2.4.4 Institutional Measures

Planning and implementation of the proposed projects would be facilitated by related institutional measures. Some of them are included as project components as indicated above.

Planning and implementation of multipurpose development projects, including the trans-basin diversion, should be coordinated by the proposed WSB Development Management Office (DEMO). Initiative by the WSB DEMO is essential for the Tha Sae dam/reservoir project, as it is an interprovincial project. Local people/ communities as well as local governments should participate from the early stages as much as possible, guided also by the WSB DEMO.

Land consolidation should be expedited in the existing irrigation areas, especially in the lower Mae Klong river basin, where the intensification of irrigated agriculture is proposed. Rationalization of water charges may also be introduced, first in the lower Mae Klong irrigation area.

Monitoring of water quality in rivers, estuaries, and coastal waters needs to be systematically improved. Considering the ubiquity of the water quality problems, local people/communities should be involved in the monitoring system to be organized through the WSB DEMO.

Table 9.2.1 (1) Sri Nagarindra Dam (Inflow)

Maximum Storage Level	Water Level	182.40 M. (MSL)	Normal Storage Level	Water Level	180.00 M. (MSL)
	Quantity Level	18,850 Million Cubic Meters		Quantity Level	17,745 Million Cubic Meters
Minimum Storage Level	Water Level	159.00 M. (MSL)	Quantity Level	10,265 Million Cubic Meters	

Year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1977								171	527	284	130	90	1,202
1978	65	67	55	63	80	119	322	1,167	1,083	1,172	247	140	4,580
1979	96	73	71	90	106	177	349	827	613	468	157	87	3,114
1980	69	51	66	73	161	183	241	413	720	738	254	122	3,091
1981	81	102	74	65	125	385	530	1,431	1,087	859	1,235	331	6,305
1982	181	102	70	97	93	256	624	1,600	1,009	706	275	149	5,162
1983	104	56	47	52	78	96	122	298	500	1,839	657	210	4,059
1984	139	101	81	103	82	322	365	662	842	865	288	159	4,009
1985	118	90	66	95	94	289	790	856	1,606	975	395	197	5,571
1986	134	83	72	106	468	176	343	659	573	566	207	140	3,527
1987	100	75	93	113	74	205	219	411	884	622	366	132	3,294
1988	107	97	71	104	349	488	410	612	1,299	2,097	446	201	6,281
1989	175	126	83	46	159	121	152	493	431	412	128	92	2,418
1990	115	114	74	63	142	195	411	386	641	796	222	117	3,276
1991	81	52	29	53	69	340	429	1,756	805	1,121	294	132	5,161
1992	135	89	42	59	53	69	288	748	458	713	256	135	3,045
1993	111	71	56	62	76	79	206	616	750	354	136	66	2,583
1994	61	94	49	46	186	295	1,445	2,037	1,279	741	225	123	6,581
1995	101	58	51	56	82	127	262	867	1,881	929	334	153	4,901
1996	105	100											
1997													
1998													
1999													
2000													
Mean	109	84	64	75	138	218	417	880	915	887	340	149	4,276
Max.	181	126	93	113	468	488	1,445	2,037	1,881	2,097	1,235	331	10,495
Min.	61	51	29	46	53	69	122	298	431	354	128	66	1,708

Table 9.2.1 (2) Sri Nagarindra Dam (Outflow)

Maximum Storage Level	Water Level	182.40 M. (MSL)	Normal Storage Level	Water Level	180.00 M. (MSL)
	Quantity Level	18,850 Million Cubic Meters		Quantity Level	17,745 Million Cubic Meters
Minimum Storage Level	Water Level	159.00 M. (MSL)	Quantity Level	10,265 Million Cubic Meters	

Year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1977								39.4	4.1	5.1	5.1	5.3	59.0
1978	5.1	26.0	80.9	124.2	78.8	5.1	5.2	4.7	2.1	1.2	1.2	1.2	335.7
1979	5.7	95.0	154.8	169.8	95.9	28.7	5.4	5.4	5.2	12.5	113.4	11.4	703.2
1980	5.4	44.4	133.5	165.0	107.1	32.0	30.1	15.4	5.2	10.1	6.0	22.0	576.2
1981	37.6	180.8	200.7	242.7	183.3	70.2	4.4	0.0	0.0	19.0	0.8	63.7	1,008.2
1982	56.2	289.6	363.0	333.5	308.9	253.5	316.7	178.5	516.4	316.5	280.6	287.6	3,501.0
1983	293.0	344.2	465.0	530.9	546.1	541.9	372.4	331.1	216.0	105.3	111.6	148.2	4,005.9
1984	149.2	386.4	498.2	486.4	458.4	323.2	211.4	390.9	532.2	272.3	478.0	131.5	4,318.1
1985	227.9	382.0	527.8	459.1	372.2	206.6	135.4	140.9	135.4	117.2	100.9	140.3	2,945.7
1986	118.4	134.3	478.2	691.2	411.1	688.7	582.8	680.1	604.8	262.1	207.4	233.0	5,092.1
1987	250.8	201.6	402.4	391.7	382.1	324.2	261.0	361.5	181.9	225.5	220.7	32.2	3,235.6
1988	114.1	126.6	241.1	202.5	251.4	260.9	373.1	362.2	352.5	249.0	269.7	223.9	3,027.0
1989	161.8	336.0	532.5	583.7	641.6	595.5	408.7	443.7	440.1	384.8	397.2	62.5	4,988.1
1990	139.6	216.2	369.7	239.7	233.7	166.8	207.1	326.5	300.8	266.5	262.3	146.7	2,875.6
1991	351.4	266.7	363.9	398.1	336.7	205.5	153.7	335.1	397.4	361.3	455.2	257.9	3,882.9
1992	281.4	362.9	549.1	489.2	440.8	419.6	290.1	171.0	326.6	290.1	242.0	357.1	4,219.9
1993	169.4	297.4	373.8	340.1	310.8	345.1	198.2	145.7	208.4	119.0	165.0	94.9	2,767.8
1994	130.9	238.0	237.2	273.2	239.2	146.5	109.3	110.4	198.3	227.3	295.6	336.3	2,542.2
1995	342.0	395.0	552.5	429.8	588.7	571.1	381.0	412.8	297.8	408.3	460.3	299.0	5,138.3
1996	415.3	260.3											
1997													
1998													
1999													
2000													
Mean	171.3	241.2	362.5	363.9	332.9	288.1	224.8	245.3	262.3	202.7	226.0	158.3	3,079.3
Max.	415.3	395.0	552.5	691.2	641.6	688.7	582.8	680.1	604.8	408.3	478.0	357.1	6,495.4
Min.	5.1	26.0	80.9	124.2	78.8	5.1	4.4	0.0	0.0	1.2	0.8	1.2	327.7

Table 9.2.1 (3) Sri Nagarindra Dam (Storage)

Maximum Storage Level — Water Level: 182.40 M. (MSL); Quantity Level: 18,850 Million Cubic Meters

Normal Storage Level — Water Level: 180.00 M. (MSL); Quantity Level: 17,745 Million Cubic Meters

Minimum Storage Level — Water Level: 159.00 M. (MSL); Quantity Level: 10,265 Million Cubic Meters

Year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1978	1,446	1,478	1,442	1,367	1,353	1,454	1,758	2,862	3,984	5,143	5,375	5,497
1979	5,569	5,526	5,411	5,301	5,289	5,402	5,751	6,562	7,153	7,626	7,653	7,710
1980	7,754	7,738	7,635	7,521	7,546	7,648	7,873	8,237	8,930	9,662	9,888	9,965
1981	9,979	9,847	9,679	9,467	9,373	9,664	10,159	11,560	12,621	13,443	14,655	14,906
1982	15,003	14,783	15,454	14,166	13,904	13,878	14,158	15,541	16,015	16,375	16,343	16,173
1983	15,951	15,620	15,149	14,599	14,065	13,574	13,295	13,237	13,495	15,216	15,720	15,752
1984	15,709	15,395	14,913	14,465	14,016	13,975	14,091	14,542	14,614	15,164	14,939	14,921
1985	14,768	14,416	13,835	13,405	13,095	13,130	13,739	14,439	15,870	16,646	16,912	16,937
1986	16,916	16,815	16,339	14,679	15,691	15,160	14,984	14,936	14,880	15,152	15,126	14,995
1987	14,786	14,611	14,226	13,859	13,498	13,309	13,240	13,264	13,867	14,226	14,349	14,409
1988	14,364	14,276	14,047	13,899	13,956	14,148	14,156	14,382	15,300	17,118	17,267	17,209
1989	17,180	16,910	16,390	15,763	15,201	14,693	14,408	14,430	14,393	14,386	14,079	14,061
1990	13,956	13,791	13,388	13,126	12,957	12,923	13,088	13,123	13,437	13,938	13,874	13,806
1991	13,497	13,248	12,848	12,435	12,133	12,242	12,485	13,881	14,261	14,933	14,801	14,644
1992	14,463	14,116	13,539	13,057	12,613	12,226	12,175	12,722	12,827	13,223	13,213	12,923
1993	12,796	12,492	12,133	11,807	11,496	11,187	11,162	11,607	12,117	12,318	12,255	12,186
1994	12,080	11,859	11,623	11,344	11,250	11,375	12,691	14,593	15,635	16,108	16,006	15,755
1995	15,477	15,087	14,526	14,094	13,543	13,060	12,909	13,335	14,891	15,385	15,228	15,046
1996	14,704	14,496										
1997												
1998												
1999												
2000												
Mean	13,608	13,390	13,008	12,529	12,331	12,211	12,374	12,964	13,547	14,172	14,253	14,200
Max.	17,180	16,910	16,390	15,763	15,691	15,160	14,984	15,541	16,015	17,118	17,267	17,209
Min.	5,569	5,526	5,411	5,301	5,289	5,402	5,751	6,562	7,153	7,626	7,653	7,710

Table 9.2.2 (1) Khao Laem Dam (Inflow)

Maximum Storage Level — Water Level 160.50 M. (MSL); Quantity Level 9,500 Million Cubic Meters
Normal Storage Level — Water Level 155.00 M. (MSL); Quantity Level 8,860 Million Cubic Meters

Minimum Storage Level — Water Level 135.00 M. (MSL); Quantity Level 3,012 Million Cubic Meters

Year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1984						473	914	1,280	985	604	193	136	4,585
1985	76	38	42	67	97	1,043	1,566	1,935	1,403	467	192	79	7,005
1986	59	47	49	66	199	280	702	1,118	563	365	136	68	3,652
1987	62	36	72	53	25	291	450	832	1,000	587	207	80	3,695
1988	64	50	17	67	272	727	562	1,121	581	950	239	100	4,750
1989	88	56	41	26	90	189	365	1,140	683	363	114	54	3,209
1990	57	45	25	34	102	466	764	871	1,029	738	158	74	4,363
1991	55	32	27	32	53	980	1,328	3,181	719	461	106	44	7,018
1992	50	20	2	8	37	155	518	1,730	775	431	134	96	3,956
1993	54	32	28	19	63	152	587	1,891	943	328	88	43	4,228
1994	40	14	22	6	132	495	3,044	3,361	1,063	442	84	33	8,736
1995	41	23	24	15	139	575	590	1,531	2,032	539	118	71	5,698
1996	40	35											
1997													
1998													
1999													
2000													
2001													
2002													
2003													
2004													
2005													
Mean	57	36	32	36	110	487	952	1,701	981	516	143	67	5,117
Max	88	56	72	67	272	1,043	3,044	3,361	2,032	950	239	100	11,324
Min.	40	14	2	6	25	152	365	832	563	328	84	33	2,444

Table 9.2.2 (2) Khao Laem Dam (Outflow)

Maximum Storage Level — Water Level: 160.50 M. (MSL); Quantity Level: 9,500 Million Cubic Meters

Normal Storage Level — Water Level: 155.00 M. (MSL); Quantity Level: 8,860 Million Cubic Meters

Minimum Storage Level — Water Level: 135.00 M. (MSL); Quantity Level: 3,012 Million Cubic Meters

Year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1984											13	160	173
1985	40	40	39	37	35	35	744	553	1,013	128	157	418	3,239
1986	326	281	396	433	530	677	419	697	635	251	206	249	5,100
1987	182	259	287	222	299	417	294	403	321	254	226	83	3,247
1988	208	357	529	464	356	292	296	301	324	149	74	80	3,430
1989	215	191	315	271	486	526	207	237	391	283	212	260	3,594
1990	278	444	588	539	596	304	311	492	485	484	365	171	5,057
1991	267	223	427	385	250	145	291	560	782	612	627	403	4,972
1992	315	341	581	482	442	556	513	448	412	529	353	214	5,186
1993	98	268	370	433	307	200	228	407	334	180	237	172	3,234
1994	236	371	528	443	380	239	176	792	1,260	657	918	700	6,700
1995	441	408	552	493	548	581	340	268	469	381	409	239	5,129
1996	343	398											
1997													
1998													
1999													
2000													
2001													
2002													
2003													
2004													
2005													
Mean	246	298	419	382	384	361	347	469	584	355	344	272	4,462
Max	441	444	588	539	596	677	744	792	1,260	657	918	700	8,356
Min.	40	40	39	37	35	35	176	237	321	128	74	80	1,242

Table 9.2.2 (3) Khao Laem Dam (Storage)

Maximum Storage Level	Water Level	160.50 M. (MSL)	Normal Storage Level	Water Level	155.00 M. (MSL)
	Quantity Level	9,500 Million Cubic Meters		Quantity Level	8,860 Million Cubic Meters
Minimum Storage Level	Water Level	135.00 M. (MSL)	Quantity Level	3,012 Million Cubic Meters	

Year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1984						939	1,403	3,040	4,008	4,591	4,758	4,659
1985	4,673	4,638	4,596	4,586	4,617	5,606	6,407	7,766	8,128	8,435	8,422	8,054
1986	7,741	7,463	7,037	6,596	6,213	5,783	6,047	6,385	6,289	6,375	6,283	6,072
1987	5,902	5,618	5,349	5,105	4,709	4,644	4,782	5,192	5,850	6,156	6,115	6,084
1988	5,905	5,550	4,955	4,497	4,382	4,795	5,044	5,844	6,078	6,851	6,992	6,986
1989	6,821	6,635	6,292	5,979	5,535	5,178	5,317	6,200	6,469	6,521	6,395	6,147
1990	5,877	5,395	4,723	4,144	3,560	3,688	4,125	4,487	5,010	5,240	5,013	4,895
1991	4,646	4,423	3,937	3,511	3,273	4,093	5,113	7,712	7,622	7,442	6,881	6,491
1992	6,191	5,822	5,164	4,599	4,139	3,695	3,674	4,939	5,280	5,158	4,914	4,774
1993	4,704	4,430	4,047	3,582	3,275	3,212	3,558	5,024	5,612	5,735	5,565	5,407
1994	5,186	4,779	4,218	3,727	3,452	3,692	6,544	9,087	8,860	8,641	7,752	7,054
1995	6,619	6,185	5,589	5,044	4,596	4,570	4,803	6,047	7,583	7,712	7,396	7,201
1996	6,868	6,459										
1997												
1998												
1999												
2000												
2001												
2002												
2003												
2004												
2005												
Mean	5,928	5,616	5,082	4,670	4,341	4,451	5,038	6,244	6,616	6,749	6,521	6,288
Max	7,741	7,463	7,037	6,596	6,213	5,783	6,544	9,087	8,860	8,614	8,422	8,054
Min.	4,646	4,423	3,937	3,511	3,273	3,212	3,558	4,487	5,010	5,158	4,914	4,774

Table 9.2.3 (1) Vajiralongkorn Diversion Work (Inflow)

Year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1970									1,853	1,243	617	508	4,221
1971	225	141	127	100	118	810	1,756	1,910	1,486	977	554	240	8,444
1972	158	91	72	90	87	699	3,627	3,346	3,344	2,479	1,094	754	15,841
1973	417	268	202	109	163	1,154	1,576	1,903	2,589	2,023	720	379	11,503
1974	242	145	114	114	268	1,122	833	3,564	2,122	3,406	1,438	588	13,956
1975	410	323	189	138	222	638	1,166	1,804	1,802	2,119	1,139	484	10,343
1976	291	178	131	96	298	430	997	1,495	2,284	1,532	1,429	514	9,675
1977	319	166	136	106	150	173	573	1,346	1,146	269	99	74	4,557
1978	76	51	66	51	67	100	267	1,782	1,527	1,377	193	125	5,682
1979	74	72	90	83	65	53	678	1,500	369	490	58	59	3,591
1980	55	61	65	86	87	73	178	359	742	500	177	135	2,518
1981	94	132	133	118	204	1,220	1,052	2,933	936	690	828	219	8,559
1982	154	166	157	195	168	309	1,131	3,178	1,513	555	237	280	8,043
1983	206	161	167	184	274	286	139	253	363	1,213	519	160	3,925
1984	200	315	377	379	400	442	140	109	336	178	199	301	-3,376
1985	186	150	194	179	203	186	922	581	1,516	1,087	389	642	6,235
1986	509	259	589	847	1,005	1,343	866	1,036	910	945	192	457	8,958
1987	445	245	386	335	416	590	187	233	239	278	537	192	4,083
1988	243	230	219	99	487	585	512	434	785	1,640	212	256	5,802
1989	330	190	294	224	396	831	316	171	317	334	185	181	3,769
1990	300	177	283	153	259	276	193	185	267	690	430	218	3,431
1991	476	105	171	207	102	135	124	830	887	1,028	714	611	5,390
1992	396	225	349	223	176	548	480	288	166	867	429	504	4,651
1993	180	120	186	198	156	384	130	216	328	413	108	111	2,530
1994	159	188	142	203	176	224	529	1,314	1,439	1,023	830	1,049	7,276
1995	656	382	455	328	557	1,099	684	466	1,618	1,530	759	578	9,112
1996	653												
1997													
1998													
1999													
2000													
Mean.	287	178	212	198	260	548	762	1,249	1,188	1,111	542	370	6,749
Max.	656	382	539	847	1,005	1,343	3,627	3,564	3,344	3,406	1,438	1,049	15,841
Min.	55	51	65	51	65	53	124	109	166	178	58	59	2,518

Table 9.2.3 (2) Vajiralongkorn Diversion Work (Outflow)

Year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1972					5	10	37	114	30	13	20	7	236
1973	7	17	14	16	13	19	69	145	125	37	33	5	500
1974	0	9	17	16	17	32	122	57	65	30	20	8	393
1975	0	10	31	35	20	24	81	134	108	77	49	11	580
1976	4	15	27	34	12	39	95	205	121	153	64	8	777
1977	8	35	59	55	50	77	155	156	243	243	142	26	1,249
1978	7	27	49	78	57	22	77	185	226	177	144	14	1,063
1979	4	55	84	89	71	59	176	271	276	266	204	19	1,574
1980	5	28	95	109	85	53	186	234	265	123	104	11	1,298
1981	3	69	92	127	74	69	139	220	231	190	90	10	1,314
1982	3	105	160	106	108	72	228	321	302	339	218	9	1,971
1983	7	108	150	160	114	106	203	236	207	155	97	27	1,570
1984	6	103	166	173	142	109	179	372	373	330	358	48	2,359
1985	14	168	266	223	122	122	215	361	311	153	245	24	2,224
1986	10	163	253	271	130	146	184	386	420	165	304	29	2,461
1987	11	170	301	300	291	216	382	573	444	414	272	26	3,400
1988	15	267	555	536	320	260	243	458	356	186	366	96	3,658
1989	30	286	550	622	599	334	279	572	577	483	503	159	4,994
1990	67	383	629	650	603	268	406	696	645	366	351	113	5,177
1991	35	342	590	598	572	351	427	633	552	442	517	159	5,218
1992	99	416	675	673	663	325	361	502	558	376	379	89	5,116
1993	72	371	513	542	538	204	330	543	434	330	409	191	4,477
1994	163	345	535	517	534	243	203	512	488	404	570	232	4,746
1995	148	376	600	642	622	231	236	460	189	214	365	141	4,224
1996	124												
1997													
1998													
1999													
2000													
Mean.	35	168	279	286	240	141	209	348	314	236	243	61	2,524
Max.	35	416	675	673	663	351	427	696	645	483	570	232	5,218
Min.	0	9	14	16	12	19	69	57	65	30	20	5	393

Table 9.2.4 (1) Kaeng Krachan Dam (Inflow)

Maximum Storage Level — Water Level: 102.70 M. (MSL); Quantity Level: 930 Million Cubic Meters

Normal Storage Level — Water Level: 99.00 M. (MSL); Quantity Level: 710 Million Cubic Meters

Minimum Storage Level — Water Level: 75.00 M. (MSL); Quantity Level: 67 Million Cubic Meters

Year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1960				7	10	38	54	127	103	240	43	29	651
1961	15	10	11	12	49	75	268	485	231	159	53	27	1,395
1962	16	9	15	17	24	62	170	278	232	115	46	24	1,008
1963	15	10	11	15	7	35	127	154	193	215	84	28	894
1964	15	9	8	14	30	31	62	138	222	176	92	34	831
1965	18	16	21	7	37	172	175	151	234	368	77	26	1,302
1966	15	10	6	15	24	29	91	100	107	87	49	14	547
1967	9	9	8	12	23	62	72	312	125	144	55	23	854
1968	10	11	13	17	5	35	76	185	142	251	50	18	813
1969	18	9	15	17	34	57	130	201	134	140	341	30	1,126
1970	17	7	5	18	22	36	154	119	81	179	55	131	824
1971	27	16	48	24	26	112	231	135	198	225	80	25	1,147
1972	14	18	19	49	20	63	214	231	176	146	104	84	1,138
1973	26	17	21	14	30	97	120	203	173	184	118	32	1,035
1974	29	18	25	40	83	289	114	363	147	342	102	42	1,594
1975	39	16	22	25	43	100	83	197	124	167	77	28	921
1976	19	12	22	24	66	59	93	130	157	76	101	23	782
1977	16	14	17	22	42	37	72	164	176	112	47	24	743
1978	18	17	17	28	40	71	76	300	155	284	59	23	1,088
1979	18	15	18	28	34	53	135	263	79	89	38	19	789
1980	14	19	23	20	44	47	61	85	108	91	43	19	574
1981	11	12	20	18	21	135	126	323	138	117	160	40	1,171
1982	19	11	19	37	34	58	136	333	197	85	57	23	1,009
1983	20	23	10	21	25	39	38	65	84	114	80	29	548
1984	19	17	17	19	22	219	111	137	125	143	44	22	895
1985	16	16	19	29	34	129	234	225	210	286	84	35	1,317
1986	21	13	12	25	105	61	163	162	85	147	55	22	871
1987	14	13	15	22	41	89	61	68	104	71	68	26	592
1988	18	19	18	30	78	185	103	89	119	259	76	29	1,023
1989	17	18	20	17	41	47	56	108	103	82	44	25	578
1990	18	13	13	12	24	39	71	79	93	81	40	17	500
Mean	18	14	17	22	37	86	121	193	148	165	79	31	930
Max.	39	23	48	49	105	289	268	485	234	368	341	131	1,594
Min.	9	7	5	7	5	29	38	65	79	71	38	14	500

Table 9.2.4 (1) Kaeng Krachan Dam (Inflow)

Maximum Storage Level	Water Level	102.70 M. (MSL)	Normal Storage Level	Water Level	99.00 M. (MSL)
	Quantity Level	930 Million Cubic Meters		Quantity Level	710 Million Cubic Meters
Minimum Storage Level	Water Level	75.00 M. (MSL)	Quantity Level	67 Million Cubic Meters	

Year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1991	13	27	13	14	18	28	60	230	107	144	50	24	728
1992	20	16	16	14	22	28	56	105	84	61	44	18	484
1993	15	11	13	18	24	24	55	150	85	124	49	19	587
1994	14	12	14	17	20	43	225	500	288	131	22	16	1,302
1995	11	8	7	16	21	43	38	113	241	237	38	17	790
1996	11	8											
1997													
1998													
1999													
2000													
2001													
2002													
2003													
2004													
2005													
2006													
2007													
2008													
2009													
2010													
2011													
Mean	14	11	13	16	22	35	94	217	175	138	38	18	789
Max.	20	27	16	18	24	43	225	500	288	237	50	24	1,472
Min.	11	8	7	14	20	24	38	105	84	61	22	16	410

Table 9.2.4 (2) Kaeng Krachan Dam (Outflow)

Maximum Storage Level	Water Level	102.70 M. (MSL)	Normal Storage Level	Water Level	99.00 M. (MSL)
	Quantity Level	930 Million Cubic Meters		Quantity Level	710 Million Cubic Meters
Minimum Storage Level	Water Level	75.00 M. (MSL)	Quantity Level	67 Million Cubic Meters	

Year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1960				7	10	38	54	127	103	240	43	29	651
1961	15	10	11	12	49	75	268	485	231	159	53	27	1,395
1962	16	9	15	17	24	62	170	278	232	115	46	24	1,008
1963	15	10	11	15	7	35	127	154	193	215	84	28	894
1964	15	9	8	14	30	31	62	138	222	176	92	34	831
1965	18	16	21	3	27	102	113	145	217	375	96	9	1,142
1966	2	5	4	7	19	57	101	102	68	43	64	3	475
1967	8	13	10	10	5	33	84	119	124	52	119	32	609
1968	9	8	14	16	8	59	96	120	101	55	88	24	598
1969	25	30	42	44	69	100	132	135	128	70	183	68	1,026
1970	20	29	38	62	69	80	131	142	128	63	105	11	878
1971	9	22	35	35	38	128	138	143	133	212	139	53	1,085
1972	28	26	23	35	59	115	118	149	155	131	69	42	950
1973	34	19	46	39	66	113	131	157	154	172	71	18	1,020
1974	25	35	49	44	51	224	170	299	222	278	139	46	1,582
1975	40	40	55	70	93	107	142	141	121	82	90	29	1,010
1976	27	38	53	53	48	86	118	113	82	110	44	33	805
1977	28	41	57	55	55	97	103	106	97	75	113	50	877
1978	29	36	52	54	42	68	74	94	107	87	117	51	811
1979	40	61	82	81	88	83	110	117	125	129	115	55	1,086
1980	26	55	62	53	44	39	45	65	85	69	73	36	652
1981	16	18	25	21	20	28	81	104	113	70	60	37	593
1982	30	61	67	67	70	75	111	118	111	152	83	30	975
1983	33	63	72	73	73	76	92	76	56	21	25	52	712
1984	17	41	41	45	47	66	64	127	132	92	121	37	830
1985	23	38	43	44	45	54	88	109	148	205	235	50	1,082
1986	27	47	31	86	55	89	114	119	130	81	96	48	973
1987	24	47	55	61	62	74	100	106	103	88	16	13	749
1988	23	28	33	37	21	67	106	102	100	33	107	37	694
1989	34	57	78	82	85	65	90	105	93	48	52	42	831
1990	28	24	26	34	24	54	88	102	100	70	38	18	606
Mean	23	31	40	42	46	78	112	142	134	118	91	35	893
Max.	40	63	82	86	93	224	268	485	232	375	235	68	1,582
Min.	2	5	4	3	5	28	45	65	56	21	16	3	475

Table 9.2.4 (2) Kaeng Krachan Dam (Outflow)

Maximum Storage Level	Water Level	102.70 M. (MSL)	Normal Storage Level	Water Level	99.00 M. (MSL)
	Quantity Level	930 Million Cubic Meters		Quantity Level	710 Million Cubic Meters
Minimum Storage Level	Water Level	75.00 M. (MSL)	Quantity Level	67 Million Cubic Meters	

Year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1991	15	40	20	23	22	20	22	69	90	35	68	45	469
1992	24	37	43	45	52	58	75	75	91	26	47	36	609
1993	18	21	20	23	25	25	69	91	38	0.4	59	36	425
1994	17	23	21	24	17	16	65	271	296	151	100	41	1,042
1995	22	32	39	46	43	38	58	54	55	191	92	36	706
1996	19	52											
1997													
1998													
1999													
2000													
2001													
2002													
2003													
2004													
2005													
2006													
2007													
2008													
2009													
2010													
2011													
Mean	19	34	29	32	32	31	58	112	114	81	73	39	650
Max.	24	52	43	46	52	58	75	271	296	191	100	45	1,042
Min.	15	21	20	23	17	16	22	54	38	0	47	36	425

Table 9.2.4 (3) Kaeng Krachan Dam (Storage)

Maximum Storage Level	Water Level	102.70 M. (MSL)	Normal Storage Level	Water Level	99.00 M. (MSL)
	Quantity Level	930 Million Cubic Meters		Quantity Level	710 Million Cubic Meters
Minimum Storage Level	Water Level	75.00 M. (MSL)	Quantity Level	67 Million Cubic Meters	

Year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1967	199	193	189	188	203	232	212	406	411	497	428	413
1968	411	409	403	397	422	396	372	434	471	666	626	614
1969	602	574	540	508	467	425	415	482	494	553	707	662
1970	656	638	596	553	508	465	488	463	420	529	488	609
1971	622	609	591	576	559	538	628	616	677	686	623	594
1972	577	563	553	561	518	464	558	638	657	668	701	742
1973	730	722	690	659	621	608	595	639	656	666	711	721
1974	712	689	659	649	676	738	680	742	665	727	687	679
1975	674	645	606	558	504	497	436	490	491	574	558	554
1976	542	511	472	439	453	426	398	414	487	451	505	492
1977	476	445	400	362	347	285	253	310	388	424	356	328
1978	314	292	254	225	221	223	223	428	475	670	610	578
1979	552	501	432	374	317	285	309	454	407	366	287	249
1980	235	197	156	123	122	124	139	158	180	201	170	152
1981	146	138	131	127	127	283	327	545	568	613	711	709
1982	693	637	581	547	506	485	506	702	685	607	577	568
1983	550	506	439	384	332	293	237	224	251	341	402	372
1984	371	339	312	283	253	415	447	454	444	497	422	405
1985	392	363	331	313	301	378	517	615	679	725	673	649
1986	637	599	535	471	517	487	530	555	518	566	534	507
1987	493	450	416	368	340	353	310	268	266	247	301	310
1988	304	292	270	260	316	433	430	417	429	633	598	586
1989	566	535	434	413	359	336	301	302	309	340	329	310
1990	295	280	261	237	234	219	203	174	169	160	161	158
1991	154	134	123	112	108	114	152	309	322	433	418	392
1992	383	354	321	287	251	222	203	228	221	252	247	228
1993	222	209	199	191	189	186	171	229	273	395	381	361
1994	355	340	329	318	319	343	500	726	714	691	610	581
1995	566	537	499	465	439	440	416	472	655	698	641	618
1996	607	557										
Mean	477	451	412	384	369	374	384	446	463	514	501	490
Max.	730	722	690	659	676	738	680	742	714	727	711	742
Min.	146	134	123	112	108	114	139	158	169	160	161	152

Table 9.2.5 (1) Pranburi Dam (Inflow)

Maximum Storage Level	Water Level	58.10 M. (MSL)	Normal Storage Level	Water Level	55.00 M. (MSL)
	Quantity Level	650 Million Cubic Meters		Quantity Level	445 Million Cubic Meters
Minimum Storage Level	Water Level	37.00 M. (MSL)	Quantity Level	60 Million Cubic Meters	

Year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1977		7.0	5.0	1.0	7.0	0.0	13.0	62.0	93.0	70.0	13.0	2.0	273.0
1978	5.0	3.0	0.0	5.0	25.0	28.0	22.0	128.0	78.0	152.0	28.0	3.0	477.0
1979	2.0	0.0	0.0	0.0	0.0	11.0	50.0	157.0	24.0	9.0	0.0	0.0	253.0
1980	0.0	0.0	0.0	0.0	0.0	5.0	14.0	10.0	18.0	18.0	2.0	0.0	67.0
1981	0.0	0.0	0.0	6.0	10.0	118.0	46.0	181.0	74.0	61.0	235.0	24.0	755.0
1982	9.0	13.0	0.0	19.0	17.0	31.0	55.0	130.0	69.0	41.0	20.0	11.0	415.0
1983	5.0	1.0	0.0	0.0	1.0	0.0	0.0	16.0	34.0	64.0	102.0	13.0	236.0
1984	8.0	3.0	0.0	2.0	3.0	94.0	46.0	55.0	70.0	37.0	2.0	5.0	325.0
1985	12.0	9.0	0.0	6.0	16.0	71.0	77.0	99.0	14.0	54.0	21.0	27.0	406.0
1986	13.0	0.0	16.0	0.0	32.0	1.0	38.0	52.0	49.0	199.0	32.0	20.0	452.0
1987	5.0	6.0	0.0	6.0	0.0	30.0	10.0	14.0	34.0	33.0	102.0	44.0	284.0
1988	9.0	14.0	14.0	13.0	21.0	77.0	36.0	25.0	43.0	127.0	31.0	6.0	416.0
1989	9.0	3.0	0.0	2.0	6.0	12.0	14.0	35.0	58.0	60.0	58.0	9.0	266.0
1990	4.0	6.0	2.0	5.0	11.0	12.0	16.0	41.0	37.0	35.0	28.0	4.0	201.0
1991	0.0	0.0	2.0	1.0	9.0	11.0	18.0	114.0	47.0	155.0	44.0	9.0	410.0
1992	6.0	0.0	0.0	0.0	0.0	7.0	13.0	39.0	30.0	60.0	22.0	8.0	185.0
1993	4.0	0.0	8.0	6.0	11.0	19.0	26.0	76.0	58.0	111.0	37.0	35.0	391.0
1994	5.0	10.0	7.0	2.0	3.0	19.0	89.0	237.0	73.0	52.0	13.0	0.0	510.0
1995	2.0	0.0	0.0	4.0	1.0	12.0	15.1	52.0	133.0	268.0	29.0	18.2	534.3
1996	8.6	8.4											
1997													
1998													
1999													
2000													
Mean	5.6	4.2	2.8	4.1	9.1	29.4	31.5	80.2	54.5	84.5	43.1	12.5	361.5
Max.	13.0	14.0	16.0	19.0	32.0	118.0	89.0	237.0	133.0	268.0	235.0	44.0	1218.0
Min.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0	14.0	9.0	0.0	0.0	33.0

Table 9.2.5 (2) Pranburi Dam (Outflow)

Maximum Storage Level Water Level 58.10 M. (MSL) Normal Storage Level Water Level 55.00 M. (MSL)
Quantity Level 650 Million Cubic Meters Quantity Level 445 Million Cubic Meters

Minimum Storage Level Water Level 37.00 M. (MSL) Quantity Level 60 Million Cubic Meters

Year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1978				19.0	23.0	19.0	21.0	23.0	86.1	142.3	55.6	17.5	406.5
1979	7.0	8.2	9.9	7.8	7.9	8.3	8.8	85.1	25.0	20.6	12.8	13.0	214.4
1980	13.0	15.0	18.0	24.3	26.4	16.7	17.5	20.8	23.3	24.0	12.3	8.6	219.9
1981	9.0	17.3	16.0	20.4	17.1	5.3	26.8	101.1	69.6	55.5	207.6	14.7	560.4
1982	14.4	22.1	24.1	23.8	35.4	30.7	40.4	49.7	60.5	36.8	26.5	11.6	376.0
1983	10.4	15.3	22.4	29.4	39.9	38.3	51.4	37.6	42.8	26.3	13.2	18.8	345.8
1984	10.8	8.8	14.9	12.0	25.4	26.3	23.0	52.7	35.1	39.2	52.0	26.8	327.0
1985	18.4	20.6	8.4	16.9	8.4	7.4	26.2	27.6	55.6	19.3	41.0	24.9	274.7
1986	20.4	6.8	24.6	14.2	11.1	29.5	33.0	50.4	50.3	35.9	37.4	26.9	340.5
1987	9.7	10.3	25.3	29.8	32.8	32.8	46.8	66.9	50.1	43.1	22.4	12.9	382.9
1988	7.9	22.9	40.3	37.0	24.1	40.1	48.6	48.9	40.2	32.2	41.7	16.9	400.8
1989	6.7	15.3	29.6	41.5	41.4	24.5	16.0	33.9	51.8	43.4	28.1	27.6	359.8
1990	8.7	20.6	16.2	12.5	9.7	9.5	12.6	15.1	29.8	33.5	22.8	18.1	209.1
1991	6.9	12.2	5.3	4.6	4.8	4.7	4.8	14.6	32.3	10.8	18.5	14.8	134.3
1992	5.1	29.9	29.6	51.4	39.4	18.2	13.3	27.2	41.1	20.8	28.6	25.6	330.2
1993	8.7	9.1	21.3	22.5	9.3	31.3	42.0	37.6	43.3	22.9	29.0	30.8	307.8
1994	7.5	25.6	14.8	11.4	13.8	6.7	27.1	48.8	80.3	52.9	45.0	24.7	358.6
1995	13.0	25.6	27.3	26.9	29.9	13.2	23.6	27.0	21.0	131.0	44.6	19.4	402.5
1996	5.8	25.8											
1997													
1998													
1999													
2000													
Mean	10.2	17.3	20.5	22.7	22.2	20.2	27.2	43.3	44.2	38.1	40.2	19.8	326.4
Max.	20.4	29.9	40.3	51.4	41.4	40.1	51.4	101.1	80.3	131.0	207.6	30.8	825.7
Min.	5.1	6.8	5.3	4.6	4.8	4.7	4.8	14.6	21.0	10.8	12.3	8.6	103.4

Table 9.2.5 (3) Pranburi Dam (Storage)

Maximum Storage Level — Water Level: 58.10 M. (MSL); Quantity Level: 650 Million Cubic Meters

Normal Storage Level — Water Level: 55.00 M. (MSL); Quantity Level: 445 Million Cubic Meters

Minimum Storage Level — Water Level: 37.00 M. (MSL); Quantity Level: 60 Million Cubic Meters

Year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1978	316	306	282	264	262	267	265	368	361	372	345	330
1979	322	310	292	280	267	266	307	981	379	370	352	330
1980	318	297	273	250	228	225	232	235	244	255	251	245
1981	233	216	199	181	171	281	298	372	373	374	395	402
1982	393	380	361	345	327	322	333	411	423	421	409	405
1983	395	376	345	310	267	225	187	163	152	187	273	266
1984	261	252	232	218	194	249	280	280	311	316	265	239
1985	229	214	200	185	190	247	299	365	421	453	431	429
1986	417	402	388	361	376	349	352	352	348	411	403	392
1987	383	373	335	305	266	261	223	170	153	142	225	254
1988	252	239	209	185	179	214	200	173	175	268	256	244
1989	244	229	193	151	116	102	98	98	104	120	149	133
1990	126	111	95	86	85	86	88	110	116	121	125	110
1991	98	84	79	73	75	82	94	194	207	349	371	362
1992	359	317	280	219	175	162	161	173	159	197	189	169
1993	162	148	135	116	118	106	90	127	141	228	234	208
1994	197	178	170	161	150	162	222	407	396	395	362	328
1995	316	283	247	220	187	182	169	182	297	436	415	410
1996	406	380										
1997												
1998												
1999												
2000												
Mean	284	266	237	214	198	207	214	282	259	297	300	290
Max.	417	402	388	361	376	349	352	981	423	453	431	429
Min.	98	84	79	73	75	82	88	98	104	120	125	110

Table 9.2.6 Calculation of Average Availability of Surface Water by River Basin

	Catchment area (km^2)	Average annual basin rainfall (mm)	Runoff coefficient	Average annual discharge (MCM/year)
Mae Klong				
Lower Khwai Yai	4,100			3,079*
Lower Khwai Noi	2,000			4,462**
Huai Taphpen	2,600	1,200	0.30	936
Lam Pa Chi	2,500	1,100	0.30	825
Mae Khlong plain	4,300	1,100	0.30	1,419
Sub-total	15,500			10,721
Petchaburi				
Upper Petchaburi	2,210	1,100	0.25	608
Middle "	1,328			650***
Lower "	1,027	1,100	0.25	282
Petchaburi coast	1,042	950	0.25	(247)+
Sub-total	5,607			1,540
Western Coast				
Pranburi				
- regulated	2,100			290++
unregulated	800	950	0.20	152++
P.Khirikhan coast				
- upper	1,400	1,100	0.20	308
middle	1,600	1,200	0.20	384
lower	1,200	1,300	0.20	312
Sub-total	7,100			1,446
Southeastern Coast				
Khlong Ta Taphrao	2,230	1,500	0.45	1,505
Upper coast	2,840	1,800	0.30	1,534
Lang Suan	1,650	2,000	0.40	1,320
Sub-total	6,720			4,359

Notes * regulated release from the Sri Nagarindra dam
** regulated release from the Khao Laem dam
(Inter-flows between the respective dams and the Vijiralongkorn diversion works are used mostly outside the Study Area.)
*** regulated release from the Kaen Krachan dam
+ mostly coastal runoffs (not included in the calculation)
++ regulated release from the Kaen Krachan dam plus inter-flow from the unregulated catchment area

Figure 9.2.1 RIVER BASINS IN THE WSB

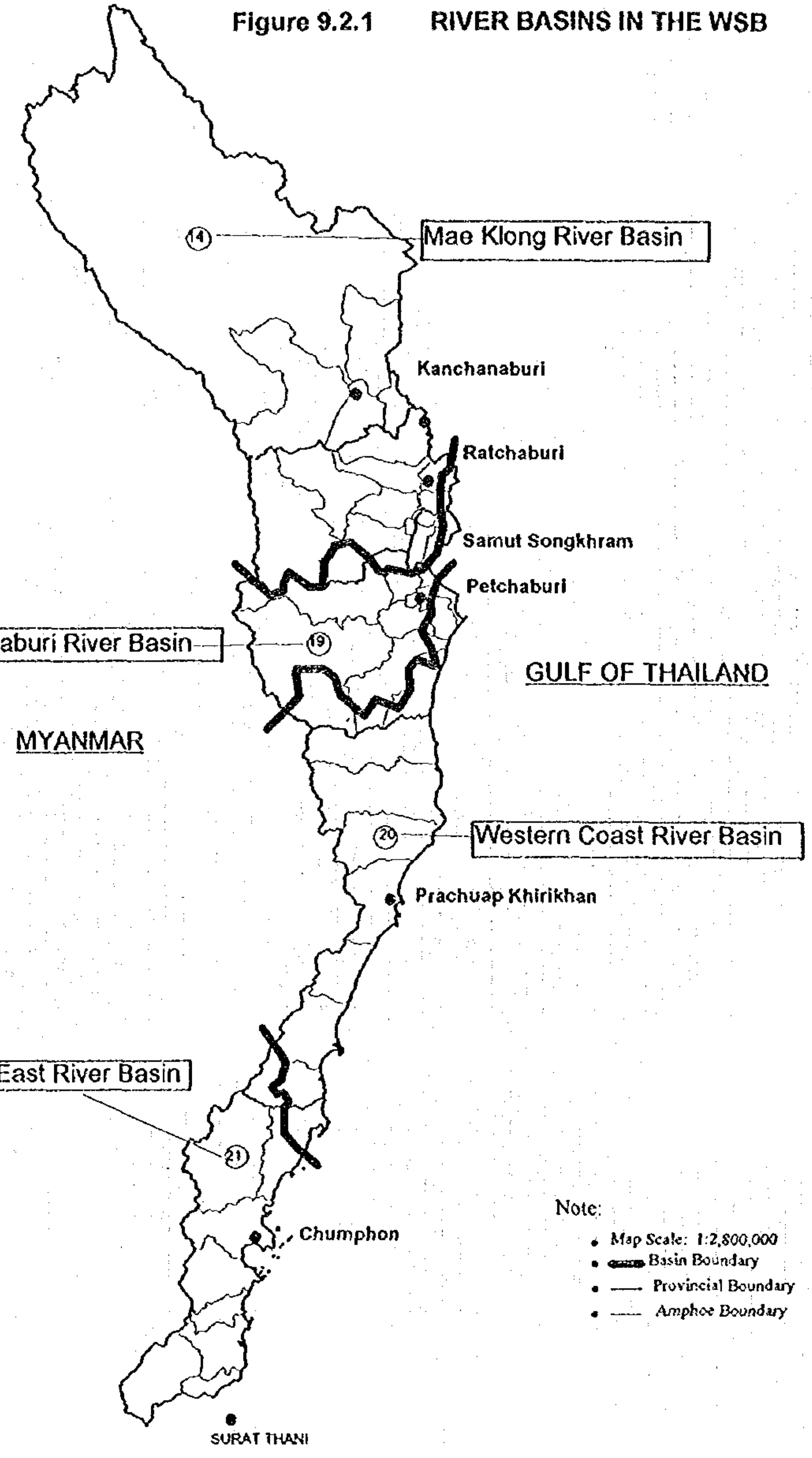


Figure 9.2.2 Annual Rainfall Contour (Mae Klong River Basin)

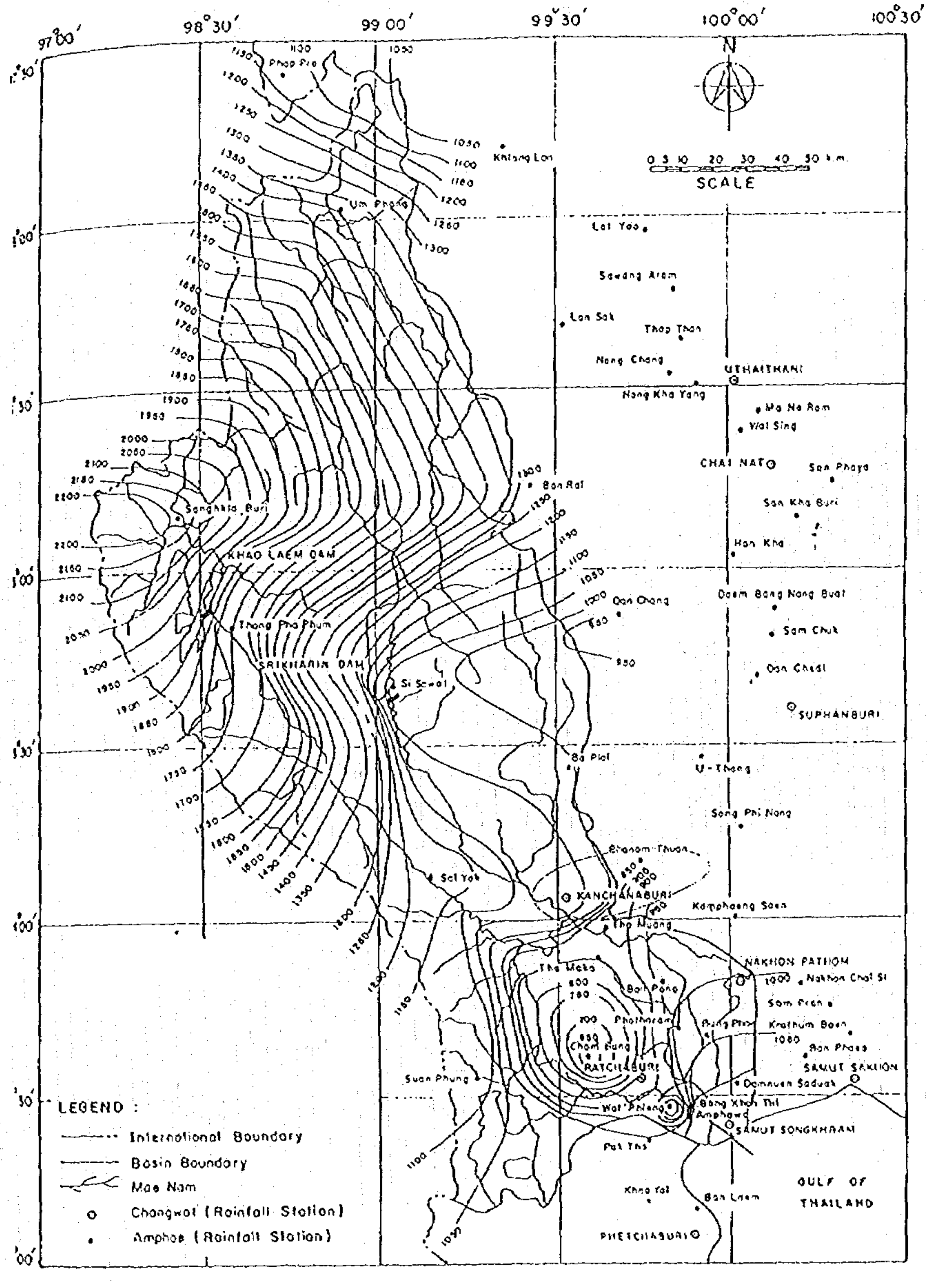


Figure 9.2.3 Annual Rainfall Contour (Petchaburi)

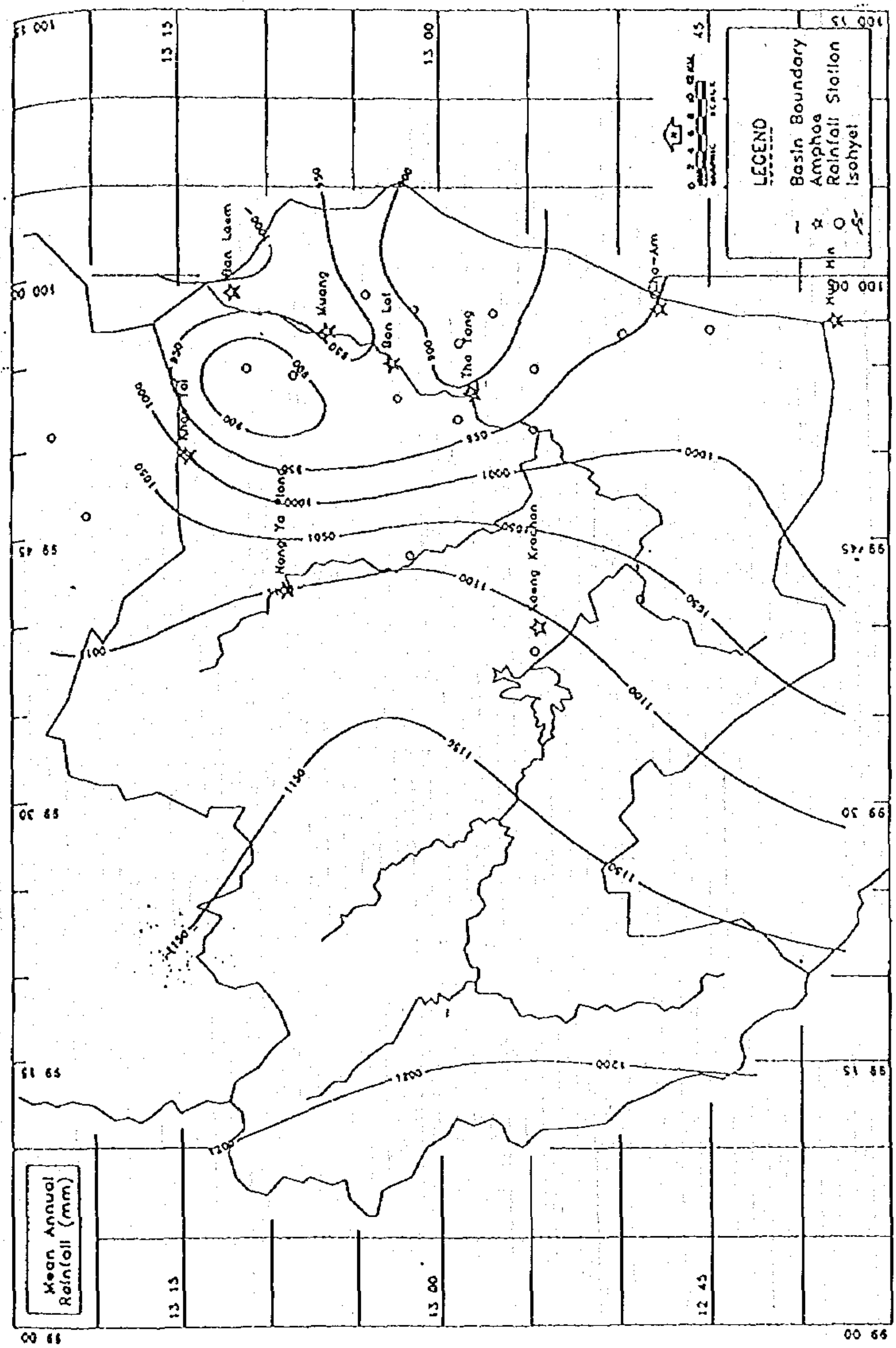
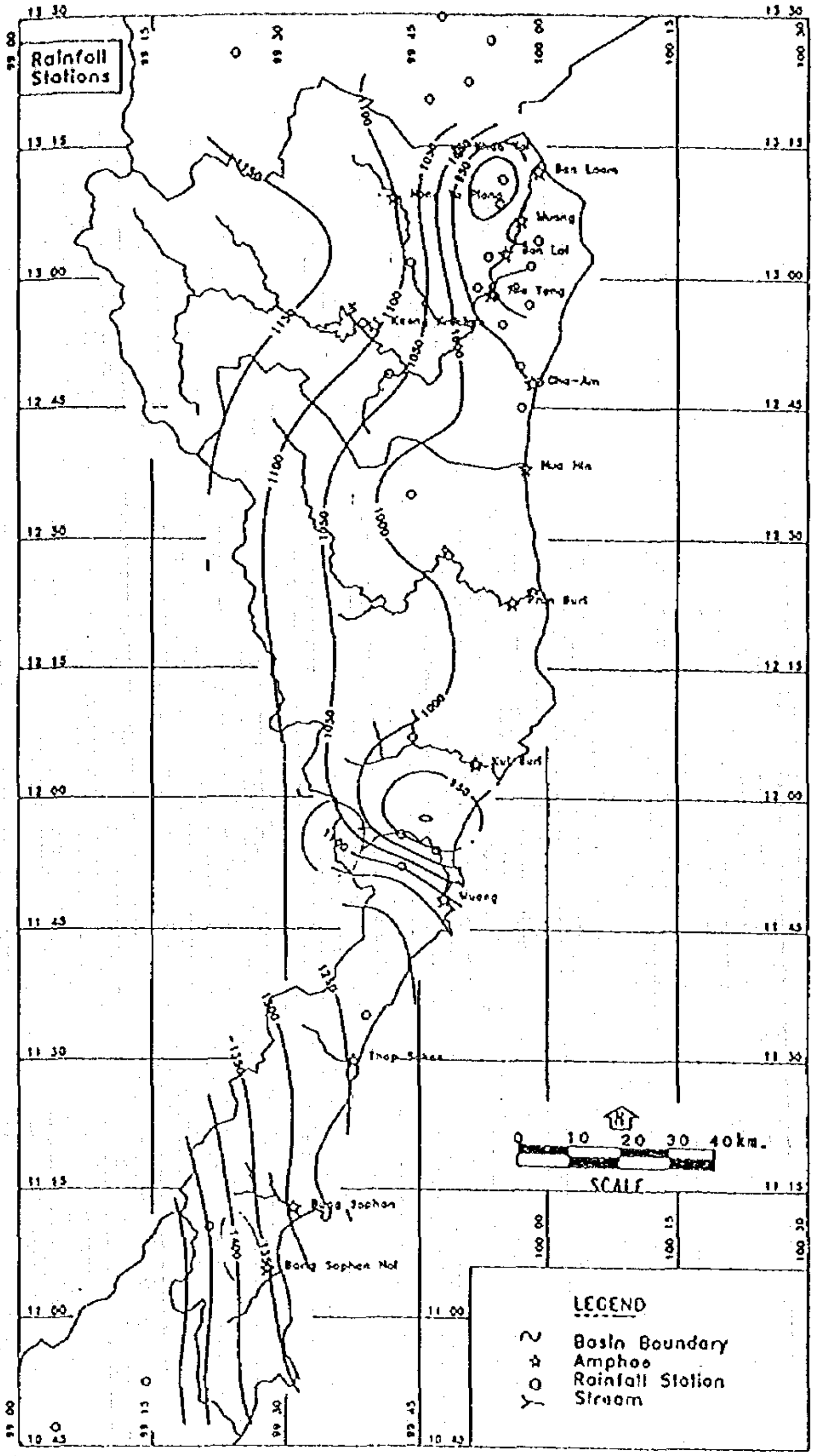


Figure 9.2.4 Annual Rainfall Contour (Western Coast)



APPENDIX I To CHAPTER 2

PROFILES OF PROPOSED PROJECTS/PROGRAMS

(Project No.)	(Project Title)	(Page)
WR1	Irrigated Agriculture Intensification	A1-1
WR2	Improvement of Water Management	A1-5
WR3	Multipurpose Reservoir Development	A1-11
WR4	Salinity Control	A1-19
WR5	Flood Control And Drainage Systems Improvement	A1-23

Project No. WR1

1. PROJECT TITLE	Irrigated Agriculture Intensification
2. LOCATION	Lower Mae Klong river basin
3. AGENCY	RID and Central Land Consolidation Office
4. OBJECTIVES	(1) To enhance productivity of irrigated agriculture in the Greater Mae Klong irrigation scheme and Petchaburi agricultural development scheme through land consolidation, agriculture mechanization, crop diversification, and more effective water management (2) To increase and stabilize incomes of farm households.
5. PHASING	Phase I, Phase II, and Phase III

6. DESCRIPTION

Irrigated agriculture has been extensively developed in the Lower Mae Klong river basin to cultivate not only paddy but also vegetables, sugar cane, and other upland crops and some fruit trees. In this area, water availability is favorable and soil is suitable for a wide range of crops. Intensification of irrigated agriculture is necessary to enhance agricultural productivity to justify continued agricultural land use against urbanization/ industrialization pressure.

To enhance agricultural productivity, the following is necessary:

(1) land consolidation for more efficient farm management and agricultural mechanization,
(2) organizing farmers to diversify crops in favor of high value-added crops, capitalizing on proximity to the growing urban markets, and also better on-farm water management, and
(3) extension services and training for new production systems.

7. RELATION WITH OTHER PROJECTS	RD 1 (Rural Development Model) AG 9 (Water Application Efficiency)
8. COST (Approximate)	Phase I = 120 million Phase II = 120 million Phase III = 120 million

WR1 IRRIGATED AGRICULTURE INTENSIFICATION

BACKGROUND

The Greater Mae Klong Irrigation Scheme (GMIS) was constructed to supply irrigation water for about 3 million rai (480,000 ha) on the left bank (2.43 million rai) and the right bank (0.59 million rai). However, on-farm development has lagged behind, and ditch-and-dike construction covers only 43 per cent (1.3 million rai). The area of land consolidation is as small as 15 per cent (439,500 rai), covering parts of Kanchanaburi (105,200 rai), Ratchaburi (193,600 rai), Petchaburi (40,000 rai), and Suphan Buri (100,700 rai). The area of ditch-and-dike development varies by sub-project; e.g., in the Phanom Thuan sub-project (irrigable area of 330,400 rai), only 93,400 rai or 28 per cent of the irrigable area had been completed by the end of 1996.

In the Petchaburi Agricultural Development Scheme (PAD), on the other hand, Keang Krachan dam/reservoir and the Petch diversion works are capable of irrigating 462,500 rai (74,000 ha). The area of land consolidation in the PAD, however, is limited to only 9.6 per cent or 42,100 rai (6,740 ha).

Judging from the above, it was concluded that the water available for irrigation in the GMIS and PAD has not been effectively and efficiently utilized for irrigated agriculture, and that the existing facilities should be utilized to the utmost extent in enhancing agricultural productivity and production in the WSB region.

In the case of ditch-and-dike development promoted by RID, drainage works are not involved and irrigated land is subject to floods and salinization. Ditch-and-dike development has been executed at no cost to farmers, while 20 per cent of land consolidation costs have been charged to farmers for repayment in 15 years. It is further noted that consolidated land is not transferable for uses other than agriculture under the Land Consolidation Act.

PROJECT CONCEPT/RATIONAL

Since water is available at the main, secondary, and tertiary irrigation canals in the GMIS and PAD, on-farm development should be implemented in irrigable areas in a more intensified form to make such a large investment in irrigation works fruitful. Agricultural productivity in the irrigated land should be enhanced through intensification of irrigated agriculture by means of on-farm development and land consolidation.

Constraints on promotion of on-farm development and land consolidation should be analyzed from technical, financial, and institutional points of view, and a solution should be worked out as to how to promote irrigated agriculture intensification in the existing GMIS and PAD irrigation areas.

PROJECT DESCRIPTION

It is proposed that an inter-agency committee be formed to discuss how to promote irrigated agriculture intensification in the GMIS and PAD irrigation areas. At least, the following agencies should take part in the joint committee:

* Ministry of Agriculture and Cooperatives;
* Department of Agricultural Economics;
* Central Land Consolidation Office;
* Royal Irrigation Department;
* Department of Agricultural Extension; and
* BAAC.

The joint committee should review all technical, financial, and institutional aspects, including the following:

(i) *Selection of crops to be cultivated in the irrigated areas on the basis of physical,* marketing, and financial studies, as well as in light of agricultural restructuring policies and farmers' intentions;

(ii) Selection of cropping patterns, including a decision whether paddy-paddy cultivation is to be continued (in this case extensive land consolidation is practicable) or paddy-upland crop cultivation is to be introduced (in this case intensive land consolidation is required);

(iii) Review of the Land Consolidation Act, to determine if Section 45 should be maintained or modified (under Section 45, it is specified that no landowner in a land consolidation area shall use the land for any purpose other than agriculture);

(iv) Decision on land consolidation method, whether it should be intensive or extensive in relation to the selection of cropping patterns;

(v) Review of RID's ditch-and-dike programs, if it should be executed without drainage improvement and if it should be implemented at no cost to the farmers;

(vi) Analysis of farm budget and capacity to pay of farmers under the new cropping patterns and investment in on-farm facilities; and

(vii) Review of BAAC financing scheme for the loans to be efficiently integrated into ditch-and-dike, drainage improvement, and land consolidation.

On the basis of the above review, the joint committee should adopt a program for irrigated agriculture intensification in the GMIS and PAD.

Provisionally, it is envisaged that about 75 per cent of irrigable area in GMIS (360,000 ha) and PAD (55,500 ha) would be designated as areas for the irrigated agriculture intensification program (totaling 415,500 ha). Exclusive of the area previously executed by land consolidation (70,300 ha in GMIS and 7,200 ha in PAD, totaling 77,500 ha) and the area executed by ditch-and-dike programs (208,000 ha), the area for the new irrigated agriculture intensification project is estimated to be around 130,000 ha.

PROJECT ASSESSMENT

The cost of the proposed intensive land consolidation cost will be about $2,800 per ha in present value. If this unit cost is applied to 130,000 ha, the total cost required for the irrigated agriculture intensification project would be in the order of $360 million. In the event that the irrigated agriculture intensification project is programmed for execution in 15 years, the annual budget is around $24 million for 8,700 ha.

RECOMMENDED ACTION(S)

It is recommended that MOAC convene a joint committee to review and work out the program and to arrange implementation of the proposed irrigated agriculture intensification program. CLCO, RID, Agricultural Extension Office, and BAAC should join the committee and assume the responsibility to be designated to each agency.

Project No. WR 2

1. PROJECT TITLE: Improvement of Water Management

2. LOCATION: Area of Greater Mae Klong Irrigation Scheme

3. AGENCY: RID

4. OBJECTIVES:
   (1) To improve water supply management along principal canals through construction of regulation ponds
   (2) To improve farm-level water management through construction of farm ponds
   (3) To improve efficiency in water management and enhance productivity at farmers' level.

5. PHASING: Phase II and Phase III

6. DESCRIPTION

The Greater Mae Klong Irrigation Scheme (GMIS) covers an area of about 480,000 ha on the left and right banks of the Mae Klong river. The main canals extend 80 km on the left bank and 110 km on the right bank. The lateral canals extend a total length of 1,200 km.

Water management through these lengthy canals is inefficient, and water can better be managed through construction of several regulation ponds along the principal canals. The regulation ponds are also effective for management against risks and for changes in water requirement due to shift in cropping patterns.

At the tertiary canal level, water management is facilitated through construction of farm ponds, particularly in the area where upland crops are cultivated.

To improve water management in the GMIS, it is proposed to construct several regulation ponds along the lateral canals and to promote construction of farm ponds together with on-farm development in the irrigated areas.

7. RELATION WITH OTHER PROJECTS: WR 1 (Irrigated Agriculture Intensification)

8. COST (Approximate):
   Phase II: $1 million for study
   Phase III: $20 million for stage-wise execution

WR 2 IMPROVEMENT OF WATER MANAGEMENT

BACKGROUND

The Greater Mae Klong Irrigation Scheme (GMIS) is composed of 10 sub-projects as follows:

	Main Canal	Lateral Canal	Sub-project	Area(ha)	Stage
Right Bank	110 km	430 km	Tha Maka	45,400	II
			Petchaburi	48,580	II
Left Bank	80 km	770 km	Phanom Thuan	53,170	II
			Seng Phinong	49,880	II
			Bang Lan	50,620	II
			Kanphang San	40,450	II
			Nakhon Pathom	58,270	I
			Nakohn Chum	42,400	I
			Ratchaburi	41,280	I
			Damnoen Saduak	53,410	I
Total	190 km	1,200 km		483,460	

Note: Stage I: Constructed in 1964-1975
Stage II: Constructed in 1970-1989

The main and lateral canals cover a sizable irrigation area in each sub-project, and water management along these canals becomes less efficient under upland crop cultivation which will substitute for paddy-paddy cultivation through a shift into cultivation of higher-value crops. To make the water supply management more efficient, it is recommended to construct several regulation ponds along the principal lateral canals.

PROJECT CONCEPT/RATIONALE

Water management becomes more and more important in the irrigated area when cultivation is shifted from paddy and sugar cane to upland crops. To this end, it is proposed to construct several regulation ponds along the principal lateral canals of the GMIS.

At the farm level, a shift in cropping patterns will require more efficient water management though the construction of farm ponds. Farm pond construction will be executed together with on-farm development and land consolidation under the Irrigated Agriculture Intensification Project (WR 1).

PROJECT DESCRIPTION

It is proposed that five regulation ponds be constructed along the main canals: i.e., three ponds along the right bank canal and two ponds along the left bank canal, as shown in attached Figure. The location of the proposed regulation ponds should be decided through further in-depth studies.

The capacity of regulation ponds will be decided on the basis of analysis as follows:

(i) Definition of the area to be commanded by the regulation pond;
(ii) Cropping patterns to be adopted;
(iii) Irrigation water requirement in the area;
(iv) Regulation pond water management practices;
(v) Risk analysis in water management along the main and lateral canals; and
(vi) Condition of land acquisition for construction of regulation pond.

It is provisionally estimated that the regulation ponds will have a capacity of 2.5 MCM to 4.2 MCM.

PROJECT ASSESSMENT

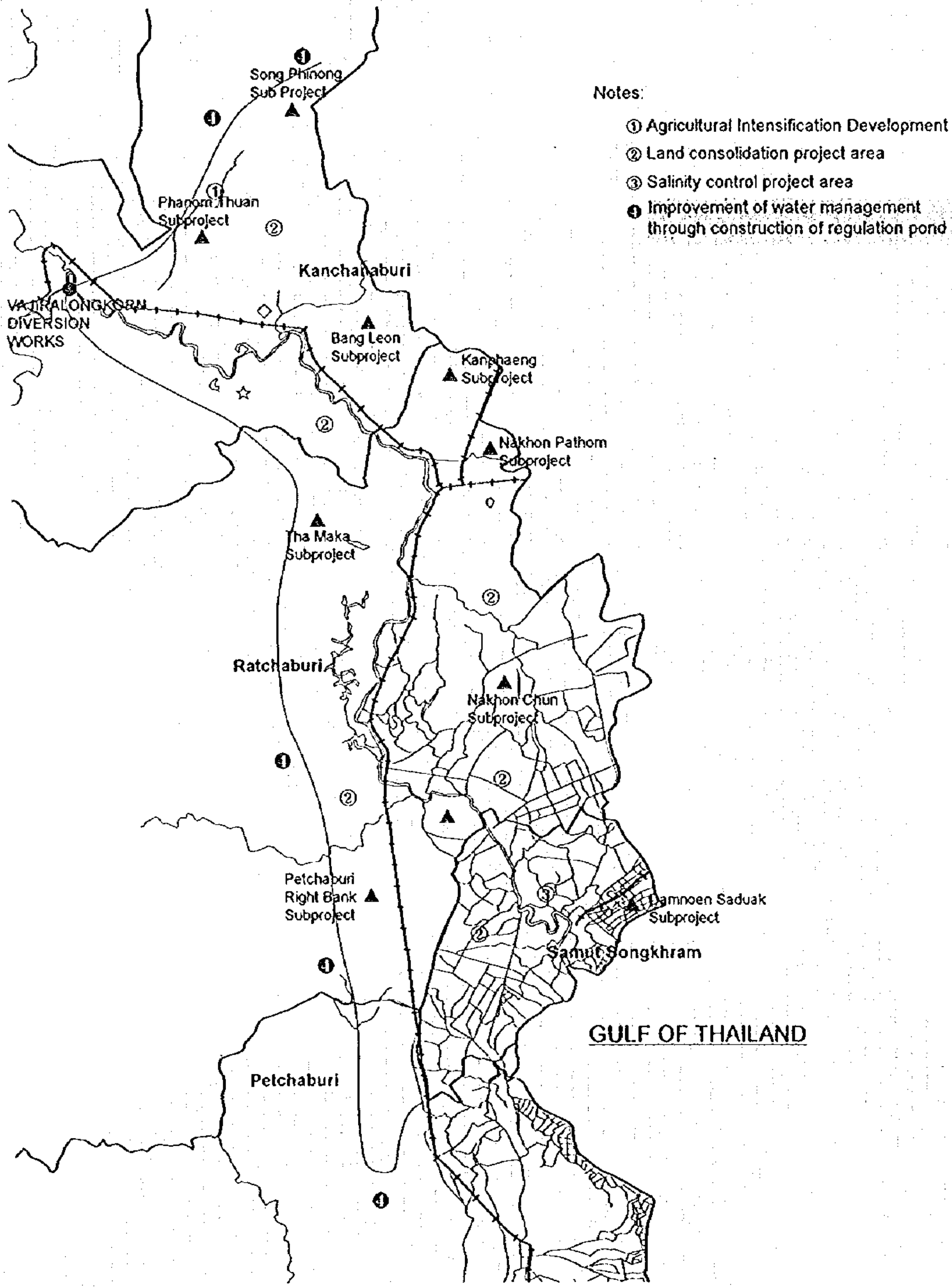
Since a shift to cultivation of higher-value crops will be gradually implemented in GMIS, it is envisaged that the construction of regulation ponds be scheduled for Phases II and III. As an indicative figure, the construction of regulation ponds is estimated to cost around $20 million.

During Phase II, it is proposed to initiate a detailed study of the construction of regulation ponds. The study cost will not exceed $1 million for technical, financial, institutional, and environmental assessments.

RECOMMENDED ACTION(S)

In the light of gradual shift in cropping patterns in the GMIS, it is recommended that a study be executed by RID on the proposed construction of regulation ponds along the principal main canals of the GMIS. The construction of farm ponds should be integrated into the Irrigated Agriculture Intensification Project (WR 1).

BASIC CONCEPT IN GMI SCHEME
(INTEGRATED AGRICULTURE DEVELOPMENT PLAN)



Checklist of Initial Environmental Examination (Project No. WR2){PRIVATE}

{PRIVATE} Environmental Parameters Affected by the Project Implementation	Impacts on the Environment	Recommended Feasible Mitigation Measures	Magnitude of Impacts			
			No Significant Effect	Significant Effect		
				Small	Moderate	Major
1. Air and Noise Pollution	1. Nuisances and health hazards to neighbors and wildlife caused by regulation pond construction.	1. Usage of low emissions and noise construction equipment, selection of proper times for land clearing and facility construction.		x		
2. Terrestrial Ecology	2. Alteration of wildlife habitats and loss of biodiversity caused by tree cutting.	2. Minimization of the amount of tree cutting and replanting precious vegetation.		x		
3. Water Quality and Aquatic Ecology	3. Alteration of aquatic habitats caused by the change of water flow, and potential water quality deterioration due to pond construction work (e.g., fecal contamination from construction camp and/or oil and grease spill from machine operation).	3. Setting up of machinery maintenance areas and construction camps away from the water bodies nearby; examining aquatic ecology of the project areas.		x		
4. Historical/Cultural Properties	4. Loss of historical/cultural properties.	4. Investigation of these properties and provision of appropriate preservation measures.	x			
5. Human Resettlement	5. Relocation of residents.	5. Consideration of alternative site selection and adequate compensation for affected residents.	x			
6. Environmental Aesthetics	6. Loss of scenic value.	6. Careful planning to minimize and offset losses.		x		

Project No. WR 3

1.	PROJECT TITLE	Multipurpose Reservoir Development
2.	LOCATION	Several river basins in the WSB
3.	AGENCY	RID
4.	OBJECTIVES	(1) To promote more effective use of limited water resources in the WSB with multi-purpose reservoirs for flood control, water supply, salinity controls and other purposes (2) To contribute to the creation of a better living environment with adequate water supply, sanitation, and landscape
5.	PHASING	Phase I for implementation of schemes at advanced stage and F/S of other schemes.

6. DESCRIPTION

Water resources availability is limited in the WSB region excepts in the Mae Klong river basin. To make more effective use of the limited water resources, several dam/reservoir projects have been identified. In the Petchaburi river basin, two reservoirs are planned on its tributaries in addition to the existing Kaeng Krachan reservoir. In Chumphon, the Tha Sae and the Lubro dam/reservoirs have been studied at the feasibility level. Several other sites for small-to-medium scale dam/reservoirs have been identified on other rivers.

These dams/reservoirs should be developed for multiple purposes as much as possible. Some of them may be important to meet local water demand such as industrial use at the community level and crop cultivation by drip irrigation. In any case, they should be taken as part of overall watershed management from the upstream to the coastal area. The Tha Sae dam/reservoir project will be implemented first during Phase I.

7.	RELATION WITH OTHER PROJECTS	ID 3 (Industrial Core/Bang Saphan initiative) UD 2 (Specific City Plans) AG 9 (Water Application Efficiency)

WR 3 MULTIPURPOSE RESERVOIR DEVELOPMENT

BACKGROUND

Water demand in the WSB region has been assessed by major river basin, as summarized below.

River Basin	Available Water	Estimated 1996	Demand 2011	Balance 2011
Mae Klong	10,720	8,077	8,133	2,607
Petchaburi	1,540	1,215	1,446	94
Western Coast	1,450	1,215	1,566	- 116
Southeastern Coast	4,360	572	1,502	2,858

As shown in the above table, water resources are abundant in the Mae Klong river basin and Southeastern coast river basins. However, water resources in the Petchaburi river basin and Western coast river basins are insufficient to meet the increasing demand in each sub-region. It is further noted that water resources in the Southeastern coast river basins are not controlled by reservoirs but running as natural flow.

In each river basin, several dam/reservoir schemes have been planned by RID, including the following:

Mae Klong river basin:

(1) Pa Chi dam on the Lam Pa Chi river which is a major tributary of the Khwae Noi, with the prime objectives to control floods and secure a potable water supply

Petchaburi river basin:

(2) Huai Mae Prachan dam for flood control and irrigation

(3) Huai Pak dam for supplemental irrigation

Southeastern Coast:

(4) Tha Sae dam for water supply to the Bang Saphan area, irrigation, and flood control

(5) Rub Ro dam for irrigation and flood control

PROJECT CONCEPT/RATIONALE

The most urgent multipurpose reservoir development scheme is the Tha Sae dam/reservoir construction in the Southeastern coast river basin (Chumphon province). The Tha Sae dam is for multiple purposes, i.e., irrigation (13,900 ha), transbasin water conveyance to the Bang Saphan industrial area in the Western coast river basin (30 MCM), and flood control.

Other dam/reservoir construction projects are also multipurpose, particularly for irrigation and flood control. Since available water is limited in the dry season in the Petchaburi river basin and Western coast river basin, it is expected that river discharges can be controlled by means of dam/reservoir construction in these river basins.

PROJECT DESCRIPTION

Tha Sae Reservoir

According to the feasibility study completed by RID, a 59 m high Tha Sae dam would have a storage capacity of 194 MCM (catchment area of 338 km^2). About 30 MCM are designed for use by industrial and urban development in the Bang Saphan area. For transbasin water conveyance to Bang Saphan, a 72 km long water pipeline is to be constructed.

In the event that the construction of the Tha Sae dam is delayed, an alternative solution is to take Tha Sae water in the upstream reach (a diversion site at 200 m above sea level, with a catchment area of 181 km^2). Since the river discharge is less than 1.0 m^3/s at this alternative site during the driest months (February-April), it is necessary to construct water storage facilities in the Bang Saphan river basin.

Rub Ro Reservoir

According to the feasibility study completed by RID, a 35 m high Rub Ro dam has a storage capacity of 143 MCM. The flood discharge would be reduced from 880 m^3/s to 530 m^3/s at the Rub Ro reservoir. Stored water would be used for irrigation (14,660 ha) on the right bank of the Tha Taphao river. Resettlement of people in the reservoir area has to be well programmed to implement the Rub Ro project.

Huai Mae Prachan and Huai Pak Reservoirs

The proposed Huai Mae Prachan reservoir is located on the Prachan river, which is a tributary of the Petchaburi river. The reservoir has a capacity of 41.5 MCM, mainly for irrigation of 3,520 ha. The Huai Pak reservoir, on the other hand, is located to the south of the existing Keang Krachan reservoir and has a storage capacity of 27.5 MCM. The two reservoirs will be effective in controlling floods in the lower reaches of the Petchaburi river.

Medium-scale Projects in the Western Coast River Basins

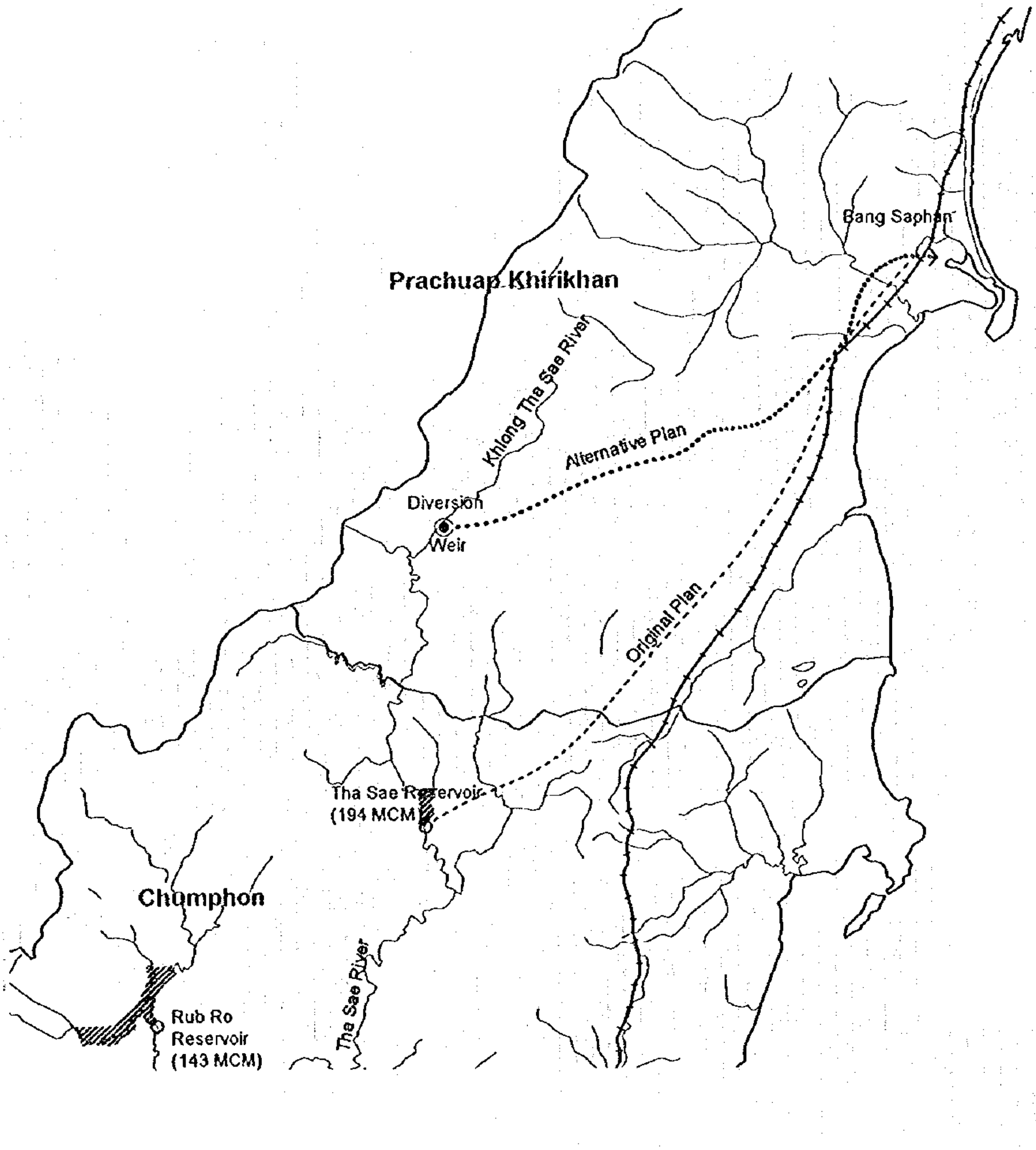
Sic medium-scale reservoirs with a total storage capacity of 62 MCM have been identified by RID for irrigation of 8,160 ha in total. Economic viability of these medium-scale reservoirs should be reviewed in further detail.

RECOMMENDED ACTION(S)

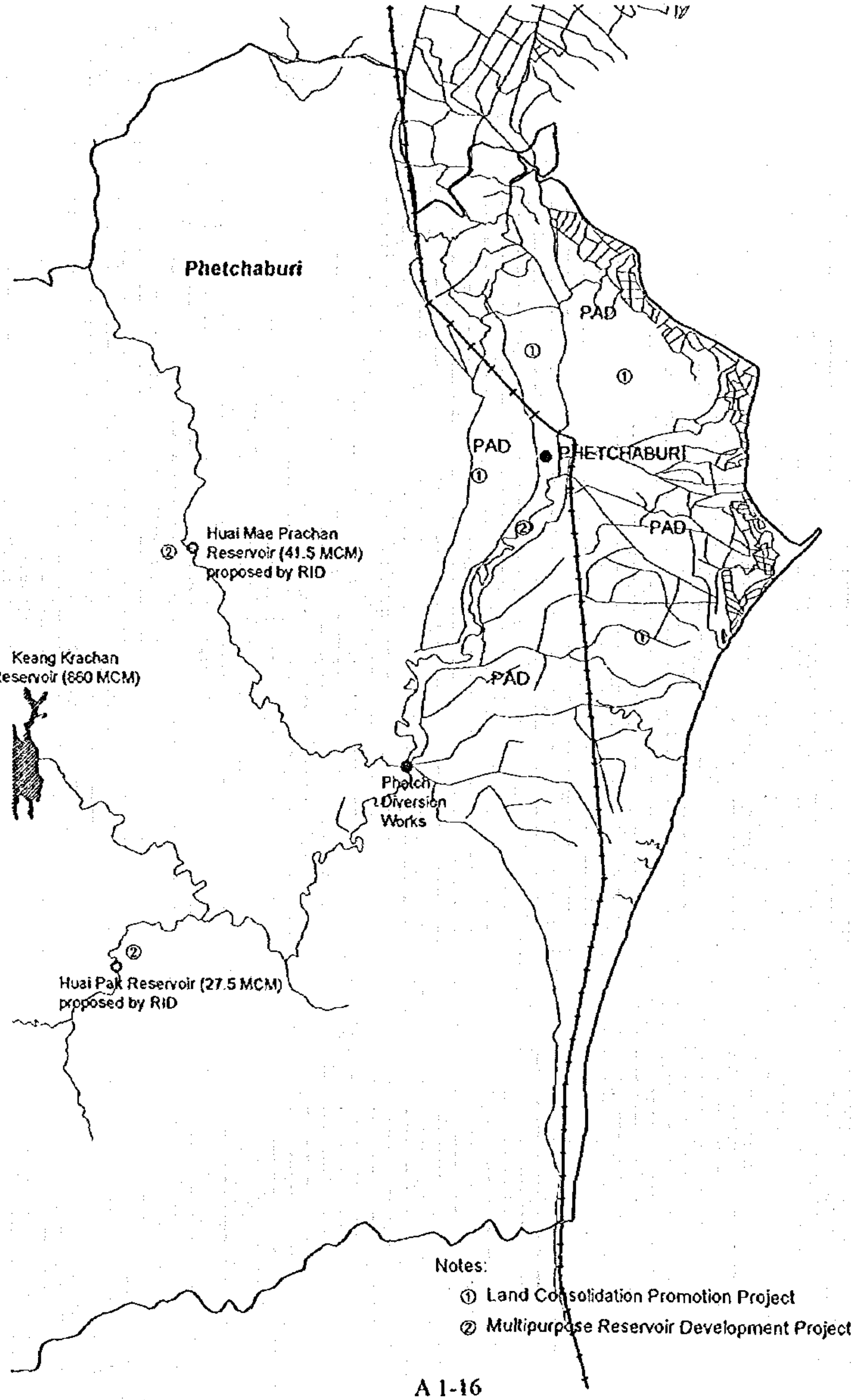
It is recommended that the EIA of the Tha Sae dam construction be reviewed and a decision be taken to implement the project as quickly as possible. The construction of the Tha Sae dam and irrigation scheme should be implemented by RID, and the transbasin water conveyance to the Bang Saphan area should be realized by IEAT.

It is also recommended that economic feasibility and environmental soundness be examined regarding the construction of the Huai Mae Prachan and Huai Pak reservoirs in the Petchaburi river basin, as well as the medium-scale reservoirs in the Western coast river basins, in order to meet the increasing water demand in these river basins.

ALTERNATIVE WATER SUPPLY PLAN FOR BANG SAPHAN



PHETCHABURI AGRICULTURE DEVELOPMENT (PAD) SCHEME



Checklist of Initial Environmental Examination (Project No. WR3){PRIVATE}

{PRIVATE} Environmental Parameters Affected by the Project Implementation	Impacts on the Environment	Recommended Feasible Mitigation Measures	Magnitude of Impacts			
			No Significant Effect	Significant Effect		
				Small	Moderate	Major
1. Air and Noise Pollution	1. Nuisances and health hazards to neighbors and wildlife caused by dam/reservoir construction.	1. Usage of low emissions and noise construction equipment, selection of proper times for land clearing and facility construction.		x		
2. Terrestrial Ecology	2. Alteration of wildlife habitats and loss of biodiversity caused by tree cutting.	2. Minimization of the amount of tree cutting and replanting precious vegetation.			x	
3. Water Quality and Aquatic Ecology	3. Alteration of aquatic habitats caused by the change of surface and ground water flow, and potential water quality deterioration due to dam/reservoir construction work (i.e., fecal contamination from construction camp and/or oil and grease spill from machine operation).	3. Setting up of machinery maintenance areas and construction camps away from the water bodies nearby; examining aquatic ecology of the project areas.		x		
4. Historical/Cultural Properties	4. Loss of historical/cultural properties.	4. Investigation of these properties and provision of appropriate preservation measures.	x			
5. Human Resettlement	5. Relocation of residents.	5. Consideration of alternative site selection and adequate compensation for affected residents.		x		
6. Environmental Aesthetics	6. Loss of scenic value.	6. Careful planning to minimize and offset losses.	x			

Project No. WR 4

1. PROJECT TITLE — Salinity Control

2. LOCATION — Lower Mae Klong river basin, and Lower reaches of Tha Taphao and Chumphon rivers

3. AGENCY — RID

4. OBJECTIVES — To control salinity in the downstream reaches of the Mae Klong river, as well as Tha Taphao and Chumphon rivers, to maintain land productivity and ensure water supply for irrigation and urban uses.

5. PHASING — Phase II for a reservoir operation study along with completion of ongoing dike construction; further implementation subject to outcome of the study and monitoring

6. DESCRIPTION

Downstream areas of major rivers in the WSB region suffer from salinization due to poor drainage and salt water intrusion. Salinization constrains more productive land and water uses. Particularly in the lower Mae Klong river basin, salt water intrusion is becoming more serious during the dry season. RID is constructing a dike along the coast to prevent the salt water intrusion.

A fundamental cause of the salt water intrusion is the drawdown of water level in the river during the dry season caused by increased extraction in the upstream and ineffective reservoir operation. It is necessary to review the reservoir operation in view of changing needs for water supply due to more intensive irrigation, changes in cropping pattern, and increasing urban and industrial uses.

Depending on the outcome of the review, the ongoing dike construction in the Lower Mae Klong river basin may be extended further to the west. In the long run, construction of a salinity control barrage may be required at the estuary, subject to assessment of environmental impact and economic viability.

7. RELATION WITH OTHER PROJECTS

8. COST (Approximate) — Phase II = $1 million (feasibility study)

WR 4 SALINITY CONTROL

BACKGROUND

Salinization is in progress in the lower basin of the Mae Klong river due mainly to: (i) seawater intrusion from the coast, (ii) saltwater intrusion in the estuary, and (iii) lack of adequate drainage systems. To protect against seawater intrusion, RID completed the construction of a 36 km long coastal dike on the right bank and planned to construct a 52 km long dike on the left bank.

The Vajiralongkorn diversion works on the Mae Klong river have been designed to secure 50 m^3/s of salinity control/maintenance flow in the downstream in the dry season. If this discharge is maintained, salinity at the mouth of Dammoen Sauak canal is kept within 2 gm/liter. However, as experienced in the drought years (1978-1980), salinity increased to the unacceptable level of 11.25 gm/liter.

Salinization is also a problem in Chumphon province. In the lower reaches of the Tha Taphao river and Chumphon river, salinity has increased in groundwater for potable water supply to villages developed in the estuary area and in soils for agricultural use.

PROJECT CONCEPT/RATIONALE

In the lower reaches of the Mae Klong river, further studies should be made to clarify the following aspects:

(i) Whether the maintenance flow of 50 m^3/s in the downstream from the Vajiralongkorn diversion works can be guaranteed through modification of reservoir operations at the Sri Nagarindra and Khao Laen reservoirs;

(ii) How large is the water requirement in the coastal lands to be protected by the coastal dike, and how drainage works can be improved in this area;

(iii) Whether water supply from the Mae Klong river basin to the BMA is indispensable; and

(iv) Whether the construction of a structure on the Mae Klong river estuary to get fresh water of 1,577 MCM is required, and whether it is economically and environmentally feasible.

In the lower reaches of the Tha Taphao river and Chumphon river, further studies should be made to clarify the following:

(i) How salinization has affected potable water supply and farming in the lower reaches;

(ii) Whether there are alternative measures to secure fresh water in the affected area; and

(iii) Whether the construction of an estuary weir is required and whether it is economically and environmentally feasible.

RECOMMENDED ACTION(S)

It is premature as this stage to conclude whether an estuary barrage is required in the lower reaches of the Mae Klong river, Tha Taphao river, and Chumphon river. It is recommended that a detailed study be conducted in Phase II to assess the viability of construction of the estuary barrage and other structures for salinity control.

Project No. WR 5

1. PROJECT TITLE — Flood Control and Drainage Systems Improvement

2. LOCATION — Major river basins in the WSB

3. AGENCY — RID

4. OBJECTIVES
   (1) To control floods to prevent damage to properties and agricultural lands
   (2) To improve drainage systems in the lower basins of major rivers to enhance land productivity
   (3) To motivate farmers to adapt themselves to new farming practices under improved drainage conditions

5. PHASING — Phase I for planning and design of priority schemes

6. DESCRIPTION

Floods are causing damage in the lower reaches of Petchaburi river, the Tha Taphao river and other rivers in Chumphon province, the Pran Buri river and other rivers in Prachuap Khirikhan province, as well as in the major tributaries of the Mae Klong river, including the Lam Pa Chi river. Floods should be controlled through construction of storage reservoirs upstream, as well as through river improvement, revetments, and other appropriate measures.

Drainage systems should be improved in the lower Mae Klong river basin, and lower basins of Petchaburi river, Chumphon river and other major rivers in the WSB region. Since the water table is relatively high in these lower basins, over drainage may cause soil salinization. Acidity/alkalinity and other soil problems may also occur, depending on the soil types. Therefore, drainage systems should be carefully planned together with selection of crops and the farming system.

In planning for the drainage systems improvement and associated agricultural development, a participatory approach is recommendable involving local farmers, who have adapted to existing local conditions. Such participatory planning would also help to motivate farmers to adopt new farming practices to be introduced under improved drainage conditions. The Chumphon river may be selected for initial application of the participatory planning followed by implementation.

7. RELATION WITH OTHER PROJECTS

8. COST (Approximate) — Phase I = $1 million (feasibility study)

WR 5 FLOOD CONTROL AND DRAINAGE SYSTEMS IMPROVEMENT

BACKGROUND

In the Mae Klong river basin, discharge control is an urgent task in the Lam Pa Chi river (a tributary of the Mae Klong), as floods in September-October 1996 caused serious damage to households (6,100 houses) and agricultural land (72,300 ha), as well as a number of bridges and other structures in the flooded areas.

The Lam Pa Chi river has a catchment area of about 2,450 km^2, with an average annual precipitation of about 1,100 mm. Runoff records (1982-1994) are available at the K25 gauging station (catchment area of 508 km^2). On the basis of monthly runoff at the K25 station (74.6 MCM), the total water available in the La Pa Chi river is estimated at around 361 MCM per annum.

Two alternative dam/reservoir sites have been identified in the Lam Pa Chi river basin for flood control, as well as irrigation and municipal water supply. The upper site is located at Ban Suan Phong with a catchment area of about 1,300 km^2. Annual runoff at this site is estimated at 191 MCM. The lower site (proposed by the Metropolitan Waterworks Authority) is located at Kho Phu Thong or about 25 km upstream of its confluence with the Khwae Noi river, with a catchment area of about 1,960 km^2. Annual runoff at the lower site is estimated at 288 MCM. On the basis of monthly runoff records in October 1985 (monthly runoff of 78 MCM), the probable flood discharge at the lower site is estimated to be around 2,270 m^3/s. This magnitude of flooding will cause serious inundation in the lower reaches of the Lam Pa Chi river and the areas upstream of the Vajiralongkorn diversion works.

In the Petchaburi river basin, floods often cause damage in the section between the Petch diversion works and Petchaburi city, as well as in the lower reaches downstream from the urban center of Petchaburi. The river course is meandering and flood conveyance capacity is limited in these sections.

In Chumphon province, floods along the Tha Taphao river (peak flood of 1,510 m^3/s) frequently cause damage in the section downstream from the confluence of Tha Sae and Rub Ro rivers.

Drainage systems in the lower Mae Klong river basin and Petchaburi river basin are inadequate because RID's ditch-and-dike projects have been implemented without improvement in drainage systems. Productivity has been relatively low in the areas where drainage systems are inadequately developed or undeveloped.

PROJECT CONCEPT/RATIONALE

For flood control and drainage systems improvement, it is required that a further detailed study be conducted of the following programs:

(i) Feasibility study of construction of the Pa Chi dam/reservoir on the tributary of the Mae Klong river;

(ii) Design of necessary structures for control of floods and improvement of drainage systems in the lower Petchaburi river basin; and

(iii) Review of economic feasibility and financial viability of flood conveyance canals and drainage systems in the Tha Taphao river basin in Chumphon.

RECOMMENDED ACTION(S)

It is recommended that the above noted studies be executed in Phase I in order to evaluate economic feasibility and priority for implementation. It is also recommended that drainage systems improvement be studied along with salinity control in the lower reaches of the Mae Klong, Petchaburi, and Tha Taphao rivers.

Chapter 3 ENERGY AND POWER SECTOR

3.1 *Energy Demand and Supply*

3.1.1 Overview

To meet the demands of its impressive economic development, Thailand has depended heavily on imported oil, which covered over 90 per cent of the country's oil requirements during the 1979/80 oil crisis. In the following years, the Thai government managed to increase the share of its indigenous energy consumption. In 1994, domestic energy production was 37.6 million tons of oil equivalent (Mtoe), or 58 per cent of the total primary energy supply. Modern energy consumption, which comprises petroleum products, natural gas, condensate, coal and lignite, hydropower, and others, increased 11.9 per cent while renewable energy grew by 10.3 per cent. In 1994, the total supply of commercial energy in Thailand was 65 Mtoe, an increase of 11 per cent over the previous year. Of the total amount, petroleum accounted for 45.2 per cent, natural gas 14 per cent, lignite 7.9 per cent, electricity 1.6 per cent, and coal 1.5 per cent. In addition, Thailand consumed about 19 Mtoe of renewable energy, about 30 percent of its total energy supply in 1994, mainly in the form of fuel wood, which remained the predominant fuel in rural households. (Refer to Table 9.3.1)

By the end of 1994, Thailand produced 1.3 Mtoe of oil, a small amount compared to its consumption of 23.4 Mtoe. Natural gas was a major domestic energy source, with the total production of natural gas at 9.3 Mtoe or 24.8 per cent of total indigenous energy production. The Electricity Generating Authority of Thailand (EGAT) is responsible for the development of lignite. However, the expansion of lignite mining has had to be severely curtailed due to geotechnical and environmental problems. In 1994, the lignite output in Thailand was 5.2 Mtoe, or 13.8 per cent of total indigenous energy production. With uncertainties surrounding the development of the country's lignite resources, it would be necessary to import coal and establish coal-fired generation by as early as 2000. Although hydropower potential is well over the utilized 2,400 MW, increased opposition to reservoir construction would make development of hydropower in Thailand extremely difficult. In rural areas, traditional fuels have dominated the daily consumption by households, two-thirds of the consumption of which is bio-mass, consisting of charcoal and firewood, causing severe impacts on the forests near inhabited areas.

3.1.2 National Energy Policies and Administration

(1) National Energy Policies

The national energy policies in the 1990s still focus on diversifying supply and utilization of domestic energy, adjusting prices of energy products for more efficient use, introducing energy conservation measures, involving the private sector in the investment and production of electricity and petroleum, and promoting cooperation with neighboring countries.

(2) National Energy Strategy

National energy strategies include: (i) investing in the exploration and development of domestic petroleum and lignite; (ii) accelerating the development of hydropower, coal, natural gas, and petroleum in neighboring countries by cooperative efforts, including the construction of natural gas pipelines; (iii) improving the transmission and distribution system for electricity; and (iv) promoting private sector participation in energy production.

(3) Development Agencies

The National Energy Policy Council (NEPC), the highest level of government in charge of energy policies and directions, is chaired by the Prime Minister. Its members include a deputy prime minister, ministers from relevant ministries, representatives from the National Economic and Social Development Board (NESDB), the director of the Budget Bureau, the secretary general of the National Energy Policy Office, and the director general of the Department of Energy Development and Promotion (DEDP). The National Energy Policy Office (NEPO), a department under the Office of the Prime Minister and the secretary to NEPC, functions as a link between NEPC and the country's state energy enterprises and conducts all energy policy work. The Department of Mineral Resources is responsible for assessment and preliminary exploration of the country's coal and petroleum reserves, while DEDP is in charge of research and development, monitoring energy sector trends, statistics, and rural energy development.

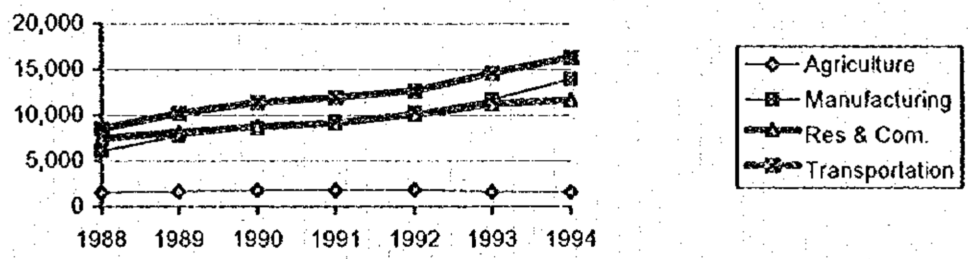
The Petroleum Authority of Thailand (PTT) is a state-owned enterprise responsible for the development and supply of petroleum, petroleum products, and natural gas. In the electricity sector, the Electricity Generating Authority of Thailand (EGAT) covers most power generation and transmission to primary substations. It also manages most minable reserves of lignite in Thailand. The Metropolitan Electricity Authority (MEA) is a power distribution company in charge of power distribution to the Bangkok

Metropolitan Area, while the jurisdiction of the Provincial Electricity Authority (PEA) includes power distribution and rural electrification to areas of the Kingdom not served by MEA. EGAT reports directly to the Prime Minister's Office and both MEA and PEA report to the Ministry of Interior.

3.1.3 Energy Demand

Transportation accounted for 37 per cent of total energy consumption in 1994, followed by manufacturing and mining (31.8 per cent), and residential and commercial consumers (25.6 per cent). The energy consumed by the transportation sector jumped from 6,025 ktoe in 1985 to 16,341 ktoe in 1994, an average annual growth rate of 12 per cent. For reference, the total share of energy consumed by the transportation sector was 32.5 per cent in 1985.

Growth of Final Energy Consumption by Economic Sectors



Energy Consumption by Economic Sector

Unit: ktoe

	1988	1989	1990	1991	1992	1993	1994
Agriculture	1,525	1,639	1,803	1,827	1,879	1,618	1,576
Mining	49	56	58	53	42	42	35
Manufacturing	6,062	7,712	8,541	9,288	10,238	11,732	13,917
Construction	99	109	147	194	220	182	333
Res. and Com.	7,496	8,114	8,725	9,135	10,055	11,173	11,647
Transportation	8,520	10,169	11,368	11,910	12,652	14,581	16,341
Total	23,749	27,799	30,642	32,407	35,104	39,328	43,849

Source: DEDP/Thailand Energy Situation in 1994.

Petroleum products represented the greatest proportion of final energy consumption in 1994, totaling 23.4 Mtoe, up 10.6 per cent over the previous year and accounting for 53.2 per cent of total energy consumption. Natural gas's role, due to new discoveries in the Gulf of Thailand and neighboring regions, is becoming more important. A total of 0.6 Mtoe was consumed in 1994, a 19.5 per cent jump from the previous year. Coal and lignite consumption in 1994 was 3.1 Mtoe, an increase of 23.1 per cent over the previous year and accounting for 7.1 per cent of the final energy consumption. Electricity consumption in 1994 was 5.3 Mtoe, an increase of 11.1 per cent over the previous year and accounting for 12.2 per cent of final energy consumption.

Total renewable energy consumption in 1994 was 11.5 Mtoe, an increase of 10.3 per cent over the previous year and accounting for 26.2 per cent of the final energy consumption.

3.1.4 Energy Supply

Rapid economic development in Thailand has led to a rapid increase in final energy consumption. Since 1989, Thailand's economy has been expanding at an annual rate of 8.9 per cent while its final energy consumption has been growing even faster, at 9.5 per cent annually.

Primary Energy Supply by Source

(million KBD)

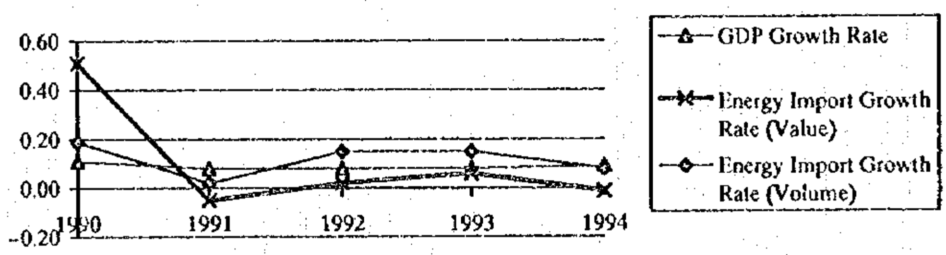
Energy Sources	1983	1993	2003
Imported Coal	2	11	69
Imported Oil	216	476	844
Imported	-	-	210
NG/LNG	3	3	50
Imported Hydro	11	53	50
Indigenous Oil	25	157	297
Indigenous NG	11	94	206
Lignite	18	17	28
Hydro			
Total	286	811	1,750

Source: PTT/Facts and Figures of Petroleum Industry in Thailand, 1994.

In 1994, Thailand produced 37.6 million tons of oil equivalent (Mtoe) and imported 28.3 Mtoe, an increase of 10 per cent and 9 per cent from the previous year, which was higher than the real GDP growth rate of 9 per cent. Thailand will continue to import oil, but imported oil's share will decrease as Thailand starts to purchase natural gas and coal from abroad. However, the import share will not exceed 70 per cent of the total, which is in line with the targets of the Eighth Five Year Plan. Due to the difficulties in developing domestic hydro power, Thailand has started to cooperate with its neighbors in exploring hydro power potential.

In 1994 Thailand imported 28,258 ktoe of energy, a 9.1 per cent increase over the previous year, among which crude oil accounted for 65.9 per cent, petroleum products for 30.4 per cent, and electricity for 0.3 per cent.

Relation between GDP and Imported Energy



Source: DEDP/Oil and Thailand 1994.

Thailand produces its own natural gas. The largest consumer for natural gas is EGAT, with 716 MMCFD in 1993, followed by industry and feedstocks, 56 MMCFD and 139 MMCFD respectively. On the supply side, most natural gas is domestically produced. PTT projects that by the year 2003 Thailand will import 1,068 MMCFD natural gas, accounting for 36.3 per cent of Thailand's total natural gas supply. Natural gas production accounted for 24.6 per cent of the total domestic energy production in 1993 and 24.8 per cent in 1994. (Refer to Table 9.3.2)

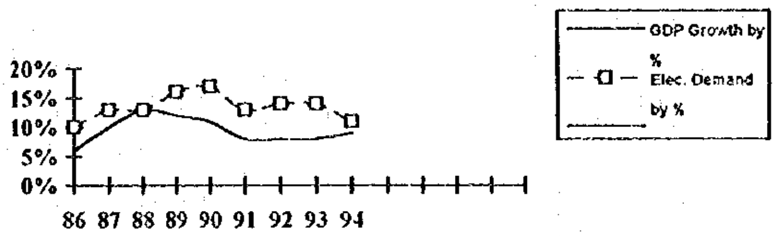
3.2 Electricity Demand and Supply

3.2.1 Electricity Consumption

Electricity consumption in Thailand increased from 20,032 GWh in 1985 to 62,510 GWh in 1994, implying an average annual growth rate of 13.5 per cent. Per capita consumption of electricity increased from 308 kWh in 1982 to 1,058 kWh in 1994. The industry sector was the largest electricity customer consuming 28,920.1 GWh or 46.2 per cent of the total, followed by the commercial sector utilizing 20,116 GWh or 32.2

per cent; residential users consumed 12,893 GWh or 20.6 per cent and others (agriculture and temporary consumers) 579.9 GWh or 1 per cent. Consumption by industry, residential, and other sectors increased by 29.3 per cent, 8.1 per cent, and 10.3 per cent respectively, while commercial sector consumption decreased by 8.5 per cent from the previous year.

Growth of GDP and Electricity Demand



Source: DEDP/Electric Power in Thailand 1994.

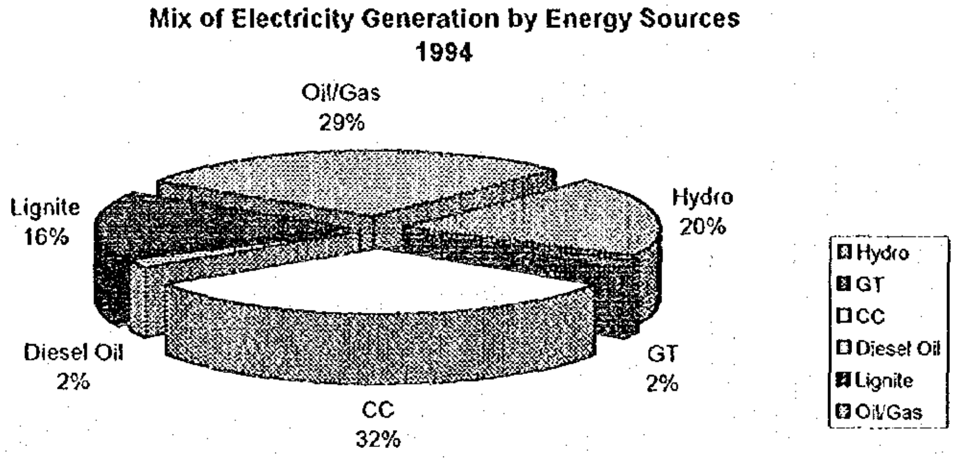
The Bangkok Metropolitan Area (BMA) consumed 27,030 GWh, or 43.2 per cent of the total consumption in the whole country, up 10.5 per cent from the previous year. Areas outside the BMA utilized 35,479 GWh or 56.8 per cent of total electricity consumed in Thailand, an increase of 11.5 per cent over the previous year.

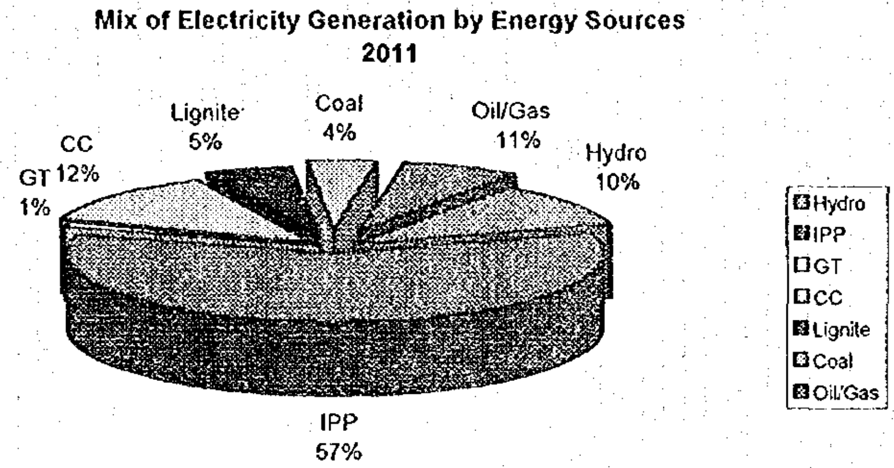
Based on its October 1996 load forecast, EGAT projected that peak demand for generation capacity will increase from 10,709 MW in 1994 to 21,423 MW by 2001, 30,464 MW by 2006, and 41,683 MW by 2011. This projection implies an average annual growth rate of 10.6 per cent in the 7th Plan, which is lower when compared with the 14.0 per cent projected in the 6th Plan. Over longer periods, the average peak demand growth rate is projected at 10.0 per cent, 7.3 per cent, and 6.5 per cent during the 8th, 9th, and 10th plan periods, respectively. (Refer to Table 9.3.3)

3.2.2 EGAT's Generation Requirement

As of September 1994, EGAT's installed capacity was 12,988.9 MW, comprising 2,578 MW hydropower (19.8 per cent), 6,102 MW oil/gas and lignite-fired thermal (47 per cent), 4,100 MW combined cycle (31.6 per cent), and 210 MW gas turbine (1.6 per cent). The share of fuel oil as a source of generation increased from 14 per cent of the total in 1985 to 27.6 per cent in 1994, while the development of hydropower has stagnated. By the end of the 7th plan, EGAT expects to have an installed capacity of 16,142 MW, with 24,102 MW expected by the end of the 8th Plan, and 39,302 MW by the end of the 9th plan, implying average rates of increase of 9.7 per cent, 9.9 per cent, and 12.6 per cent respectively.

The following figure shows the mix of electric generation by energy source in Thailand, including, but not limited to, the generation units under EGAT.





Source: EGAT PDP 97-01.

There are 54 projects that require capital expenditures in the 7th Plan period (1992-1996). Of these, 28 are ongoing projects that have been approved since the 6th Plan while 26 have been approved in the 7th Plan. The total capital expenditure in the 8th Plan requires 268,000 million Baht. Of this amount, the foreign currency requirement is 122,500 million Baht (approximately US$4.9 billion equivalent) and the local currency portion is 145,500 million Baht.

3.2.3 SPPs, IPPs, and Power Imports

The first step taken by the Government towards increasing private sector participation in the power sector was to allow co-generators and small power producers to sell power to EGAT. Co-generators are power plants that produce both steam and electricity and are often part of industrial entities. Small power producers (SPPs) have an installed capacity of 90 MW (recently increased from a lower ceiling of 60 MW) often utilizing waste materials or traditional fuels such as garbage, bagasse, rice husk, and wood. In 1992, EGAT announced its first offer of 300 MW. In 1995, in its second announcement EGAT offered to purchase up to 1,444 MW. A total of 84 SPPs, representing 4,435 MW, proposed to supply electric power to EGAT. By December 31, 1995, 18 of 50 applicants had signed a Power Sales Agreement with EGAT to provide a total capacity of 343 MW. By June 1996, 50 of 84 applicants had received EGAT's approval to supply a total of 1,720 MW of power, far exceeding the original ceiling, to meet the expected stronger demand. Of the 1,720 MW, 78 per cent is from the larger co-generation projects using natural gas, lignite, and imported coal as fuel, while the rest comes from smaller projects selling 5-20 MW each and running on agricultural waste such as paddy husk. So far, 14 SPPs have started to transmit a total of 155 MW; the majority of them supply power on a "non-firm" basis. The current basic tariff set for the purchase of SPP output stands at capacity charge of 302 Baht/kW/month and energy charge of 0.85 Baht/kWh for delivery on a firm basis and 0.87 Baht/kWh for non-firm supplies.

In response to the Government's policy of privatizing state enterprises, reducing public borrowing, improving enterprise efficiency, and increasing capital investment in the infrastructure, EGAT has started to invite independent power producers (IPPs) to build power plants. An open invitation to bid to produce power is underway following the recent approval by NEPC in May 1994 of the purchase of electricity from IPPs by EGAT in stages as follows:

Stage One:	5,800 MW
Phase One:	1,700 MW for 2000;
Phase Two:	4,100 MW for 2001-2003

By 2011, EGAT will purchase 22,500 MW of power capacity from IPPs; the fuel sources include natural gas, LPN, imported coal, and orlimulsion. Thailand purchases electricity from Lao PDR and Malaysia at the respective borders.

Electricity imports totaled 870 GWh in 1994, 95.2 per cent of which came from Lao PDR and the rest from Malaysia. The total import increased by 35.1 per cent from the previous year and the total imported value accounted for 759 million Baht. This trend is expected to continue (possibly including the import of electricity from Myanmar in the future), since Lao PDR and Malaysia are expected to expand their electricity generation and cooperation with Thailand.

Thai Government signed a new memorandum with Lao PDR to double its long-term power purchase to 3,000 MW, mostly hydropower. The power purchase price ranges from 0.043 to 0.0455 US$/kWh in 1994 prices.

Implications for the WSB Region

IPPs are expected to be active in the WSB region. As EGAT solicits more and more power supply from diversified energy sources from the private sector and Myanmar continues to supply natural gas, IPPs will play an increasingly important role in the WSB region. Presently, as Phase One of the IPP Stage One, three 600 MW gas generation IPP proposals, based in Ratchaburi, are under negotiation with EGAT. Four proposals in the WSB are shortlisted for Phase Two, three of which are based in Prachaup Khirikhan; of these three, two use coal as fuel and one uses orlimulsion. The one proposal based in Ratchaburi will use natural gas. By 2003, IPPs would account for 27 per cent in generation capacity and 37 per cent in GWh in the WSB region.

IPP Proposals in the WSB Region

Producer	Capacity	Fuel	Location
Stage One, Phase I	MW		
Tri Energy Co.,	700	Nat. gas	Ratchaburi
Bangkok Energy System	326	Nat. gas	Ratchaburi
Thai Oil Co.,	700	Nat. gas	Chonburi
Stage One, Phase II			
Union Energy	1,400	Coal	Bang Saphan
Gulf Electric Co.	700	Coal	Kui Buri
Bowin II Power	673	Nat. gas	Chonburi
BLCP Power Co.	1,341	Coal	Rayong

Source: EGAT

3.2.4 Rural Energy and Biomass Energy

PEA is responsible for rural electrification. As of September 1994, PEA's network comprised 584 circuit-km of 115 kV and 36 circuit-km of 69 kV lines, and over 188,626 circuit-km of 33 kV, 22 kV, 11 kV, and 3.5 kV lines. In the WSB region in 1996, the total length of transmission lines was 824 circuit-km and that of distribution lines is 18,122 circuit-km. There were 30 sets of substations, with a total capacity of 1,325 MVA. (Refer to Table 9.3.3)

With assistance from international organizations, PEA started a plan for rural electrification in 1970. Based on the recommendations of NESDB, the Government adopted a 25-year National Plan for Rural Electrification. The Government adopted several strategies for the successful implementation of the plan: (i) cross-price subsidies from urban to rural and from large to small customers; PEA achieved cost economies through purchasing power at rates 30 per cent lower than those paid by MEA; (ii) an increase in the connection rate and encouragement of productive uses of electricity to keep the program financially sustainable; (iii) mobilization of concessional loans and grants from bilateral and multilateral agencies; and (iv) low-cost and affordable connections. After sixteen years of efforts by the Government, the rural electrification rate is now at 98 to 99 per cent; the Government is aiming at 100 per cent by the end of next year.

In 1994, biomass energy accounted for 26.2 per cent of the total final energy consumption, second only to petroleum products. The amount of biomass energy demand has increased steadily at an average annual growth rate of 6 per cent since 1985. However, the share of biomass energy has declined continuously from 36.4 per cent in 1985 to 26.2 per cent in 1994 as industry grows at a much faster pace. Charcoal, fuelwood, paddy husk, and bagasse are the main sources of biomass energy. Among biomass energy sources, charcoal and fuelwood are used mainly for cooking, process-heating, and cottage industry in residential and commercial areas, accounting for 66 per cent of the total in 1994. The important sources of biomass use are bagasse and paddy husk. Bagasse and paddy husk are used mostly for process-heating in the manufacturing sector. About 2.67 Mtoe of bagasse was consumed in 1994, representing an increase of 34.8 per cent over the previous year; it is totally used in the manufacturing sector. In 1994, 0.448 Mtoe of rice husks was consumed, a decrease of 15.6 per cent from the previous year.

Although the manufacturing sector is experiencing rapid growth, its consumption of biomass energy seems to have declined. In the sector, sugar mills, rice mills, noodle factories, canneries, and tobacco curing establishments are the major consumers. As an agro-industrial economy, Thailand has a large biomass resource base with 60 million tons of biomass energy generated each year.

The government policies related to biomass energy are to encourage the use of domestic energy sources, energy conservation, and private sector participation.

<u>Implications for the WSB Region</u>

Several government strategies are relevant to the WSB region, as set out below:

(i) Encourage generation of electricity and heat through renewable energy;
(ii) Promote high efficiency charcoal making kilns, biomass combustion, and energy saving cooking stoves;
(iii) Enhance private sector involvement in reforestation activities;
(iv) Encourage small-scale producers (SPP) to invest in and produce electricity and heat from renewable energy sources in the form of co-generation; and
(v) Increase public awareness.

As noted by the Ratchaburi Regional Energy Center (RREC), sugar cane is one of the main agricultural products in the WSB region. Sugar factories use bagasse to generate power; some of them have signed contracts with EGAT to provide surplus to the grid. Rural electrification is very high in the region, 98 per cent. However, consistent with the national trend, about 70 per cent of rural households rely on firewood and charcoal, with a majority using inefficient traditional cooking stoves. There are over ten units of Wind for Pumping in Petchaburi and Ratchaburi, but the wind potential in the WSB is low. There are around 1,200 windmill pumps in RREC's Western region (which is bigger than the WSB). However, their numbers will be severely reduced after some are converted to salt farms. The region is experiencing a rice husk shortage as brick factories have to import rice husks from neighboring regions. Previously there was a bio-digester program in which the Government subsidized part of the initial cost to build the digesters, but the budget for this program was eliminated a few years ago. Approximately half of the installed bio-digesters are still operational in the region; there are about 173 biogas digesters for cooking in the area covered by the RREC. RREC planned to build 14 in 1996 and 10 in 1997 solar PV battery charging stations in Kanchanaburi.

The Potential of Agriculture Residues in the Region

CROP	Residue	Conversion factor	Output	Potential	KTOE
Rice	Husk	0.267	731.4	195.3	1.95
Sugar cane	Bagasse	0.291	10039.8	2921.6	473.1
Cassava	Stalk	0.088	881.9	77.6	NA
Maize	Corn cob	0.273	25.2	6.9	NA

3.2.5 *Demand Side Management (DSM)*

According to an evaluation of 110 countries and economies by the Global Environmental Facility (GEF), Thailand, with its DSM program, is one of the eight countries that have succeeded in the environmental protection efforts. As the first in the ASEAN region to adopt a DSM program, EGAT is invited by various international organizations to present its DSM program to neighboring developing countries.

The first Five-year (1993-1997) pilot DSM Master Plan was approved by the Government of Thailand in December 1991. EGAT was nominated as the implementing agency. The DSM plan has projected annual savings of 311 MW in peak demand and 1,826 GWh in energy by the end of 1997 at a cost of US$189 million. Using an avoided cost of $1,000/kW, the program will have saved US$122 million, plus additional benefits in environmental protection.

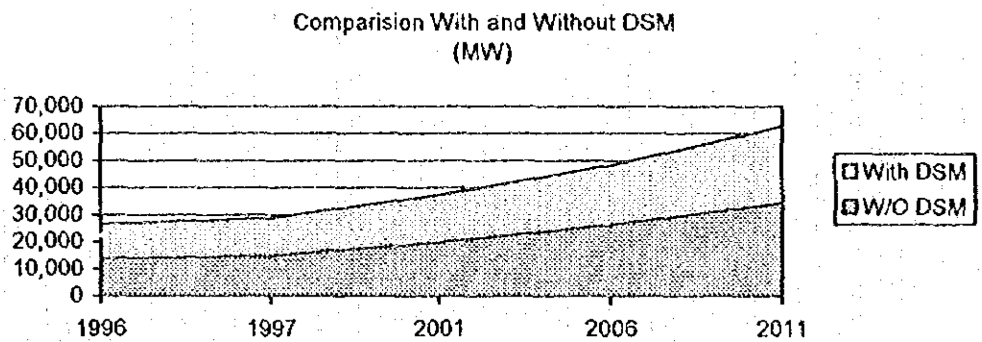
EGAT's DSM plan consists of six sectoral programs, namely Residential Sector, Commercial Sector, Industrial Sector, Load Management, Attitude Creation, and Monitoring and Evaluation. Funding of the program comes from a DSM surcharge in the tariff mechanism, a grant from the World Bank, under the auspices of GEF, and a concessional loan from Overseas Economic Cooperation Fund of Japan.

Thai utilities:	US$ 149 million
GEF:	US$ 15 million
OECF	US$ 25 million
Total	US$ 189 million

EGAT is also the first in Southeast Asia to have experimented with an Energy Saving Company (ESCO) system. With Thailand's own version of ESCO operations, EGAT's

DSM office is expected to recover part, hopefully all, of the DSM program cost through reimbursement from savings by the beneficiaries. (Refer to Table 9.3.4) The current DSM program involves a four-pronged approach, focusing on the provision of economic incentives for consumers to adopt energy saving practices, development of standards and testing facilities, introduction of new building and appliance codes, and pursuit of best available technologies.

The long-term DSM plan is based on the 17-year Power Development Plan and government policies. Based on estimates of DSM potential, the reduction of accumulated capacity and energy demand is expected to be 551 MW, 3,303 GWh in 1997-2001, 1,551 MW, 9,305 GWh in 2002-2006, and 2,426 MW, 14,553 GWh by 2007-2011.



Implications for the WSB Region

EGAT's DSMO is about to start a pilot program to help four manufacturers to improve their energy consumption process. All of them will be located in the BMA region. There is no specific DSM program in the WSB region, an area that will to be one of major power generation bases in Thailand, with its total generating capacity peaking at 17,236 MW by the year 2009. According to DSMO's projection of 6.4 per cent of savings from the total projected load demand of EGAT, the DSM program might reduce regional generation demand to 16,133 MW. The possible 1,103 MW saved in the WSB implies a major reduction in environmental impacts in the region.

As discussed with EGAT, the industrial program should also be extended to the WSB as economic development in the region accelerates as projected under the social and economic framework. Since it is cheaper, for EGAT as well as for business owners, to install energy efficient equipment in new factories and buildings than it is to retrofit and replace equipment in existing factories, DSMO should formulate new programs specifically targeting new investors in the whole Kingdom in general, and in the WSB in particular.

3.3 *Power Situation in the WSB Region*

3.3.1 Power Demand in the WSB

The WSB region recorded the use 2433.3 GWh of electricity in 1994, or 3.9 per cent of the total consumption in the Kingdom. Per capita electricity consumption in the WSB was 840 kWh, lower than the national average of 1,058 kWh. (For reference, per capita GDP in the WSB region was 48,620 Baht, while the national average was 61,355 Baht.)

Electricity Consumption in WSB in 1994

Province	Consumption (GWh)	Rural Electrification (Villages)	Rural Electrification (Household)
Kanchanaburi	435.8	93.9%	86.8%
Samut Songkhram	119.6	100%	81.7%
Ratchaburi	886.3	100%	97.8%
Petchaburi	312.1	99.5%	96.5%
Prachuap Khirikhan	455.0	99.5%	94.4%
Chumphon	224.5	99.5%	95.6%
Total	2,433.3	98.7%	92.1%

Source: NESDB and DEDP/Electric Power in Thailand 1994.

In the past ten years, the growth of industry has outpaced the growth of agriculture, following a similar pattern to that of the national economic structure. Under the medium-growth scenario, the industry sector is expected to grow faster, at an average annual growth rate of 10.8 per cent between 1995 and 2011, agriculture at 2.9 per cent, and the service sector at 9.0 per cent. The whole gross regional product is expected to grow at 9.0 per cent per annum. Based on these growth rates and an energy demand elasticity of 1.1, the Study Team projects that energy demand will increase by 10 per cent per annum, which is close to PEA's demand forecast for the WSB.

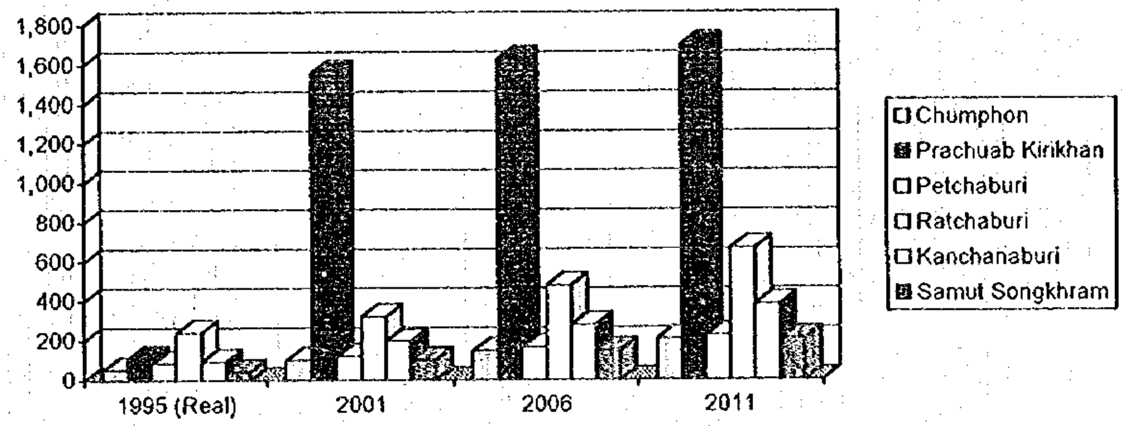
The following table presents PEA's load forecast for the WSB area. The forecast has taken into consideration the huge demand in the Bang Saphan area during the 8th and 9th plan period. (Refer to Table 9.3.5 and Table 9.3.6)

Load Forecast in the WSB Area

(Unit: MW)

Province	1995 (Real)	2001	2006	2011	Average Annual Growth by %
Chumphon	51.9	101.2	147.7	207.1	9%
Prachuap Khirikhan	107.7	1558.6	1628.8	1700.3	19%
Petchaburi	85.3	118.4	164.6	223.6	6%
Ratchaburi	239.7	319.8	476.6	667.0	7%
Kanchanaburi	90.1	195.0	276.3	382.6	9%
Samut Songkhram	39.6	100.8	146.6	206.9	11%
Total	614.3	2,393.8	3,840.6	3,387.5	11%

Source: PEA



According to statistics for 1995, 98.7 per cent of villages and 92.1 per cent of households in the WSB region have access to electricity. The comparable statistics for the whole Kingdom in 1995 were 98.2 per cent for villages and 92.8 per cent for households. (Refer to Table 9.3.7)

3.3.2 Power Generation in the WSB Area

There are several hydropower stations in the region: Khao Laem Dam (3 x 100 MW), Srinagarind Dam (3 x 120 MW and 2 x 180 MW), Tha Thung Na Dam (2 x 19 MW), and Kaeng Krachan Dam (1x 17.5).

EGAT is planning to build 3 x 600 MW combined cycle power units, and 4 x 700 MW thermal power units, in the 8th Five-Year plan period using imported natural gas from Myanmar. The four thermal power units will be gas/oil dual purpose units for power supply security reasons. For planning purposes, EGAT has tentatively decided to build, before 2011, the first five units of imported coal-fired thermal plants in Prachuap Khirikhan province. Based on this plan, EGAT will expand its electricity generation capacity in the WSB region with an addition of 4,600 MW between now and 2001, and by 4,800 MW between 2001 and 2011. PTT has signed a contract to import natural gas (525 MMCFD), through the pipeline presently under construction by PTT on Thailand side, from Myanmar for 30 years from 1998. An international consortium is building the gas pipeline on the Myanmar side, with construction scheduled to be completed in 1998. This amount of gas is sufficient for the new power units in Ratchaburi.

Presently, EGAT is negotiating with independent power producers (IPPs) to purchase power from a power plant possibly located in Ratchaburi (600-700 MW) and in Prachuap Khirikhan (1,400 MW or more).

In the long run, EGAT also plans to invite IPPs to build about 4,000 to 5,000 MW generation units (using either imported coal or natural gas) near the Bang Saphan area, where a private sector concern is constructing a large steel production complex and a deep-sea port. To transmit power along the WSB corridor, EGAT has planned a 500 kV line from Bang Saphan to the Bangkok Metropolitan Region. The 500 kV line project is expected to be completed by 2001. Thus, before that year, EGAT's grid only will have limited capacity to accept an additional 700 MW of capacity from IPPs in the WSB region. (Refer to Table 9.3.8)

Generation Capacity Increase in WSB

Project	Number of Units	Total Capacity	Commissioning Year
Combined Cycle	3 x 600	1,800 MW	1999
Thermal (oil & gas)	4 x 700	2,800 MW	2001
IPP (1)	1 x700	700 MW	2000
IPP(2)	2x700+2x350	2,100 MW	2001
New Thermal (coal)	2x1,000	2,000 MW	2006
Total		9,400	2006

Source: EGAT Power Development Plan (PDP-97-01)

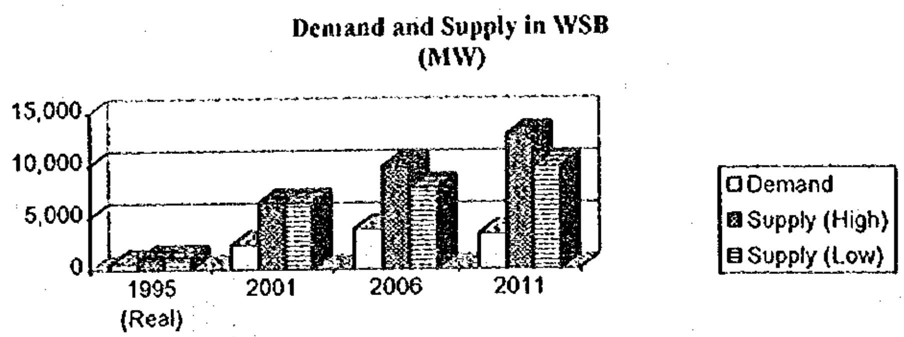
Electric power in the WSB region is interconnected to the national grid through 230 kV and/or 115 kV transmission lines. EGAT also has a plan to construct a 500 kV transmission line to integrate the IPPs in Ratchaburi and the IPPs in Prachuap Khirikhan by 2001. (Refer to Table 9.3.9)

3.3.3 Demand vs. Supply

The whole EGAT power grid is an integrated power system; any surplus or deficit in power supply and demand in the WSB region can be adjusted according to the balance of national and local power demand. But within the WSB region the generation capacity now stands at around 1036 MW. In the high-growth GRP scenario put forward in the Macroeconomic Development Scenarios of this Study, real GRP in the WSB will grow at an average annual rate of 10.7 per cent, up to the year 2011. According to the EGAT Power Development Plan (PDP-97-01), the total newly installed generation capacity in the Study Area will be 9,400 MW during the same period, implying an annual growth rate of about 16 per cent, meaning that the WSB region will export much more power by the end of the 10th Five-Year Plan. Assuming that some of the existing generation units will be retired or produce less power by then, one may assume a deduction of about 10 per cent from the planned capacity of 9,400 MW; but the reduction in energy intensity due to new technologies and demand side management is likely to compensate for this effect, considering that one study by an international organization found that DSM could save about 10 per cent of Thailand's electric power consumption.

Growth of Power and GRP

	1996	2011	Growth GRP & MW Rate	Growth GRP & MW Elasticity
High Power Growth	1,036 MW	12,736 MW	18%	1.68
Low Power Growth	1,036 MW	9,736 MW	16%	1.50
1988-1994 GDP				1.43*



3.4 Direction of Energy/Power Development in the WSB Region

3.4.1 Constraints and Potentials

The situation of energy and power in the WSB, as reviewed in the previous section, still presents some constraints on development. Major constraints are enumerated below.

(i) Low Power Consumption Rate: The per capita consumption of 840 kWh/person in the WSB was lower than the national average of 1,058 kWh/person in 1994. This low consumption level in the region reflected a low industrialization level. For reference, per capita GDP in the WSB area was 48,610 Baht, lower than the national average of 61,331 Baht. The intensity of energy consumption showed a similar pattern: 17,285 kWh per 1 million Baht of GDP for the WSB and 17,359 kWh for the whole Kingdom in 1994. Regional energy generation accounted for 2.8 per cent of the total national energy production in the same year while GDP in the WSB was a mere 3.9 per cent that of the Kingdom.

(ii) Unstable Power Supply: According to a survey in the WSB conducted by the Study Team, 36.8 per cent of the existing industrial enterprises complained that the quality of electricity supply was poor and there were too many brownouts and outages. Some large hotels complained that power shortages occurred during the hottest time of the year. The unstable power supply is mainly caused by the unique characteristics of the region. PEA uses bare wires for its transmission lines, stretching through forests and orchards. Lightening and tree overgrowth often disrupt the power supply, and salt erosion of the electric poles occurs throughout the region. PEA offices in the region have planned and budgeted for the gradual replacement of bare wires with partially insulated cable (PIC), and the installation of better insulation.

(iii) Lack of incentives to steer farmers away from wasteful energy consumption: Deforestation was identified in the Eighth National Economic and Social Development Plan as a major problem. During the first two years of the Seventh Plan, a forest area of about one million rai was exploited each year, while afforestation could cover only 160,000 rai. The WSB region faces the same problem. According to the RREC, the Western region covering several provinces in the Study Area consumes about 4-5 million m^3 of trees, half by rural households as fuelwood, and half by the ceramic and lime industries. About 70 per cent of the rural households use fuelwood or charcoal as fuel, feeding mainly inefficient, traditional cooking stoves. If the new energy-saving cooking stoves could be introduced to each household, the area could save about 40 per cent of its fuelwood requirement. The ceramic and lime industries, with adequate technical and financial support from the government, can also convert their kilns from consuming fuelwood to gas or lignite, although several issues should be addressed before this can happen: (i) tightening of law enforcement against illegal logging and the cutting of public trees; (ii) providing technical assistance and economic incentives for companies to retrofit their kilns; and (iii) making available an alternative energy source, namely domestic lignite, imported coal, and LPG at a reasonable price.

(iv) Environment: The environment could be an issue since some coal-fired power projects have been proposed in upper Prachuap Khirikhan province, an area known for its bird sanctuary, national park, and coastal amenity zone. An environmental economic cost analysis should be carried out to justify the location of the coal-fired power plants.

On the other hand, the WSB region has significant potential in the energy/power sector. This includes the following:

(i) Government and Private Sector Cooperation for regional economic development. Several industries are envisioned in the WSB area: the Bang Saphan steel complex and related industries, research and tourism centers in Petchaburi and part of Prachuap Khirikhan, a gas pipeline connecting to Myanmar and possible downstream gas industries in Ratchaburi, a new airport at Pathiu in Chumphon province, and several industrial estates. To meet the energy/power demand, a huge power plant using gas from Myanmar is under construction and a 500 Kv line connecting future IPPs is planned in the area. EGAT has also planned to build about 5,000 MW in the WSB region, leaving the area with surplus power to support other regions' economic development in the long run.

(ii) More IPPs. As Thailand starts to import natural gas from Myanmar and purchase power from the private sector, the WSB region, with its proximity to the load center, and its availability of a deep-sea port, plus the planned 500 kV line to be built to Bang Saphan, will attract more IPPs. Among the eight IPP proposals shortlisted for Stage One, Phase Two, five propose to build power plants in the WSB region, including four in Prachuap Khirikhan, where the WSB's deep-sea port is located.

(iii) Improving Transmission and Distribution System. EGAT has planned to build a two double-circuit 500 kV line to the Bang Saphan area reserving enough transmission capacity in the region for IPPs. PEA also plans to meet the huge increase in regional power demand by expanding substation and distribution capacity.

(iv) Improvement of Rural Energy Efficiency. There is easy-to-use technology in the region. According to the Ratchaburi Regional Energy Center, replacement of traditional cooking stoves in the region alone could save 0.7 MMCM of trees and save about 139 million Baht of government funds used to replant them each year, not to say the additional, but important benefits of providing biodiversity, saving farmers' labor time and cost, and reducing flood damage. By giving incentives and disincentives for more ceramic and lime factories to switch from charcoal and wood to LPG, LNG, and lignite, more trees can be saved to achieve one of the major targets in the Eighth-Five Year Plan.

(v) Subregional Cooperation in Diversification. With the government's interest in subregional cooperation, Thailand will start to import natural gas from Myanmar as early as 1998. With another deposit found in Myanmar (i.e., Yetagun), Thailand is expected to import more natural gas. Hydropower is another area for cooperation. Myanmar has plenty of hydro potential, with at least two points on the Tenasserim river possible hydropower station sites. This power could be sent to the Myanmar city of Tavoy (Dawei) and the Thailand border city of Soi Yok. In the Chumphon area, the Kra river, an international border river between Myanmar and Thailand, is another point of cooperation where Myanmar could export power to Thailand for badly needed hard currency.

(vi) The WSB's Deep-Sea Port Potential makes power plants fired by imported coal possible. With 4 million tons/year/coal handling capacity in Prachuap port at Bang Saphan, the new power plants in the region can use imported coal as fuel. The Bang Saphan Development Plan has already envisioned a coal handling berth of 4.4 million tons per year, which would be sufficient for coal-fired power plants in the medium term.

Further expansion may be needed if EGAT has finally decided to build all five thermal power plants (5x1,000 MW) it plans in the area.

3.4.2 Development Objectives and Strategies

In the 8th Plan, the Government of Thailand emphasizes the importance of cooperating with neighboring countries to invest in and develop energy sources abroad, promoting efficient and economic use of energy and conservation measures, and encouraging competition in energy production.

To reflect national policies in energy and power development in the WSB region, development objectives are proposed as the following 4 "Ss":

Support To support regional and national economic development through a proactive approach to energy supply and introduction of efficient and productive energy consumption in the WSB region.

Security To achieve power supply security and reduce environmental impact through diversifying the sources of supply and fuel types, exploiting the strategic location of the WSB as a corridor between North and South, as well as between East and West, and also to improve power supply reliability.

Sustainability To promote environment-friendly technology, especially in rural areas where farmers have to rely on primary energy supplies in their daily lives.

Subregional Cooperation To promote subregional cooperation to induce economic development in both Thailand and Myanmar, benefiting people on both sides of the border.

Development of the energy and power sector is proposed to be implemented in a strategic manner, as outlined below.

(i) Making optimum use of gas imports from Myanmar to meet the energy demand of the region and the country.

(ii) Soliciting power from IPPs and SPPs to encourage more efficient production of energy through introduction of competition in the power generation system.

(iii) Initiating a study of possible development of several subregional projects, development of hydropower projects in Myanmar and/or along the border, for the supply of power to load centers in Thailand.

(iv) Building natural gas-fired power plants and imported coal-fired power plants to achieve diversification in electricity generation. Given the region's deep-sea port potential (Bang Saphan) and the stable international price for coal, coal-fired thermal power plants might be seriously considered there.

(v) Promoting demand side management (DSM) for the new industries coming to the area since it is cheaper to adopt energy-saving standards from the beginning than to retrofit or revamp existing equipment.

(vi) Introducing good but affordable technologies in rural energy consumption to preserve the environment through dissemination of energy-saving cooking stoves to curtail the degradation of forest areas.

(vii) Initiating a study to find the best solution for alternative energy supply to the bulk energy consuming industries in the WSB such as lime and ceramic industries.

(viii) Tightening environmental monitoring and testing measures, establishing proper evaluation methods and procedures to evaluate the potential environmental cost of proposed power projects in the region.[1] If justifiable, encouraging power plants to use state-of-art technologies to mitigate the environmental impact in the region.

(ix) Improving stability and reliability in power supply through enhancement of regional transmission and distribution systems and replacement of bare wires with PIC.

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[1] A comparative economic cost study should be initiated to evaluate the cost-benefit of imported hydropower against an imported coal-fired power plant in Prachuap Khirikhan. According to a World Bank estimate, power generated by imported coal could cost US$0.056/kWh, while EGAT purchases power from Lao PDR at only US$0.043/kWh (1994 prices). Of course, EGAT will have to bear the cost of building a transmission line to the border.

3.5 Ongoing and Planned Projects

3.5.1 Ongoing Projects

Major ongoing projects in the energy/power sector in the WSB region are summarized as follows:

(i) Natural Gas Pipeline From the Border to Ratchaburi

A natural gas pipeline from the Thai-Myanmar border will be linked to a Ratchaburi Power Plant. PTT has signed a contract with Myanmar to import about 525 MMCFD of natural gas, at a border price of around US$3 per MMBTU. PTT is also responsible for the construction of the gas pipeline, which is expected to be completed by 1998 when the first of the plant's combined cycle generators starts to operate. The estimated investment cost is around 16.4 billion Baht, equivalent to US$656 million.

The natural gas will come from two offshore fields in Myanmar, Yadana (estimated deposit: 6-7 trillion cubic feet) and Yetagun (estimated deposit: 1.4 trillion cubic feet). EGAT is negotiating to import more gas for power generation. The surplus gas, if the price is reasonable and the quality is suitable, could also be utilized by downstream gas industries in the WSB region.

(ii) Oil Pipeline From the Gulf of Thailand to Ratchaburi

Oil will be provided to Ratchaburi Power Plant as a back-up source. However, three of the four units are scheduled to use oil as the first 525 MMCFD of contracted natural gas is insufficient for all four thermal units. The estimated oil consumption is 126,027,000 MMBTU per year and the total investment cost of the 36 km pipeline is 5 billion Baht. The supply of oil may leave some surplus natural gas for other purposes. The total estimated cost of this project is US$200 million.

(iii) Power Plant in Ratchaburi

EGAT's power plant in Ratchaburi is composed of three units of combined cycle generators (3x600 MW) and four units of oil/gas dual-purpose thermal generators (4x700). The total capacity, upon completion in 2001, will be 4,600 MW with full energy generation at about 4900 GWh, 23 per cent of the estimated total national electricity supply in that year. The power plant, along with the possible contracting of an IPP (700 MW), would provide Ratchaburi with the status of an important energy center in the nation. It will certainly have positive impact on local economic development.

When the scheduled 500 kV line to Bang Saphan is completed in 2001, EGAT will be able to receive and transmit, if necessary, power in large amounts between Ratchaburi and the Bang Saphan area to support the rapid industrialization of the WSB region. The total estimated cost of this project is US$4,840 million.

(iv) *IPP Stage One in the WSB*

For Stage One, Phase One, three proposals have been shortlisted to build a 326 to 600 MW natural gas-fired power plant in Ratchaburi, to be commissioned in the year 2000. In the Stage One, Phase Two IPP program, EGAT has so far shortlisted eight groups as candidates for the supply of 2,800 MW between 2001 and 2003. Five groups have proposed to build power plants in the WSB, three among them proposing coal-fired power units, one proposing use of orlimulsion, and the other the use of natural gas Two of the proposers, Union Energy and Gulf Electric Co, ranked number one and two on the shortlist, propose imported coal as fuel in conformity with EGAT's intention to diversify primary energy supply and take advantage of the stable international coal price. Also considering the advantage of the region in having the potential for a significant deep-sea port, the probability is reasonably high that EGAT will select at least one of these two proposals for development. The total estimated generation capacity would be as follows: natural gas-fired, 1x600 MW, coal-fired, 2x700. The total estimated investment cost would be US$367.1 million for the natural gas-fired development and US$1,330 million for gas-fired development.

The concentration of coal-fired power units would bring about economies of scale in terms of coal port facilities and the process center and water supply. The down side, though, is the possible environmental impact. In this respect, it is important to conduct an economic analysis to compare advantages and disadvantages between imported coal-fired power plants and possible hydropower imports from Myanmar.

3.5.2 Proposed Intraregional Projects

Several projects and programs are proposed for implementation within the WSB region, including:

(i) Cooking Stove Dissemination

Around 60-70 per cent of the 750,468 households in the WSB area use old stoves that could be replaced by new energy saving stoves, consuming less than 40 per cent of energy per unit; the benefit in terms of trees that the Royal Forestry Department would avoid planting because of the conversion to the new stove would amount to 139 million Baht for the 0.7 MMCM, a figure provided by the Ratchaburi Regional Energy Center. Based on a preliminary calculation, the benefit of providing new stoves at the same price to farmers with the government picking up the cost to cover the price difference between the old and new far exceeds the cost of the status quo. (Refer to Table 9.3.10)

The energy cooking stoves were developed under assistance from the United States Agency for International Development (USAID) about ten years ago but their dissemination has been slow, with only around 3 per cent of the potential beneficiaries now using them. Two actions are required for wider dissemination: stronger government commitment and support, and participation by NGOs. Government support is needed to at least subsidize some part of the cost of converting old stoves to the new ones, but NGOs may prove vital to farmers' acceptance of the new stoves. In the past, it was mainly government officials who drove around and showed farmers the new stoves. Because government officials have other priorities and their time is severely constrained, it is very hard for them to pursue the project in a persistent manner. Since NGOs have long worked with farmers and have established a trusting relationship with them, it is much easier for them to introduce the energy saving cooking stoves.

(ii) Study of Alternative Energy for the Lime and Ceramic Industries

In the WSB region, especially in Ratchaburi, the ceramic industry is important consuming 30 per cent of the fuelwood in the region while the lime industry consumes about 20 per cent, with the remaining 50 per cent consumed by households. Lime is used by sugar factories, shrimp farming, and the construction industry. About 50 per cent of lime factories have now converted from using fuelwood to lignite from the North, while the remaining factories continue to use wood or charcoal as fuel, legally, and in many cases, illegally. Almost all ceramic factories use charcoal or wood as fuel. Each year, a large quantity of trees is cut for fuel purposes. Although the government bans the cutting of trees on public land, it lacks resources and manpower to enforce the law. Also, because the trees are free and an alternative energy source (lignite transportation could be a problem) is not readily available, it is cheaper for local businessmen to give bribes than to convert their kilns to use lignite or gas.

The project will initiate a study to evaluate alternative affordable sources of fuel, lignite, imported lignite or coal, piped natural gas, or LPG, among others. By the end of the project, an affordable alternative energy source including transportation availability will be decided, and relevant government actions will be recommended.

(iii) Demand Side Management

Demand side management is an integral part of power development. EGAT's Demand Side Management Office has planned a pilot program to help four large manufacturers in Bangkok to improve their energy consumption process. As more and more new industries will be moving to the WSB region and as it is cheaper, for EGAT as well as for business owners, to install energy-efficient equipment for the new factories and buildings than to retrofit the old ones, the Study Team recommends that a DSM project be initiated in the WSB region. New large investors, in Bang Saphan or other industrial estates, should be informed of the DSM program when they apply for power connections, and one factory should be selected among the interested group to start a similar DSM project.

(iv) Replacement of Bare Wires with PICs

As noted before, the unstable power supply in the WSB region is caused by the special characteristics of the region. PEA uses bare wires for transmission lines, passing through orchards. It is very difficult to trim the fruit trees, and the overgrowth of tree branches sometimes cuts off the transmission lines, causing power supply disruptions. PEA intends to gradually replace bare wires with partially insulated cables (PICs). The estimated cost will be further studied.

(v) Installation of New Transmission Lines and Substations

Both EGAT and PEA have plans to build new transmission lines and substations to match the ever-increasing demand for power generation. Most significantly, EGAT plans to build a 500 kV line to connect the BMR with the Bang Saphan area to receive IPP power supply. PEA also has a plan to expand its transmission and distribution capacity in the region.

3.5.3 Proposed Subregional Projects

<u>Kra Buri River Hydropower Project</u>

1.	Project Title:	Kra River Hydropower Project
2.	Location:	Ranong province
3.	Beneficiary:	Chumphon
4.	Implementation:	EGAT
5.	Objectives:	Electricity generation with 130 MW installed capacity and 210 GWh annual energy generation.
6.	Expected effects:	To ensure a reliable supply of electricity to Chumphon area to support regional economic development.

7. Implementation Schedule: Commissioning in 2002

8. Project Description:

A possible location is in Ranong province on the Kra Buri river, an international river and border line between Myanmar and Thailand. Power generation capacity is estimated at 2x65 MW. EGAT undertook a pre-feasibility study in 1990 and is seeking financial support for feasibility study. Further geological, construction material investigation and topographic, environmental and ecological investigations should be undertaken for the final recommendation.

Reference on Subregional Cooperation

Tenasserim Hydropower Project

1.	Project Title:	Tenasserim River Hydropower Project
2.	Location:	Myanmar
3.	Beneficiary	Prachuap Khirikhan and the WSB
4.	Objectives:	Electricity generation with a possible 700 MW of installed capacity
5.	Expected Effects	To ensure a reliable supply of electricity to the WSB area to support regional economic development.

6. Project Description

Tenasserim River runs on the Myanmar side of the border, parallel to the WSB region. Downstream Tenasserim river near Tenasserim town has a catchment area of 16,000 km^2. A promising reservoir site is found about 190 km from the estuary, with a catchment area of 9,870 km^2. The potential generation capacity is estimated at 700 MW. A pre-feasibility study will be required at the promising reservoir site.

Table 9.3.1 Total Primary Energy Supply by Sources

unit : kt(
%

SOURCES	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Modern energy	**16,173**	**16,862**	**19,505**	**21,816**	**25,726**	**30,340**	**33,075**	**36,254**	**40,885**	**45,691**
	60.1	**59.3**	**61.5**	**63.1**	**64.3**	**67.2**	**68.4**	**69.0**	**69.8**	**70.2**
Anthracite	6	3	2	5	5	10	14	14	16	6
	–	–	–	–	–	–	–	–	–	–
Coke	56	26	38	50	55	60	56	48	54	72
	0.2	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1
Other Coal 1/	151	112	156	185	240	148	261	293	602	884
	0.6	0.4	0.5	0.5	0.6	0.4	0.6	0.5	1.0	1.4
Lignite	1,376	1,486	1,898	2,031	2,463	3,575	4,135	4,439	4,706	5,158
	5.1	5.2	6.0	5.9	6.2	7.9	8.5	8.4	8.1	7.9
Petroleum	11,384	11,641	13,339	14,285	16,443	17,761	19,436	22,933	26,489	30,190
	42.3	41.0	42.0	41.3	41.1	39.3	40.2	43.7	45.2	46.4
Petroleum Produc	2,322	2,301	3,135	4,388	5,233	7,630	8,110	7,550	8,147	8,311
	8.6	8.1	10.0	12.7	13.1	16.9	16.8	14.4	13.9	12.8
Electricity	878	1,293	937	872	1,287	1,156	1,063	977	871	1,070
	3.3	4.5	2.9	2.5	3.2	2.6	2.2	1.9	1.5	1.6
Renewable Energy	**10,726**	**11,571**	**12,201**	**12,776**	**14,284**	**14,782**	**15,286**	**16,281**	**17,731**	**19,378**
	39.9	***40.7***	***38.5***	***36.9***	***35.7***	***32.8***	***31.6***	***31.0***	***30.2***	***29.8***
Fuel Wood	8,446	9,422	10,217	10,868	11,664	12,437	12,863	13,814	15,181	16,228
	31.4	33.2	32.2	31.4	29.2	27.6	26.6	26.3	25.9	25.0
Paddy Husk	1,061	919	760	624	731	630	455	607	571	483
	4.0	3.2	2.4	1.8	1.8	1.4	1.0	1.2	1.0	0.7
Bagasse	1,219	1,320	1,224	1,284	1,889	1,715	1,968	1,860	1,979	2,667
	4.5	4.3	3.9	3.7	4.7	3.8	4.0	3.5	3.3	4.1
Total	**26,899**	**28,433**	**31,706**	**34,592**	**40,010**	**45,122**	**48,361**	**52,535**	**58,616**	**65,069**
	100.0	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Note : 1/ Included bituminous, briquettes and others.

Table 9.3.2 Demand/Supply of Natural Gas

UNIT : MMCFD

	1993	1998	2003
DEMAND	911	1,733	2,943
EGAT	716	1,224	1,918
INDUSTRY	56	320	836
FEEDSTOCKS	139	189	189
SUPPLY	911	1,733	2,943
UNOCAL	765	925	1,100
BONGKOT	39	500	500
ESSO	56	65	65
THAI STEEL	51	60	60
JDA			150
IMPORT		183	1,068

Source : PTT, Facts and Figures, 1994

Table 9.3.3 TOTAL EGAT GENERATION REQUIREMENT
(1995 TLFS FORECAST : HIGH CASE)

Fiscal Year	Peak Generation			Energy Generation			Load Factor
		Increase			Increase		
	MW	MW	%	GWh	GWh	%	%
				Actual			
1985	3,878.40	331.10	9.33	23,36.57	2,290.13	10.87	68.75
1986	4,180.90	302.50	7.80	24,779.53	1,422.96	6.09	67.66
1987	4,733.90	533.00	13.23	28,193.16	3,413.63	13.78	67.99
1988	5,444.00	710.10	15.00	31,996.94	3,803.78	13.49	67.09
1989	6,232.70	788.70	14.49	36,457.09	4.460.16	13.94	66.77
1990	7,093.70	861.00	13.81	43,188.79	6,731.69	18.46	69.50
1991	8,045.00	951.30	13.41	49,225.03	6,036.25	13.98	69.85
1992	8,876.90	831.90	10.34	56,006.44	6,781.41	13.78	72.02
1993	9,730.00	853.10	9.61	62,179.73	6,173.29	11.02	72.95
1994	10,708.80	978.80	10.06	69,651.14	7,471.41	12.02	74.25
1995	12,267.90	1,559.10	14.56	78,880.37	9,229.23	13.25	73.40
1996	13,310.90	1,043.00	8.50	85,924.13	7,043.77	8.93	73.69
Average Growth							
1987-1996	_	913.00	12.28	_	6,114.46	13.24	_
				Forecast			
1997	14,904.00	1,593.10	11.97	97,716.00	11,791.87	13.72	74.84
1998	16,445.00	1,541.00	10.34	108,234.00	10,518.00	10.76	75.13
1999	18,010.00	1,565.00	9.52	118,797.00	10,563.00	9.76	75.30
2000	19,658.00	1,648.00	9.15	129,601.00	10,804.00	9.09	75.26
2001	21,423.00	1,765.00	8.98	141,598.00	11,997.00	9.26	75.50
2002	23,131.00	1,708.00	7.97	153,141.00	11,543.00	8.15	75.58
2003	24,848.00	1,717.00	7.42	165,460.00	12,319.00	8.04	76.01
2004	26,645.00	1,797.00	7.23	179,206.00	13,746.00	8.31	76.78
2005	28,518.00	1,873.00	7.03	193,097.00	13,891.00	7.75	77.30
2006	30,464.00	1,946.00	6.82	206,566.00	13,469.00	6.98	77.40
2007	32,536.00	2,072.00	6.80	221,170.00	14,604.00	7.07	77.60
2008	34,692.00	2,156.00	6.63	236,964.00	15,794.00	7.14	77.97
2009	36,914.00	2,222.00	6.40	251,909.00	14,945.00	6.31	77.90
2010	39,247.00	2,333.00	6.32	267,557.00	15,648.00	6.21	77.82
2011	41,683.00	2,436.00	6.21	283,858.00	16,301.00	6.09	77.74
Average Growth							
1982-1986	_	318.44	10.06	_	1,763.91	9.20	_
1987-1991	_	772.82	13.99	_	4,889.10	14.71	_
1992-1996	_	1,053.18	10.60	_	7,339.82	11.79	_
1997-2001	_	1,622.42	9.99	_	11,134.77	10.51	_
2002-2006	_	1,808.20	7.30	_	12,993.60	7.85	_
2007-2011	_	2,243.80	6.47	_	15,458.40	6.56	_

Thailand Load Forecast Subcommittee, October 1996

Table 9.3.4 Demand Savings

(Cumulative Peak MW)

Programs	1993	1994	1995	1996	1997
Residential Sector					
Refrigerator	0	0.25	2	12	27
Air-conditioning	0	2	4	8	22
Lighting System	10	30.5	76	122	145
Res. Sub + Total	10	32.75	82	142	194
Commercial Sector					
Lighting Retrofit	2	15.25	30.5	45.75	61
New commercial & Government	1.5	4.5	9	15	20
Com. Sub + Total	3.5	19.75	39.5	60.75	81
Industrial Sector					
Motor and Invertes	0.6	1.4	9.5	15	30
Lighting System	0.2	0.6	1.5	3	6
Ind. Sub + Total	0.8	2	11	18	36
Totals	**14.3**	**54.5**	**132.5**	**220.75**	**311**

(Cumulative Annual GWh)

Programs	1993	1994	1995	1996	1997
Residential Sector					
Refrigerator	0	2	15	80	186
Air-conditioning	0	10	20	40	117
Lighting System	50	153	380	610	797
Res. Sub + Total	50	165	415	730	1100
Commercial Sector					
Lighting Retrofit	10	76	153	229	328
New commercial & Government	10	30	60	105	140
Com. Sub + Total	20	106	213	334	466
Industrial Sector					
Motor and Invertes	4	10	70	110	225
Lighting System	1	3	8	15	33
Ind. Sub + Total	5	13	78	125	258
Totals	75	284	706	1189	1826

Table 9.3.5 Forecast of Electrical Demand for the WSB

DEMAND : MW (NON-COINCIDENT)

Province	Actual	Forecast															
	2538	2539	2540	2541	2542	2543	2544	2545	2546	2547	2548	2549	2550	2551	2552	2553	2554
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Knachanaburi	90.1	104.0	140.1	154.1	167.2	180.8	195.0	209.8	225.3	241.5	258.4	276.3	295.2	315.2	336.3	358.7	382.6
Ratchaburi	239.7	275.2	239.6	241.3	266.6	292.7	319.8	347.7	378.0	409.4	442.0	476.6	510.4	546.7	584.8	625.1	667.0
S. Songkhram	39.6	44.8	50.3	76.8	84.7	92.6	100.8	109.2	117.9	127.0	136.5	146.6	157.2	168.5	180.5	193.3	206.9
Petchburi	85.3	80.0	87.1	94.5	102.2	110.1	118.4	126.9	135.8	145.0	154.6	164.6	175.1	186.2	198.0	210.4	223.6
P.Khiri Khan	107.0	146.4	177.3	218.6	750.2	1,094.2	1,558.6	1,583.5	1,593.8	1,604.7	1,616.1	1,628.2	1,641.0	1,654.5	1,668.9	1,684.2	1,700.3
Chumphon	51.9	59.6	67.5	75.6	83.9	92.5	101.2	110.1	119.0	128.2	137.7	147.7	158.3	169.4	181.2	193.8	207.1
Total	613.6	710.0	761.9	860.9	1,454.8	1,862.9	2,393.8	2,487.2	2,569.8	2,655.8	2,745.3	2,840.0	2,937.2	3,040.5	3,149.7	3,265.5	3,387.5

Table 9.3.6 PEA's Power System in Western Seaboard Areas

NO.	PROVINCE	<--- 7th Plan --->		<--- 8th Plan --->		<--- 9th Plan --->	
		2535	2539	2540	2544	2545	2549
1	Kanchanaburi	67.09	122.59	140.12	195.05	209.85	276.300
2	Ratchaburi	188.36	265.85	248.15	527.32	573.25	759.42
3	Samut Songkhram	24.52	44.83	50.29	68.67	74.31	99.04
4	Petchaburi	63.92	79.95	108.03	148.62	159.74	208.71
5	Prachuap Khirikha	44.92	164.07	187.54	1,572.67	1,598.59	1,648.17
6	Chumporn	37.12	59.58	67.47	121.46	132.06	177.30
Total		425.93	736.87	801.600	2,633.79	2,747.80	3,168.94
Average Growth (%)			14.69		29.01		3.77

Table 9.3.7 Number of Electrified Villages

	FY 1980	FY 1980	FY 1981	FY 1982	FY 1983	FY 1984	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	FY 1991	FY 1992	FY 1993
Total Number of Villages	51,221	51,733	52,250	54,492	55,309	56,139	56,981	57,391	58,252	59,126	60,222	61205	62262	63273
Villages Electrified in the FY		5,155	4,457	3,786	2,120	3,876	4,096	5,810	2,165	3,515	3,405	2,193	2,674	1,029
Number of Villages electrified	17,466	22,621	27,078	30,864	32,984	36,860	40,956	46,766	48,931	52,446	555,851	58,044	60,718	61,747
% of Electrification	34.10%	43.70%	51.80%	56.60%	59.60%	65.70%	71.90%	81.50%	84.00%	88.70%	92.70%	94.80%	97.50%	97.60%

Source: Asian Development Bank Electric Utility Data Book for the Asian and Pacific Region, 1993 and PEA Annual Report 1980 to 1993

Table 9.3.8 Planned Hydro Power Plant Projects

Project	Basin	Province	Installed Capacity (MW)	Generating Energy (GWh/Yr)	Running Energy (GWh/Yr)
1. Vajiralongkorn	Mae Nam Mae Klong	Kanchanaburi	430	380	540
2. Kang Krachan	Mae Nam Phetchburi	Petchburi	800	700	1,000
3. Pranburi No.1	West Coast Gulf	Prachuap Khirikhan	1,500	1,300	1,900
4. Pranburi No.2	West Coast Gulf	Prachuap Khirikhan	470	414	590
5. Khao Laem Yai	Mae Nam Mae Klong	Kanchanaburi	180	160	230
Total			3,380	2,954	4,260

Source : Potential of Southwest Pumped Storage Project
Water Resiurces Planning and Development Division
Hydro Power Engineering Department
1988/1/7

Table 9.3.9 PEA's Power System in Western Seaboard Areas

As of February, 1996

No.	Description	Provinces						Total
		Kanchanaburi	Ratchaburi	Petchaburi	P. Khirikhan	S. Songkhram	Chumphon	
1	Length of transmission Lines (circuit-km)	272.1	200.65	193.00	73.0	–	85.0	823.75
2	Substations - Number (Set - Size of transfor (MVA)	 8 7*50 1*25	 8 8*50	 6 4*50 2*25	 5 4*50 1*25	 0.00 0.00	 3 – 3*25	 30 23*50 7*25
3	Length of distribution system (circuit-km)	4,624	4,420	2,115	3,181	590	3,191	18,122
4	Peak Load Deman (megawatt)	82.8	208.7	760.0	128.6	30.0	47.0	573.1

Table 9.3.10 Cost and Benefit of Distributing the Energy Saving Cooking Stove With Government Covering the Difference Between Old and New (The Whole WSB)

Million Baht

Year	Cost with Project			Cost without Project					Net Benefits
	Cost of Subsidies	Operating Cost	Cost of Using New Stove	Replant Cost	Farmer Labor Cost	lood Damag Cost	Env. Cost	ost of Usin Old Stove	
1998	34.15	3.41	37.56	0.00	0	0		0.00	-37.56
1999	0.00	0.00	0.00	140	14	7		161	161.00
2000	34.15	3.41	37.56	140	14	7		161	123.44
2001	0.00	0.00	0.00	140	14	7		161	161.00
Sub-total	68.29	6.83	75.12	420.00	42.00	21.00	0.00	483.00	407.88

No. of Household	750468
Estimated cooking stove at 65%	487804.2
Difference between old and new, Baht/Unit	70
Operation cost as % of the total	10%
Trees saved MMCM	0.70
Tree replant cost MillionBaht/MMCM	200
Farmer labor saved in picking wood as % of total tree value	10%
Flood damage reduced in value as % of total tree value	5%
Net present value of total cost using new stove, Million Bahts	60.27
Net present value of total cost using old stove, Million Bahts	345.26
NPV of avoided cost of using new stoves to the economy, Million Bahts	284.99
Economic Internal Rate of Return	410%
Discount rate	12%

Data to be further sought:

Labor cost for picking up wood Baht/cm or Baht/kg

Environment cost:

1) Health cost reduced by living near the trees the insurance cost of longevity in Thailand and US (mixed) or lodd of productivity due to sick related to the loss of trees

2) Real estate price of wooded area vs. non-wooded area in same district

3) Extra cost to prevent soil erosion

Energy system in WSB