,382	137	68	487	419	306	541	54	36
04-0370	Macambira	1,145	761	30	15	74	59	197	82	8	5
04-0390	Malhador	2,655	2,041	27	13	172	159	595	191	21	12
04-0410	Moita Bonita	2,585	1,768	60	30	168	138	229	186	18	12
04-0680	Sao Domingos	1,225	828	30	15	79	64	215	88	9	5
05-0550	Poco Verde	1,503	631	97	48	97	49	51	108	7	4
05-0710	Simao Dias	4,876	3,142	143	72	316	244	170	351	32	20
05-0740	Tobias Barreto	4,503	3,239	80	40	292	252	315	324	33	17
06-0350	Lagarto	12,045	8,966	167	83	781	697	418	867	90	41
06-0580	Riachao do Dantas	4,670	3,613	43	22	303	281	649	336	37	23
07-0010	Amparo de Sao Francisco	289	241	0	0	19	19	-	21	3	3
07-0070	Brejo Grande	677	500	10	5	44	39	389	49	6	0
07-0110	Canhoba	639	468	10	5	41	36	364	46	5	5
07-0160	Cedro de Saò Joao	386	279	7	3	25	22	325	28	3	3
07-0270	Ilha das Flores	1,444	1,204	0	0	94	94	-	104	13	0
07-0440	Neopolis	615	298	33	17	40	23	70	44	3	1
07-0470	Nossa Senhora de Lourdes	1,218	994	3	2	79	77	2,319	88	10	9
07-0570	Propri	951	728	10	5	62	57	566	68	8	3
07-0730	Telha	788	657	0	0	51	51	-	57	7	6
07-0999	Santana do Sao Francisco	165	137	0	0	11	11	-	12	2	1
08-0130	*Capela*	2,888	2,235	27	13	187	174	652	208	23	19
08-0200	Divina Pastora	437	343	3	2	28	27	800	31	4	2
08-0650	Santa Rosa de Lima	226	167	3	2	15	13	389	16	2	1
08-0720	*Siriri*	1,541	1,177	17	8	100	92	549	111	12	3
09-0330	Japaratuba	2,230	1,516	53	27	145	118	221	161	16	3
09-0340	Japoata	1,743	1,260	30	15	113	98	327	126	13	3
09-0490	Pacatuba	2,065	1,528	30	15	134	119	396	149	16	2
09-0530	Pirambu	1,384	1,004	23	12	90	78	335	100	11	2
09-0690	Sao Francisco	257	150	10	5	17	12	117	19	2	1
10-0150	*Carmopolis*	309	257	0	0	20	20	-	22	3	1
10-0250	General Maynard	339	239	7	3	22	19	279	24	3	1
10-0360	Laranjeiras	117	76	3	2	8	6	177	8	1	1
10-0400	Maruim	1,150	830	20	10	75	65	323	83	9	3
10-0590	Riachuelo	209	174	0	0	14	14	-	15	2	1
10-0610	Rosario do Catete	320	267	0	0	21	21	-	23	3	1
10-0660	Santo Amaro das Brotas	291	71	27	13	19	6	21	21	1	1
11-0030	Aracaju	0	0	0	0	0	0	-	0	0	0
11-0060	Barra dos Coqueiros	17,569	14,598	7	3	1,139	1,135	17,031	1,265	146	0
11-0480	Nossa Senhora do Socorro	471	393	0	0	31	31	-	34	4	1
11-0670	*Sao Cristovao*	1,183	964	3	2	77	75	2,249	85	10	2
12-0010	Araua	1,677	1,205	30	15	109	94	312	121	13	7
12-0067	Boquim	2,004	1,263	63	32	130	98	155	144	13	6
12-0170	Cristinapolis	6,088	4,966	17	8	395	385	2,318	438	50	20
12-0300	Itabaianinha	5,965	4,414	87	43	387	343	396	430	45	27
12-0510	Pedrinhas	702	512	7	3	45	42	632	51	6	2
12-0620	Salgado	3,876	3,016	33	17	251	235	701	279	31	5
12-0750	Tomar do Geru	3,599	2,806	30	15	233	218	728	259	29	16
12-0760	Umbauba	3,752	2,891	37	18	243	225	613	270	29	9
13-0210	*Estancia*	6,574	5,114	57	28	426	398	702	473	52	8
13-0280	Indiaroba	2,413	1,754	40	20	156	136	341	174	18	4
13-0320	Itaporanga d'Ajuda	2,345	1,526	67	33	152	119	178	169	16	3
13-0630	Santa Luzia do Itanhy	3,775	2,974	27	13	245	231	867	272	30	5

CHAPTER 6 PLAN OF IRRIGATION WATER SUPPLY

Irrigation water resources development plan is proposed in Table-6.1. Of the eight proposed projects, water resources development for Sao Francisco and Vaza Barris projects are newly proposed as following multi-purpose projects with domestic and industrial water supply project.

- Xingo Dam Pipeline Project
- Vaza Barris Dam Project

Another six projects were proposed by COHIDRO. In view of water resources, the three irrigation projects to draw water from Sao Francisco River have no water source problem because of plenty water resources. The Ladeirinhas irrigation projects is located in the east side of Sergipe State, around where has large surface potential. Although Mundeu River has no flow data, Santo Antonio River near Ladeirinhas site has abundant surface potential of about 140 $m^3/s/km^2$ of (Q7,10) discharge. The irrigation projects of Entre Rios and Estancinha are located in Piauitinga River Basin, which has surface potential of 50-120 $m^3/s/km^2$ of (Q7,10) discharge. Therefore these irrigation projects are estimated to be feasible in view of water resources.

Table-6.1 Plan of Irrigation Water Resources Development

Project Name	Irrigation Area (ha)	Peak Irrigation Water (m^3/s)	Water Sources	Water Resources Development Plan
Quixabeira	3,668	2.944	SFR: Direct Intake from Xingo Dam Reservoir	The irrigation site is located 11 km upstream from the dam. Thus irrigation water should be abstracted from the Xingo Dam reservoir with direct intake facilities.
Jacare-Curituba	3,681	3.051	SFR: Xingo Dam Conduit	This is a on-going project, which has been constructing pipeline from Xingo Dam conduit to the irrigation site.
Sao Francisco	16,000	10.454	SFR: Xingo Dam Conduit	To utilize the water from two conduits prepared for Sergipe State. This project should be implemented as a multi-purpose project with domestic and industrial water supply sector.
Ladeirinhas	890	0.721	Mundeu R / JR: New Dam	The irrigation site is located in the place with high potential of both surface water and groundwater as well as water quality. Mundeu River Dam to be constructed is the water sources of irrigation.
Jacarecica II	1,100	1.097	Jacarecica R / SR: Jacarecica II Dam	The dam construction, which has been implemented by CEHOP, is almost complete but the irrigation pipeline and land reclamation has not yet been constructed.
Vaza Barris	2,500	2.912	VR: Vaza Barris Dam	The dam is planned in the main stream of Vaza Barris River at 2 km downstream from the Ribeira River confluence. This project should be implemented as a multi-purpose project with domestic and industrial water supply sector.
Entre Rios	261	0.180	Grotao R. or Quebradas R. and Piauitinga R/PR: Direct Intake	The irrigation site is located in the place with high potential of both surface water and groundwater as well as water quality. Since water requirement is small, direct intake from Quebrados River and Piauitinga River is estimated to be possible.
Estancinha	109	0.062	Piauitinga River	The irrigation site is located in the place with high potential of both surface water and groundwater as well as water quality. Since water requirement is small, direct intake from Piauitinga River is estimated to be possible.

CHAPTER 7 WATER RESOURCES DEVELOPMENT PLAN FOR RIVER BASINS

7.1 Plan of Sao Francisco River Basin

(1) Water Demand and Shortage

Water demand and shortage in Sao Francisco River basin is estimated as shown in Table-7.1.

Table-7.1 Water Demand and Shortage in Sao Francisco River Basin

River	Year	1997	1998	2000	2005	2010	2015	2020
Urban and Large Rural Area	Water Demand (m^3/day)	34,679	35,502	37,150	47,808	60,945	77,542	98,762
	Private Industrial Water (m^3/day)	6,773	7,170	7,964	11,620	15,725	20,240	24,418
	Necessary Supply Water (m^3/day)	40,744	41,294	42,395	52,108	63,609	78,080	97,646
	-Industrial Water	370	387	421	2,508	6,549	13,189	24,100
	-Municipal Water: Urban Area	31,660	32,169	33,188	40,788	48,234	56,050	64,675
	-Municipal Water: Large Rural Area	8,714	8,738	8,786	8,813	8,825	8,840	8,871
	Current Water Supply Capacity (m^3/day)	28,472	28,472	28,472	28,472	28,472	28,472	28,472
	Supply Water Shortage (m^3/day)	12,273	12,823	13,923	23,637	35,137	49,608	69,175
	Supply Water Shortage Rate (%)	43	45	49	83	123	174	243
	Source Water Shortage (m^3/day)	14,727	15,387	16,708	28,364	42,164	59,530	83,010
Small Rural Area	Water Demand (m^3/day)	2,332	2,306	2,255	2,147	2,060	1,992	1,941
	Necessary Supply Water (m^3/day)	866	914	1,010	1,231	1,432	1,619	1,797
	Current Water Supply Capacity (m^3/day)	369	361	345	305	265	225	185
	Supply Water Shortage (m^3/day)	496	553	665	926	1,167	1,394	1,612
	Supply Water Shortage Rate (%)	134	154	193	303	440	620	873
	Source Water Shortage (m^3/day)	866	914	1,010	1,231	1,432	1,619	1,797

(2) Plan of Water Resources Development and Supply

Plan of water resources development and supply in Sao Francisco River basin for the target year 2020 is shown in Table-7.3 and Figure-7.1. Source water to be developed within the basin and supply water to be consumed inside of the basin are explained in Table-7.2 and summarized as follows:

- As for urban and large rural water supply, 242 thousand m^3/day of water is newly developed within the basin. Of this source water, 69 thousand m^3/day (29 %) of water is supplied to the own basin and 173 thousand m^3/day (71 %) to other basins. Supply water into the basin is supplied with almost 100% from the own basin.
- Surface water is the main source in the basin, accounting for 98 % in domestic/industrial water supply and for 99.7 % include irrigation water.
- Irrigation water is supplied from the own basin by surface water, occupying 85 % of total inner source water.

Table-7.2 Source and Supply Water in Sao Francisco River

Item	U/L Rural			S Rural	Irrigation	Total		
	S/W	G/W	Total	G/W	S/W	S/W	G/W	Total
Source water to inner basin	66,525	2,565	69,090	1,612	1,421,227	1,487,752	4,177	1,491,929
Source water to outer basin	172,816	49	172,865	-	-	172,816	49	172,865
Total inner source water	239,341	2,614	241,955	1,612	1,421,227	1,660,568	4,226	1,664,794
Supply water from inner source	66,525	2,565	69,090	1,612	1,421,227	1,487,752	4,177	1,491,929
Supply water from outer source	0	85	85	-	-	0	85	85
Total supply water	66,525	2,650	69,175	1,612	1,421,227	1,487,752	4,262	1,492,014

Note: Source water in U/L rural is expressed as supply water base.

Table-7.3 Water Resources Development Plan of Sao Francisco River Basin

Project	Water Resources	Source Water Development (m^3/day)	Benefited Municipality	Supply Water (m^3/day) Total	Inner Water Source	Outer Water Source
Municipal/Industrial Water Supply	Surface Water	287,211	-	239,341	66,525	172,816
	Groundwater	4,853	-	4,311	4,262	49
Urban and Large Rural Area (Total)	Surface Water	287,211	-	239,341	66,525	172,816
	Groundwater	3,241	-	2,699	2,650	49
Urban and Large Rural Area (Inside)	Surface Water	287,211	-	239,341	66,525	172,816
	Groundwater	3,139	-	2,614	2,565	49
Urban and Large Rural Area (Outside)	Surface Water	0	-	0	0	0
	Groundwater	102	-	85	85	0
Integrated System (Total)	Surface Water	256,531	-	213,776	40,960	172,816
	Groundwater	0	-	0	0	0
Integrated System (Inside)	Surface Water	256,531	-	213,776	40,960	172,816
	Groundwater	0	-	0	0	0
Integrated System (Outside)	Surface Water	0	-	0	0	0
	Groundwater	0	-	0	0	0
Sao Francisco	SFR: Direct Intake at Propria (north)	181,919	Total	151,600	0	151,600
			Laranjeiras (SR)	61,090	0	61,090
			Aracaju (SR/VR)	63,799	0	63,799
			N. S. do Socorro (SR)	26,711	0	26,711
Xingo Dam	SFR: Xingo Dam Conduit	52,799	Total	43,999	25,260	18,739
			Caninde do S. F.	18,484	18,484	0
			N. S. da Gloria	13,473	6,776	6,697
			Carira	3,033	0	3,033
			Frei Paulo	3,031	0	3,031
			N. S. Aparecida	831	0	831
			Pedra Mole	186	0	186
			Pinhao	797	0	797
			Ribeiropolis	2,064	0	2,064
			Sao Miguel do A.	226	0	226
			Moita Bonita	1,875	0	1,875
Propria	SFR: Direct Intake at Propria (south)	7,427	Total	6,189	6,173	16
			Malhada dos Bois	830	814	16
			Cedro de Sao Joao	155	155	0
			Propria	5,097	5,097	0
			Telha	107	107	0
Alto Sertao	SFR: Direct Intake at Amparo do Sao Francisco	6,594 New Dev. 1,879	Total	5,495	5,495	0
			Monte Alegre de S.	2,507	2,507	0
			Poco Redondo	1,808	1,808	0
			Porto da Folha	1,180	1,180	0
Sertaneja	SFR: Direct Intake at Porto da Folha	7,792 New Dev. 0	Total	6,493	4,032	2,461
			Feira Nova	1,891	0	1,891
			Gararu: (half of large Rural)	135	135	0
			Gracho Cardoso	416	221	195
			Itabi	387	387	0
			Aquidaba	2,202	2,179	23
			Cumbe	287	0	287
			Amparo de S. F.	126	126	0
			Canhoba	0	0	0
			N. S. de Lourdes	1,050	1,050	0
Independent System (Total)	Surface Water	30,680	-	25,565	25,565	0
	Groundwater	3,241	-	2,699	2,650	49
Independent System (Inside)	Surface Water	30,680	-	25,565	25,565	0
	Groundwater	3,139	-	2,614	2,565	49
Independent System (Outside)	Surface Water	0	-	0	0	0
	Groundwater	102	-	85	85	0
Gararu (Urban and Half of Large Rural)	SFR: Direct Intake	612	Gararu (urban and half of large rural)	510	510	0
Muribeca	*Deep Well: 0/7 wells*	*2*	*Muribeca*	*2*	*2*	-
Brejo Grande	Deep Well: 2/2 wells	867	Brejo Grande	722	722	0
Ilha das Flores	Deep Well: 2/2 wells	946	Ilha das Flores	788	788	0
Neopolis	SFR: Direct Intake	20,300	Neopolis	16,916	16,916	0
Santana do Sao Francisco	SFR: Direct Intake	4,610	Santana do S. F.	3,841	3,841	0
Japaratuba	*Deep Well: 0/16 wells*	*100*	*Japaratuba*	*83*	*83*	-
Japoata	Deep Well: 4/4 wells	566	Japoata	471	436	35
Pacatuba	Santo Antonio R./ Betume R./ SFR	5,158	Pacatuba	4,298	4,298	0
Pirambu	Deep Well: 1/7 wells	312	Pirambu	260	260	0
Sao Francisco	Deep Well: 4/4 wells	448	Sao Francisco	373	359	14
Small Rural Area	Groundwater	1,612	-	1,612	1,612	0
Single Well System	Deep Well: 217 wells	1,612	-	1,612	1,612	0
Irrigation W. Supply	Surface Water	1,421,227	-	1,421,227	1,421,227	0
Quixabeira	SFR: Direct Intake from Xingo Dam Reservoir	254,394	-	254,394	254,394	0
Jacare-Curituba	SFR: Xingo Dam Conduit	263,607	-	263,607	263,607	0
Sao Francisco	SFR: Xingo Dam Conduit	903,226	-	903,226	903,226	0

Note: Italic characters mean outer water resources of this river basin.

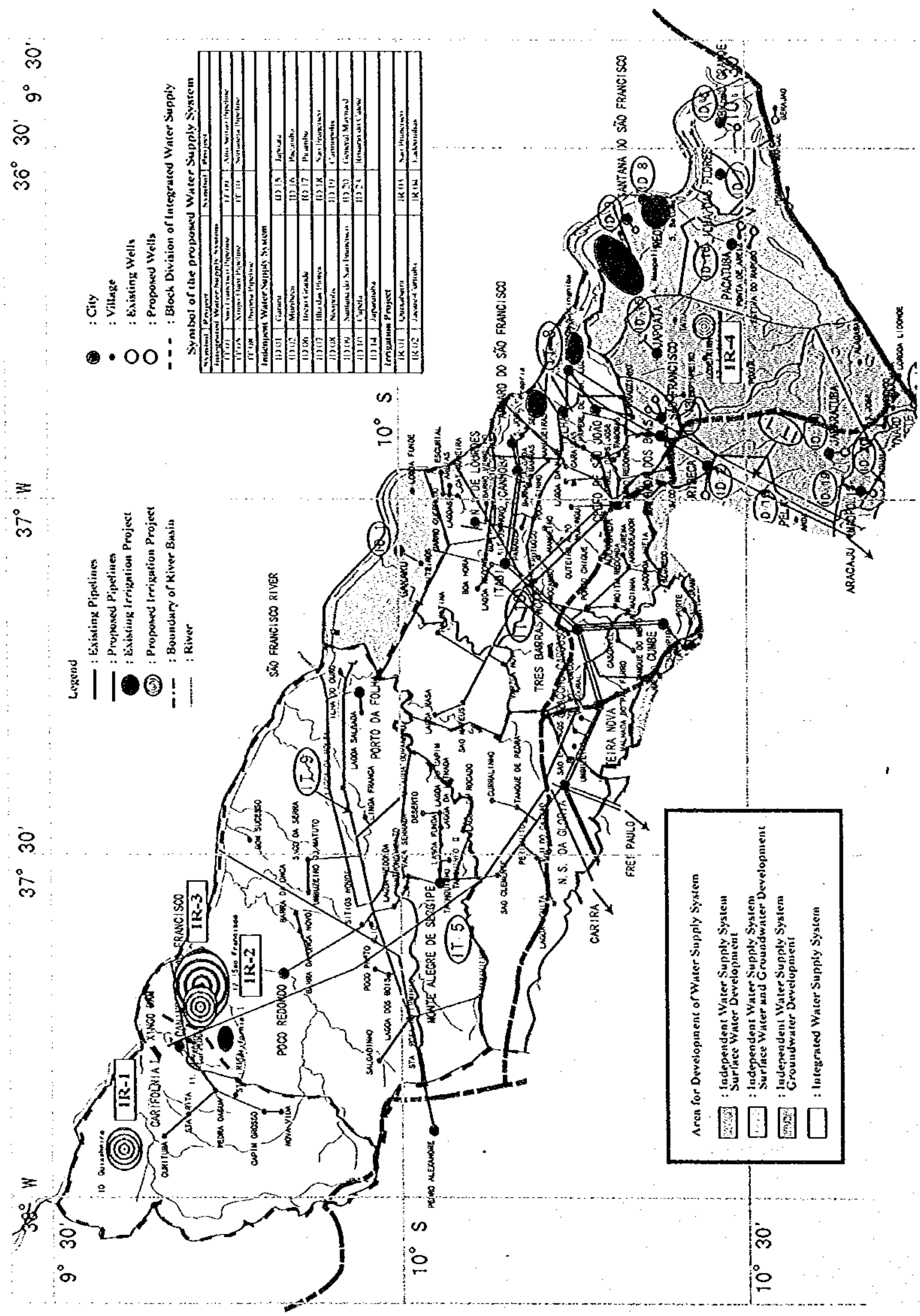


Figure-7.1 Water Resources Development Plan of Sao Francisco River Basin

7.2 Plan of Japaratuba River Basin

(1) Water Demand and Shortage

Water demand and shortage in Japaratuba River basin is estimated as shown in Table-7.4.

Table-7.4 Water Demand and Shortage in Japaratuba River Basin

River	Year	1997	1998	2000	2005	2010	2015	2020
Urban and Large Rural Area	Water Demand (m^3/day)	27,816	28,982	31,313	39,583	50,018	63,303	80,271
	Private Industrial Water (m^3/day)	15,791	16,717	18,569	23,324	28,660	35,239	42,891
	Necessary Supply Water (m^3/day)	18,140	18,405	18,935	23,645	30,183	38,316	49,174
	Industrial Water	4	5	5	2,362	6,381	11,670	19,183
	Municipal Water: Urban Area	15,525	15,746	16,186	18,326	20,593	23,109	25,998
	Municipal Water: Large Rural Area	2,611	2,655	2,744	2,958	3,210	3,537	3,993
	Current Water Supply Capacity (m^3/day)	14,312	14,312	14,312	14,312	14,312	14,312	14,312
	Supply Water Shortage (m^3/day)	3,828	4,093	4,623	9,333	15,871	24,004	34,862
	Supply Water Shortage Rate (%)	27	29	32	65	111	168	244
	Source Water Shortage (m^3/day)	4,594	4,911	5,547	11,199	19,045	28,805	41,834
Small Rural Area	Water Demand (m^3/day)	754	755	757	768	788	821	873
	Necessary Supply Water (m^3/day)	415	427	451	516	592	685	809
	Current Water Supply Capacity (m^3/day)	177	173	165	146	127	108	89
	Supply Water Shortage (m^3/day)	238	254	285	370	465	578	720
	Supply Water Shortage Rate (%)	134	147	173	253	366	536	814
	Source Water Shortage (m^3/day)	498	512	541	619	710	822	971

(2) Plan of Water Resources Development and Supply

Plan of water resources development and supply in Japaratuba River basin for the target year 2020 is shown in Table-7.6 and Figure-7.2. Source water to be developed within the basin and supply water to be consumed inside of the basin are explained in Table-7.5 and summarized as follows:

- As for urban and large rural water supply, 35.2 thousand m^3/day of water is newly developed within the basin. Of this source water, 33.2 thousand m^3/day (94 %) of water is supplied to the own basin and 2.0 thousand m^3/day (6 %) to other basins. Supply water into the basin is supplied with 95% from the own basin.
- Surface and ground water sources in the basin is nearly equal, accounting for 48 % and 52 % respectively in water supply for urban and large rural area, but 81 % and 19 % if including small rural and irrigation water supply.
- Irrigation water is supplied from the own basin by surface water, occupying 63 % of total inner source water.

Table-7.5 Source and Supply Water in Japaratuba River

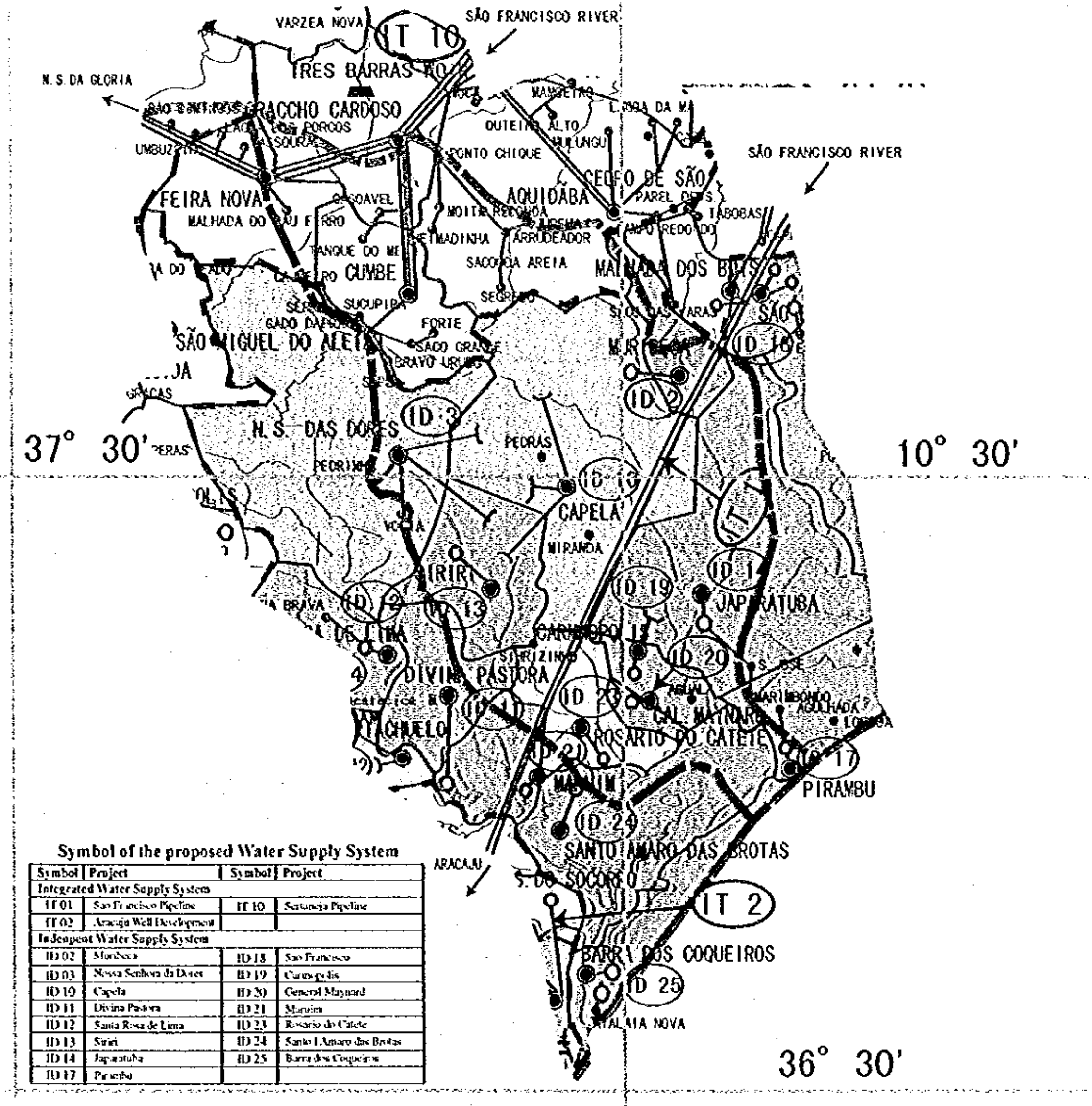
Item	U/L Rural			S Rural	Irrigation	Total		
	S/W	G/W	Total	G/W	S/W	S/W	G/W	Total
Source water to inner basin	15,025	18,204	33,229	720	62,300	77,325	18,924	96,249
Source water to outer basin	1,871	99	1,970	-	-	1,871	99	1,970
Total inner source water	16,896	18,303	35,199	720	62,300	79,196	19,023	98,219
Supply water from inner source	15,025	18,204	33,229	720	62,300	77,325	18,924	96,249
Supply water from outer source	1,493	140	1,633	-	-	1,493	140	1,633
Total supply water	16,518	18,344	34,862	720	62,300	78,818	19,064	97,882

Note: Source water in U/L rural is expressed as supply water base.

Table-7.6 Water Resources Development Plan of Japaratuba River Basin

Project	Water Resources	Source Water Development (m^3/day)	Benefited Municipality	Supply Water (m^3/day) Total	Inner Water Source	Outer Water Source
Municipal/Industrial Water Supply	Surface Water	35,495	-	29,578	16,518	13,060
	Groundwater	22,854	-	19,023	19,061	99
Urban and Large Rural Area (Total)	Surface Water	35,495	-	29,578	16,518	13,060
	Groundwater	22,134	-	18,303	18,344	99
Urban and Large Rural Area (Inside)	Surface Water	20,276	-	16,896	15,025	1,871
	Groundwater	21,966	-	18,303	18,204	99
Urban and Large Rural Area (Outside)	Surface Water	15,219	-	12,682	1,493	11,189
	Groundwater	168	-	140	140	0
Integrated System (Total)	Surface Water	15,219	-	12,682	1,493	11,189
	Groundwater	0	-	0	0	0
Integrated System (Inside)	Surface Water	0	-	0	0	0
	Groundwater	0	-	0	0	0
Integrated System (Outside)	Surface Water	15,219	-	12,682	1,493	11,189
	Groundwater	0	-	0	0	0
Propria	*SFR: Direct Intake at Propria (south)*	*7,427*	*Total*	*6,189*	*16*	*6,173*
			Malhada dos Bois	*830*	*16*	*814*
			Cedro de Sao Joao	*155*	*0*	*155*
			Propria	*5,097*	*0*	*5,097*
			Telha	*107*	*0*	*107*
Sertaneja	*SFR: Direct Intake at Porto da Folha*	*7,792* *New Dev: 0*	*Total*	*6,493*	*1,477*	*5,016*
			Feira Nova	*1,891*	*972*	*919*
			Gararu (half of large Rural)	*135*	*0*	*135*
			Gracho Cardoso	*416*	*195*	*221*
			Itabi	*387*	*0*	*387*
			Aquidaba	*2,202*	*23*	*2,179*
			Cumbe	*287*	*287*	*0*
			Amparo de S. F.	*126*	*0*	*126*
			Canhoba	*0*	*0*	*0*
			N. S. de Lourdes	*1,050*	*0*	*1,050*
Independent System (Total)	Surface Water	20,276	-	16,896	15,025	1,871
	Groundwater	22,134	-	18,443	18,344	99
Independent System (Inside)	Surface Water	20,276	-	16,896	15,025	1,871
	Groundwater	21,966	-	18,303	18,204	99
Independent System (Outside)	Surface Water	0	-	0	0	0
	Groundwater	168	-	140	140	0
Muribeca	Deep Well. 7/7 wells	558	Muribeca	465	463	2
Nossa Senhora das Dores	Pinol R / Siriri R / JR	3,963	Nossa Senhora das Dores	3,302	1,440	1,862
Capela	Siriri R./JR, Adeira R./JR	8,033	Capela	6,694	6,694	0
Divina Pastora	*Deep Well: 0 4 wells*	*26*	*Divina Pastora*	*22*	*22*	-
Siriri	Deep Well: 4/5 wells	618	Siriri	515	515	0
Japaratuba	Deep Well: 16/16 wells	3,353	Japaratuba	2,794	2,711	83
Japoata	*Deep Well: 0 4 wells*	*42*	*Japoata*	*35*	*35*	-
Pirambu	Deep Well: 6/7 wells	2,286	Pirambu	1,905	1,905	0
Sao Francisco	*Deep Well: 0 4 wells*	*17*	*Sao Francisco*	*14*	*14*	-
Carmopolis	Deep Well: 4/4 wells	1,070	Carmopolis	891	891	0
General Maynard	Deep Well: 3/3 wells	466	General Maynard	388	388	0
Maruim	*Deep Well: 0 19 wells*	*48*	*Maruim*	*40*	*40*	-
Rosario do Catete	Siriri R./ JR	8,280	Rosario do Catete	6,900	6,891	9
	Deep Well: 50/50 wells	12,758		10,631	10,617	14
Santo Amaro das Brotas	*Deep Well: 0 3 wells*	*35*	*Santo Amaro das Brotas*	*29*	*29*	-
Barra dos Coqueiros	Deep Well: 1/13 wells	857	Barra dos Coqueiros	714	714	0
Small Rural Area	Groundwater	720	-	720	720	0
Single Well System	Deep Well: 104 wells	720	-	720	720	0
Irrigation W. Supply	Surface Water	62,300	-	62,300	62,300	0
Ladeirinhas	Mundeu R / JR: New Dam	62,300	-	62,300	62,300	0

Note: Italic characters mean outer water resources of this river basin.



Symbol of the proposed Water Supply System

Symbol	Project	Symbol	Project
Integrated Water Supply System			
IT 01	San Francisco Pipeline	IT 10	Sertaneja Pipeline
IT 02	Aracaju Well Development		
Indepent Water Supply System			
ID 02	Muribeca	ID 18	Sao Francisco
ID 03	Nossa Senhora da Dores	ID 19	Carmopolis
ID 10	Capela	ID 20	General Maynard
ID 11	Divina Pastora	ID 21	Maruim
ID 12	Santa Rosa de Lima	ID 23	Rosario do Catete
ID 13	Siriri	ID 24	Santo I Amaro das Brotas
ID 14	Japaratuba	ID 25	Barra dos Coqueiros
ID 17	Pirambu		

Area for Development of Water Supply System

- : Independent Water Supply System Surface Water Development
- : Independent Water Supply System Surface Water and Groundwater Development
- : Independent Water Supply System Groundwater Development
- : Integrated Water Supply System

Legend

- : Existing Pipelines
- : Proposed Pipelines
- O : Existing Wells
- O : Proposed Wells
- : Boundary of River Basin
- : City
- : Village
- : River
- : Block Division of Integrated Water Supply

Figure-7.2 Water Resources Development Plan of Japaratuba River Basin

7.3 Plan of Sergipe River Basin

(1) Water Demand and Shortage

Water demand and shortage in Sergipe River basin is estimated as shown in Table-7.7.

Table-7.7 Water Demand and Shortage in Sergipe River Basin

River	Year	1997	1998	2000	2005	2010	2015	2020
Urban and Large Rural Area	Water Demand (m^3/day)	271,523	283,391	307,127	363,208	433,888	522,545	633,454
	Private Industrial Water (m^3/day)	129,772	137,382	152,601	183,363	218,398	258,066	302,250
	Necessary Supply Water (m^3/day)	233,993	238,803	248,424	274,895	313,711	367,323	439,623
	Industrial Water	17,516	18,314	19,911	38,076	63,578	98,854	147,057
	Municipal Water: Urban Area	215,141	218,807	226,138	232,705	244,062	259,941	280,679
	Municipal Water: Large Rural Area	1,336	1,682	2,375	4,114	6,071	8,528	11,887
	Current Water Supply Capacity (m^3/day)	180,272	180,272	180,272	180,272	180,272	180,272	180,272
	Supply Water Shortage (m^3/day)	53,722	58,532	68,152	94,624	133,439	187,051	259,352
	Supply Water Shortage Rate (%)	30	32	38	52	74	104	144
	Source Water Shortage (m^3/day)	64,466	70,238	81,782	113,549	160,127	224,461	311,222
Small Rural Area	Water Demand (m^3/day)	1,702	1,710	1,724	1,806	1,958	2,209	2,600
	Necessary Supply Water (m^3/day)	1,047	1,066	1,104	1,242	1,463	1,822	2,408
	Current Water Supply Capacity (m^3/day)	448	438	418	370	321	272	224
	Supply Water Shortage (m^3/day)	600	628	686	872	1,142	1,550	2,184
	Supply Water Shortage Rate (%)	134	144	164	236	356	569	976
	Source Water Shortage (m^3/day)	1,047	1,066	1,104	1,242	1,463	1,822	2,408

(2) Plan of Water Resources Development and Supply

Plan of water resources development and supply in Sergipe River basin for the target year 2020 is shown in Table-7.9 and Figure-7.3. Source water to be developed within the basin and supply water to be consumed inside of the basin are explained in Table-7.8 and summarized as follows:

- As for urban and large rural water supply, 54.9 thousand m^3/day of water is newly developed within the basin. Of this source water, 52.6 thousand m^3/day (96 %) of water is supplied to the own basin and 2.3 thousand m^3/day (4 %) to other basins. Of 259.4 m^3/day of total supply water, 80 % of water comes from other basins (mainly from Sao Francisco River) and 20 % inside of the basin.
- Groundwater sources are larger than surface water sources, occupying 69 % and 31 % respectively in water supply for urban and large rural area. To the contrary, surface water sources become larger than groundwater sources if including small rural and irrigation water, accounting for 74 % and 26 % respectively.
- Irrigation water is supplied from the own basin by surface water, occupying 62 % of total inner source water.

Table-7.8 Source and Supply Water in Sergipe River

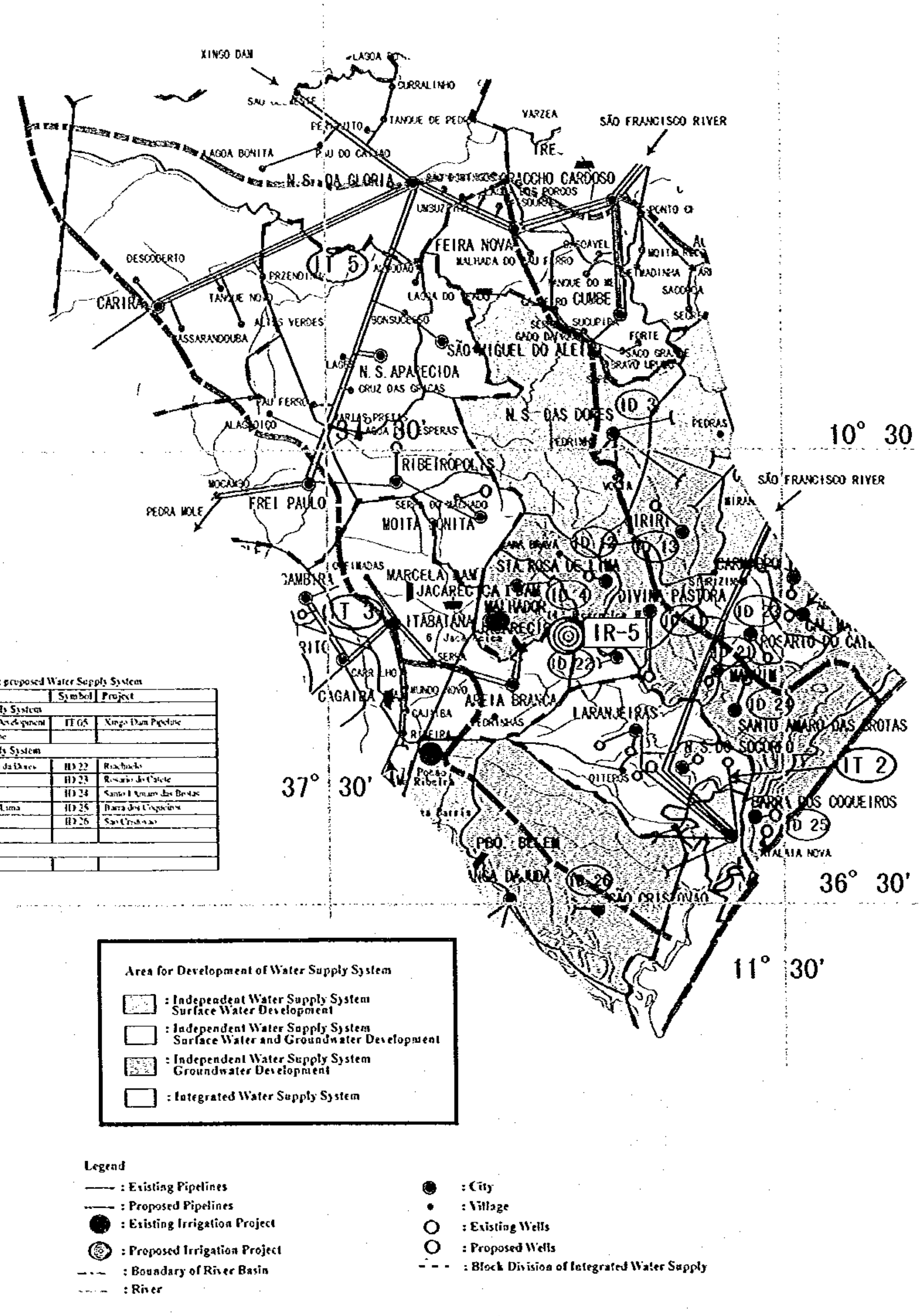
Item	U/L Rural			S Rural	Irrigation	Total		
	S/W	G/W	Total	G/W	S/W	S/W	G/W	Total
Source water to inner basin	14,651	37,932	52,583	2,184	94,742	109,393	40,116	149,509
Source water to outer basin	2,190	91	2,281	-	-	2,190	91	2,281
Total inner source water	16,841	38,023	54,864	2,184	94,742	111,583	40,207	151,790
Supply water from inner source	14,651	37,932	52,583	2,184	94,742	109,393	40,116	149,509
Supply water from outer source	206,755	14	206,769	-	-	206,755	14	206,769
Total supply water	221,406	37,946	259,352	2,184	94,742	316,148	40,130	356,278

Note: Source water in U/L rural is expressed as supply water base.

Table-7.9 Water Resources Development Plan of Sergipe River Basin

Project	Water Resources	Source Water Development (m^3/day)	Benefited Municipality	Supply Water (m^3/day) Total	Inner Water Source	Outer Water Source
Municipal/Industrial Water Supply	Surface Water	408,663	-	340,553	221,406	119,147
	Groundwater	47,830	-	40,221	40,130	91
Urban and Large Rural Area (Total)	Surface Water	408,663	-	340,553	221,406	119,147
	Groundwater	45,646	-	38,037	37,946	91
Urban and Large Rural Area (Inside)	Surface Water	20,210	-	16,841	14,651	2,190
	Groundwater	45,629	-	38,023	37,932	91
Urban and Large Rural Area (Outside)	Surface Water	388,453	-	323,712	206,755	116,957
	Groundwater	17	-	14	14	0
Integrated System (Total)	Surface Water	361,082	-	300,903	214,703	86,200
	Groundwater	27,950	-	23,292	23,292	0
Integrated System (Inside)	Surface Water	14,440	-	12,033	9,843	2,190
	Groundwater	27,950	-	23,292	23,292	0
Integrated System (Outside)	Surface Water	346,642	-	288,870	204,860	84,010
	Groundwater	0	-	0	0	0
Sao Francisco	*SFR: Direct Intake at Propria (north)*	*181,919*	*Total*	*151,600*	*151,600*	*0*
			Laranjeiras (SR)	*61,090*	*61,090*	*0*
			Aracaju (SR·VR)	*63,799*	*63,799*	*0*
			N. S. do Socorro (SR)	*26,711*	*26,711*	*0*
Aracaju Well Development	Deep Well: 9 wells	27,950	Total	23,292	23,292	0
			Laranjeiras	9,386	9,386	0
			Aracaju	9,802	9,802	0
			N. S. do Socorro	4,104	4,104	0
Agreste	Total	26,640	Total	22,200	18,159	4,041
	Jacarecica II Dam/SR	14,440	Areia Branca	4,861	4,669	192
	Cajaiba, Ribeira : VR	*12,200*	Campo do Brito	2,220	0	2,220
			Itabaiana	13,878	13,490	388
			Macambira	415	0	415
			Sao Domingos	825	0	825
Xingo Dam	*SFR: Xingo Dam Conduit*	*52,799*	*Total*	*43,999*	*11,901*	*32,098*
			Caninde do S. F.	*18,484*	*0*	*18,484*
			N. S. da Gloria	*13,473*	*6,697*	*6,776*
			Carira	*3,033*	*180*	*2,853*
			Frei Paulo	*3,031*	*28*	*3,003*
			N. S. Aparecida	*831*	*831*	*0*
			Pedra Mole	*186*	*0*	*186*
			Pinhao	*797*	*0*	*797*
			Ribeiropolis	*2,064*	*2,064*	*0*
			Sao Miguel do A.	*226*	*226*	*0*
			Moita Bonita	*1,875*	*1,875*	*0*
Vaza Barris Dam	*VR (Vaza Barris Dam)*	*91,932*	*Total*	*76,611*	*32,126*	*44,485*
			Areia Branca	*8,601*	*8,260*	*341*
			Campo do Brito	*3,928*	*0*	*3,928*
			Itabaiana	*24,553*	*23,866*	*687*
			Macambira	*734*	*0*	*734*
			Sao Domingos	*1,460*	*0*	*1,460*
			Poco Verde	*1,231*	*0*	*1,231*
			Simao Dias	*5,032*	*0*	*5,032*
			Lagarto	*29,792*	*0*	*29,792*
			Riachao do Dantas	*1,280*	*0*	*1,280*
Sertaneja	*SFR: Direct Intake at Porto da Folha*	*7,792*	*Total*	*6,493*	*917*	*5,576*
		New Dev.	*Feira Nova*	*1,891*	*917*	*974*
		0	*Gararu: (half of large Rural)*	*135*	*0*	*135*
			Gracho Cardoso	*416*	*0*	*416*
			Itabi	*387*	*0*	*387*
			Aquidaba	*2,202*	*0*	*2,202*
			Cumbe	*287*	*0*	*287*
			Amparo de S. F.	*126*	*0*	*126*
			Canhoba	*0*	*0*	*0*
			N. S. de Lourdes	*1,050*	*0*	*1,050*
Independent System (Total)	Surface Water	47,581	-	39,650	6,703	32,947
	Groundwater	17,696	-	14,745	14,654	91
Independent System (Inside)	Surface Water	5,770	-	4,808	4,808	0
	Groundwater	17,679	-	14,731	14,640	91
Independent System (Outside)	Surface Water	41,811	-	34,842	1,895	32,947
	Groundwater	17	-	14	14	0
Nossa Senhora das Dores	*Pinol R./ Siriri R.: JR*	*3,963*	*Nossa Senhora das Dores*	*3,302*	*1,862*	*1,440*
Malhador	Vermelho R./ SR	1,162	Malhador	968	968	0
	Deep Well: 6/6 wells	491		409	409	0
Divina Pastora	Deep Well: 4/4 wells	575	Divina Pastora	479	457	22
Santa Rosa de Lima	Deep Well: 4/4 wells	368	Santa Rosa de Lima	306	306	0
Siriri	Deep Well: 4/5 wells	111	Siriri	92	92	0
Maruim	Deep Well: 19/19 wells	3,588	Maruim	2,990	2,950	40
Riachuelo	Jacarecica R./SR	4,608	Riachuelo	3,840	3,840	0
	Deep Well: 27/27 wells	4,710		3,925	3,925	0
Rosario do Catete	*Siriri R./ JR*	*8,280*	*Rosario do Catete*	*6,900*	*9*	*6,891*
	Deep Well: 0/30 wells	*17*		*14*	*14*	-
Santo Amaro das Brotas	Deep Well: 3/3 wells	968	Santo Amaro das Brotas	807	778	29
Barra dos Coqueiros	Deep Well: 12/13 wells	6,676	Barra dos Coqueiros	5,563	5,563	0
Sao Cristovao	Deep Well: 1/26 wells	192	Sao Cristovao	160	160	0
Itaporanga D'Ajuda	Tejupeba R./ VR	7,280	Itaporanga d'Ajuda	6,067	6	6,061
	Fundo R.: PR	*22,288*		*18,573*	*18*	*18,555*
Small Rural Area	Groundwater	2,184	-	2,184	2,184	0
Single Well System	Deep Well: 286 wells	2,184	-	2,184	2,184	0
Irrigation W. Supply	Surface Water	94,742	-	94,742	94,742	0
Jacarecica II	Jacarecica R./ SR: Jacarecica II Dam	94,742	-	94,742	94,742	0

Note: Italic characters mean outer water resources of this river basin.



Symbol of the proposed Water Supply System

Symbol	Project	Symbol	Project
Integrated Water Supply System			
IT 02	Aracaju Well Development	IT 05	Xingo Dam Pipeline
IT 03	Agreste Pipeline		
Indenpent Water Supply System			
ID 03	Nossa Senhora da Dores	ID 22	Riachuelo
ID 04	Malhador	ID 23	Rosario do Catete
ID 11	Divina Pastora	ID 24	Santo Amaro das Brotas
ID 12	Santa Rosa de Lima	ID 25	Barra dos Coqueiros
ID 13	Siriri	ID 26	Sao Cristovao
ID 21	Maruim		
Irrigation Project			
IR 05	Jacarecica II		

Figure-7.3 Water Resources Development Plan of Sergipe River Basin

7.4 Plan of Vaza Barris River Basin

(1) Water Demand and Shortage

Water demand and shortage in Vaza Barris River basin is estimated as shown in Table-7.10.

Table-7.10 Water Demand and Shortage in Vaza Barris River Basin

River	Year	1997	1998	2000	2005	2010	2015	2020
Urban and Large Rural Area	Water Demand (m^3/day)	38,414	39,884	42,822	52,753	65,156	80,796	100,597
	Private Industrial Water (m^3/day)	17,458	18,482	20,529	25,602	31,280	38,204	46,204
	Necessary Supply Water (m^3/day)	28,542	29,232	30,612	37,663	46,692	57,567	71,488
	Industrial Water	256	268	291	3,030	7,566	13,571	22,032
	Municipal Water: Urban Area	26,733	27,165	28,030	31,231	34,717	38,658	43,236
	Municipal Water: Large Rural Area	1,553	1,799	2,291	3,402	4,408	5,338	6,220
	Current Water Supply Capacity (m^3/day)	23,744	23,744	23,744	23,744	23,744	23,744	23,744
	Supply Water Shortage (m^3/day)	4,798	5,488	6,868	13,920	22,948	33,823	47,744
	Supply Water Shortage Rate (%)	20	23	29	59	97	142	201
	Source Water Shortage (m^3/day)	5,757	6,586	8,242	16,704	27,537	40,588	57,293
Small Rural Area	Water Demand (m^3/day)	1,326	1,325	1,325	1,327	1,334	1,345	1,361
	Necessary Supply Water (m^3/day)	974	984	1,004	1,058	1,118	1,185	1,260
	Current Water Supply Capacity (m^3/day)	417	408	389	344	299	254	208
	Supply Water Shortage (m^3/day)	558	577	615	714	819	931	1,051
	Supply Water Shortage Rate (%)	134	142	158	208	274	367	505
	Source Water Shortage (m^3/day)	974	984	1,004	1,058	1,118	1,185	1,260

(2) Plan of Water Resources Development and Supply

Plan of water resources development and supply in Vaza Barris River basin for the target year 2020 is shown in Table-7.12 and Figure-7.4. Source water to be developed within the basin and supply water to be consumed inside of the basin are explained in Table-7.11 and summarized as follows:

- As for urban and large rural water supply, 97.3 thousand m^3/day of water is newly developed within the basin. Of this source water, 20.0 thousand m^3/day (21 %) of water is supplied to the own basin and 77.3 thousand m^3/day (79 %) to other basins. Supply water into the basin is supplied with 42 % from the own basin and 58 % from others.
- Surface water is main sources in the basin, accounting for 95 % in water supply for urban and large rural area and 98 % in total water sources.
- Irrigation water is supplied from the own basin by surface water, occupying 72 % of total inner source water.

Table-7.11 Source and Supply Water in Vaza Barris River

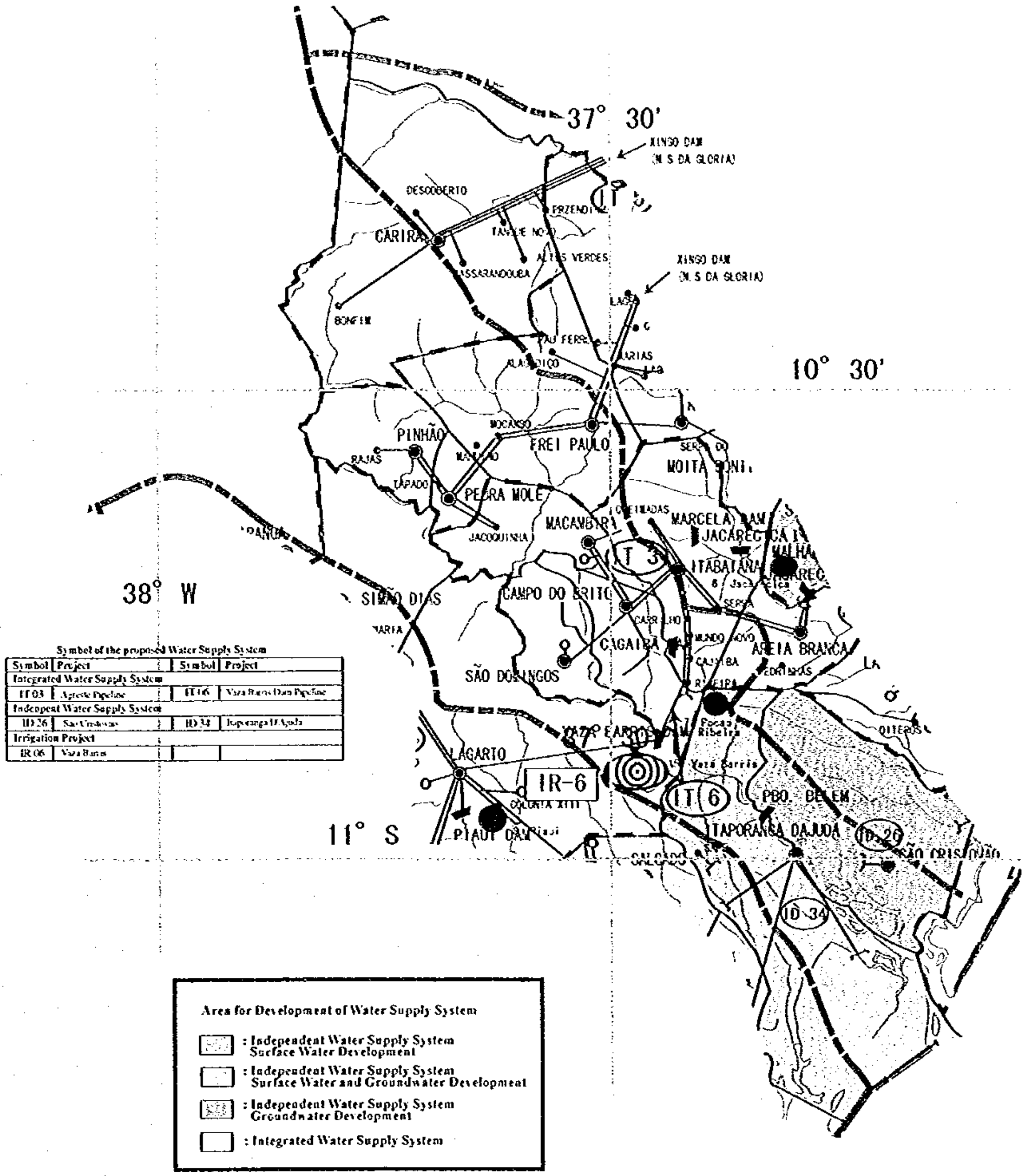
Item	U/L Rural			S Rural	Irrigation	Total		
	S/W	G/W	Total	G/W	S/W	S/W	G/W	Total
Source water to inner basin	15,521	4,439	19,960	1,051	251,613	267,134	5,490	272,624
Source water to outer basin	77,323	0	77,323	-	-	77,323	0	77,323
Total inner source water	92,844	4,439	97,283	1,051	251,613	344,457	5,490	349,947
Supply water from inner source	15,521	4,439	19,960	1,051	251,613	267,134	5,490	272,624
Supply water from outer source	27,663	121	27,784	-	-	27,663	121	27,784
Total supply water	43,184	4,560	47,744	1,051	251,613	294,797	5,611	300,408

Note: Source water in U/L rural is expressed as supply water base.

Table-7.12 Water Resources Development Plan of Vaza Barris River Basin

Project	Water Resources	Source Water Development (m^3/day)	Benefited Municipality	Supply Water (m^3/day)		
				Total	Inner Water Source	Outer Water Source
Municipal·Industrial	Surface Water	227,089	-	189,241	43,184	146,057
Water Supply	Groundwater	16,468	-	13,898	5,611	8,287
Urban and Large	Surface Water	227,089	-	189,241	43,184	146,057
Rural Area (Total)	Groundwater	15,417	-	12,847	4,560	8,287
Urban and Large	Surface Water	111,412	-	92,845	15,521	77,324
Rural Area (Inside)	Groundwater	5,327	-	4,439	4,439	0
Urban and Large	Surface Water	115,677	-	96,396	27,663	68,734
Rural Area (Outside)	Groundwater	10,090	-	8,408	121	8,287
Integrated System	Surface Water	197,521	-	164,601	18,880	145,721
(Total)	Groundwater	10,090	-	8,408	121	8,287
Integrated System	Surface Water	104,132	-	86,778	9,537	77,241
(Inside)	Groundwater	0	-	0	0	0
Integrated System	Surface Water	93,389	-	77,823	9,343	68,481
(Outside)	Groundwater	10,090	-	8,408	121	8,287
Agreste	Total	26,640	Total	22,200	4,010	18,160
	Jacarecica II Dam SR	*14,440*	Areia Branca	4,861	192	4,669
	Cajaiba, Ribeira /VR	12,200	Campo do Brito	2,220	2,220	0
			Itabaiana	13,878	388	13,490
			Macambira	415	415	0
			Sao Domingos	825	825	0
Piauitinga	*Total*	*36,240*	*Total: Surface Water*	*21,791*	*314*	*21,477*
	Piaui R. and Dam PR	*26,150*	*Total: Groundwater*	*8,408*	*121*	*8,287*
	Deep Well (PR)	*10,090*	*Poco Verde*	*995*	*0*	*995*
			Simao Dias	*4,070*	*169*	*3,901*
			Lagarto	*24,099*	*266*	*23,833*
			Riachao do Dantas	*1,035*	*0*	*1,035*
Xingo Dam	*SFR: Xingo Dam Conduit*	*52,799*	*Total*	*43,999*	*6,839*	*37,160*
			Caninde do S. F.	*18,484*	*0*	*18,484*
			N. S. da Gloria	*13,473*	*0*	*13,473*
			Carira	*3,033*	*2,853*	*180*
			Frei Paulo	*3,031*	*3,003*	*28*
			N. S. Aparecida	*831*	*0*	*831*
			Pedra Mole	*186*	*186*	*0*
			Pinhao	*797*	*797*	*0*
			Ribeiropolis	*2,064*	*0*	*2,064*
			Sao Miguel do A.	*226*	*0*	*226*
			Moita Bonita	*1,875*	*0*	*1,875*
Vaza Barris Dam	VR (Vaza Barris Dam)	91,932	Total	76,611	7,687	68,924
			Areia Branca	8,601	341	8,260
			Campo do Brito	3,928	3,928	0
			Itabaiana	24,553	687	23,866
			Macambira	734	734	0
			Sao Domingos	1,460	1,460	0
			Poco Verde	1,231	0	1,231
			Simao Dias	5,032	209	4,823
			Lagarto	29,792	328	29,464
			Riachao do Dantas	1,280	0	1,280
Independent System	Surface Water	29,568	-	24,640	24,304	336
(Total)	Groundwater	5,327	-	4,439	4,439	0
Independent System	Surface Water	7,280	-	6,067	5,984	83
(Inside)	Groundwater	5,327	-	4,439	4,439	0
Independent System	Surface Water	22,288	-	18,573	18,320	253
(Outside)	Groundwater	0	-	0	0	0
Sao Cristovao	Deep Well: 25/26 wells	5,327	Sao Cristovao	4,439	4,439	0
Itaporanga D'Ajuda	Tejupeba R / VR	7,280	Itaporanga d'Ajuda	6,067	5,984	83
	Fundo R. PR	*22,288*		*18,573*	*18,320*	*253*
Small Rural Area	Groundwater	1,051	-	1,051	1,051	0
Single Well System	Deep Well: 140 wells	1,051	-	1,051	1,051	0
Irrigation W. Supply	Surface Water	251,613	-	251,613	251,613	0
Vaza Barris	VR: Vaza Barris Dam	251,613	-	251,613	251,613	0

Note: Italic characters mean outer water resources of this river basin.



Legend

—— : Existing Pipelines	● : City
—— : Proposed Pipelines	• : Village
● : Existing Irrigation Project	O : Existing Wells
⊚ : Proposed Irrigation Project	O : Proposed Wells
—·— : Boundary of River Basin	- - - : Block Division of Integrated Water Supply
..... : River	

Figure-7.4 Water Resources Development Plan of Vaza Barris River Basin

7.5 Plan of Piaui River Basin

(1) Water Demand and Shortage

Water demand and shortage in Piaui River basin is estimated as shown in Table-7.13.

Table-7.13 Water Demand and Shortage in Piaui River Basin

River	Year	1997	1998	2000	2005	2010	2015	2020
Urban and Large Rural Area	Water Demand (m³/day)	56,118	57,819	61,222	76,388	95,727	120,580	152,577
	Private Industrial Water (m³/day)	20,789	22,008	24,446	30,902	38,006	45,167	52,327
	Necessary Supply Water (m³/day)	47,198	47,933	49,403	62,282	78,936	101,493	131,329
	Industrial Water	104	109	118	6,116	15,637	30,502	51,771
	Municipal Water: Urban Area	41,368	41,664	42,256	47,178	52,520	58,542	65,526
	Municipal Water: Large Rural Area	5,727	6,161	7,029	8,988	10,780	12,449	14,032
	Current Water Supply Capacity (m³/day)	24,752	24,752	24,752	24,752	24,752	24,752	24,752
	Supply Water Shortage (m³/day)	22,447	23,181	24,651	37,530	54,185	76,741	106,577
	Supply Water Shortage Rate (%)	91	94	100	152	219	310	431
	Source Water Shortage (m³/day)	26,936	27,818	29,581	45,036	65,022	92,090	127,893
Small Rural Area	Water Demand (m³/day)	2,819	2,825	2,838	2,878	2,929	2,992	3,069
	Necessary Supply Water (m³/day)	1,473	1,524	1,627	1,897	2,188	2,501	2,842
	Current Water Supply Capacity (m³/day)	626	613	585	517	449	381	313
	Supply Water Shortage (m³/day)	847	912	1,042	1,380	1,738	2,120	2,529
	Supply Water Shortage Rate (%)	135	149	178	267	387	556	808
	Source Water Shortage (m³/day)	1,473	1,524	1,627	1,897	2,188	2,501	2,842

(2) Plan of Water Resources Development and Supply

Plan of water resources development and supply in Piaui River basin for the target year 2020 is shown in Table-7.15 and Figure-7.5. Source water to be developed within the basin and supply water to be consumed inside of the basin are explained in Table-7.14 and summarized as follows:

- As for urban and large rural water supply, 99.6 thousand m³/day of water is newly developed within the basin. Of this source water, 70.8 thousand m³/day (71 %) of water is supplied to the own basin and 28.9 thousand m³/day (29 %) to other basins. Supply water into the basin is supplied with 66% from the own basin and 34 % from others.
- Surface water is main sources in the basin, accounting for 87 % in water supply for urban and large rural area and 85 % in total water resources.
- Irrigation water is supplied from the own basin by surface water, occupying 17 % of source water to the own basin.

Table-7.14 Source and Supply Water in Piaui River

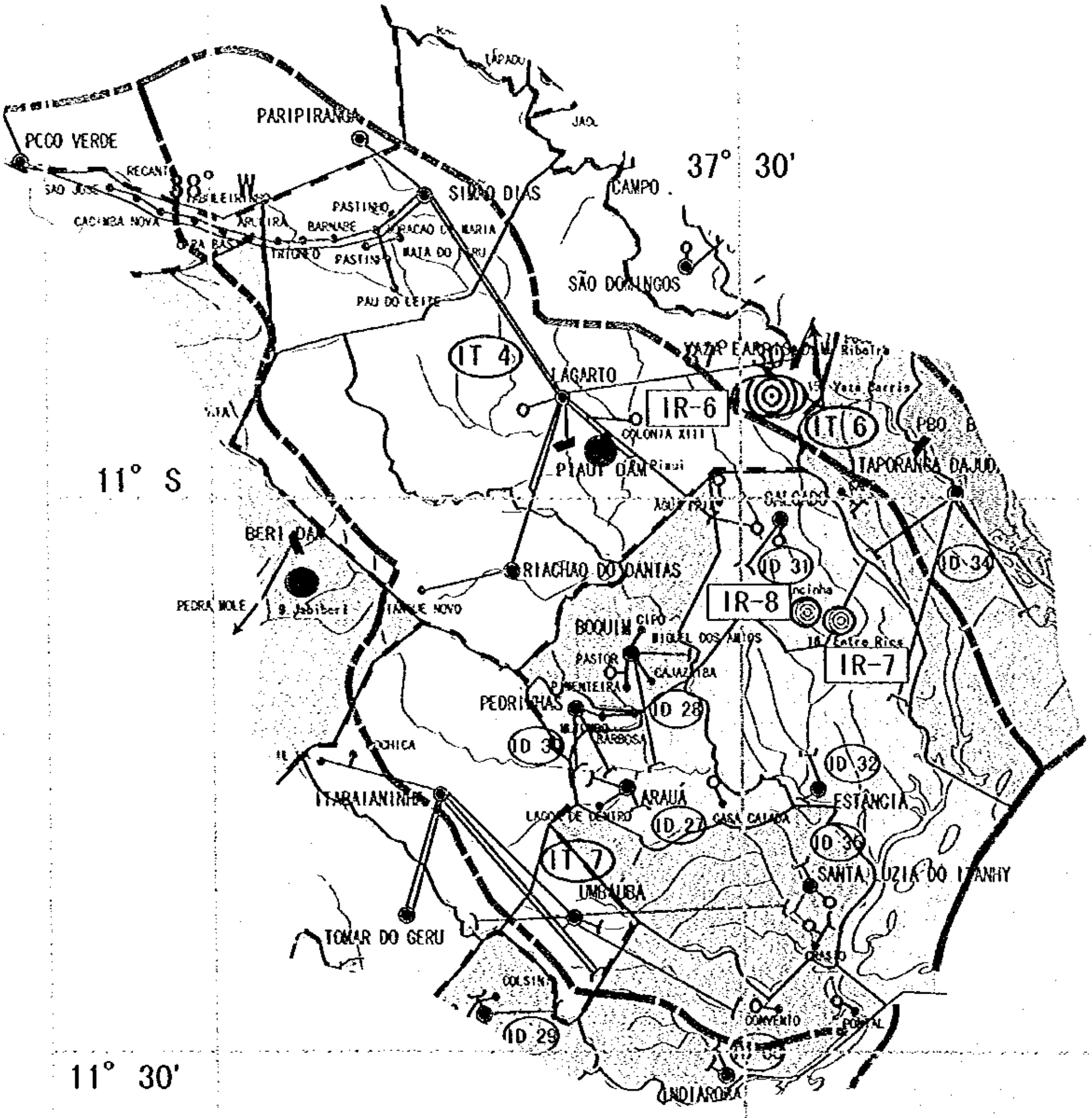
Item	U/L Rural			S Rural	Irrigation	Total		
	S/W	G/W	Total	G/W	S/W	S/W	G/W	Total
Source water to inner basin	57,897	12,868	70,765	2,529	20,956	78,853	15,397	94,250
Source water to outer basin	28,414	437	28,851	-	-	28,414	437	28,851
Total inner source water	86,311	13,305	99,616	2,529	20,956	107,267	15,834	123,101
Supply water from inner source	57,897	12,868	70,765	2,529	20,956	78,853	15,397	94,250
Supply water from outer source	35,812	0	35,812	-	-	35,812	0	35,812
Total supply water	93,709	12,868	106,577	2,529	20,956	114,665	15,397	130,062

Note: Source water in U/L rural is expressed as supply water base.

Table-7.15 Water Resources Development Plan of Piaui River Basin

Project	Water Resources	Source Water Development (m^3/day)	Benefited Municipality	Supply Water (m^3/day) Total	Inner Water Source	Outer Water Source
Municipal/Industrial Water Supply	Surface Water	213,386	-	177,820	93,709	84,111
	Groundwater	18,496	-	15,834	15,397	437
Urban and Large Rural Area (Total)	Surface Water	213,386	-	177,820	93,709	84,111
	Groundwater	15,967	-	13,305	12,868	437
Urban and Large Rural Area (Inside)	Surface Water	103,575	-	86,311	57,897	28,414
	Groundwater	15,967	-	13,305	12,868	437
Urban and Large Rural Area (Outside)	Surface Water	109,811	-	91,509	35,812	55,697
	Groundwater	0	-	0	0	0
Integrated System (Total)	Surface Water	134,067	-	111,722	63,077	48,645
	Groundwater	10,090	-	8,408	7,971	437
Integrated System (Inside)	Surface Water	42,135	-	35,112	27,693	7,419
	Groundwater	10,090	-	8,408	7,971	437
Integrated System (Outside)	Surface Water	91,932	-	76,610	35,384	41,226
	Groundwater	0	-	0	0	0
Piauitinga	Total	36,240	Total: Surface Water	21,791	20,657	1,134
	Piaui R. and Dam/PR	26,150	Total: Groundwater	8,408	7,971	437
	Deep Well (PR)	10,090	Poco Verde	995	10	985
			Simao Dias	4,070	3,887	183
			Lagarto	24,099	23,833	266
			Riachao do Dantas	1,035	898	137
Vaza Barris Dam	*VR (Vaza Barris Dam)*	*91,932*	*Total*	*76,610*	*35,384*	*41,226*
			Areia Branca	*8,601*	*0*	*8,601*
			Campo do Brito	*3,928*	*0*	*3,928*
			Itabaiana	*24,553*	*0*	*24,553*
			Macambira	*734*	*0*	*734*
			Sao Domingos	*1,460*	*0*	*1,460*
			Poco Verde	*1,231*	*5*	*1,226*
			Simao Dias	*5,032*	*4,806*	*226*
			Lagarto	*29,792*	*29,464*	*328*
			Riachao do Dantas	*1,280*	*1,109*	*171*
Itabaianinha	Guararema R./PR, Indiaroba R./PR	15,985	Total	13,321	7,036	6,285
			Itabaianinha	6,735	3,580	3,155
			Tomar do Geru	2,646	0	2,646
			Umbauba	3,940	3,456	484
Independent System (Total)	Surface Water	79,319	-	66,098	30,632	35,466
	Groundwater	5,877	-	4,897	4,897	0
Independent System (Inside)	Surface Water	61,440	-	51,199	30,204	20,995
	Groundwater	5,877	-	4,897	4,897	0
Independent System (Outside)	Surface Water	17,879	-	14,899	428	14,471
	Groundwater	0	-	0	0	0
Tobias Barreto	*Jabiberi R.: RR (Jabiberi Dam)*	*9,273*	*Tobias Barreto*	*7,727*	*46*	*7,681*
Araua	Camboata R./ Araua R./ PR	1,128	Araua	940	940	0
	Deep Well: 18/18 wells	888		740	740	0
Boquim	Gaiangal R./ Araua R./ PR	3,515	Boquim	2,929	2,929	0
Cristinapolis	Itamirim R./ PR	3,186	Cristinapolis	2,656	0	2,656
Pedrinhas	Tributary/ Araua R./ PR	1,480	Pedrinhas	1,233	1,233	0
	Deep Well: 9/9 wells	497		414	414	0
Salgado	Grilo R./ Piauitinga R./ PR	2,496	Salgado	2,080	2,080	0
	Deep Well: 16/16 wells	992		826	826	0
Estancia	Piauitinga R./ PR. PR (Main River)	25,010	Estancia	20,841	20,841	0
	Deep Well: 50/50 wells	3,500		2,917	2,917	0
Indiaroba	*Paripe R.: RR: Expansion*	*1,326*	*Indiaroba*	*1,105*	*305*	*800*
Itaporanga d'Ajuda	*Tejupeba R.: VR*	*7,280*	*Itaporanga d'Ajuda*	*6,067*	*77*	*5,990*
	Fundo R./ PR	22,288		18,573	234	18,339
Santa Luzia do Itanhy	Ariquitiba R./ Guararema R./ PR	2,337	Santa Luzia do Itanhy	1,947	1,947	0
Small Rural Area	Groundwater	2,529	-	2,529	2,529	0
Single Well System	Deep Well: 330 wells	2,529	-	2,529	2,529	0
Irrigation W. Supply	Surface Water	20,956	-	20,956	20,956	0
Entre Rios	Quebrados R. and Piauitinga R./PR: Direct Intake	15,576	-	15,576	15,576	0
Estancinha	Piauitinga R./PR: Direct Intake	5,380	-	5,380	5,380	0

Note: Italic characters mean outer water resources of this river basin.



Area for Development of Water Supply System

- : Independent Water Supply System Surface Water Development
- : Independent Water Supply System Surface Water and Groundwater Development
- : Independent Water Supply System Groundwater Development
- : Integrated Water Supply System

Legend

- : Existing Pipelines
- : Proposed Pipelines
- : Existing Irrigation Project
- : Proposed Irrigation Project
- : Boundary of River Basin
- : River
- : City
- : Village
- : Existing Wells
- : Proposed Wells
- : Block Division of Integrated Water Supply

Symbol of the proposed Water Supply System

Symbol	Project	Symbol	Project
Integrated Water Supply System			
IT 04	Paripiranga Pipeline		
IT 06	Vaza Barris Dam Pipeline	IT 07	Itabaianinha Pipeline
Indenpent Water Supply System			
ID 27	Araua	ID 32	Estancia
ID 28	Boquim	ID 33	Indiaroba
ID 29	Cristinapolis	ID 34	Itaporanga D'Ajuda
ID 30	Pedrinhas	ID 35	Santa Luzia do Itanhy
ID 31	Salgado		
Irrigation Project			
IR 06	Vaza Barris	IR 08	Estancinha
IR 07	Entre Rios		

Figure-7.5 Water Resources Development Plan of Piaui River Basin

7.6 Plan of Real River Basin

(1) Water Demand and Shortage

Water demand and shortage in Real River basin is estimated as shown in Table-7.16.

Table-7.16 Water Demand and Shortage in Real Basin

River	Year	1997	1998	2000	2005	2010	2015	2020
Urban and Large Rural Area	Water Demand (m^3/day)	14,402	14,706	15,312	16,912	18,895	21,332	24,330
	Private Industrial Water (m^3/day)	679	718	798	900	999	1,060	1,068
	Necessary Supply Water (m^3/day)	16,535	16,995	17,916	20,202	22,868	26,044	29,860
	Industrial Water	36	38	41	268	577	1,032	1,665
	Municipal Water: Urban Area	15,279	15,496	15,929	16,812	17,978	19,444	21,258
	Municipal Water: Large Rural Area	1,220	1,462	1,946	3,123	4,314	5,568	6,937
	Current Water Supply Capacity (m^3/day)	9,888	9,888	9,888	9,888	9,888	9,888	9,888
	Supply Water Shortage (m^3/day)	6,648	7,108	8,028	10,315	12,981	16,156	19,972
	Supply Water Shortage Rate (%)	67	72	81	104	131	163	202
	Source Water Shortage (m^3/day)	7,977	8,529	9,634	12,378	15,577	19,387	23,967
Small Rural Area	Water Demand (m^3/day)	1,210	1,218	1,233	1,281	1,343	1,421	1,518
	Necessary Supply Water (m^3/day)	684	702	740	854	998	1,179	1,405
	Current Water Supply Capacity (m^3/day)	297	290	277	245	213	181	148
	Supply Water Shortage (m^3/day)	387	412	462	609	785	998	1,257
	Supply Water Shortage Rate (%)	131	143	167	248	369	553	848
	Source Water Shortage (m^3/day)	684	702	740	854	998	1,179	1,405

(2) Plan of Water Resources Development and Supply

Plan of water resources development and supply in Real River basin for the target year 2020 is shown in Table-7.18 and Figure-7.6. Source water to be developed within the basin and supply water to be consumed inside of the basin are explained in Table-7.17 and summarized as follows:

- As for urban and large rural water supply, 8.8 thousand m^3/day of water is newly developed within the basin. Of this source water, 8.5 thousand m^3/day (96 %) of water is supplied to the own basin and 0.4 thousand m^3/day (4 %) to other basins. Supply water into the basin is supplied with 42 % from the own basin and 58 % from others.
- Only surface water is the water source in the basin for water supply in urban and large rural area, and occupying 88 % of total water sources if including small rural water supply sources.

Table-7.17 Source and Supplied Water in Real River

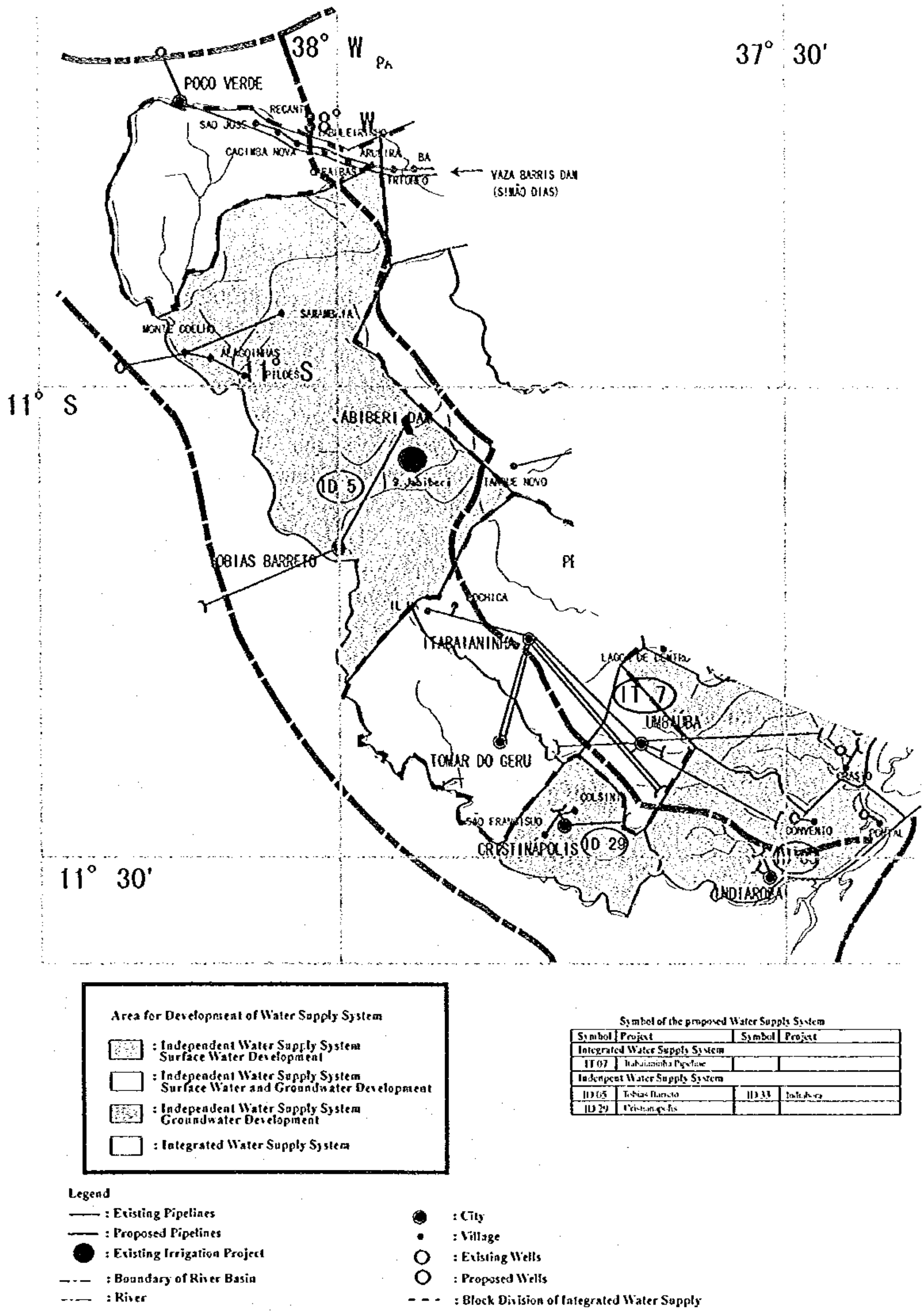
Item	U/L Rural			S Rural	Irrigation	Total		
	S/W	G/W	Total	G/W	S/W	S/W	G/W	Total
Source water to inner basin	8,481	0	8,481	1,257	-	8,481	1,257	9,738
Source water to outer basin	351	0	351	-	-	351	0	351
Total inner source water	8,832	0	8,832	1,257	0	8,832	1,257	10,089
Supply water from inner source	8,481	0	8,481	1,257	-	8,481	1,257	9,738
Supply water from outer source	11,175	316	11,491	-	-	11,175	316	11,491
Total supply water	19,656	316	19,972	1,257	0	19,656	1,573	21,229

Note: Source water in U/L rural is expressed as supply water base.

Table-7.18 Water Resources Development Plan of Real River Basin

Project	Water Resources	Source Water Development (m^3/day)	Benefited Municipality	Supply Water (m^3/day) Total	Inner Water Source	Outer Water Source
Municipal/Industrial Water Supply	Surface Water	147,852	-	123,211	19,656	103,555
	Groundwater	11,347	-	9,665	1,573	8,092
Urban and Large Rural Area (Total)	Surface Water	147,852	-	123,211	19,656	103,555
	Groundwater	10,090	-	8,408	316	8,092
Urban and Large Rural Area (Inside)	Surface Water	10,599	-	8,832	8,481	351
	Groundwater	0	-	0	0	0
Urban and Large Rural Area (Outside)	Surface Water	137,253	-	114,379	11,175	103,204
	Groundwater	10,090	-	8,408	316	8,092
Integrated System (Total)	Surface Water	134,067	-	111,723	8,519	103,204
	Groundwater	10,090	-	8,408	316	8,092
Integrated System (Inside)	Surface Water	0	-	0	0	0
	Groundwater	0	-	0	0	0
Integrated System (Outside)	Surface Water	134,067	-	111,723	8,519	103,204
	Groundwater	10,090	-	8,408	316	8,092
Piauitinga	*Total*	*36,240*	*Total: Surface Water*	*21,791*	*820*	*20,971*
	Piaui R. and Dam PR	*26,150*	*Total: Groundwater*	*8,408*	*316*	*8,092*
	Deep Well (PR)	*10,090*	*Poco Verde*	*995*	*985*	*10*
			Simao Dias	*4,070*	*14*	*4,056*
			Lagarto	*24,099*	*0*	*24,099*
			Riachao do Dantas	*1,035*	*137*	*898*
Vaza Barris Dam	*VR (Vaza Barris Dam)*	*91,932*	*Total*	*76,611*	*1,414*	*75,197*
			Areia Branca	*8,601*	*0*	*8,601*
			Campo do Brito	*3,928*	*0*	*3,928*
			Itabaiana	*24,553*	*0*	*24,553*
			Macambira	*734*	*0*	*734*
			Sao Domingos	*1,460*	*0*	*1,460*
			Poco Verde	*1,231*	*1,226*	*5*
			Simao Dias	*5,032*	*17*	*5,015*
			Lagarto	*29,792*	*0*	*29,792*
			Riachao do Dantas	*1,280*	*171*	*1,109*
Itabaianinha	*Guararema R. PR, Indiaroba R. PR*	*15,985*	*Total*	*13,321*	*6,285*	*7,036*
			Itabaianinha	*6,735*	*3,155*	*3,580*
			Tomar do Geru	*2,646*	*2,646*	*0*
			Umbauba	*3,940*	*484*	*3,456*
Independent System (Total)	Surface Water	13,785	-	11,488	11,137	351
	Groundwater	0	-	0	0	0
Independent System (Inside)	Surface Water	10,599	-	8,832	8,481	351
	Groundwater	0	-	0	0	0
Independent System (Outside)	Surface Water	3,186	-	2,656	2,656	0
	Groundwater	0	-	0	0	0
Tobias Barreto	Jabiberi R./ RR (Jabiberi Dam)	9,273	Tobias Barreto	7,727	7,681	46
Cristinapolis	*Itamirim R. PR*	*3,186*	*Cristinapolis*	*2,656*	*2,656*	*0*
Indiaroba	Paripe R / RR: Expansion	1,326	Indiaroba	1,105	800	305
Small Rural Area	Groundwater	1,257	-	1,257	1,257	0
Single Well System	Deep Well: 165 wells	1,257	-	1,257	1,257	0

Note: Italic characters mean outer water resources of this river basin.



Symbol of the proposed Water Supply System

Symbol	Project	Symbol	Project
Integrated Water Supply System			
IT 07	Itabaianinha Pipeline		
Indenpent Water Supply System			
ID 05	Tobias Barreto	ID 33	Indiaroba
ID 29	Cristinapolis		

Figure-7.6 Water Resources Development Plan of Real River Basin

CHAPTER 8 IMPLEMENTATION SCHEDULE

8.1 Water Resources Development Projects

Implementation schedule of the projects for domestic and industrial water supply and irrigation water supply is shown in Table-8.1. The following distinctions were set to give high priority to the projects proposed in the Master Plan: 1) Large water shortage and rate of beneficiaries, 2) Long period for plan and construction, 3) Large construction volume, and 4) Multi-purpose project.

(1) Integrated Water Supply Projects for Urban and Large Rural Area

On-going projects and existing planned projects proposed to PROAGUA, such as 1) Expansion Project of Sao Francisco Pipeline System, 2) Aracaju Well Development Project, 3) Project Expansion of Agreste and Piauitinga projects, should firstly be completed. As Xingo Dam Pipeline Project and Vaza Barris Dam Project are expected to take long period and as these projects supply water to the area of large water shortage and rate, these should start as soon as possible. These projects should divide into two phases to develop water according to the increase of water demand. Since the area covered by Project Expansion of Itabaianinha Pipeline Project also have large water shortage and rate but water demand is gradually increasing, this project was divided into three phases. The first phase of this project should start earlier. As the water shortage and rate of the other projects are relatively small, these project have not so high priority. These projects should divide into two phases to develop water according to the increase of water demand.

Water supply programs of the blocks of Piauitinga (Lagarto), Agreste (Itabaiana) and Sertaneja [3] are shown in Figure-8.1.

(2) Independent Water Supply Projects for Urban and Large Rural Area

The 35 projects of independent water supply should complete within 20 years until the year of 2020. According to water shortage and water shortage rate of benefited area, priority was put to each project. Depending on the increasing rate of water demand, some projects were divided into two phases. Deep well development projects should be implemented in line with increased demand.

Water supply programs of Maruim (deep well), Rosario do Catete (weir and deep well) and Itaporanga D'Ajuda (weir only) are shown in Figure-8.2.

(3) Water Supply Projects for Small Rural Area

Deep well development projects for small rural area should be implemented step by step in line with increased demand.

(4) Irrigation Water Supply Projects

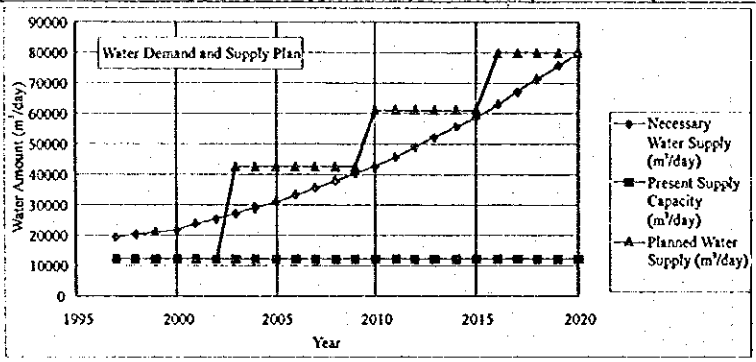
As Jacare-Curituba and Jacarecica II irrigation projects are on-going, these projects should firstly be completed. Sao Francisco irrigation project has large irrigation area and project period of 10 years is necessary to be implemented. Vaza Barris irrigation project should commence after completion of Vaza Barris dam.

Table-8.1 Implementation Schedule

Project	Water Developed (m³/day)	Project Cost (1,000R$)	1st: 2000-2004					2nd 2005-2009					3rd: 2010-2014					4th: 2015-2019					
			2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Industrial and Municipal Water Supply	**515,605**	**945,806**																					
Urban and Large Rural Area (Integrated System)	**347,901**	**701,938**																					
Project Expansion of Sao Francisco Pipeline System	151,600	258,011	##	##	##									##									
Aracaju Well Development Project	23,292	27,003	**	##																			
Project Expansion of Agreste Pipeline System	22,200	14,562		**	##																		
Project Expansion of Piauitinga Pipeline System	30,200	9,293		**	##																		
Xingo Dam Pipeline Project	43,999	145,662			==	==	==	==				==	==	==									
Caninde Block	-	53,729		**	**	##									##								
Nossa Senhora da Gloria Block	-	54,872		**	**		##						##										
Frei Paulo Block	-	37,061		**	**			##						##									
Vaza Barris Dam Project	76,610	154,618		==	==	==	==	==	==		==	==			==	==	==	==					
Dam Construction	-	-		**	**	**	##	##	##														
Water Supply facilities (Itabaiana)	-	-						**	##						**	##							
Water Supply facilities (Lagarto)	-	-									**	##					**	##					
Project Expansion of Itabaianinha Pipeline System	13,321	34,305			**	##			**	##					##								
Project Expansion of Propria Pipeline System	6,189	4,814							**	##					##								
Project Expansion of Alto Sertao Pipeline System	5,495	20,518								**	##					##							
Project Expansion of Sertaneja Pipeline System	6,493	33,152								**	##					##							
Urban and Large Rural Area (Independent System)	**158,351**	**170,002**																					
Gararu: SFR Direct Intake	510	635									**	##											
Muribeca: Deep Well Development	465	846								##		##		##		##		##		##		##	
Nossa Senhora das Dores: Pinol R. Development	3,302	2,870							**	##													
Malhador: Vermelha R. Development	1,377	2,113									**	##											
: Deep Well Development	-	598															##	##	##	##	##	##	
Tobias Barreto: Jabiberi Dam Raising Project	7,727	16,787					**	**	##														
Brejo Grande: Deep Well Development	722	564						##										##					
Ilha das Flores: Deep Well Development	788	594					##										##						
Neopolis: SFR Direct Intake	16,916	8,310			**	##			##								##						
Santana do Sao Francisco: SFR Direct Intake (Exp.)	3,841	1,861					**	##					##										
Capela: Siriri R. Development	6,694	3,650					**	##															
: Adeira R. Development	-	3,301														**	##						
Divina Pastora: Deep Well Development	479	523					##					##					##					##	
Santa Rosa de Lima: Deep Well Development	306	457					##					##					##					##	
Siriri: Deep Well Development	607	628												##		##		##		##		##	
Japaratuba: Deep Well Development	2,794	1,762					##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	
Japoata: Deep Well Development	471	540										##			##			##			##		
Pacatuba: Santo Antonio R. Development	4,298	1,922				**	##							##									
Pirambu: Deep Well Development	2,165	1,327		##			##			##			##			##			##			##	
Sao Francisco: Deep Well Development	373	503								##			##			##			##			##	
Carmopolis: Deep Well Development	891	612														##		##		##		##	
General Maynard: Deep Well Development	388	465						##							##							##	
Maruim: Deep Well Development	2,990	1,511		##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	
Riachuelo: Jacarecica R. Development	7,765	1,793			**	##			**	##													
: Deep Well Development	-	2,039													##	##	##	##	##	##	##	##	
Rosario do Catete: Siriri R. Development	17,531	2,012		**	##				##														
: Deep Well Development	-	3,454											##	##	##	##	##	##	##	##	##	##	
Santo Amaro das Brotas: Deep Well Development	807	552						##							##							##	
Barra dos Coqueiros: Deep Well Development	6,277	2,925						##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	
Sao Cristovao: Deep Well Development	4,599	2,732								##	##	##	##	##	##	##	##	##	##	##	##	##	
Araua: Camboata R. Development	1,680	1,195								**	##												
: Deep Well Development	-	1,159											##	##	##	##	##	##	##	##	##	##	
Boquim: Garangal R. Development	2,929	3,748									**	##											
Cristinapolis: Itamirim R. Development	2,656	4,106							**	##							##						
Pedrinhas: Araua R. Development	1,647	2,193							**	##													
: Deep Well Development	-	644										##	##	##	##	##	##	##	##	##			
Salgado: Grilo R. Development	2,906	2,002							**	##													
: Deep Well Development	-	1,159												##	##	##	##	##	##	##	##	##	
Estancia: Piauitinga R. Development	23,758	6,825				**	##																
: Piaui R. Development	-	4,061								**	##						##						
: Deep Well Development	-	2,938																			##	##	
Indiaroba: Paripe R. Development	1,105	1,184									**	##											
Itaporanga d'Ajuda: Fundo R. Development	24,640	5,851		**	##							**	##										
: Tejupeba R. Development	-	63,538																	**	##			
Santa Luzia do Itanhy: Ariquitiba R. Development	1,947	1,481						**	##					##									
Small Rural Area (Municipal Water Supply Only)	**9,353**	**73,866**																					
Single Well System (Public Tap)	9,353	73,866		##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	
Irrigation Water Supply	**1,906,301**	**427,497**																					
Quixabeira	262,873	35,051													**	##	##	##					
Jacare-Curituba	272,394	37,852	##	##																			
Sao Francisco	933,333	223,071			**	##	##	##	##	##	##	##	##	##	##								
Ladeirinhas	58,147	28,742												**	**	##	##	##					
Jacarecica II	97,900	44,545	##	##	##																		
Vaza Barris	260,000	54,839						**	##	##	##	##											
Entre Rios	16,095	2,397																**	##	##			
Estancinha	5,559	1,001																		**	##	##	

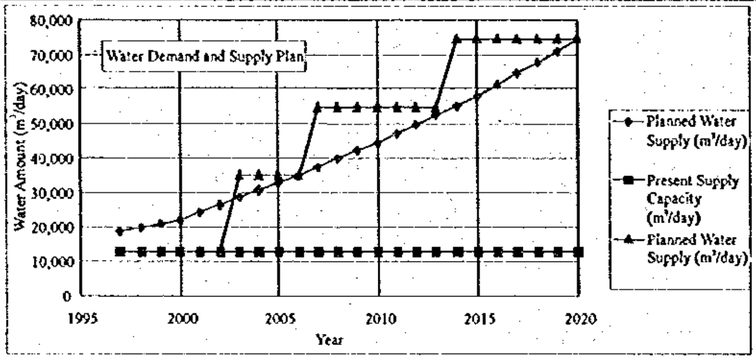
Note: **: Plan and Design ##: Construction

WATER SUPPLY PROGRAM						
Items	1997	2000	2005	2010	2015	2020
Present Supply Capacity (m^3/day)	12,130	12,130	12,130	12,130	12,130	12,130
(1) Expansion of Piauitinga P.	0	0	30,200	30,200	30,200	30,200
(2) Vaza Barris Dam Project Phase-I	0	0	0	18,667	18,667	18,667
(3) Vaza Barris Dam Project Phase-II	0	0	0	0	0	18,667
Planned Water Supply (m^3/day)	12,130	12,130	42,330	60,997	60,997	79,664



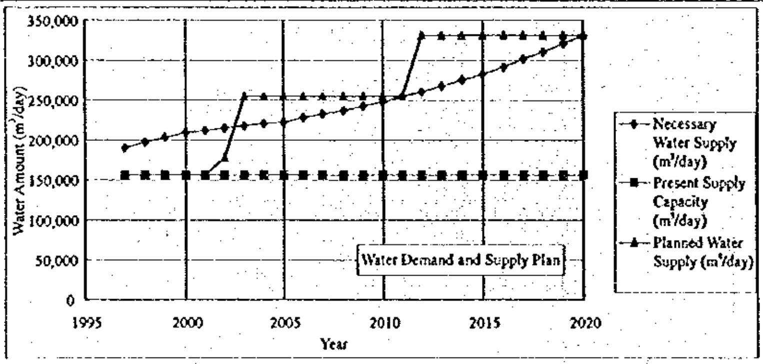
Piauitinga Block
(Lagarto)

WATER SUPPLY PROGRAM						
Items	1997	2000	2005	2010	2015	2020
Present Supply Capacity (m^3/day)	12,810	12,810	12,810	12,810	12,810	12,810
(1) Expansion of Agreste P.	0	0	22,200	22,200	22,200	22,200
(2) Vaza Barris Dam Project Phase-I	0	0	0	19,638	19,638	19,638
(3) Vaza Barris Dam Project Phase-II	0	0	0	0	19,638	19,638
Planned Water Supply (m^3/day)	12,810	12,810	35,010	54,648	74,286	74,286



Agreste Block
(Itabaiana)

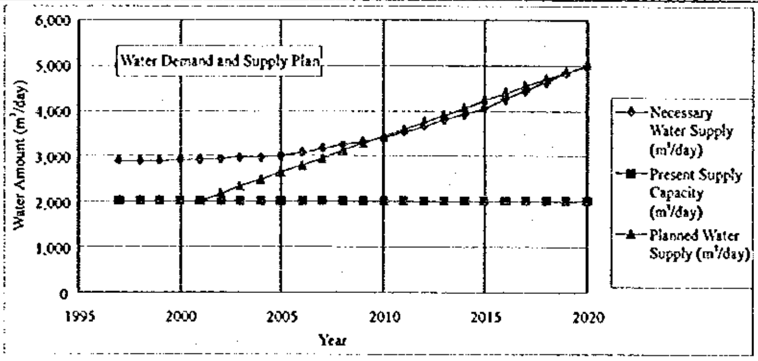
WATER SUPPLY PROGRAM						
Items	1997	2000	2005	2010	2015	2020
Present Supply Capacity (m^3/day)	155,315	155,315	155,315	155,315	155,315	155,315
(1) Expansion of Sao F. P. Phase-I	0	0	75,800	75,800	75,800	75,800
(2) Expansion of Sao F. P. Phase-II	0	0	0	0	75,800	75,800
(3) Aracaju Well Development	0	0	23,292	23,292	23,292	23,292
Planned Water Supply (m^3/day)	155,315	155,315	254,407	254,407	330,207	330,207



Aracaju Block

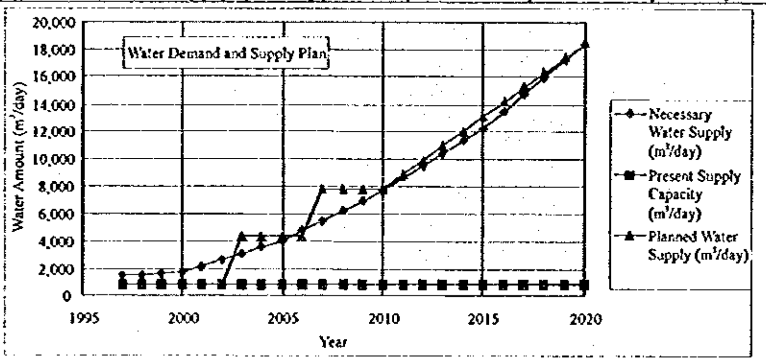
Figure-8.1 Water Supply Program of Integrated Pipeline System

WATER SUPPLY PROGRAM						
Items	1997	2000	2005	2010	2015	2020
Present Supply Capacity (m^3/day)	2,015	2,015	2,015	2,015	2,015	2,015
(1) Deep Well development	0	0	629	1,416	2,203	2,990
Planned Water Supply (m^3/day)	2,015	2,015	2,644	3,431	4,218	5,005



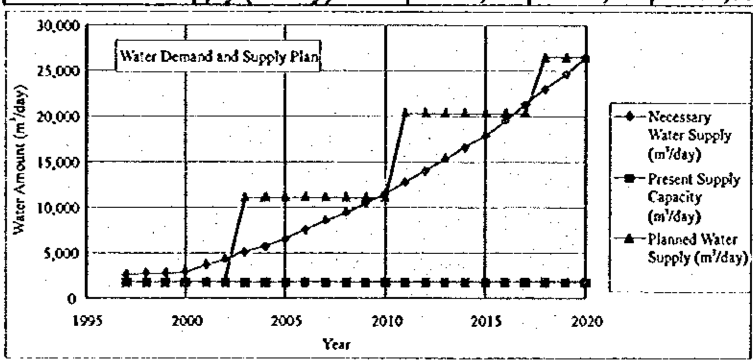
Marim

WATER SUPPLY PROGRAM						
Items	1997	2000	2005	2010	2015	2020
Present Supply Capacity (m^3/day)	880	880	880	880	880	880
(1) Siriri R. Development Phase-I	0	0	6,900	6,900	6,900	6,900
(2) Siriri R. Development Phase-II	0	0	0	0	17,250	34,500
(3) Deep Well Development	0	0	0	0	10,631	
Planned Water Supply (m^3/day)	880	880	7,780	7,780	35,661	42,280



Rosario do Catete

WATER SUPPLY PROGRAM						
Items	1997	2000	2005	2010	2015	2020
Present Supply Capacity (m^3/day)	1,773	1,773	1,773	1,773	1,773	1,773
(1) Fundo R. Development Phase-I	0	0	9287	9,287	9,287	9,287
(2) Fundo R. Development Phase-II	0	0	0	9,286	9,286	9,286
(3) Tejupeba R. Development	0	0	0	0	0	6,067
Planned Water Supply (m^3/day)	1,773	1,773	11,060	20,346	20,346	26,413



Itaporanga d'Ajuda

Figure-8.2 Water Supply Program of Independent Pipeline System

JAPAN INTERNATIONAL COOPERATION AGENCY

STATE SECRETARIAT OF PLANNING, SCIENCE AND TECHNOLOGY
THE STATE OF SERGIPE, THE FEDERATIVE REPUBLIC OF BRAZIL

THE STUDY
ON
WATER RESOURCES DEVELOPMENT
IN THE STATE OF SERGIPE
IN
THE FEDERATIVE REPUBLIC OF BRAZIL

FINAL REPORT
SUPPORTING
(VOLUME I)
MASTER PLAN STUDY

[H] FACILITY DESIGN AND COST ESTIMATE

MARCH 2000

YACHIYO ENGINEERING CO., LTD. (YEC)

THE STUDY ON WATER RESOURCES DEVELOPMENT IN THE STATE OF SERGIPE IN THE FEDERATIVE REPUBLIC OF BRAZIL

SUPPORTING REPORT (H) FACILITY DESIGN AND COST ESTIMATE

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CHAPTER 1 INTRODUCTION

This supporting report (H) covers the details of Plan, Design and Cost Estimate of the Projects included in the Master Plan Study.

CHAPTER 2 FACILITY DESIGN

2.1 Design Criteria

2.1.1 General

(1) Codes and Standards

Facilities to be required in the Master Plan Study shall be designed in accordance with the Codes and Standards published and authorized by federal, regional, state, municipal and/or any other public organizations or authorities in Brazil.

When applicable Codes and Standards are not specified by the related organizations mentioned above, the Codes, Standards and Regulations in Japan shall be used with some adjustment in accordance with the local conditions in the State of Sergipe.

(2) Units of Measurements

Units of measurements in design shall be in SI/MKS metric system.

(3) Method of Design of Facilities

In principle, allowable stress design method shall be applied for all structural design of the facilities.

(4) Materials to be Used

All materials to be used for construction of facilities required in the Master Plan shall be in accordance with Brazilian Technical Standards (ABNT) or equivalent Japanese Industrial Standards (JIS) or other internationally accepted standards.

2.1.2 Design of Dams

(1) Codes and Standards

Unless otherwise specified by the related organizations, the following codes and standards shall be used for the design of dams:

- Design Criteria for Dams, Japanese National Committee on Large Dams, Japan
- Manual for river works in Japan, River Bureau, Ministry of Construction, Japan
- Manual of small dam, SUDENE, Brazil

(2) Loads to be Considered

In principle, the following loads are considered in the design of dams:

- Dead weight of dam
- Hydrostatic pressure

- Pore pressure
- Silt pressure
- Uplift pressure
- Seismic body force : Not to be considered.
- Hydrodynamic pressure : Not to be considered.

(3) Selection of Type of Dam

The full consideration shall be given to various requirements such as topographical, geological and hydrological conditions of the dam site, dam materials and others.

(4) Determination of Dam Size

The size of dam shall be determined on the basis of the design flood run-off for dam, water levels used for design of dam such as normal water level, surcharge water level and design flood level. Consideration shall also be given to the structural aspects of dam body and its base ground in order to determine the size of dam. Largest flood run-off shall be supposed to occur in every 200 to 1,000 years. The rate of sediment discharge shall be 12.7 m^3 per year per one km^2 of catchment area.

(5) Spillway and Other Discharge Installations

The concrete dam should be equipped with the following discharge installations:

- Spillway
- Low water discharge installation to control the normal flow of water in the river

Fill dam should be equipped with a discharge installation which can lower the water level of the reservoir in addition to the above.

(6) Safety Requirements

1) Fill Dams
   - Safety against sliding failure
   - Safety against seepage

2) Concrete Dams
   - Safety against shear failure of the contact plane between dam body and bedrock as well as of the weak zone within the bedrock
   - Safety on stress in concrete
   - Stability of bedrock

2.1.3 Design of Water Supply Facility

(1) Codes and Standards

Unless otherwise specified by the related organizations, the following codes and standards shall be used for the design of water supply facilities:

- Japan Water Works Association (JWWA)
- American Water Works Association (AWWA)
- Japanese Industrial Standard (JIS)
- American Standard of Testing Materials (ASTM)

(2) Loads to be Considered

In principle, the following loads are considered in the design of structures in the Water Supply Systems:

- Dead Weight
- Floor loads
- Live loads
- Equipment loads
- Earth pressure
- Groundwater pressure
- Hydrostatic pressure
- Uplift pressure
- Wind loads
- Seismic body force : Not to be considered.
- Hydrodynamic pressure : Not to be considered.

(3) Design Parameters and Water Supply Volume

- Estimated population at the target year, P (person)
- Design daily water supply volume per capita, q (litter/day)
- Coefficient of daily maximum consumption : k1 = 1.2
- Coefficient of hourly maximum consumption : k2 = 1.5
- Rate of water loss : r_L = 0.42 in 1998
  = 0.25 in 2020
- Daily maximum water supply volume, Q_{DM} (litter/day)

$$Q_{DM} = \frac{P \times q \times k1}{1 - r_L}$$

- Hourly maximum water supply volume, Q_{HM} (litter/day)

$$Q_{HM} = Q_{DM} \times k2 = \frac{P \times q \times k1 \times k2}{1 - r_L}$$

(4) Design of Water Supply System

1) Raw Water Pump Station

The required capacity of raw water pump to be installed in raw water pump station, RWPS, shall be determined based on Q_{DM} when a water storage tank elevated (ET) or on the ground (AT) is installed in the system. The pump shall be selected using head-discharge curves of pump and system. Actual suction head shall be the difference in water levels between suction (intake) side and discharge side in meters. Fluctuation of water levels and siphon effect shall also be considered in determining the actual suction head. Although item 5.7.3 of Norm NBR1218 in July 1994 recommends to use Colebrook-White formula for calculation of head loss in pipeline, head loss in pipeline shall be calculated using Hazen-Williams formula because of the simplicity in calculation to deal with tremendous cases of water pipeline systems and because of the standard method in Japan for calculation of head loss. Materials of pipe shall be cast-iron or PVC.

2) Water Main

The water main from RWPS to the Water Treatment Station, WTS shall be capable of transfer of pumped-up water to WTS. Materials of pipe shall be steel or cast-iron.

3) Water Treatment Station
Water treatment station, WTS, shall be a conventional type and have the capacity to meet Q_{HM}. The treated water distribution pump in treated water pump station, TWPS, shall have the capacity to meet Q_{HM}. Filter shall be direct ascending type. Desalinizer shall be portable REVERSE OSMOSIS type installed where pumped-up water is saline, especially in rural area in the State of Sergipe. The required capacity of storage tank shall be determined as one third of Q_{DM}.

4) Distribution Main
The distribution main from TWPS or AT to the distribution network shall be capable of transfer of water to meet Q_{HM}. Materials of pipe shall be steel or cast-iron.

5) Distribution Network
The distribution network shall be sufficient enough to supply water to each user.

2.2 Design of Independent Water Supply System

2.2.1 Design Concept

(1) Independent Surface Water Supply Systems

1) Components included
The components included in the Surface Water Supply Systems are as follows:

- Dam or weir where required
- Intake and Raw Water Pump Station RWPS
- Pipelines (From Raw water intake to water treatment station)
- Water treatment station, WTS, composed of chemical house, filters, auxiliary water storage tank AT, elevated water storage tank ET, and treated water pumps TWP
- Distribution pipeline and network

Conceptual sketch of the system is as shown in Figure-2.1.

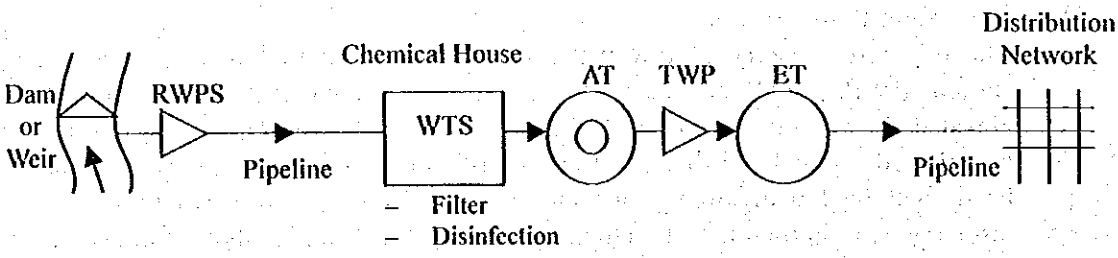

Figure-2.1 Conceptual Sketch of Integrated Surface Water Supply System

2) Design Conditions
In addition to the design criteria specified in Section 2.1.3, the following design conditions are followed:

- Water to be supplied for industrial consumption and domestic consumption in urban and large rural areas
- Water supply volume per capita Urban : 160 liter/day
  Large Rural : 120 liter/day

(2) Independent Groundwater Supply Systems

1) Components included

The components included in the Groundwater Supply Systems are as follows:

- Wells
- Raw Water Pump RWP
- Pipelines (From Raw water pump to water treatment station)
- Water treatment station WTS, composed of disinfection unit DIU, auxiliary water storage tank AT, elevated water storage tank ET, and treated water pumps TWP
- Distribution pipeline and network

Conceptual sketch of the system is as shown in Figure-2.2.

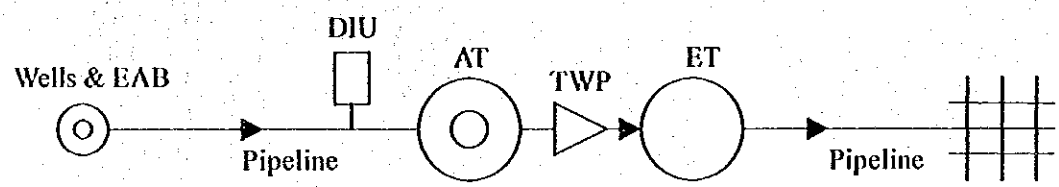

Figure-2.2 Conceptual Sketch of Integrated Groundwater Supply System

2) Design Conditions

Design conditions are as same as for Independent Surface Water Supply System except described below.

- Depth of well to be 100 m
- Number of drilling to be the required number of wells divided by expected success rate and fresh rate of groundwater
- Desalination unit not to be provided even if water in the drilled well contains high salinity. Additional drilling to be performed until to find acceptable well

2.2.2 Specific System Design

<Jabiberi Dam Raising Project for the Municipality of Tobias Barreto>

Jabiberi Dam was constructed in 1986 as a concrete gravity dam for the purpose of irrigation water supply. The main specifications are 118 km^2 in catchment area, 0.2 m^3/s of development discharge, 21.5 m in dam height, 290 m in dam length, 4,300,000 m^3 in reservoir volume and 605,000 m^2 in reservoir area. To meet the future source water shortage (9,273 m^3/day) in the year 2,020 for the municipality of Tobias Barreto, Jabiberi Dam Raising Project is proposed. Raise in 3 m of dam height can develop 1.8 million m^3 of additional reservoir volume, providing approximately 10,000 m^3/day of water supply during 6 months of drought period in each year. General profile of raise of dam height is shown in Figure-2.3.

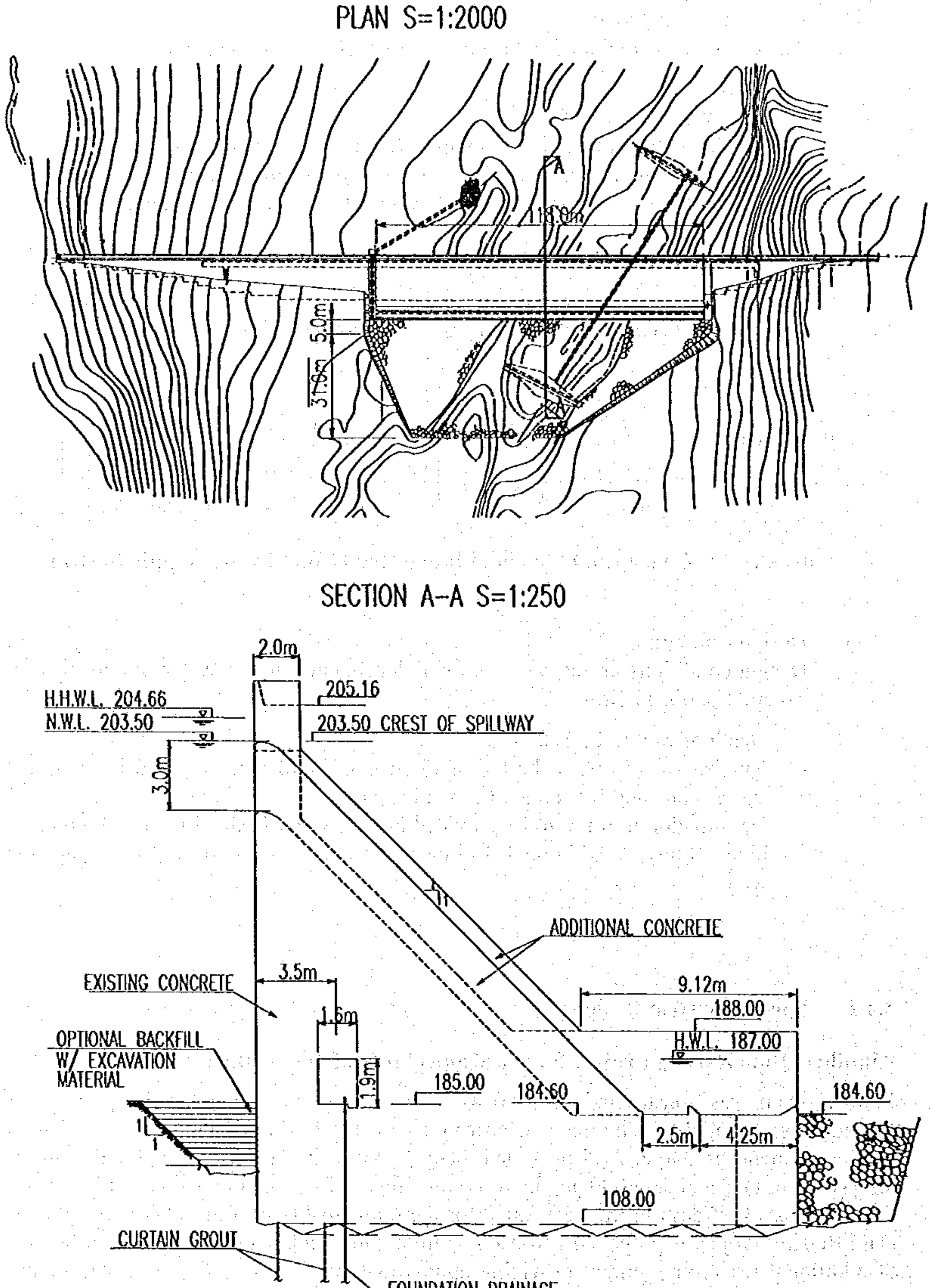

Figure-2.3 General Profile of Raise in Dam Height of Jabiberi Dam

2.3 Integrated Water Supply for Urban and Large Rural Area

2.3.1 Selection of Optimum Plans

(1) Selection Method

Optimum plan is selected by evaluating each alternative plan based on the results of design and cost estimation of component projects. The concept of Annual Expense is introduced for economical evaluation of alternative plans.

(2) Definition of Annual Expense

Annual expense is defined as the expense expected annually, after completion of construction of integrated water supply system and during operational period, and consists of the followings;

- **Expense for Reimbursement, AEc**
  - expense for reimbursement of loans for construction of the system
  - depreciation of constructed facilities in the system
- **Expense for Operation and Maintenance of the System, AEo**
  - expenses for operation and maintenance of the facilities in the system, including expenses for personnel, consumable materials, electricity and other expenses required for operation and maintenance of the system

(3) Basic Cost Parameters

The basic cost parameters required for evaluation of annual expense for water supply system are as follows;

1) The basic cost parameters are calculated in US dollar

2) Construction cost for dam, C_d (R$)
C_d is made up of the construction cost of dam, spillway, check dam, low flow diversion channel and other auxiliary facilities .

3) Construction cost of pipeline, C_{pl} (R$)
C_{pl} can be given by multiplication of unit cost for construction of pipeline per linear meter(R$/m) and length of pipeline (m).

4) Construction cost of pump stations
This cost can be divided into the construction cost for civil works, C_{pfc} (R$) and for electrical and mechanical works, C_{pfe} (R$).

5) Construction cost of common projects and other required facility
The construction cost for additional water treatment facility, water storage facility and water distribution facility are not considered in evaluation of alternative plans, because these costs are nothing to do with the route of proposed pipelines and are the same for every alternative project. Land acquisition cost is also disregarded because depreciation of land is not necessary to be counted.

The following enlargement or improvement projects are common in all alternative plans and are not covered in this evaluation because the enlargement or expansion of each system involved can be done within its system and does not affect the costs of proposed alternative projects.

- Enlargement Project of Propria Pipeline System
- Enlargement Project of Itabaianinha Pipeline System
- Jabiberi Dam Raising Project near Tobias Barreto
- Independent Water Resources Development Project in Leste Sergipano
- Water Resources Development Plan for Small Rural Area
- Irrigation Water Supply Projects

6) Interest and depreciation rate of constructed facility
The followings are the rates of interest and depreciation considered in this evaluation:

- Interest for loan, r : 0.025
- Depreciation rate

for civil works,	m1	dam	: 0.0125 (80 years)
	m2	RC structures	: 0.0250 (40 years)
	m3	steel pipeline	: 0.0667 (15 years)
for electrical and mechanical works,	m4	pump facility	: 0.0667 (15 years)

7) Cost for electricity, f_e (R$/kWh)
Operation cost of pomp facility is evaluated as cost for energy consumption of pump and unit cost of electricity is given as 0.0499 R$/kWh determined from the data presented by ENERGIPE.

8) Unit Cost for Operation and maintenance, f_o (R$/m^3)
Unit cost for operation and maintenance, except for electricity and depreciation, is given by the following expression obtained by analysis of O & M cost presented by DESO:

$$f_o = 9{,}075.74 \times e^{2.08655E\text{-}05Q} \times \text{R\$ } 1.18/\text{US\$}$$

where Q : Daily production capacity of pump station (m^3/day).

(4) Annual Expense

1) Annual expense AEc

$$AEc = AEc_d + AEc_{pfc} + AEc_{pl} + AEc_{pfe}$$
$$AEc_d = C_d \times (r + m1)$$
$$AEc_{pfc} = C_{pfc} \times (r + m2)$$
$$AEc_{pl} = C_{pl} \times (r + m3)$$
$$AEc_{pfe} = C_{pfe} \times (r + m4)$$

2) Annual expense AEo

$$AEo = AEoe + AEoo$$
$$AEoe = fe \times P \times 24 \times 365$$
$$AEoo = fo \times Q \times 365$$

where P : Power of pump units (kW).

(5) Construction Cost of Dam

1) Facilities included
The dam includes dam body, spillway, check dam, low flow diversion channel and other auxiliary facilities.

- Dam :Rock fill dam.
- Spillway :Free overflow reinforced concrete open channel. To be constructed apart from dam body. Design flood discharge to be 1,600 m^3/s.
- Check dam :Concrete dam. To be constructed for regulation of water level at water inflow for low flow diversion channel. To be located 30 km upstream of main dam.
- Low flow diversion channel :Open channel of inverted-trapezoidal section with concrete lining. To be constructed for prevention of high salinity river flow go into the reservoir. To be constructed on river terrace.

2) Development Discharge, Dam Specification and Construction Cost

Among all alternative plans, construction of dam is included in the Cases-XV1, XV2, XV3, VV1, VV2 and VV3. Development discharge and dam specification for each case is shown in Table-2.1.

Table-2.1 Development Discharge and Dam Specification

Case		Unit	Case XV1-3	Case VV1-3	Single Purpose		
					Water Supply		Irrigation
					Case A	Case B	
Development Discharge	Domestic	m^3/s	0.518	1.064	0.518	1.064	-
	Irrigation	m^3/s	2.912	2.912	-	-	2.912
	Total	m^3/s	3.430	3.976	0.518	1.064	2.912
Dam Specification	N.W.L.	EL.m	47.6	49.4	43.0	45.6	45.8
	Crest Elevation	EL.m	54.0	56.0	49.0	52.0	52.0
	Dam Height	m	34.0	36.0	29.0	32.0	32.0
	Reservoir. Area	km^2	15.0	16.0	12.4	14.0	14.0
	Dam Material Volume	$x10^3m^3$	533	633	331	445	445
Construction Cost	Dam Body	M.R$	12.18	16.63	6.30	8.26	8.26
	Spillway	M.R$	35.55	35.55	35.55	35.55	35.55
	Low Flow Diver. Channel	M.R$	6.51	6.51	6.51	6.51	6.51
	Check Dam	M.R$	2.21	2.21	2.21	2.21	2.21
	Land Acquisition	M.R$	1.06	1.13	0.87	0.99	0.99
	Total	M.R$	57.51	62.03	51.45	53.52	53.52
Cost Allocation	For water supply system	M.R$	28.19	31.02	51.45	53.52	0.00
	For irrigation system	M.R$	29.32	31.02	0.00	0.00	53.52

Note:
1) N.W.L.: Normal Water Level
2) Cases-XX1, XX2 and XX3 is for water supply to Vaza Barris Irrigation Project only.
3) Cases-XV1, XV2 and XV3 is for domestic water supply to Lagarto only and for irrigation water supply to Vaza Barris Project.
4) Cases-VV1, VV2 and VV3 is for domestic water supply to Itabaiana and Lagarto in addition to irrigation water supply to Vaza Barris Project.
5) Ratio of allocation of dam construction cost for water supply and irrigation for Cases XV1 to XV3 is given by the ratio of dam construction cost for single purpose of water supply in Case A and dam construction cost for single purpose of irrigation..
6) Ratio of allocation of dam construction cost for water supply and irrigation for Cases VV1 to VV3 is given by the ratio of dam construction cost for single purpose of water supply in Case B and dam construction cost for single purpose of irrigation..

Construction costs are also shown in Table-2.1. The construction cost of Multi-purpose dam for water supply and irrigation purposes can be allocated in proportion to the following dam construction cost;

- Construction cost of dam developed solely for water supply purpose
- Construction cost of dam developed solely for irrigation purpose

Cost allocation of construction of dam for irrigation and domestic water supply is taken as 51% for irrigation and 49% for domestic water supply for Cases-XV1 to XV3 and as 50% for each water supply for Cases-VV1 to VV3.

(6) Conditions for Design and Cost Estimation of Water Supply Pipelines

The following conditions are applied to the economic evaluation of water supply system;

1) The total water demand and supply for each water supply block is concentrated at the center of each block and distribution of water from the center of block to any other place of consumption in the block is neglected.

2) Full capacity of existing water supply facility is used for current water supply. Additional water supply facility shall be provided for additional supply of water in any blocks of consumption.

3) A segment of pipelines is composed of single continuous pipe with single diameter, starting from a water intake point or a center of block to another center of block. Material of pipe is steel. Most economical diameter for each segment is selected based on the results of annual expenses for different diameters in 10 cm pitch.

4) Water intake points and centers of blocks are as shown in Figure-2.4.

5) Flow volume, Q (m^3/s), to be transported through a segment of pipeline is determined by the volume of demand in future minus current water supply capacity.

6) One pump station for one segment of pipeline.

7) Actual suction head and friction head loss, h_f, are considered for calculation of total head loss, H, and other miscellaneous head losses are neglected.

8) Construction cost of a pump station is proportional to the potential of pump.

9) Potential of pump, P (kW)
Potential of pump can be obtained with flow volume and total head.
Friction head loss can be calculated by Hazen·Williams formula.

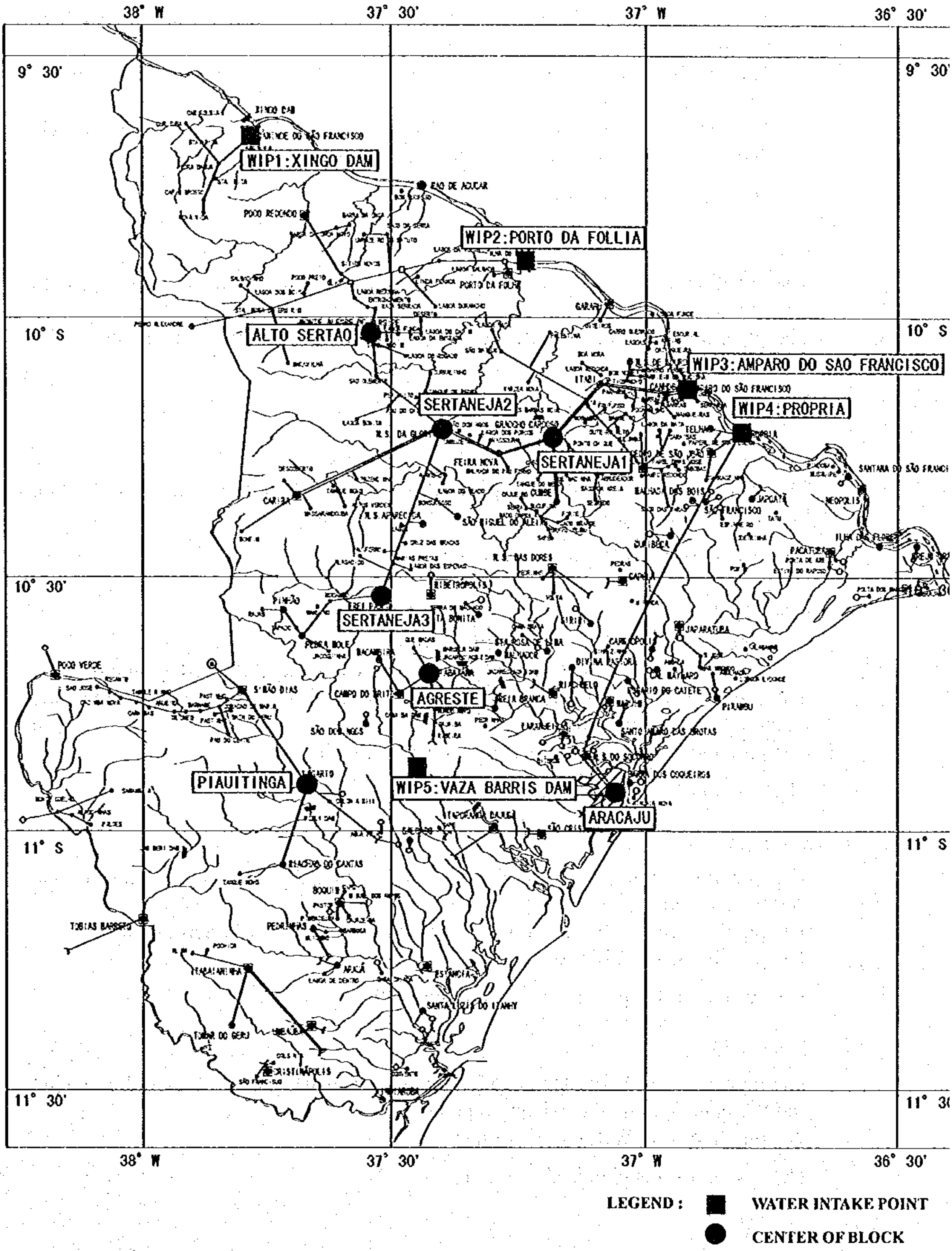

Figure - 2.4 Water Intake Points and Center of Blocks for Integrated Water Supply

(7) Description of Alternative Projects

1) Case-XX1

- The pipeline from Xingo dam, WIP1, led directly to Agreste and went to Piauitinga
- The pipeline from Porto da Folha, WIP2, to Alto Sertao along the existing Alto Sortie pipeline
- The pipeline from Amparo do Sao Francisco, WIP3, to Sertaneja3 via Sertaneja1 and Sertaneja2 along the existing Sertaneja pipeline.

The system of this plan is shown in Figure-2.5.

2) Case-XX2

- The pipeline from Xingo dam, WIP1, led directly to Sertaneja2 and went to Piauitinga
- The pipeline from Porto da Folha, WIP2, to Alto Sertao along the existing Alto Sertao pipeline

The system of this plan is shown in Figure-2.6.

3) Case-XX3

- The pipeline from WIP1 led poco Profundo to Piauitinga via Alto Sertao, Sertaneja2, Sertaneja3 and Agreste along the existing pipelines.

The system of this plan is shown in Figure-2.7.

4) Case-XV1

- The pipeline from WIP1 led directly to Agreste
- The pipeline from WIP2 to Alto Sertao along the existing Alto Sertao pipeline
- The pipeline from WIP3 to Sertaneja3 via Sertaneja1 and Sertaneja2 along the existing Sertaneja pipeline.
- The pipeline from Vaza Barris Dam, WIP5, to Piauitinga.

The system of this plan is shown in Figure-2.8.

5) Case-XV2

- The pipeline from WIP1 led directly to Sertaneja2 and went to Agreste via Sertaneja3 along the existing pipelines.
- The pipeline from WIP2 to Alto Sertao along the existing Alto Sertao pipeline
- The pipeline from WIP5 to Piauitinga.

The system of this plan is shown in Figure-2.9.

6) Case-XV3

- The pipeline from WIP1 led poco Profundo to Agreste via Alto Sertao, Sertaneja2 and Sertaneja3 along the existing pipelines.
- The pipeline from WIP5 to Piauitinga.

The system of this plan is shown in Figure-2.10.

7) Case-VV1

- The pipeline from WIP2 to Alto Sertao along the existing Alto Sertao pipeline
- The pipeline from WIP3 to Sertaneja3 via Sertaneja1 and Sertaneja2 along the

existing Sertaneja pipeline.
- The pipeline from WIP5 to Agreste.
- The pipeline from WIP5 to Piauitinga.

The system of this plan is shown in Figure-2.11.

8) Case-VV2
- The pipeline from WIP1 led directly to Sertaneja2 and went to Sertaneja3.
- The pipeline from WIP2 to Alto Sertao along the existing Alto Sertao pipeline
- The pipeline from WIP5 to Agreste.
- The pipeline from WIP5 to Piauitinga.

The system of this plan is shown in Figure-2.12.

9) Case-VV3
- The pipeline from WIP1 led to Sertaneja3 via Poco Profundo, Alto Sertao and Sertaneja2.
- The pipeline from WIP5 to Agreste.
- The pipeline from WIP5 to Piauitinga.

The system of this plan is shown in Figure-2.13.

10) Case-SS1
- The pipeline from WIP2 to Alto Sertao along the existing Alto Sertao pipeline
- The pipeline from WIP3 to Sertaneja3 via Sertaneja1 and Sertaneja2 along the existing Sertaneja pipeline.
- The pipeline from Propria, WIP4, to Piauitinga via Aracaju and Agreste along the existing Sao Francisco Pipeline.

The system of this plan is shown in Figure-2.14.

(8) Results of Calculation of Annual Expenses for Each Alternative Plan

Calculation results of annual expense for each alternative project are attached in Table-2.3 to Table-2.12. The summary of the results is shown in Table-2.2.

Table-2.2 Summary of Construction Cost and Annual Expense for Alternative Plans

Unit: Million R$

Alternative Plan	Construction Cost					Annual Expense		
	Dam	Pipeline	Civil Works	Equipm't	Total	AEc	AEo	Total
XX1	0.0	129.8	4.1	15.9	149.9	13.6	5.9	19.5
XX2	0.0	135.5	4.1	16.5	156.1	14.1	8.8	22.9
XX3	0.0	138.1	5.2	21.5	164.7	14.9	12.1	27.0
XV1	28.8	97.8	3.2	12.3	142.1	11.3	4.7	16.0
XV2	28.8	96.5	2.8	11.2	139.4	11.1	4.8	15.9
XV3	28.8	97.9	3.5	14.2	144.4	11.5	6.0	17.5
VV1	31.6	45.5	3.1	11.7	91.9	6.6	4.3	10.9
VV2	31.6	51.9	2.6	10.3	96.4	7.0	3.7	10.7
VV3	31.6	61.4	2.5	10.3	105.7	7.9	4.0	11.9
SS1	0.0	137.2	4.4	17.0	158.6	10.6	6.2	16.8

1) Construction costs and annual expenses for alternative plans with dam, Cases-XV1, XV2, XV3, VV1, VV2 and VV3 are lower than those for alternative plans without dam, Cases-XX1, XX2, XX3 and SS-1. This result means that the cost for water transportation from any places of Sao Francisco River down to Itabaiana and Lagarto is quite high compared with the cost for water development in the vicinity of Itabaiana and Lagarto. It suggests that, in the economical point of view, the water development in central and south eastern regions in Sergipe State shall be conducted in their respective river basin.
2) In case of long distance water transportation by pipeline from Xingo dam to Itabaiana and Lagarto, annual expense for Case-XX1 is lower than those for Cases-XX2 and XX3. This is because the pipelines in Cases-XX2 and XX3 pass through the existing water supply facilities located in high land cities and villages.
3) In comparison of Cases-VV1, VV2 and VV3, water transportation from Xingo dam to Frei Paulo, the center of block of Sertaneja3, without passing through the existing high land water supply facilities, is lower than from Amparo do Sao Francisco to Frei Paulo along the existing pipeline route. The pipeline route from Xingo dam is advantageous for water transportation to Frei Paulo
4) Comparison of the results of Cases-XV1, XV2, XV3, VV1, VV2 and VV3 shows that if Vaza Barris Dam is constructed, the water to Itabaiana shall be supplied from the Vaza Barris Dam as well and not from Sao Francisco River.

(9) Conclusion of Evaluation of Alternative Plan

It is concluded that the alternative project VV2 is most economical than any other projects in their annual expense basis.

Outline of alternative plan VV2 is shown in Figure-2.15.

Table-2.3 Construction Cost and Annual Expense for Case-XX1

Intake	Flow Volume	Water Elevation	Highest Elevation	Geographical difference in Elevation	Length of Pipeline	Pipe Dia.	Head Loss	Total Head	Investment (R$: millions)				Annual Expense (R$: millions)		
	m^3/s	m	m	m	km	m	m	m	Pipe line	Pump Civil	Pump Equip	Total	AEc	AEo	Total
Xingo	1.065	138.0	285.0	147.0	122.5	1.0	209.0	356.0	82.7	2.2	8.7	93.7	8.50	2.82	11.32
Alto Sertao	0.022	18.0	410.0	392.0	54.5	0.2	180.0	572.0	2.1	0.1	0.2	2.5	0.22	0.21	0.44
Sertaneja 1	0.499	0.0	260.0	260.0	38.6	0.7	92.0	352.0	13.8	1.1	4.0	18.9	1.69	1.31	3.00
Sertaneja 2	0.410	242.0	322.0	80.0	28.3	0.7	46.9	126.9	10.1	0.4	1.2	11.7	1.06	0.59	1.65
Sertaneja 3	0.125	322.0	396.5	74.5	39.5	0.4	111.0	185.5	5.2	0.1	0.6	5.9	0.53	0.32	0.85
Frei Paulo	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Itabaiana	0.519	200.0	250.0	50.0	35.0	0.8	46.8	96.8	15.8	0.2	1.2	17.2	1.57	0.66	2.23
Vaza Barris-Itabaiana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vaza Barris-Piaui	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sao Francisco	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total									129.8	4.1	15.9	149.9	13.57	5.91	19.48

Table-2.4 Construction Cost and Annual Expense for Case-XX2

Intake	Flow Volume	Water Elevation	Highest Elevation	Geographical difference in Elevation	Length of Pipeline	Pipe Dia.	Head Loss	Total Head	Investment (R$: millions)				Annual Expense (R$: millions)		
	m^3/s	m	m	m	km	m	m	m	Pipe line	Pump Civil	Pump Equip	Total	AEc	AEo	Total
Xingo	1.564	138.0	322.0	184.0	78.0	1.2	111.5	295.5	73.0	2.7	10.7	86.5	7.81	4.80	12.61
Alto Sertao	0.022	18.0	410.0	392.0	54.5	0.2	180.0	572.0	2.1	0.1	0.2	2.5	0.22	0.21	0.44
Sertaneja 1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sertaneja 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sertaneja 3	1.190	322.0	396.5	74.5	39.5	1.1	52.0	126.5	31.6	0.8	3.5	36.0	3.27	2.14	5.40
Frei Paulo	1.065	288.0	288.0	0.0	19.0	1.0	32.4	32.4	12.9	0.2	0.8	13.9	1.26	0.98	2.24
Itabaiana	0.519	200.0	250.0	50.0	35.0	0.8	46.8	96.8	15.8	0.2	1.2	17.2	1.57	0.66	2.23
Vaza Barris-Itabaiana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vaza Barris-Piaui	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sao Francisco	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total									135.5	4.1	16.5	156.1	14.14	8.79	22.93

Table-2.5 Construction Cost and Annual Expense for Case-XX3

Intake	Flow Volume	Water Elevation	Highest Elevation	Geographical difference in Elevation	Length of Pipeline	Pipe Dia.	Head Loss	Total Head	Investment (R$: millions)				Annual Expense (R$: millions)		
	m^3/s	m	m	m	km	m	m	m	Pipe line	Pump Civil	Pump Equip	Total	AEc	AEo	Total
Xingo	1.586	138.0	410.0	272.0	53.9	1.2	79.1	351.1	50.4	3.2	12.9	66.4	5.96	5.35	11.30
Alto Sertao	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sertaneja 1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sertaneja 2	1.510	273.5	322.0	48.5	29.3	1.2	39.3	87.8	27.4	0.7	3.1	31.2	2.83	2.95	5.78
Sertaneja 3	1.190	322.0	396.5	74.5	39.5	1.1	52.0	126.5	31.6	0.8	3.5	36.0	3.27	2.14	5.40
Frei Paulo	1.065	288.0	288.0	0.0	19.0	1.0	32.4	32.4	12.9	0.2	0.8	13.9	1.26	0.98	2.24
Itabaiana	0.519	200.0	250.0	50.0	35.0	0.8	46.8	96.8	15.8	0.2	1.2	17.2	1.57	0.66	2.23
Vaza Barris-Itabaiana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vaza Barris-Piaui	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sao Francisco	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total									138.1	5.2	21.5	164.7	14.89	12.07	26.96

Table-2.6 Construction Cost and Annual Expense for Case-XV1

Intake	Flow Volume	Water Elevation	Highest Elevation	Geographical difference in Elevation	Length of Pipeline	Pipe Dia.	Head Loss	Total Head	Investment (R$:millions)				Annual Expense (R$: millions)		
	m^3/s	m	m	m	km	m	m	m	Pipe line	Pump Civil	Pump Equip	Total	AEc	AEo	Total
Xingo	0.546	138.0	285.0	147.0	122.5	0.8	180.1	327.1	55.5	1.1	4.1	60.7	5.51	1.36	6.87
Alto Sertao	0.022	18.0	410.0	392.0	54.5	0.2	180.0	572.0	2.1	0.1	0.2	2.5	0.22	0.21	0.44
Sertaneja 1	0.499	0.0	260.0	260.0	38.6	0.7	92.0	352.0	13.8	1.1	4.0	18.9	1.69	1.31	3.00
Sertaneja 2	0.410	242.0	322.0	80.0	28.3	0.7	46.9	126.9	10.1	0.4	1.2	11.7	1.06	0.59	1.65
Sertaneja 3	0.125	322.0	396.5	74.5	39.5	0.4	111.0	185.5	5.2	0.1	0.6	5.9	0.53	0.32	0.85
Frei Paulo	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Itabaiana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vaza Barris-Itabaiana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vaza Barris-Piaui	0.519	50.0	190.0	140.0	24.5	0.8	32.8	172.8	11.1	0.5	2.1	13.7	1.24	0.87	2.11
Sao Francisco	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vaza Barris Dam									0.0	28.8	0.0	28.8	1.09	0.00	1.09
Total									97.8	32.0	12.3	142.1	11.34	4.66	16.00

Table-2.7 Construction Cost and Annual Expense for Case-XV2

Intake	Flow Volume	Water Elevation	Highest Elevation	Geographical difference in Elevation	Length of Pipeline	Pipe Dia.	Head Loss	Total Head	Investment (R$: millions)				Annual Expense (R$: millions)		
	m^3/s	m	m	m	km	m	m	m	Pipe line	Pump Civil	Pump Equip	Total	AEc	AEo	Total
Xingo	0.967	138.0	322.0	184.0	78.0	1.0	111.3	295.3	52.6	1.7	6.6	60.9	5.51	2.25	7.76
Alto Sertao	0.022	18.0	410.0	392.0	54.5	0.2	180.0	572.0	2.1	0.1	0.2	2.5	0.22	0.21	0.44
Sertaneja 1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sertaneja 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sertaneja 3	0.671	322.0	396.5	74.5	39.5	0.9	47.9	122.4	22.1	0.5	1.9	24.4	2.22	0.93	3.15
Frei Paulo	0.546	288.0	288.0	0.0	19.0	0.8	27.9	27.9	8.6	0.1	0.4	9.1	0.83	0.48	1.31
Itabaiana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vaza Barris-Itabaiana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vaza Barris-Piaui	0.519	50.0	190.0	140.0	24.5	0.8	32.8	172.8	11.1	0.5	2.1	13.7	1.24	0.87	2.11
Sao Francisco	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vaza Barris Dam									0.0	28.8	0.0	28.8	1.09	0.00	1.09
Total									96.5	31.6	11.2	139.4	11.10	4.76	15.86

Table-2.8 Construction Cost and Annual Expense for Case-XV3

Intake	Flow Volume	Water Elevation	Highest Elevation	Geographical difference in Elevation	Length of Pipeline	Pipe Dia.	Head Loss	Total Head	Investment (R$: millions)				Annual Expense (R$: millions)		
	m^3/s	m	m	m	km	m	m	m	Pipe line	Pump Civil	Pump Equip	Total	AEc	AEo	Total
Xingo	0.989	138.0	410.0	272.0	53.9	1.0	80.2	352.2	36.3	2.0	8.0	46.4	4.17	2.60	6.76
Alto Sertao	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sertaneja 1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sertaneja 2	0.913	273.5	322.0	48.5	29.3	1.0	37.6	86.1	19.8	0.5	1.8	22.1	2.01	1.11	3.12
Sertaneja 3	0.671	322.0	396.5	74.5	39.5	0.9	47.9	122.4	22.1	0.5	1.9	24.4	2.22	0.93	3.15
Frei Paulo	0.546	288.0	288.0	0.0	19.0	0.8	27.9	27.9	8.6	0.1	0.4	9.1	0.83	0.48	1.31
Itabaiana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vaza Barris-Itabaiana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vaza Barris-Piaui	0.519	50.0	190.0	140.0	24.5	0.8	32.8	172.8	11.1	0.5	2.1	13.7	1.24	0.87	2.11
Sao Francisco	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vaza Barris Dam									0.0	28.8	0.0	28.8	1.09	0.00	1.09
Total									97.9	32.3	14.2	144.4	11.54	5.99	17.53

Table-2.9 Construction Cost and Annual Expense for Case-VV1

Intake	Flow Volume	Water Elevation	Highest Elevation	Geographical difference in Elevation	Length of Pipeline	Pipe Dia.	Head Loss	Total Head	Investment (R$: millions)				Annual Expense (R$: millions)		
	m^3/s	m	m	m	km	m	m	m	Pipe line	Pump Civil	Pump Equip	Total	AEc	AEo	Total
Xingo	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alto Sertao	0.022	18.0	410.0	392.0	54.5	0.20	180.0	572.0	2.1	0.1	0.2	2.5	0.22	0.21	0.44
Sertaneja 1	0.499	0.0	260.0	260.0	38.6	0.70	92.0	352.0	13.8	1.1	4.0	18.9	1.69	1.26	2.95
Sertaneja 2	0.410	242.0	322.0	80.0	28.3	0.60	99.4	179.4	7.7	0.5	1.7	9.8	0.87	0.66	1.53
Sertaneja 3	0.125	322.0	396.5	74.5	39.5	0.40	111.0	185.5	5.2	0.1	0.6	5.9	0.53	0.30	0.83
Frei Paulo	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Itabaiana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vaza Barris-Itabaiana	0.546	50.0	200.0	150.0	22.5	0.70	63.4	213.4	8.0	0.7	2.7	11.4	1.01	0.97	1.98
Vaza Barris-Piaui	0.519	50.0	190.0	140.0	24.5	0.70	62.8	202.8	8.7	0.6	2.5	11.8	1.06	0.90	1.96
Sao Francisco	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vaza Barris Dam									0.0	31.6	0.0	31.6	1.19	0.00	1.19
Total									45.5	34.7	11.7	91.9	6.58	4.30	10.88

Table-2.10 Construction Cost and Annual Expense for Case-VV2

Intake	Flow Volume	Water Elevation	Highest Elevation	Geographical difference in Elevation	Length of Pipeline	Pipe Dia.	Head Loss	Total Head	Investment (R$: millions)				Annual Expense (R$: millions)		
									Pipe line	Pump Civil	Pump Equip	Total	AEc	AEo	Total
	m^3/s	m	m	m	km	m	m	m							
Xingo	0.499	138.0	322.0	184.0	78.0	0.70	186.0	370.0	27.8	1.1	4.2	33.2	3.00	1.31	4.31
Alto Sertao	0.022	18.0	410.0	392.0	54.5	0.20	180.0	572.0	2.1	0.1	0.2	2.5	0.22	0.21	0.44
Sertaneja 1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sertaneja 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sertaneja 3	0.125	322.0	396.5	74.5	39.5	0.40	111.0	185.5	5.2	0.1	0.6	5.9	0.53	0.30	0.83
Frei Paulo	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Itabaiana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vaza Barris-Itabaiana	0.546	50.0	200.0	150.0	22.5	0.70	63.4	213.4	8.0	0.7	2.7	11.4	1.01	0.97	1.98
Vaza Barris-Piaui	0.519	50.0	190.0	140.0	24.5	0.70	62.8	202.8	8.7	0.6	2.5	11.8	1.06	0.90	1.96
Sao Francisco	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vaza Barris Dam									0.0	31.6	0.0	31.6	1.19	0.00	1.19
Total									51.9	34.2	10.3	96.4	7.02	3.68	10.70

Table-2.11 Construction Cost and Annual Expense for Case-VV3

Intake	Flow Volume	Water Elevation	Highest Elevation	Geographical difference in Elevation	Length of Pipeline	Pipe Dia.	Head Loss	Total Head	Investment (R$: millions)				Annual Expense (R$: millions)		
									Pipe line	Pump Civil	Pump Equip	Total	AEc	AEo	Total
	m^3/s	m	m	m	km	m	m	m							
Xingo	0.521	138.0	410.0	272.0	53.9	0.8	72.6	344.6	24.4	1.1	4.1	29.6	2.67	1.35	4.01
Alto Sertao	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sertaneja 1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sertaneja 2	0.444	273.5	322.0	48.5	29.3	0.7	56.3	104.8	10.5	0.2	1.1	11.8	1.07	0.58	1.65
Sertaneja 3	0.125	322.0	396.5	74.5	39.5	0.4	111.0	185.5	5.2	0.1	0.6	5.9	0.53	0.32	0.85
Frei Paulo	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Itabaiana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vaza Barris-Itabaiana	0.546	50.0	200.0	150.0	22.5	0.8	33.1	183.1	10.1	0.6	2.4	13.1	1.18	0.93	2.11
Vaza Barris-Piaui	0.519	50.0	190.0	140.0	24.5	0.8	32.8	172.8	11.1	0.5	2.1	13.7	1.24	0.87	2.11
Sao Francisco	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vaza Barris Dam									0.0	31.6	0.0	31.6	1.19	0.00	1.19
Total									61.4	34.1	10.3	105.7	7.88	4.05	11.93

Table-2.12 Construction Cost and Annual Expense for Case-SS1

Intake	Flow Volume	Water Elevation	Highest Elevation	Geographical difference in Elevation	Length of Pipeline	Pipe Dia.	Head Loss	Total Head	Investment (R$: millions)				Annual Expense (R$: millions)		
									Pipe line	Pump Civil	Pump Equip	Total	AEc	AEo	Total
	m^3/s	m	m	m	km	m	m	m							
Xingo	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alto Sertao	0.022	18.0	410.0	392.0	54.5	0.2	180.0	572.0	2.1	0.1	0.2	2.5	0.22	0.21	0.44
Sertaneja 1	0.499	0.0	260.0	260.0	38.6	0.7	92.0	352.0	13.8	1.1	4.0	18.9	1.69	1.31	3.00
Sertaneja 2	0.410	242.0	322.0	80.0	28.3	0.7	46.9	126.9	10.1	0.4	1.2	11.7	1.06	0.59	1.65
Sertaneja 3	0.125	322.0	396.5	74.5	39.5	0.4	111.0	185.5	5.2	0.1	0.6	5.9	0.53	0.32	0.85
Frei Paulo	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Itabaiana	0.519	200.0	250.0	50.0	35.0	0.8	46.8	96.8	15.8	0.2	1.2	17.2	1.57	0.66	2.23
Vaza Barris-Itabaiana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vaza Barris-Piaui	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sao Francisco	1.065	0.0	171.2	171.2	133.5	1.0	227.8	399.0	90.2	2.5	9.8	102.4	5.53	3.07	8.60
Total									137.2	4.4	17.0	158.6	10.61	6.16	16.77

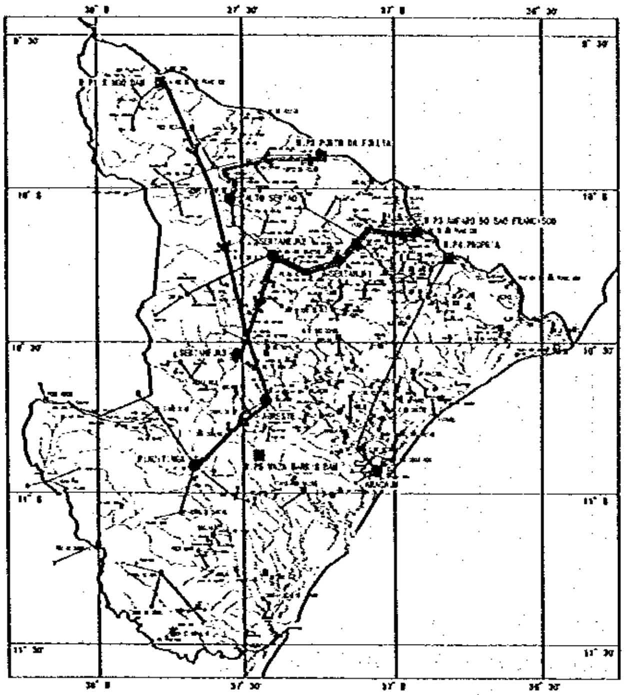

Figure -2.5 Conceptual Route Map of Case -XX1

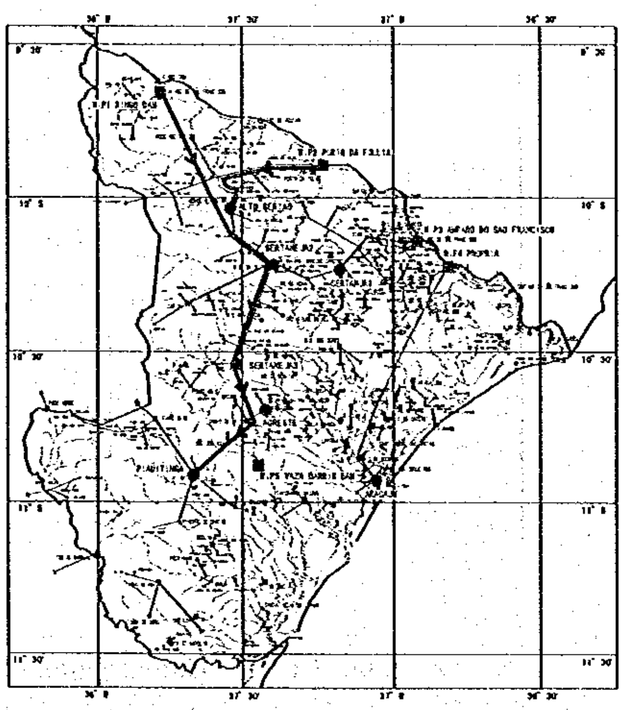

Figure -2.6 Conceptual Route Map of Case - XX2

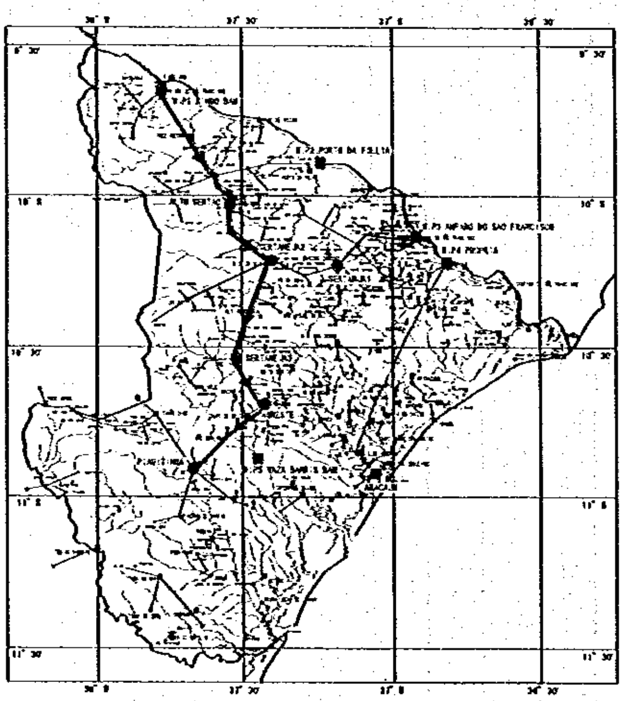

Figure -2.7 Conceptual Route Map of Case - XX3

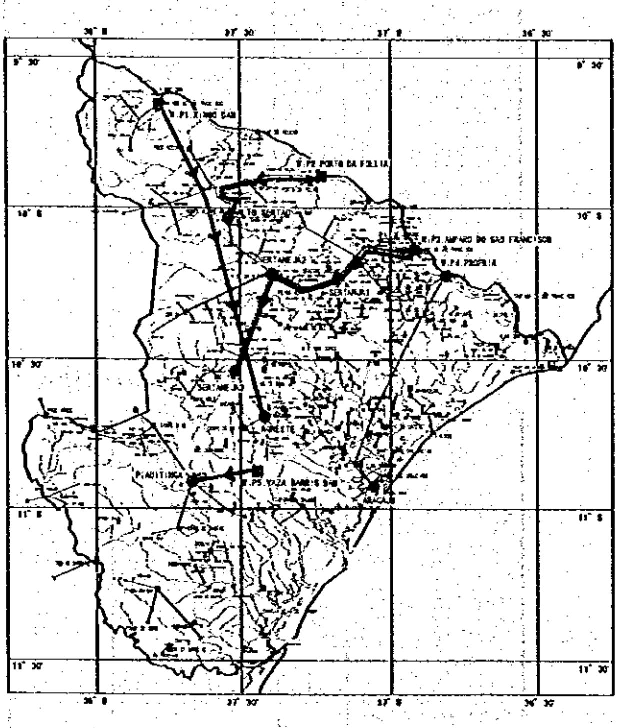

Figure -2.8 Conceptual Route Map of Case - XV1

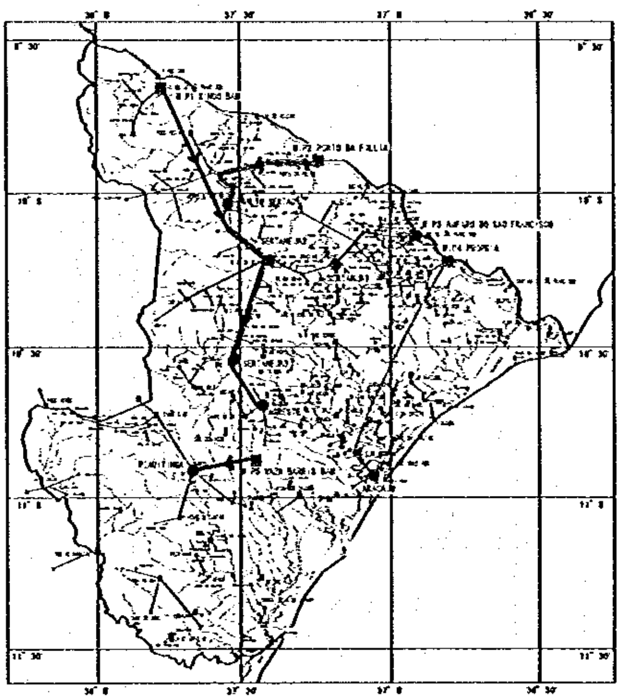

Figure -2.9 Conceptual Route Map of Case -XV2

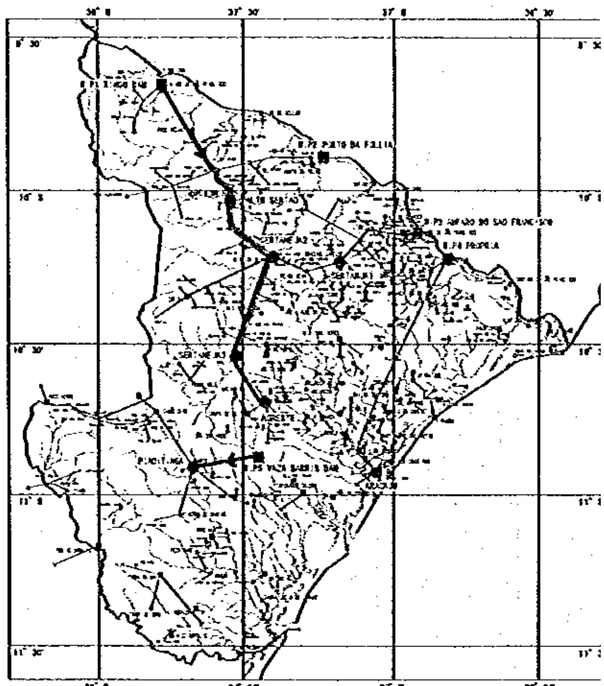

Figure -2.10 Conceptual Route Map of Case - XV3

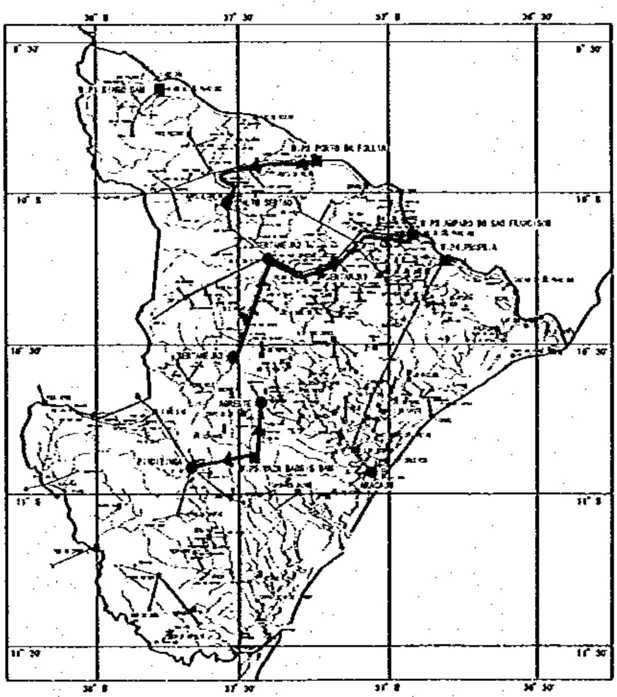

Figure -2.11 Conceptual Route Map of Case - VV1

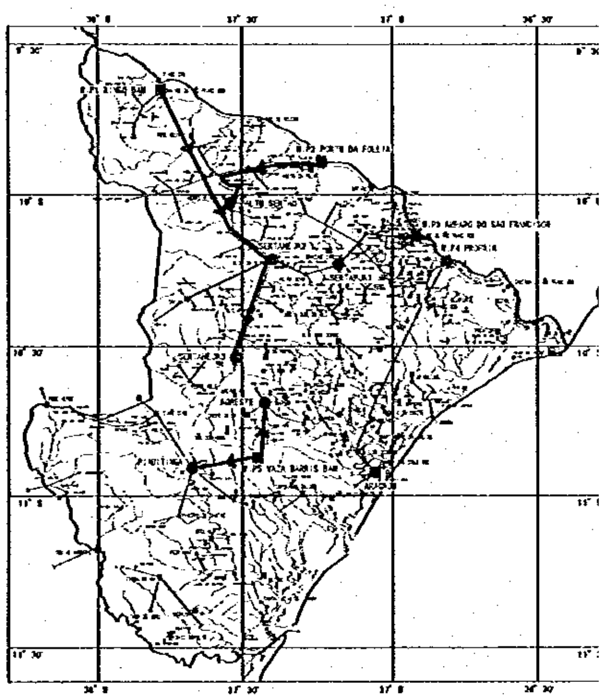

Figure -2.12 Conceptual Route Map of Case - VV2

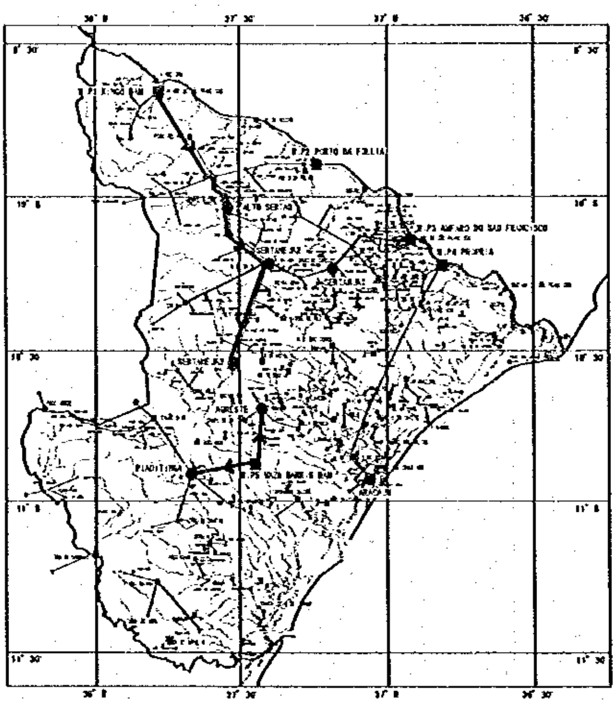

Figure -2.13 Conceptual Route Map of Case -VV3

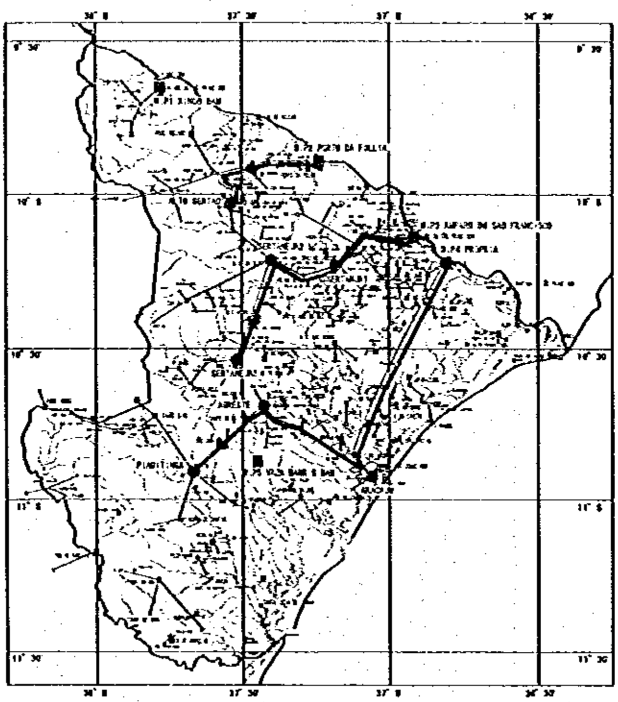

Figure -2.14 Conceptual Route Map of Case - SS1

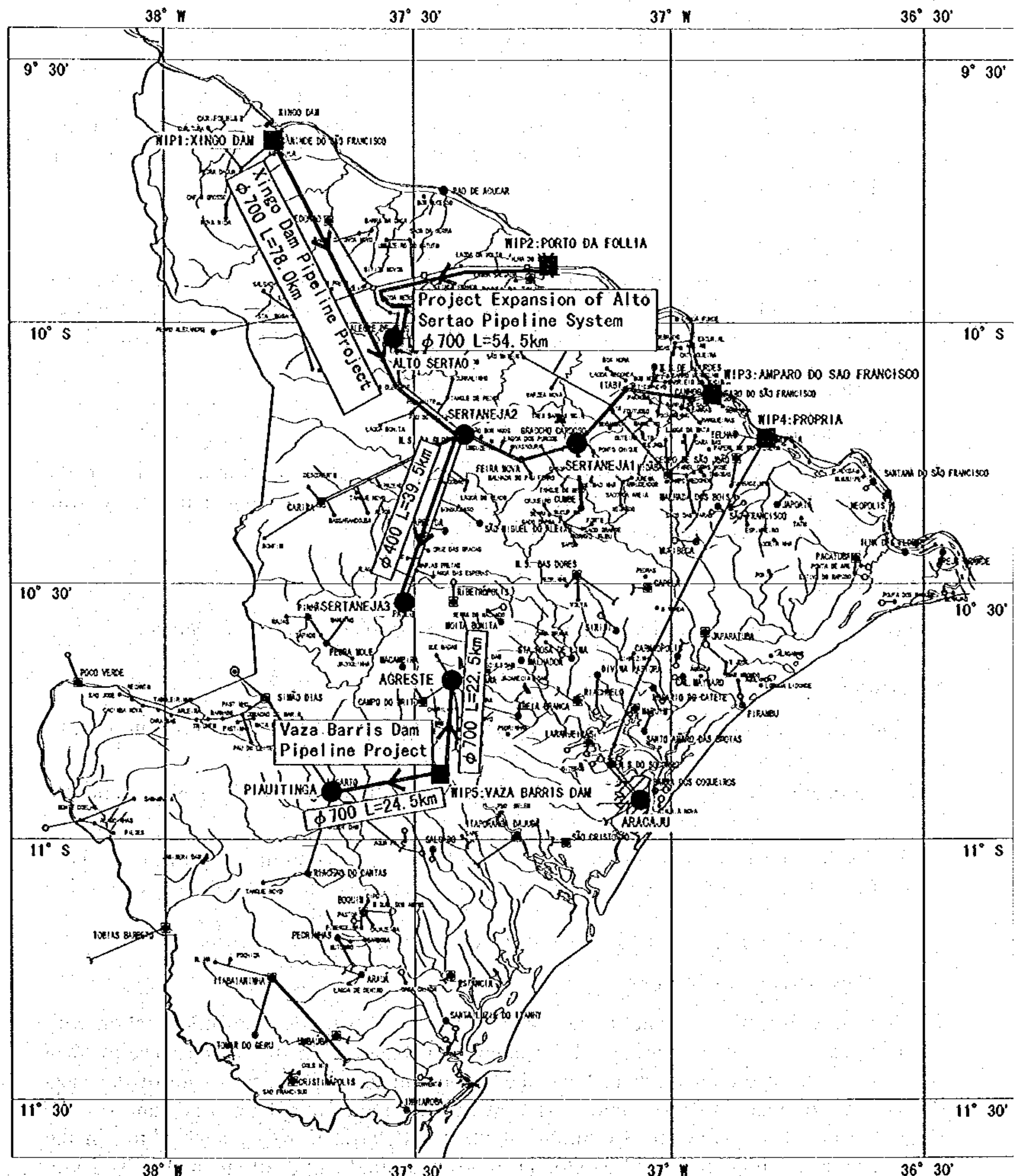

Figure - 2.15 Optimum Plan for Integrated Water Supply System (Case - VV2)