(3) Nonthaburi (NB) Aquifer (Figure 4.2.3)

By plotting on the diamond-shape diagram, the samples can broadly be divided into two (2) groups: one is plotted on the upper-right part and the other is plotted on the lower-right part of the diagram. The two (2) groups differ in the anion compositions. The samples belonging to the former group are chloride-rich whereas the samples of the latter group are bicarbonate-rich.

4.2.2 Stiff Diagram Analysis

The Stiff diagrams having four (4) axes in both cations and anions were prepared for the three (3) aquifers. Each diagram was plotted at the location of the monitoring well.

(1) Phra Pradaeng (PD) Aquifer (Figure 4.2.4)

The samples having high ion contents show chloride as dominant in the anion composition. But the cation compositions of those samples can be classified into two (2) groups: one is characterized by the dominance of (Na+K) and the other is characterized by an almost equal content of (Na+K) and (Ca). The former group is in Samut Prakan and western Bangkok, while the latter group is in northern Bangkok, Pathum Thani, and Nonthaburi.

(2) Nakhon Luang (NL) Aquifer (Figure 4.2.5)

The samples having high ion contents are distributed along the shoreline in Samut Prakan, western Bangkok, and along the Chao Phraya River in Nonthaburi and Pathum Thani. The samples taken from the coastal area are characterized by high content of chloride and (Na+K). The saline water may have originated from sea water. However, the samples taken inland are characterized by high calcium as well as (Na+K) contents in cations. This result indicates that the source of saline water inland may be different from that in the coastal area.

(3) Nonthaburi (NB) Aquifer (Figure 4.2.6)

The samples having high ion contents are distributed in Samut Prakan, western Bangkok, Samut Sakhon, and northern Bangkok to Pathum Thani. The samples taken from the southern part of the Study Area are rich in chloride and (Na+K). However, the samples taken inland are characterized by a high calcium content in cations, which is similar to NL Aquifer.

4.3 Chloride Concentration

Maps of chloride concentration were prepared for the three (3) aquifers. The lines of equal concentration were obtained by the Kriging method.

(1) Phra Pradaeng (PD) Aquifer (Figure 4.3.1)

The high chloride concentration lies from Samut Sakhon to Pathum Thani along the Chao Phraya River and extends to northern Bangkok. High concentration area is also found in Samut Prakan. The concentration partly exceeds 5,000 mg/L in those areas.

(2) Nakhon Luang (NL) Aquifer (Figure 4.3.2)

Two (2) major areas of high chloride concentration can be found in the map: the coastal area from Samut Prakan to Samut Sakhon showing 3,000 to 16,000 mg/L and along the Chao Phraya River showing 2,000 to 6,000 mg/L.

(3) Nonthaburi (NB) Aquifer (Figure 4.3.3)

From the mouth of the Chao Phraya River to Samut Sakhon shows high chloride concentration ranging from 2,400 to 13,000 mg/L. High concentration is also found in eastern Samut Prakan. However, a small chloride concentration below 1,000 mg/L is found in the coastal area of central Samut Prakan. An isolated high chloride concentration which ranges from 1,000 to 5,700 mg/L is found inland from Pathum Thani to northern Bangkok.

(4) Effects of Sampling Method

Though submersible pump was used to remove stagnant water from the monitoring wells prior to the sampling, the results show that most chloride concentration values are similar to the past values obtained by the DMR (1992). The changes in electric conductivity during pumping are also small in most cases.

Table 4.2.1 RESULTS OF CHEMICAL ANAYSES OF GROUNDWATER SAMPLES TAKEN BY SUBMERSIBLE PUMP (1/7)

ST. NO.	WELL NO	pH	E.C. (uS/cm)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	Fe (mg/L)	Mn (mg/L)	Cl (mg/L)	SO4 (mg/L)	HCO3 (mg/L)	NO2 (mg/L)	NO3 (mg/L)	Br (mg/L)	I (mg/L)	DATE OF SAMPLING	DATE OF ANALYSIS
1	PD08	4.4	12300	1020.0	290.0	1070.0	17.0	30.00	1.90	4310.0	35.0	6.0	0.01	0.0	6.30	0.02	08-Nov-93	16-Dec-93
1	NL62	9.3	767	6.7	7.7	170.0	2.3	0.18	0.02	76.0	2.0	159.0	0.00	0.0	0.54	0.04	08-Nov-93	24-Nov-93
1	NB05	7.4	4750	320.0	110.0	460.0	6.3	6.80	2.40	1440.0	45.0	253.0	0.01	0.0	4.00	0.23	08-Nov-93	16-Dec-93
2	PD05	7.4	2860	230.0	69.0	220.0	9.4	12.00	2.30	770.0	7.0	299.0	0.02	0.4	1.20	0.12	10-Nov-93	16-Dec-93
2	NL11	7.1	11100	970.0	220.0	980.0	16.0	21.00	11.00	3780.0	84.0	274.0	0.01	0.0	8.40	0.63	10-Nov-93	16-Dec-93
2	NB08	7.6	3570	240.0	77.0	350.0	7.0	4.20	3.00	1050.0	4.0	247.0	0.00	0.0	2.30	0.16	10-Nov-93	16-Dec-93
3	PD38	8.1	1920	30.0	23.0	230.0	1.6	0.38	0.16	190.0	67.0	406.0	0.01	0.9	1.10	0.12	17-Sep-93	25-Nov-93
3	NL03	8.1	869	21.0	3.1	180.0	2.0	3.00	0.21	30.0	65.0	443.0	0.01	0.8	0.83	0.08	17-Sep-93	16-Dec-93
4	PD07	8.4	1300	47.0	47.0	140.0	9.8	0.42	0.05	390.0	1.0	16.0	0.00	0.0	0.00	0.03	07-Nov-93	24-Nov-93
5	PD55	6.6	24300	900.0	690.0	4100.0	70.0	33.00	8.60	9200.0	430.0	301.0	0.04	0.0	17.00	0.92	10-Nov-93	13-Nov-93
5	NL05	7.4	11300	810.0	290.0	1100.0	35.0	61.00	1.30	3600.0	350.0	367.0	0.01	8.3	5.30	0.28	10-Sep-93	17-Nov-93
5	NB04	7.9	2040	86.0	58.0	240.0	5.5	0.13	0.18	640.0	4.0	53.0	0.03	0.1	0.56	0.04	10-Nov-93	13-Nov-93
6	PD03	7.4	14800	590.0	480.0	1800.0	36.0	23.00	3.40	5300.0	75.0	85.0	0.02	0.3	13.00	0.08	16-Sep-93	25-Nov-93
7	PD06	6.8	13600	480.0	300.0	1900.0	33.0	29.00	4.90	4600.0	70.0	155.0	0.01	0.1	10.00	0.80	27-Sep-93	17-Nov-93
7	NB01	8.0	1150	22.0	11.0	230.0	2.7	0.26	0.27	120.0	72.0	400.0	0.02	0.1	0.91	0.35	27-Sep-93	17-Nov-93
8	PD02	7.7	2610	91.0	47.0	400.0	4.7	0.14	0.69	690.0	56.0	261.0	1.30	0.0	2.70	0.03	08-Nov-93	13-Nov-93
8	NL55	7.1	34000	530.0	530.0	6400.0	130.0	77.00	2.20	13000.0	1200.0	405.0	0.03	0.0	46.00	0.67	08-Nov-93	13-Nov-93
8	NB49	8.5	1310	13.0	26.0	250.0	5.1	0.05	0.07	240.0	51.0	258.0	0.02	0.1	1.30	0.06	08-Nov-93	13-Nov-93
9	PD04	7.9	1390	31.0	57.0	170.0	10.0	2.30	0.03	280.0	2.0	354.0	1.90	1.1	0.00	0.04	30-Sep-93	25-Nov-93
10	PD01	7.6	8980	63.0	170.0	1400.0	62.0	22.00	0.44	2700.0	350.0	157.0	0.01	2.6	3.40	0.03	07-Oct-93	17-Nov-93
10	NL67	6.6	21100	1700.0	330.0	2300.0	32.0	0.52	2.70	7700.0	220.0	12.0	0.02	0.1	20.00	0.21	07-Oct-93	17-Nov-93
10	NB53	6.4	35800	1400.0	630.0	5600.0	61.0	0.78	3.90	13000.0	560.0	14.0	0.01	0.1	44.00	0.20	07-Oct-93	17-Nov-93
11	NL04	6.9	10120	890.0	140.0	910.0	21.0	0.56	1.30	3400.0	25.0	11.0	0.02	0.1	5.90	0.12	07-Oct-93	17-Nov-93
12	PD39	8.1	780	12.0	2.3	170.0	2.0	0.02	0.07	29.0	47.0	402.0	0.03	0.0	0.63	0.04	11-Nov-93	13-Nov-93
12	NL50	8.1	819	14.0	4.8	180.0	1.2	0.00	0.09	47.0	33.0	416.0	0.34	0.0	1.00	0.04	11-Nov-93	13-Nov-93
12	NB41	9.2	638	1.6	4.4	150.0	4.3	0.00	0.00	38.0	12.0	251.0	0.04	0.1	0.70	0.04	11-Nov-93	13-Nov-93
12	NB10	7.9	1240	34.0	11.0	220.0	4.3	0.65	0.00	220.0	44.0	321.0	0.03	0.7	1.50	0.05	11-Nov-93	13-Nov-93
13	PD22	10.6	1420	2.4	1.9	280.0	4.3	0.05	0.03	380.0	4.0	0.0	0.04	0.0	0.44	0.03	11-Nov-93	13-Nov-93
13	NL10	7.4	5090	470.0	79.0	450.0	10.0	1.10	3.40	1700.0	97.0	157.0	0.04	4.9	4.80	0.05	12-Nov-93	13-Nov-93
13	NB30	9.4	3260	210.0	21.0	490.0	7.4	0.95	0.05	1200.0	3.0	9.0	0.03	0.0	3.50	0.06	11-Nov-93	13-Nov-93
14	PD78	7.1	24000	2000.0	440.0	2900.0	31.0	0.83	11.00	8800.0	730.0	153.0	0.04	7.0	24.00	0.05	10-Nov-93	13-Nov-93
14	NL01	8.2	42900	940.0	1100.0	8600.0	120.0	0.66	0.10	16000.0	2400.0	22.0	0.03	0.1	53.00	0.07	08-Nov-93	13-Nov-93
14	NB77	8.2	3640	27.0	70.0	640.0	37.0	0.02	0.17	1000.0	13.0	320.0	0.11	0.1	0.16	0.08	10-Nov-93	13-Nov-93
16	PD51	7.9	1820	50.0	29.0	330.0	1.6	0.15	0.12	180.0	340.0	376.0	0.00	0.0	1.60	0.29	23-Oct-93	24-Nov-93
16	NL07	9.6	1120	0.0	8.0	250.0	2.3	0.09	0.01	130.0	2.0	208.0	0.00	0.0	1.60	0.37	23-Oct-93	24-Nov-93
16	NB07	8.0	3190	67.0	75.0	530.0	2.7	0.22	0.50	900.0	65.0	213.0	0.00	0.0	3.40	0.29	23-Oct-93	24-Nov-93
17	PD28	6.3	3030	140.0	120.0	340.0	7.8	62.00	1.50	960.0	2.0	77.0	0.00	0.0	1.90	0.12	24-Oct-93	24-Nov-93
18	NL02	7.7	1150	57.0	20.0	180.0	1.6	0.38	0.49	190.0	34.0	369.0	0.17	0.9	0.93	0.03	13-Nov-93	13-Nov-93
19	PD42	8.2	1010	18.0	25.0	190.0	1.2	0.20	0.16	53.0	120.0	414.0	0.04	0.0	0.66	0.13	20-Oct-93	25-Nov-93
19	NL08	8.3	1030	13.0	18.0	200.0	1.6	0.22	0.04	150.0	6.0	365.0	0.10	0.0	0.49	0.11	20-Oct-93	25-Nov-93

Table 4.2.1 RESULTS OF CHEMICAL ANAYSES OF GROUNDWATER SAMPLES TAKEN BY SUBMERSIBLE PUMP (2/7)

ST. NO.	WELL NO.	pH	E.C. (uS/cm)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	Fe (mg/L)	Mn (mg/L)	Cl (mg/L)	SO4 (mg/L)	HCO3 (mg/L)	NO2 (mg/L)	NO3 (mg/L)	Br (mg/L)	I (mg/L)	DATE OF SAMPLING	DATE OF ANALYSIS
19	NB06	7.6	784	27.0	9.9	150.0	2.0	0.12	0.06	10.0	44.0	456.0	0.02	0.0	0.38	0.06	20-Oct-93	25-Nov-93
20	NL09	7.3	12700	720.0	320.0	1400.0	22.0	56.00	4.80	4100.0	340.0	182.0	0.02	0.1	8.20	0.27	15-Sep-93	17-Nov-93
20	NL09	7.4	12100	740.0	450.0	1400.0	25.0	121.00	5.00	4100.0	370.0	178.0	0.04	0.1	4.80	0.12	15-Nov-93	13-Nov-93
21	PD46	8.8	1470	34.0	31.0	220.0	12.0	0.35	0.01	450.0	2.0	23.0	0.00	0.0	1.50	0.03	20-Oct-93	24-Nov-93
21	NB02	7.1	10400	360.0	400.0	1400.0	47.0	18.00	0.55	3700.0	11.0	229.0	0.02	6.8	14.00	0.25	01-Oct-93	24-Nov-93
22	PD26	7.4	2000	150.0	94.0	160.0	7.8	0.82	1.60	510.0	2.0	312.0	0.02	0.0	0.79	0.12	05-Nov-93	24-Nov-93
22	NL06	7.3	746	28.0	26.0	71.0	27.0	0.38	0.12	74.0	180.0	64.0	0.03	0.0	0.00	0.00	05-Nov-93	24-Nov-93
22	NB36	8.2	652	9.0	19.0	130.0	2.7	0.17	0.04	48.0	60.0	253.0	0.02	0.2	0.88	0.06	05-Nov-93	24-Nov-93
24	PD62	6.6	23500	460.0	550.0	4400.0	110.0	27.00	1.30	8700.0	240.0	202.0	7.10	31.0	34.00	1.00	17-Nov-93	13-Nov-93
24	NL18	6.8	33600	870.0	1000.0	6000.0	100.0	0.63	0.95	12000.0	1000.0	17.0	7.30	29.0	45.00	0.18	17-Nov-93	13-Nov-93
24	NB66	6.2	34600	940.0	630.0	6800.0	130.0	1.80	2.40	13000.0	620.0	13.0	0.04	0.1	33.00	0.15	17-Nov-93	13-Nov-93
25	PD09	6.6	11900	1110.0	290.0	1070.0	22.0	24.00	16.00	4120.0	210.0	126.0	0.06	0.1	9.10	0.25	18-Oct-93	16-Dec-93
26	PD12	7.8	4260	210.0	120.0	460.0	12.0	5.50	1.60	1200.0	89.0	323.0	0.11	0.0	4.70	0.05	15-Sep-93	25-Nov-93
26	NL37	9.5	645	1.6	5.0	150.0	2.7	0.14	0.01	31.0	5.0	197.0	0.05	0.0	0.58	0.03	15-Sep-93	25-Nov-93
26	NB29	9.3	618	2.4	6.0	140.0	2.7	0.14	0.01	44.0	10.0	170.0	0.02	0.0	0.63	0.03	15-Sep-93	25-Nov-93
27	PD11	7.0	14200	950.0	580.0	1400.0	31.0	17.00	5.40	5000.0	340.0	175.0	5.30	0.0	11.00	0.15	13-Nov-93	13-Nov-93
27	NL43	9.1	1040	3.4	3.1	220.0	2.0	0.01	0.02	170.0	34.0	207.0	0.03	0.0	1.20	0.11	13-Nov-93	13-Nov-93
27	NB18	6.0	26800	1000.0	930.0	4100.0	55.0	64.00	10.00	10000.0	1200.0	85.0	1.00	0.0	18.00	0.26	13-Nov-93	13-Nov-93
28	NB16	7.2	15200	620.0	480.0	2200.0	35.0	62.00	0.81	5700.0	51.0	34.0	0.00	0.0	10.00	0.55	23-Oct-93	24-Nov-93
29	PD14	8.1	2500	62.0	45.0	400.0	3.5	0.20	0.39	620.0	55.0	343.0	0.01	0.0	1.90	0.20	24-Sep-93	25-Nov-93
29	NL81	10.2	1020	0.0	3.9	210.0	3.5	1.80	0.00	140.0	9.0	17.0	0.08	0.0	0.30	0.06	24-Sep-93	25-Nov-93
29	NB78	9.9	1090	0.0	9.7	230.0	3.5	0.40	0.00	150.0	3.0	113.0	0.03	0.0	0.32	0.11	24-Sep-93	25-Nov-93
30	PD15	6.9	4710	200.0	140.0	520.0	7.0	7.60	1.90	1500.0	75.0	16.0	0.01	0.0	1.50	0.22	26-Sep-93	25-Nov-93
30	NB83	9.9	1840	0.0	18.0	340.0	3.9	0.18	0.00	510.0	1.0	40.0	0.03	0.0	4.00	0.40	26-Sep-93	25-Nov-93
31	PD75	7.7	2490	71.0	55.0	400.0	7.4	0.32	0.59	460.0	240.0	421.0	0.02	1.1	1.90	0.03	21-Oct-93	25-Nov-93
31	NL13	9.6	888	5.0	3.8	170.0	3.1	0.19	0.01	190.0	3.0	91.0	0.01	0.0	1.00	0.56	02-Nov-93	16-Dec-93
31	NB75	10.0	367	3.2	2.3	67.0	3.1	2.80	0.00	59.0	11.0	19.0	0.03	0.0	0.03	0.14	21-Oct-93	25-Nov-93
32	PD13	3.6	20600	420.0	760.0	3200.0	70.0	130.00	4.40	7600.0	100.0	0.0	0.00	0.0	7.30	0.00	11-Nov-93	24-Nov-93
33	PD40	7.9	2480	95.0	67.0	310.0	5.9	0.26	1.30	620.0	44.0	322.0	0.02	0.0	0.75	0.14	26-Sep-93	25-Nov-93
33	NL16	7.9	792	19.0	12.0	160.0	1.6	0.08	0.14	11.0	40.0	439.0	0.00	0.0	0.63	0.05	08-Nov-93	24-Nov-93
33	NB46	9.1	1190	2.4	11.0	240.0	1.6	0.14	0.00	230.0	21.0	184.0	0.12	1.8	1.20	0.53	26-Sep-93	25-Nov-93
34	PD85	7.9	2660	69.0	48.0	460.0	1.2	0.44	0.00	470.0	310.0	433.0	0.06	0.0	1.30	0.04	25-Sep-93	25-Nov-93
34	NB82	8.0	171	9.0	6.9	16.0	10.0	1.30	0.00	13.0	7.0	78.0	0.05	3.5	0.10	0.00	25-Sep-93	25-Nov-93
35	PD68	7.1	3690	300.0	96.0	280.0	11.0	0.58	2.00	1000.0	24.0	302.0	0.01	0.0	3.40	0.05	21-Oct-93	25-Nov-93
35	NL12	7.0	6280	470.0	140.0	590.0	9.4	8.50	6.10	2000.0	120.0	253.0	0.01	0.0	5.90	0.07	21-Oct-93	25-Nov-93
35	NB69	10.4	620	0.8	0.4	120.0	6.3	0.14	0.00	110.0	1.0	0.0	0.04	0.0	0.34	0.06	21-Oct-93	25-Nov-93
36	PD72	7.8	1230	24.0	13.0	220.0	2.0	0.54	0.00	78.0	130.0	454.0	0.03	0.3	0.76	0.21	04-Oct-93	17-Nov-93
36	NL14	9.8	1480	1.9	0.4	310.0	3.5	0.18	0.00	230.0	2.0	250.0	0.02	0.2	2.20	0.61	04-Oct-93	17-Nov-93
36	NB73	9.4	367	2.9	0.4	69.0	3.9	0.42	0.01	44.0	3.0	103.0	0.01	0.1	0.73	0.45	04-Oct-93	17-Nov-93
37	PD67	7.6	4510	320.0	120.0	460.0	2.3	0.74	0.14	1200.0	220.0	426.0	0.04	0.0	4.90	0.07	26-Oct-93	25-Nov-93

Table 4.2.1 RESULTS OF CHEMICAL ANAYSES OF GROUNDWATER SAMPLES TAKEN BY SUBMERSIBLE PUMP (3/7)

ST. NO.	WELL NO.	pH	E.C. (uS/cm)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	Fe (mg/L)	Mn (mg/L)	Cl (mg/L)	SO4 (mg/L)	HCO3 (mg/L)	NO2 (mg/L)	NO3 (mg/L)	Br (mg/L)	I (mg/L)	DATE OF SAMPLING	DATE OF ANALYSIS
37	NL76	9.8	899	1.1	8.2	170.0	2.7	0.08	0.00	190.0	2.0	59.0	0.03	0.0	1.10	0.61	26-Oct-93	25-Nov-93
37	NB12	9.1	456	10.0	1.8	90.0	1.6	0.15	0.02	16.0	30.0	176.0	0.02	0.0	0.28	0.03	26-Oct-93	16-Dec-93
38	PD74	6.9	13000	920.0	170.0	1500.0	16.0	0.26	1.90	4500.0	170.0	14.0	0.01	0.1	11.00	0.27	06-Oct-93	17-Nov-93
38	NL78	7.3	4200	310.0	110.0	320.0	10.0	3.40	5.10	1200.0	67.0	256.0	0.01	0.1	2.10	0.06	06-Oct-93	17-Nov-93
38	NB13	7.0	6010	450.0	140.0	560.0	9.0	12.00	5.70	1900.0	120.0	243.0	0.10	0.0	5.30	0.74	06-Oct-93	25-Nov-93
39	PD59	6.0	18300	1900.0	450.0	1600.0	20.0	33.00	23.00	6500.0	260.0	71.0	0.04	0.1	16.00	0.55	09-Nov-93	13-Nov-93
39	NL71	9.8	830	53.0	2.2	87.0	5.9	0.13	0.01	240.0	6.0	12.0	0.03	0.1	1.10	0.02	09-Nov-93	13-Nov-93
39	NB15	7.5	5360	450.0	96.0	510.0	9.4	1.60	4.10	1700.0	81.0	240.0	0.04	0.0	4.50	0.04	09-Nov-93	13-Nov-93
40	PD47	7.1	19100	700.0	450.0	3000.0	55.0	15.00	2.20	6600.0	680.0	175.0	0.05	0.1	13.00	0.48	14-Nov-93	13-Nov-93
40	NL65	7.2	13300	800.0	280.0	1900.0	47.0	0.72	1.80	5200.0	98.0	24.0	0.05	0.1	11.00	0.27	14-Nov-93	13-Nov-93
40	NB14	8.6	6090	570.0	42.0	580.0	18.0	1.00	0.01	2100.0	3.0	10.0	0.05	0.1	0.44	0.07	14-Nov-93	13-Nov-93
41	NL47	7.8	512	15.0	15.0	60.0	6.6	0.03	0.03	48.0	41.0	134.0	0.00	0.0	0.26	0.01	11-Nov-93	24-Nov-93
41	NB17	7.3	340	6.1	9.7	48.0	7.8	0.06	0.02	73.0	1.0	62.0	0.02	12.0	0.05	0.00	27-Sep-93	25-Nov-93
42	NL17	7.4	1140	66.0	32.0	100.0	5.5	0.38	0.06	340.0	2.0	17.0	0.00	0.0	0.58	0.07	21-Oct-93	24-Nov-93
43	PD64	7.8	5080	140.0	120.0	850.0	2.7	0.28	0.01	1300.0	270.0	502.0	0.02	0.0	4.10	0.40	25-Sep-93	25-Nov-93
43	NL22	8.6	1260	2.4	11.0	270.0	0.0	0.42	0.00	210.0	2.0	343.0	0.04	0.0	1.40	0.74	25-Sep-93	25-Nov-93
44	PD53	7.6	1420	86.0	49.0	100.0	6.6	0.56	0.00	300.0	10.0	283.0	0.02	1.4	1.10	0.04	08-Oct-93	17-Nov-93
44	NL68	9.7	603	3.4	0.5	120.0	7.8	0.48	0.00	140.0	6.0	51.0	0.01	0.1	1.50	0.05	08-Oct-93	17-Nov-93
45	NL19	7.7	606	39.0	23.0	64.0	2.7	0.26	0.05	7.2	16.0	353.0	0.02	0.1	0.23	0.02	16-Oct-93	17-Nov-93
46	NL20	6.4	17600	730.0	340.0	2500.0	32.0	130.00	3.90	6200.0	61.0	26.0	0.01	0.1	16.00	1.20	10-Sep-93	17-Nov-93
47	NL25	7.5	3100	130.0	70.0	390.0	9.0	2.70	0.26	1000.0	7.0	29.0	0.00	0.0	1.60	0.14	07-Nov-93	24-Nov-93
48	PD52	7.4	5520	500.0	200.0	330.0	13.0	1.30	2.60	1800.0	180.0	256.0	0.11	0.1	5.20	0.06	18-Nov-93	13-Nov-93
48	NL24	7.1	8760	910.0	180.0	720.0	16.0	1.40	3.60	2900.0	23.0	239.0	0.15	0.0	9.30	0.12	18-Nov-93	13-Nov-93
48	NB60	7.6	2660	230.0	100.0	170.0	7.8	0.75	0.52	730.0	28.0	297.0	0.05	0.0	3.50	0.03	18-Nov-93	13-Nov-93
49	PD76	7.6	4140	260.0	66.0	440.0	4.3	0.69	0.53	1200.0	42.0	299.0	0.02	0.0	4.80	0.10	28-Oct-93	16-Dec-93
49	NL23	7.7	1080	56.0	17.0	170.0	2.3	16.00	1.00	26.0	190.0	419.0	0.05	0.5	0.24	0.09	28-Oct-93	16-Dec-93
50	NL21	8.2	1760	42.0	24.0	300.0	2.0	5.10	0.54	340.0	79.0	358.0	0.01	0.0	1.70	0.71	05-Oct-93	25-Nov-93
51	PD58	6.7	11900	820.0	450.0	1000.0	19.0	27.00	9.30	4000.0	260.0	181.0	0.06	0.0	11.00	0.29	19-Oct-93	25-Nov-93
51	NL72	10.4	733	25.0	1.9	110.0	3.9	0.12	0.02	200.0	3.0	5.0	0.04	0.0	0.59	0.03	19-Oct-93	25-Nov-93
51	NB19	10.7	431	0.8	1.2	80.0	3.9	0.20	0.00	48.0	1.0	0.0	0.03	0.0	0.04	0.02	19-Oct-93	25-Nov-93
52	NL26	9.4	5630	430.0	70.0	590.0	7.8	0.32	0.02	1900.0	2.0	19.0	0.03	0.0	6.30	0.15	22-Oct-93	25-Nov-93
52	NB21	8.6	5700	430.0	100.0	530.0	6.3	0.36	0.02	1900.0	2.0	13.0	0.04	0.0	7.40	0.15	22-Oct-93	25-Nov-93
53	PD16	7.6	1140	30.0	30.0	200.0	7.4	1.10	0.27	190.0	16.0	367.0	0.06	1.1	1.20	0.03	30-Sep-93	24-Nov-93
53	NL27	7.6	1160	17.0	14.0	230.0	5.1	0.14	0.02	270.0	2.0	196.0	0.00	0.0	1.30	0.01	30-Sep-93	24-Nov-93
53	NB31	7.9	7180	620.0	140.0	680.0	16.0	1.90	0.02	2400.0	42.0	19.0	0.09	0.0	5.30	0.08	30-Sep-93	24-Nov-93
54	NL28	7.8	592	5.8	6.9	130.0	5.9	0.13	0.06	41.0	2.0	306.0	0.00	0.0	0.82	0.02	30-Sep-93	24-Nov-93
55	PD24	7.5	654	33.0	23.0	85.0	5.9	0.77	0.27	15.0	4.0	402.0	0.03	0.0	0.72	0.02	20-Oct-93	24-Nov-93
55	NL29	8.0	1500	22.0	67.0	200.0	8.6	1.30	0.23	370.0	2.0	249.0	0.00	0.0	1.30	0.07	20-Oct-93	24-Nov-93
55	NB22	8.7	772	0.0	18.0	160.0	2.7	0.40	0.00	80.0	2.0	272.0	0.00	0.0	0.94	0.03	20-Oct-93	24-Nov-93
56	PD20	7.4	3070	180.0	71.0	320.0	11.0	2.30	0.53	920.0	15.0	103.0	0.00	0.0	3.30	0.06	07-Nov-93	24-Nov-93

Table 4.2.1 RESULTS OF CHEMICAL ANAYSES OF GROUNDWATER SAMPLES TAKEN BY SUBMERSIBLE PUMP (4/7)

ST. NO.	WELL NO.	pH	E.C. (uS/cm)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	Fe (mg/L)	Mn (mg/L)	Cl (mg/L)	SO4 (mg/L)	HCO3 (mg/L)	NO2 (mg/L)	NO3 (mg/L)	Br (mg/L)	I (mg/L)	DATE OF SAMPLING	DATE OF ANALYSIS
56	NL35	8.7	555	3.7	5.6	130.0	2.7	0.09	0.01	15.0	2.0	250.0	0.00	0.0	0.86	0.01	07-Nov-93	24-Nov-93
56	NB23	8.8	508	3.4	6.8	120.0	3.5	0.13	0.01	20.0	2.0	229.0	0.00	0.0	0.81	0.02	07-Nov-93	24-Nov-93
57	PD29	8.2	1960	110.0	20.0	230.0	13.0	0.64	0.02	600.0	3.0	17.0	0.00	0.0	2.00	0.03	21-Nov-93	16-Dec-93
57	NL30	8.0	1080	23.0	39.0	190.0	3.1	0.10	0.13	180.0	7.0	345.0	0.00	0.0	0.39	0.05	11-Nov-93	24-Nov-93
57	NB39	8.8	767	3.2	13.0	160.0	2.3	0.10	0.02	74.0	41.0	249.0	0.02	0.0	0.93	0.07	27-Sep-93	25-Nov-93
58	NL31	7.9	965	31.0	22.0	150.0	4.3	0.30	0.46	130.0	2.0	370.0	0.00	0.0	0.67	0.04	24-Oct-93	24-Nov-93
59	NL41	8.8	2900	190.0	37.0	330.0	13.0	0.21	0.00	940.0	3.0	25.0	0.05	0.0	3.50	0.03	19-Nov-93	13-Nov-93
59	NB24	9.5	680	3.4	5.7	140.0	3.9	0.36	0.00	81.0	4.0	153.0	0.04	0.0	0.91	0.03	19-Nov-93	13-Nov-93
60	PD18	7.6	1160	110.0	32.0	81.0	4.7	0.14	0.53	200.0	18.0	358.0	0.02	0.0	0.57	0.04	02-Nov-93	16-Dec-93
60	NL32	7.8	544	20.0	12.0	69.0	5.9	0.44	0.01	120.0	3.0	107.0	0.01	0.0	0.52	0.03	02-Nov-93	16-Dec-93
60	NB25	8.0	313	4.3	8.1	48.0	4.7	0.12	0.00	43.0	3.0	120.0	0.01	0.0	0.27	0.02	02-Nov-93	16-Dec-93
61	PD17	8.2	4850	340.0	190.0	290.0	18.0	9.50	3.80	1500.0	110.0	132.0	0.01	0.1	2.30	0.06		17-Nov-93
61	NL34	8.1	2430	160.0	62.0	200.0	7.0	1.80	4.00	700.0	19.0	96.0	0.01	0.1	1.10	0.03		17-Nov-93
61	NB27	8.3	1930	64.0	32.0	250.0	5.9	1.10	1.10	520.0	14.0	111.0	0.01	0.1	1.70	0.04		17-Nov-93
62	NB26	7.3	10200	450.0	150.0	1420.0	34.0	0.45	3.20	3490.0	41.0	67.0	0.01	0.0	7.50	0.21	11-Nov-93	16-Dec-93
63	PD21	8.2	2210	190.0	17.0	200.0	9.0	0.20	0.03	880.0	3.0	16.0	0.01	0.0	1.20	0.10	09-Nov-93	16-Dec-93
63	NL36	9.7	615	3.0	3.8	130.0	2.7	0.07	0.01	66.0	4.0	136.0	0.01	0.0	0.70	0.03	09-Nov-93	16-Dec-93
63	NB28	8.8	738	5.6	8.5	160.0	2.7	0.09	0.01	87.0	4.0	247.0	0.01	0.0	0.91	0.04	09-Nov-93	16-Dec-93
64	PD25	6.4	5200	330.0	110.0	560.0	19.0	0.77	0.92	1800.0	3.0	8.0	0.00	0.0	4.90	0.10	06-Nov-93	24-Nov-93
64	NL39	7.8	389	12.0	11.0	74.0	4.7	0.12	0.06	6.8	3.0	246.0	0.03	0.0	0.55	0.02	06-Nov-93	24-Nov-93
64	NB32	8.0	599	29.0	15.0	100.0	5.9	0.09	0.22	9.2	2.0	382.0	0.00	0.0	0.91	0.03	06-Nov-93	24-Nov-93
65	PD23	7.8	729	26.0	10.0	150.0	4.7	0.06	0.14	33.0	2.0	433.0	0.00	0.0	0.00	0.00	11-Nov-93	24-Nov-93
65	NL38	8.9	615	2.9	12.0	140.0	0.8	0.10	0.00	40.0	2.0	234.0	0.11	0.0	0.83	0.02	21-Oct-93	24-Nov-93
65	NB33	8.5	3750	330.0	53.0	350.0	11.0	0.76	0.00	1200.0	3.0	40.0	0.00	0.0	3.80	0.04	21-Oct-93	24-Nov-93
66	PD50	7.7	2590	110.0	54.0	310.0	2.7	0.38	0.62	660.0	19.0	326.0	0.01	0.1	1.60	0.05	01-Oct-93	17-Nov-93
66	NL40	9.5	1120	1.6	2.5	210.0	3.9	0.20	0.01	240.0	1.0	141.0	0.02	0.1	1.20	0.03	01-Oct-93	17-Nov-93
66	NB34	8.4	964	6.1	18.0	190.0	2.0	0.64	0.04	140.0	2.0	307.0	0.15	0.0	0.86	0.09	01-Oct-93	25-Nov-93
67	PD27	7.4	13700	990.0	530.0	1200.0	24.0	9.70	6.90	4800.0	310.0	261.0	0.02	0.0	14.00	0.27	29-Sep-93	25-Nov-93
67	NL42	8.3	1130	29.0	35.0	180.0	3.5	0.22	0.31	170.0	2.0	405.0	0.06	0.0	0.90	0.04	29-Sep-93	25-Nov-93
67	NB35	8.3	879	10.0	18.0	170.0	7.0	0.36	0.04	120.0	3.0	340.0	0.02	0.0	0.77	0.03	29-Sep-93	25-Nov-93
68	PD30	7.4	19500	830.0	650.0	2600.0	32.0	8.80	7.30	6700.0	520.0	294.0	0.02	0.0	18.00	0.54	28-Sep-93	25-Nov-93
68	NL44	7.9	797	33.0	18.0	140.0	3.5	0.09	0.30	62.0	4.0	416.0	0.03	0.0	0.86	0.02	11-Nov-93	24-Nov-93
68	NB37	7.9	6710	150.0	170.0	1000.0	39.0	1.20	0.07	2200.0	6.0	27.0	0.05	0.0	3.90	0.16	28-Sep-93	25-Nov-93
69	PD32	8.1	4710	290.0	120.0	480.0	8.6	0.84	0.04	1600.0	2.0	15.0	0.00	0.0	0.30	0.16	23-Oct-93	24-Nov-93
69	NL45	10.0	1040	0.0	18.0	200.0	5.9	1.40	0.00	270.0	2.0	13.0	0.00	0.0	1.00	0.05	23-Oct-93	24-Nov-93
69	NB38	9.9	583	0.0	8.3	120.0	3.9	0.00	0.00	57.0	31.0	47.0	0.00	0.0	0.79	0.02	23-Oct-93	24-Nov-93
70	PD31	7.1	16300	1300.0	510.0	1800.0	24.0	22.00	5.90	6000.0	1400.0	243.0	0.04	0.1	12.00	0.57	16-Nov-93	13-Nov-93
70	NL46	7.6	5470	460.0	140.0	480.0	8.6	1.80	4.40	1800.0	10.0	276.0	0.04	0.1	6.00	0.23	16-Nov-93	13-Nov-93
71	PD34	9.5	1960	100.0	31.0	240.0	14.0	0.09	0.03	610.0	2.0	5.0	0.00	0.0	0.13	0.07	06-Nov-93	24-Nov-93
71	NL48	8.3	560	11.0	12.0	120.0	4.7	0.04	0.02	19.0	2.0	280.0	0.00	0.0	0.59	0.02	06-Nov-93	24-Nov-93

Table 4.2.1 RESULTS OF CHEMICAL ANAYSES OF GROUNDWATER SAMPLES TAKEN BY SUBMERSIBLE PUMP (5/7)

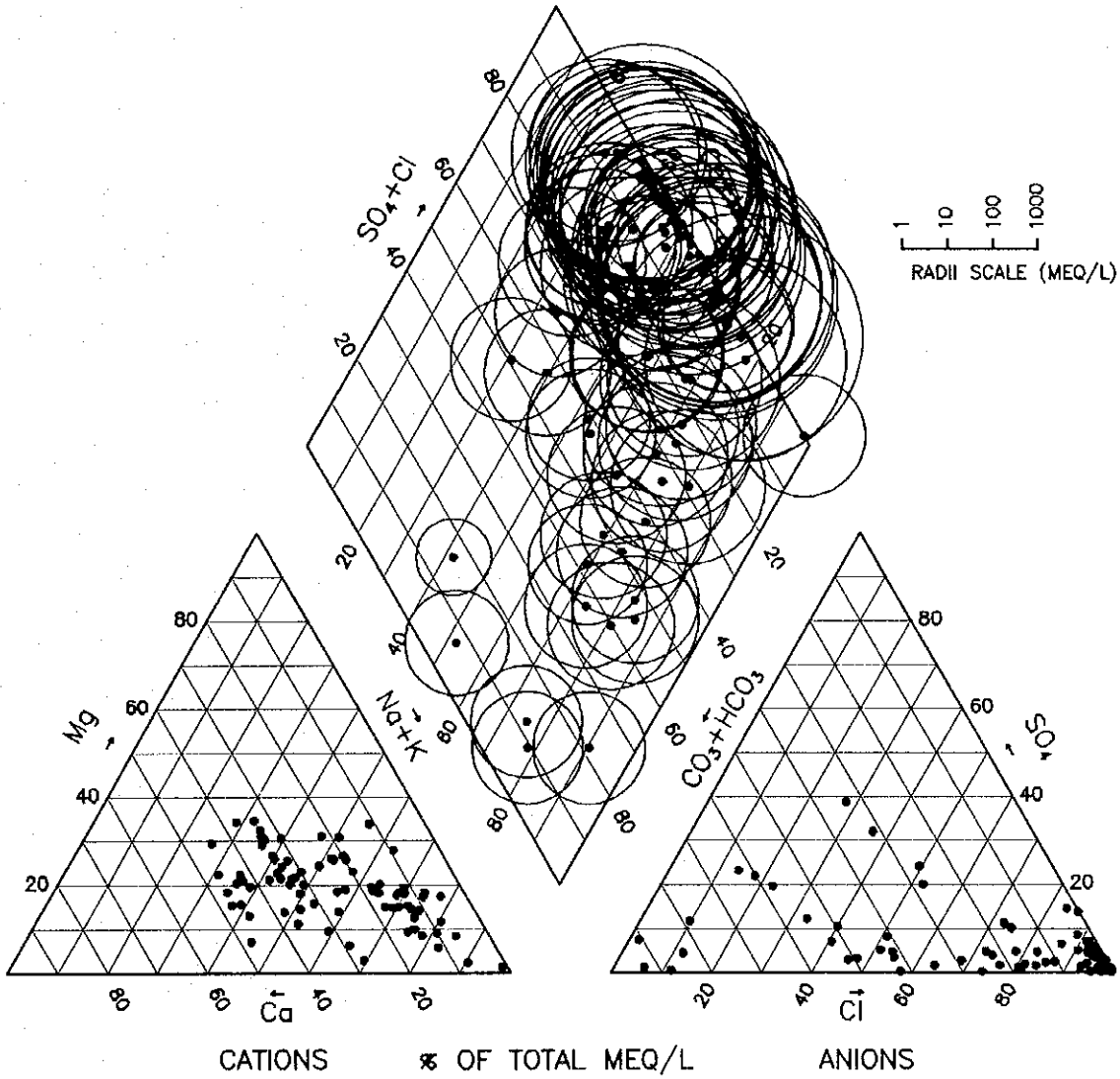
ST. NO.	WELL NO.	pH	E.C. (uS/cm)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	Fe (mg/L)	Mn (mg/L)	Cl (mg/L)	SO4 (mg/L)	HCO3 (mg/L)	NO2 (mg/L)	NO3 (mg/L)	Br (mg/L)	I (mg/L)	DATE OF SAMPLING	DATE OF ANALYSIS
71	NB42	9.5	485	3.5	2.8	110.0	3.5	0.12	0.01	25.0	2.0	180.0	0.05	0.0	0.62	0.01	06-Nov-93	24-Nov-93
73	PD37	7.7	4030	260.0	120.0	350.0	8.6	0.62	2.20	1200.0	45.0	249.0	0.03	0.0	2.30	0.15	27-Sep-93	25-Nov-93
73	NL51	7.9	1110	50.0	26.0	170.0	2.0	0.07	0.37	140.0	29.0	436.0	0.00	0.0	1.30	0.06	09-Nov-93	24-Nov-93
73	NB44	10.7	1120	0.0	2.9	210.0	2.7	0.22	0.01	190.0	17.0	0.0	0.03	0.0	0.76	0.17	27-Sep-93	25-Nov-93
74	PD36	8.2	1880	92.0	5.6	260.0	5.9	0.20	0.01	560.0	3.0	27.0	0.00	0.0	1.90	0.08	10-Nov-93	16-Dec-93
74	NL52	8.3	831	14.0	10.0	170.0	2.3	0.09	0.14	83.0	5.0	342.0	0.01	0.0	0.87	0.04	10-Nov-93	16-Dec-93
74	NB45	9.0	705	5.9	4.4	150.0	2.0	0.06	0.00	46.0	45.0	240.0	0.01	0.0	0.67	0.08	10-Nov-93	16-Dec-93
75	PD84	7.3	9580	630.0	250.0	1000.0	31.0	1.00	2.70	3200.0	93.0	256.0	0.00	0.0	7.90	0.56	07-Nov-93	24-Nov-93
75	NL54	9.4	808	0.0	9.2	190.0	1.6	0.17	0.01	62.0	2.0	175.0	0.00	0.0	0.51	0.06	08-Nov-93	24-Nov-93
75	NB47	10.5	1570	0.0	2.9	310.0	2.7	0.16	0.01	430.0	13.0	0.0	0.03	0.0	1.80	0.42	08-Nov-93	24-Nov-93
76	NL53	8.1	1490	30.0	1.5	290.0	4.7	0.11	0.28	280.0	4.0	429.0	0.07	0.0	1.10	0.04	01-Nov-93	16-Dec-93
77	PD41	7.5	2410	210.0	59.0	190.0	7.8	1.50	2.40	650.0	11.0	259.0	0.00	0.1	1.10	0.08	09-Nov-93	16-Dec-93
77	NL56	8.7	930	7.2	16.0	170.0	2.7	0.18	0.07	150.0	3.0	235.0	0.02	0.1	0.62	0.06	09-Nov-93	16-Dec-93
77	NB51	10.4	777	4.0	3.4	150.0	2.0	0.17	0.00	100.0	4.0	4.0	0.03	0.3	0.92	0.06	09-Nov-93	16-Dec-93
78	PD82	7.0	13500	460.0	300.0	1900.0	36.0	24.00	2.80	4600.0	66.0	210.0	0.02	0.1	9.90	0.83	09-Oct-93	17-Nov-93
78	NL57	11.0	1040	6.9	0.9	170.0	4.7	0.52	0.00	210.0	2.0	0.0	0.03	0.2	0.00	0.02	09-Oct-93	17-Nov-93
78	NB50	7.8	950	16.0	3.8	160.0	5.9	0.02	0.00	250.0	1.0	67.0	0.02	0.0	0.66	0.03	09-Oct-93	17-Nov-93
79	NL58	6.8	10150	900.0	120.0	860.0	21.0	0.48	1.30	3400.0	27.0	14.0	0.02	0.0	7.80	0.14	07-Oct-93	17-Nov-93
79	NB54	7.1	26400	1400.0	290.0	4000.0	36.0	0.74	1.30	9600.0	320.0	14.0	0.01	0.1	36.00	0.22	07-Oct-93	17-Nov-93
80	PD44	7.1	2570	170.0	100.0	190.0	16.0	4.00	1.50	680.0	22.0	240.0	0.04	0.0	1.10	0.03	21-Oct-93	24-Nov-93
80	NL59	7.8	1020	17.0	31.0	170.0	3.9	0.39	0.15	160.0	5.0	358.0	0.00	0.0	0.99	0.04	21-Oct-93	24-Nov-93
80	NB55	8.9	698	2.7	13.0	170.0	3.5	0.09	0.01	80.0	2.0	254.0	0.00	0.0	0.87	0.02	21-Oct-93	24-Nov-93
81	PD43	7.8	1300	38.0	16.0	230.0	6.3	0.18	0.42	250.0	29.0	333.0	0.03	1.8	0.54	0.04	09-Nov-93	13-Nov-93
81	NL60	7.5	5410	270.0	130.0	720.0	13.0	0.97	2.00	1700.0	85.0	253.0	0.03	0.0	4.40	0.11	10-Nov-93	13-Nov-93
81	NB48	10.4	1130	2.1	1.1	220.0	4.7	0.04	0.00	260.0	5.0	11.0	0.14	0.1	0.85	0.04	10-Nov-93	13-Nov-93
82	PD79	7.9	1230	28.0	8.5	230.0	2.7	0.28	0.30	180.0	42.0	402.0	2.30	0.8	1.60	0.06	09-Nov-93	13-Nov-93
82	NL61	8.1	803	17.0	6.6	170.0	3.1	0.00	0.08	44.0	47.0	396.0	0.02	0.0	0.49	0.04	09-Nov-93	13-Nov-93
82	NB56	8.1	813	31.0	4.7	150.0	4.3	0.58	0.08	69.0	55.0	320.0	0.04	0.0	0.69	0.05	09-Nov-93	13-Nov-93
83	NL63	8.2	1010	27.0	21.0	170.0	2.7	0.34	0.44	120.0	30.0	385.0	0.02	0.0	0.73	0.03	16-Sep-93	25-Nov-93
83	NB57	8.2	893	29.0	15.0	160.0	2.7	0.36	0.24	89.0	43.0	367.0	0.02	0.5	0.83	0.06	16-Sep-93	25-Nov-93
84	PD45	6.7	9070	550.0	270.0	850.0	24.0	36.00	6.20	2900.0	210.0	99.0	0.01	0.1	5.40	0.21	29-Sep-93	17-Nov-93
84	NL64	7.8	738	54.0	15.0	76.0	6.3	0.26	0.49	74.0	1.0	322.0	0.02	0.1	0.90	0.02	29-Sep-93	17-Nov-93
84	NB58	8.1	689	2.7	8.3	130.0	5.1	0.12	0.01	90.0	2.0	244.0	0.02	0.1	0.47	0.04	29-Sep-93	17-Nov-93
85	PD48	6.7	11000	670.0	300.0	1100.0	25.0	37.00	4.80	3800.0	240.0	120.0	0.03	0.0	11.00	0.18	15-Nov-93	13-Nov-93
85	NB59	8.2	3000	190.0	21.0	360.0	10.0	0.00	0.00	960.0	3.0	17.0	0.04	0.0	2.90	0.05	15-Nov-93	13-Nov-93
86	PD65	7.9	798	24.0	9.1	160.0	0.4	0.18	0.00	5.6	30.0	468.0	0.01	0.1	0.40	0.05	01-Oct-93	17-Nov-93
86	NL66	10.3	1420	7.0	0.4	250.0	5.5	0.28	0.00	370.0	7.0	30.0	0.04	0.1	0.73	0.12	07-Oct-93	17-Nov-93
86	NB67	10.4	1420	8.6	0.5	250.0	3.1	0.28	0.00	370.0	7.0	14.0	0.02	0.5	0.43	0.11	01-Oct-93	17-Nov-93
87	PD49	8.1	1580	94.0	12.0	240.0	2.3	0.12	0.54	310.0	26.0	409.0	0.04	0.3	1.20	0.05	29-Oct-93	16-Dec-93
88	PD54	7.6	1270	84.0	40.0	110.0	4.3	0.22	0.07	220.0	30.0	324.0	0.01	0.6	0.97	0.03	16-Oct-93	17-Nov-93

Table 4.2.1 RESULTS OF CHEMICAL ANAYSES OF GROUNDWATER SAMPLES TAKEN BY SUBMERSIBLE PUMP (6/7)

ST. NO.	WELL NO.	pH	E.C. (uS/cm)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	Fe (mg/L)	Mn (mg/L)	Cl (mg/L)	SO4 (mg/L)	HCO3 (mg/L)	NO2 (mg/L)	NO3 (mg/L)	Br (mg/L)	I (mg/L)	DATE OF SAMPLING	DATE OF ANALYSIS
88	NL69	7.9	980	61.0	35.0	97.0	4.7	0.46	0.29	140.0	4.0	351.0	0.04	0.0	0.01	0.04	16-Oct-93	25-Nov-93
88	NB61	8.1	752	36.0	26.0	76.0	4.3	0.26	0.13	92.0	2.0	289.0	0.01	0.1	0.42	0.03	16-Oct-93	17-Nov-93
89	PD56	6.6	11900	1120.0	220.0	990.0	21.0	23.00	16.00	4070.0	190.0	120.0	0.01	0.0	9.60	0.21	30-Oct-93	16-Dec-93
89	NB63	8.0	2840	79.0	31.0	440.0	7.4	0.12	0.02	870.0	2.0	34.0	0.00	0.0	2.90	0.14	30-Oct-93	16-Dec-93
90	PD57	7.1	13200	840.0	390.0	1500.0	16.0	4.40	5.10	4500.0	460.0	160.0	0.04	0.0	11.00	0.06	03-Nov-93	13-Nov-93
90	NL70	7.4	13000	900.0	360.0	1500.0	16.0	0.74	5.80	4700.0	340.0	183.0	0.02	0.0	9.00	0.14	03-Nov-93	13-Nov-93
90	NB62	6.6	19000	1400.0	500.0	2200.0	29.0	1.50	4.80	7200.0	120.0	13.0	0.02	0.1	6.20	0.21	03-Nov-93	13-Nov-93
91	PD60	5.7	21300	1600.0	580.0	2500.0	35.0	84.00	23.00	7900.0	1700.0	34.0	0.04	0.1	17.00	0.28	15-Nov-93	13-Nov-93
91	NL74	7.7	4670	420.0	82.0	370.0	15.0	0.08	0.02	1500.0	3.0	31.0	0.03	0.0	5.00	0.06	15-Nov-93	13-Nov-93
91	NB64	7.8	12000	950.0	160.0	1500.0	20.0	0.29	0.04	4500.0	3.0	32.0	0.03	0.1	8.80	0.43	15-Nov-93	13-Nov-93
92	PD61	6.2	12700	930.0	470.0	1100.0	17.0	29.00	8.10	4300.0	300.0	83.0	0.02	0.0	13.00	0.29	19-Oct-93	25-Nov-93
92	NL73	10.9	737	16.0	0.9	110.0	6.6	0.30	0.03	170.0	10.0	0.0	0.05	0.0	0.16	0.04	18-Oct-93	25-Nov-93
92	NB65	10.5	424	3.0	0.1	78.0	4.3	0.22	0.00	40.0	1.0	0.0	0.02	0.0	0.00	0.02	19-Oct-93	25-Nov-93
93	PD63	6.8	6080	270.0	120.0	680.0	22.0	0.30	0.21	2000.0	3.0	10.0	0.02	0.1	6.10	0.17	19-Sep-93	17-Nov-93
94	PD66	6.0	17700	1300.0	570.0	1900.0	25.0	31.00	25.00	6300.0	440.0	77.0	0.03	0.0	13.00	0.21	09-Nov-93	13-Nov-93
94	NL75	8.0	488	13.0	8.1	92.0	1.6	0.03	0.17	13.0	6.0	304.0	0.04	0.0	6.70	0.11	09-Nov-93	13-Nov-93
94	NB66	9.6	422	2.1	2.0	87.0	5.9	0.01	0.01	15.0	3.0	130.0	0.03	0.0	0.46	0.02	09-Nov-93	13-Nov-93
95	PD69	7.6	2730	41.0	36.0	470.0	5.9	0.83	0.07	610.0	32.0	446.0	1.10	0.8	2.40	0.09	12-Nov-93	13-Nov-93
95	NL77	7.5	3630	130.0	58.0	560.0	9.4	4.40	0.19	960.0	88.0	462.0	0.04	0.1	3.00	0.52	12-Nov-93	13-Nov-93
95	NB71	7.8	5680	110.0	210.0	880.0	27.0	1.70	0.12	1500.0	630.0	327.0	0.05	0.0	5.60	0.52	12-Nov-93	13-Nov-93
96	PD70	7.7	341	30.0	5.2	23.0	15.0	0.28	0.01	14.0	7.0	169.0	0.01	0.1	0.81	0.02	04-Oct-93	17-Nov-93
96	NL79	10.1	206	2.7	0.4	35.0	3.9	1.00	0.00	21.0	2.0	41.0	0.01	0.1	0.80	0.06	04-Oct-93	17-Nov-93
96	NB70	9.2	963	3.4	1.1	220.0	2.0	0.16	0.01	80.0	2.0	376.0	0.02	0.1	0.73	0.98	04-Oct-93	17-Nov-93
97	PD71	7.8	2030	55.0	34.0	300.0	3.1	0.84	0.01	260.0	310.0	391.0	0.01	0.2	1.20	0.17	30-Sep-93	17-Nov-93
97	NL80	10.0	1070	2.7	3.8	210.0	7.8	0.20	0.01	220.0	1.0	94.0	0.02	0.1	0.96	0.06	30-Sep-93	17-Nov-93
97	NB72	8.1	1130	21.0	9.1	220.0	1.2	0.38	0.26	110.0	72.0	390.0	0.02	0.1	1.00	0.40	30-Sep-93	17-Nov-93
98	PD73	7.9	1000	32.0	18.0	160.0	0.0	0.38	0.02	81.0	96.0	359.0	0.01	0.1	0.19	0.04	05-Oct-93	17-Nov-93
98	NB74	9.9	605	3.4	0.6	110.0	7.0	0.52	0.00	140.0	6.0	37.0	0.01	0.1	0.30	0.09	05-Oct-93	17-Nov-93
101	PD83	7.4	16100	580.0	380.0	2300.0	35.0	5.00	6.80	5300.0	300.0	225.0	0.10	0.2	15.00	0.80	17-Oct-93	17-Nov-93
101	NL83	11.1	1070	9.3	1.1	170.0	4.7	0.16	0.00	210.0	1.0	0.0	0.11	0.3	0.00	0.02	17-Oct-93	17-Nov-93
101	NB81	7.9	947	15.0	3.4	170.0	5.1	0.00	0.01	250.0	1.0	55.0	0.01	0.1	0.96	0.02	17-Oct-93	17-Nov-93
102	PD86	8.1	1250	17.0	13.0	250.0	0.4	0.18	0.01	150.0	75.0	429.0	0.05	0.2	1.10	0.19	24-Sep-93	25-Nov-93
102	NL85	10.3	956	1.3	3.4	190.0	9.8	0.24	0.00	160.0	2.0	40.0	0.03	0.0	0.12	0.14	25-Sep-93	25-Nov-93
102	NB84	9.3	903	3.8	4.8	180.0	11.0	0.16	0.00	110.0	45.0	199.0	0.04	0.0	0.16	0.11	25-Sep-93	25-Nov-93
103	PD81	7.9	1220	75.0	23.0	140.0	11.0	0.32	0.00	210.0	45.0	290.0	0.05	0.1	0.00	0.02	08-Oct-93	17-Nov-93
103	NL87	9.5	697	2.6	10.0	120.0	4.7	0.18	0.00	160.0	1.0	56.0	0.01	0.1	0.07	0.03	08-Oct-93	17-Nov-93
103	NB85	9.8	457	1.6	1.0	97.0	4.3	0.20	0.00	25.0	2.0	153.0	0.01	0.1	0.00	0.03	08-Oct-93	17-Nov-93
	ST001	7.8	819	31.0	3.4	160.0	1.6	0.15	0.13	34.0	60.0	405.0	0.02	0.0	0.68	0.07	12-Dec-93	16-Dec-93
	ST008	8.0	729	31.0	2.9	140.0	2.3	0.15	0.06	38.0	56.0	335.0	0.07	0.2	0.64	0.05	11-Nov-93	16-Dec-93
	ST028	7.8	782	30.0	7.1	150.0	1.2	0.10	0.10	9.2	42.0	466.0	0.02	0.1	0.55	0.06		16-Dec-93

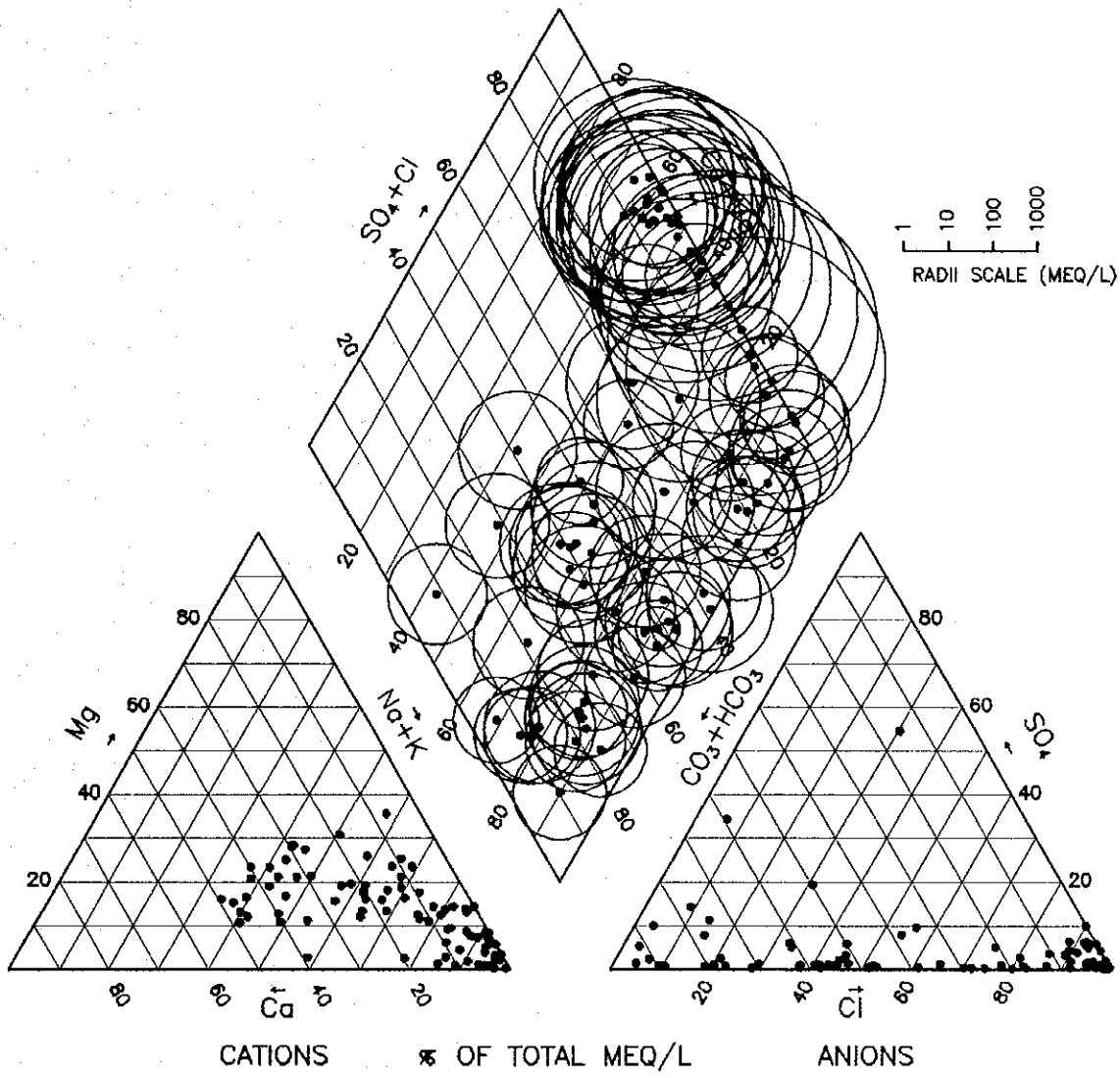
Table 4.2.1 RESULTS OF CHEMICAL ANAYSES OF GROUNDWATER SAMPLES TAKEN BY SUBMERSIBLE PUMP (7/7)

ST. NO.	WELL NO.	pH	E.C. (uS/cm)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	Fe (mg/L)	Mn (mg/L)	Cl (mg/L)	SO4 (mg/L)	HCO3 (mg/L)	NO2 (mg/L)	NO3 (mg/L)	Br (mg/L)	I (mg/L)	DATE OF SAMPLING	DATE OF ANALYSIS
	ST028	7.7	1310	80.0	0.0	210.0	2.3	0.08	0.04	220.0	28.0	406.0	0.11	0.6	1.70	0.06	12-Dec-93	16-Dec-93
	ST028	7.7	793	29.0	5.5	160.0	2.3	0.08	0.19	15.0	48.0	454.0	0.00	0.0	0.76	0.08		16-Dec-93
	ST028	7.7	769	30.0	4.8	150.0	1.6	0.10	0.09	9.2	36.0	465.0	0.04	0.1	0.76	0.05	12-Dec-93	16-Dec-93
	ST028	7.7	779	30.0	4.4	160.0	2.0	0.05	0.20	12.0	40.0	448.0	0.05	0.0	0.79	0.06		16-Dec-93
	ST034	8.0	800	26.0	5.0	170.0	1.6	0.09	0.06	14.0	42.0	465.0	0.02	0.1	0.85	0.06	12-Dec-93	16-Dec-93
	ST034	7.7	788	28.0	4.2	160.0	1.6	0.06	0.13	13.0	41.0	459.0	0.01	0.0	0.85	0.06	12-Dec-93	16-Dec-93
	ST068	7.7	680	36.0	3.2	130.0	2.7	0.20	0.18	4.4	26.0	434.0	0.02	0.0	0.45	0.02	11-Nov-93	16-Dec-93
	1	9.3	464	9.3	0.9	97.0	1.6	0.16	0.01	16.0	30.0	143.0	0.02	0.0	0.44	0.06	06-Dec-93	16-Dec-93
	2	7.9	2430	140.0	17.0	320.0	33.0	0.55	0.15	620.0	24.0	302.0	0.09	1.0	2.80	0.04	06-Dec-93	16-Dec-93
	3	7.9	808	47.0	16.0	99.0	7.0	0.12	0.01	99.0	35.0	279.0	0.03	0.1	0.77	0.03	09-Dec-93	16-Dec-93
	4	8.0	689	32.0	6.8	130.0	3.5	0.10	0.05	4.0	38.0	408.0	0.02	0.2	0.56	0.05	10-Dec-93	16-Dec-93
	5	7.7	605	39.0	6.3	97.0	3.1	0.31	0.01	32.0	10.0	339.0	0.03	0.8	0.62	0.02	11-Dec-93	16-Dec-93
	6	7.4	627	39.0	5.1	99.0	3.5	0.25	0.55	43.0	15.0	324.0	0.01	0.1	0.43	0.01	14-Dec-93	16-Dec-93



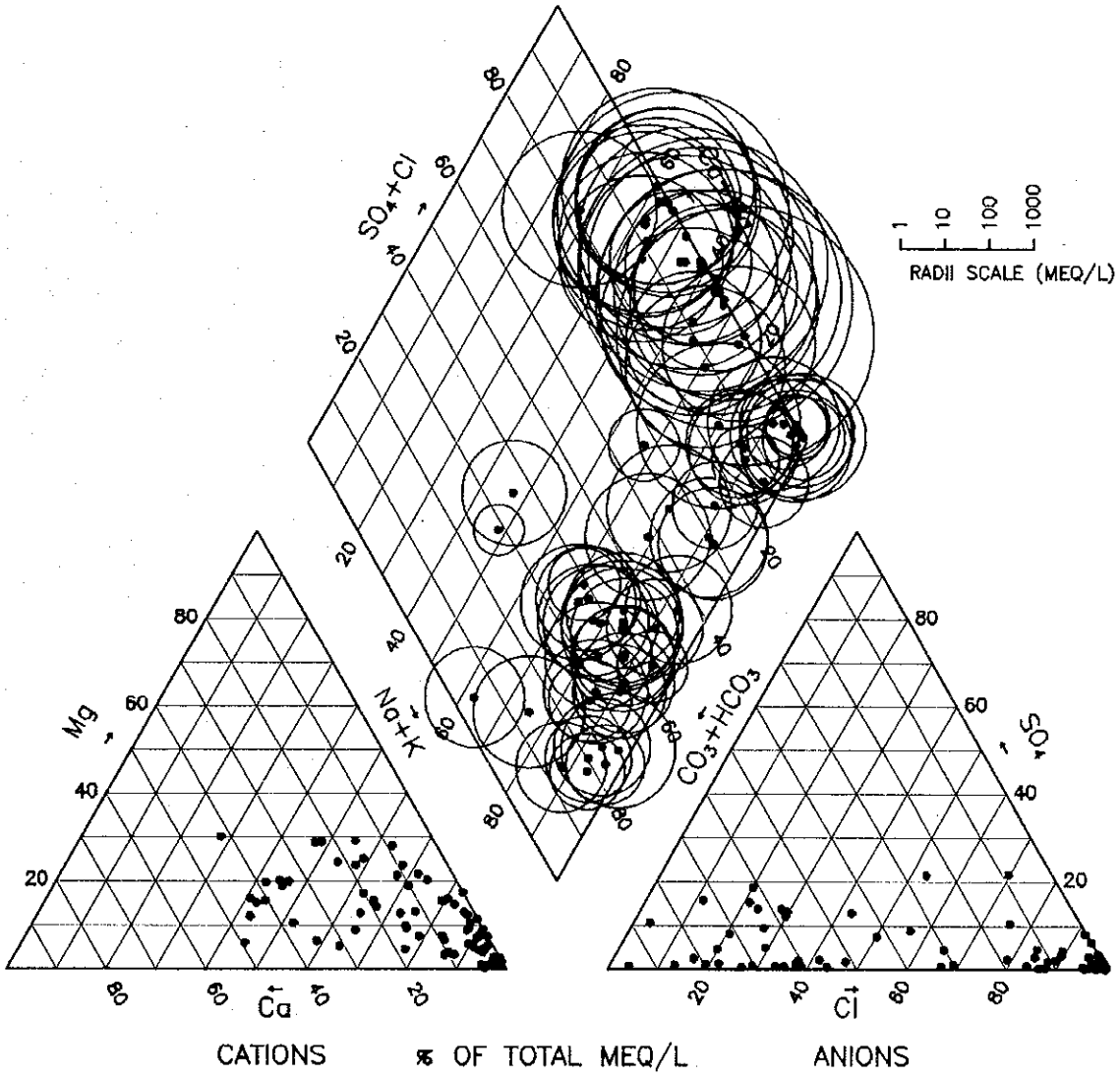
(Water samples were collected by the Study Team in 1993.)

Figure 4.2.1	TRILINEAR DIAGRAM OF PHRA PRADAENG AQUIFER
THE STUDY ON MANAGEMENT OF GROUNDWATER AND LAND SUBSIDENCE IN THE BANGKOK METROPOLITAN AREA AND ITS VICINITY	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	KOKUSAI KOGYO CO., LTD.



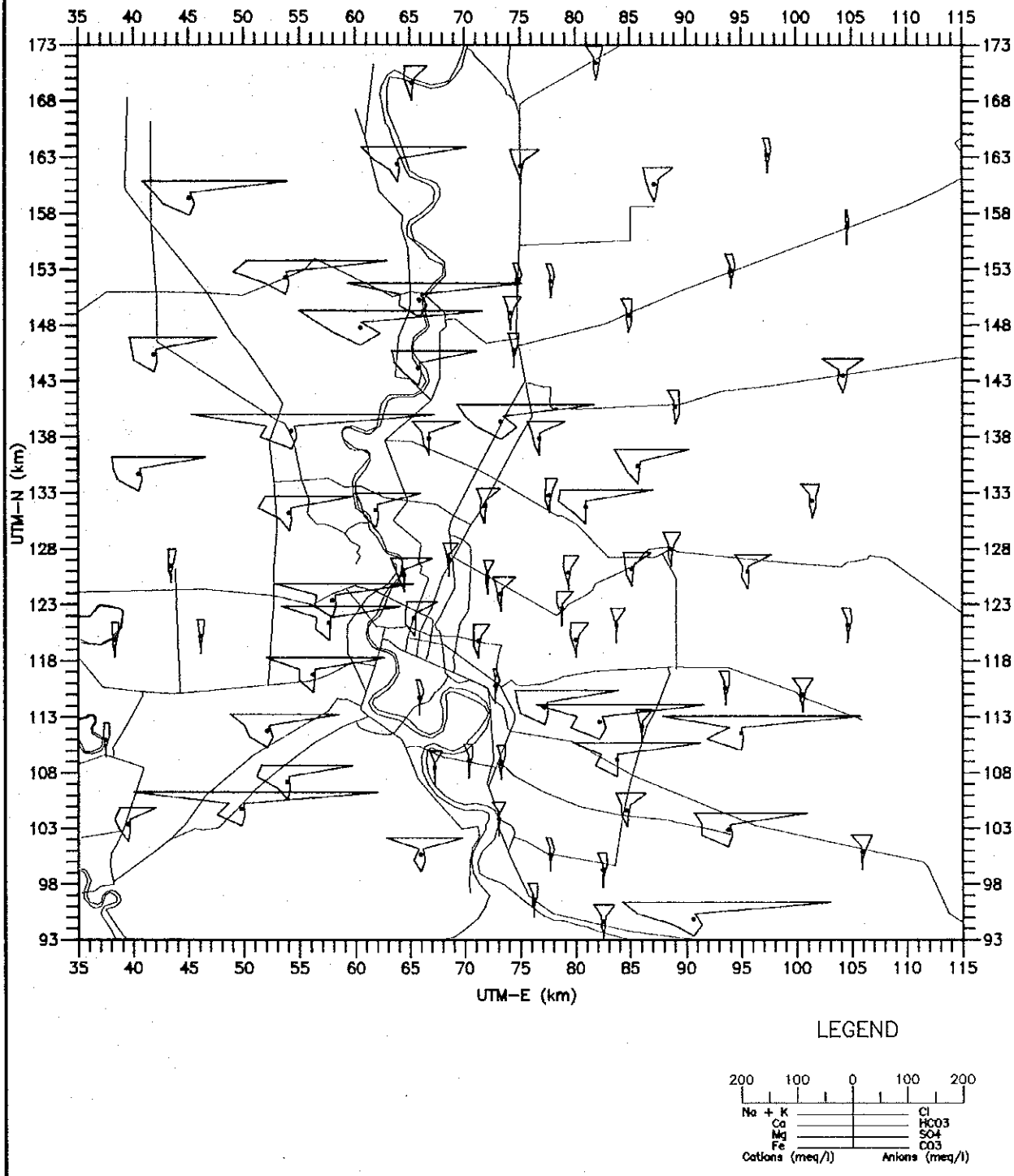
(Water samples were collected by the Study Team in 1993.)

Figure 4.2.2	TRILINEAR DIAGRAM OF NAKHON LUANG AQUIFER
THE STUDY ON MANAGEMENT OF GROUNDWATER AND LAND SUBSIDENCE IN THE BANGKOK METROPOLITAN AREA AND ITS VICINITY	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	KOKUSAI KOGYO CO., LTD.



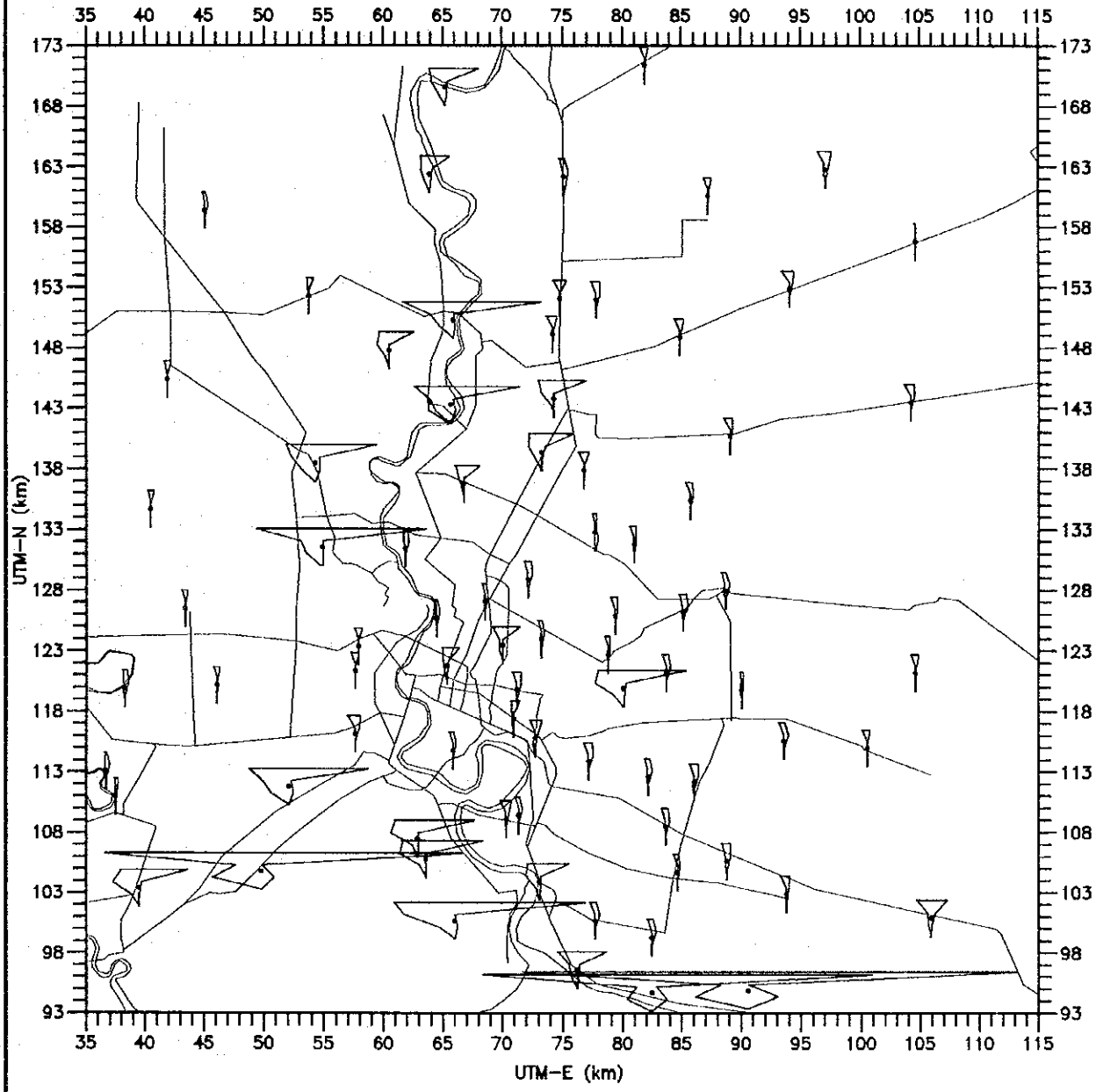
(Water samples were collected by the Study Team in 1993.)

Figure 4.2.3	TRILINEAR DIAGRAM OF NONTHABURI AQUIFER
THE STUDY ON MANAGEMENT OF GROUNDWATER AND LAND SUBSIDENCE IN THE BANGKOK METROPOLITAN AREA AND ITS VICINITY	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	KOKUSAI KOGYO CO., LTD.



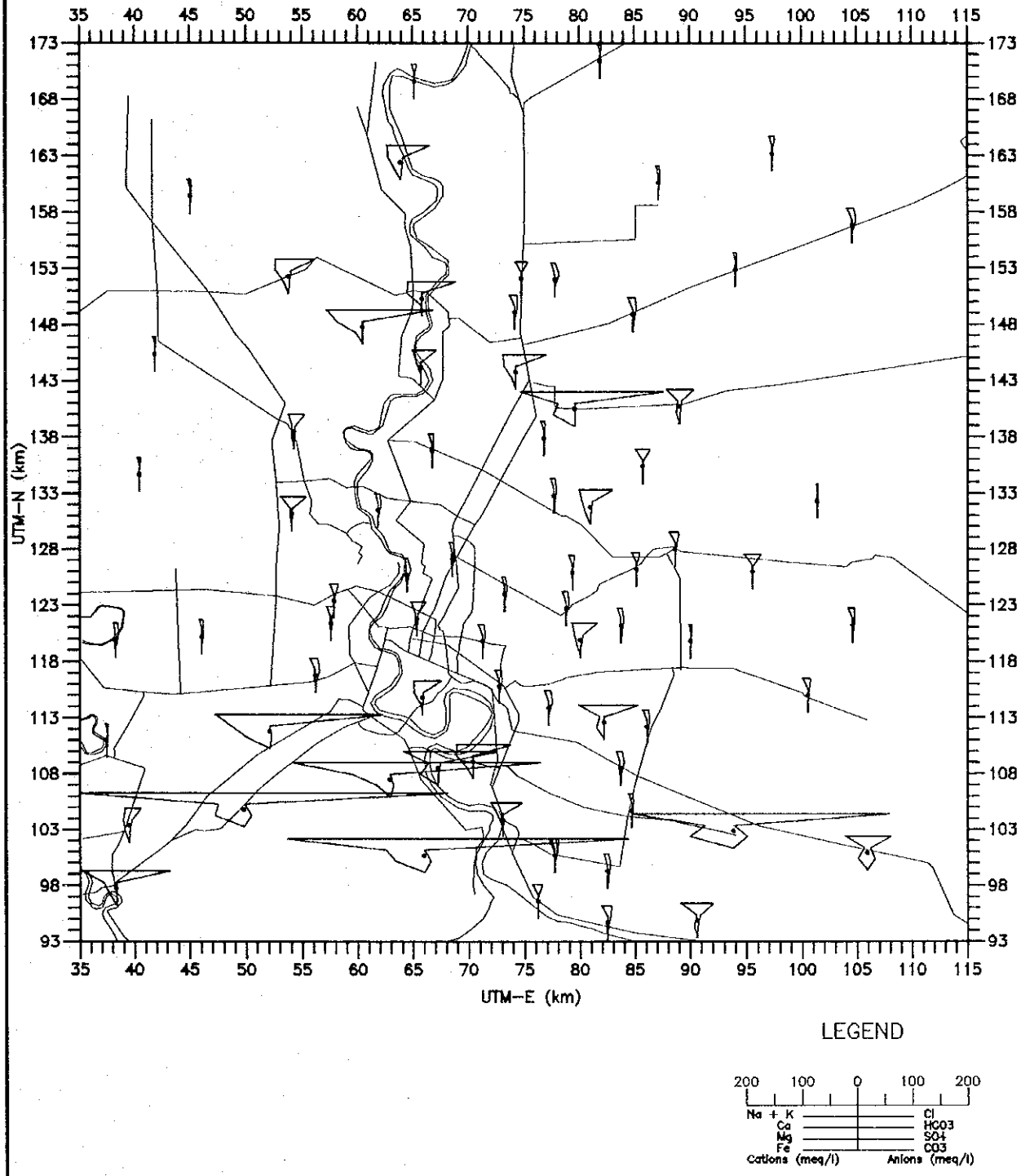
(Water samples were collected by the Study Team in 1993.)

Figure 4.2.4	STIFF DIAGRAMS OF PHRA PRADAENG AQUIFER
THE STUDY ON MANAGEMENT OF GROUNDWATER AND LAND SUBSIDENCE IN THE BANGKOK METROPOLITAN AREA AND ITS VICINITY	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	KOKUSAI KOGYO CO., LTD.



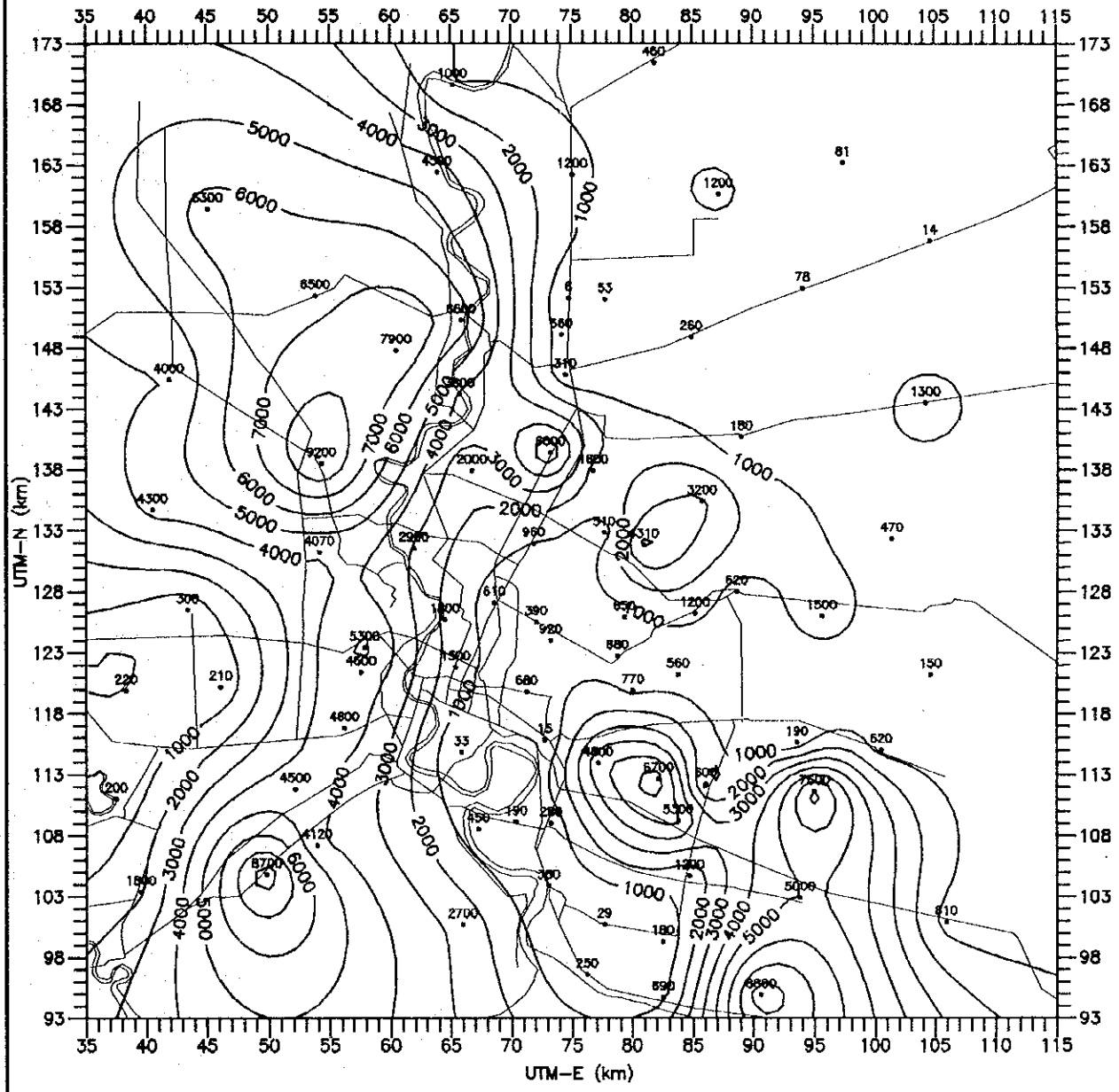
(Water samples were collected by the Study Team in 1993.)

Figure 4.2.5	STIFF DIAGRAMS OF NAKHON LUANG AQUIFER
THE STUDY ON MANAGEMENT OF GROUNDWATER AND LAND SUBSIDENCE IN THE BANGKOK METROPOLITAN AREA AND ITS VICINITY	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	KOKUSAI KOGYO CO., LTD.



(Water samples were collected by the Study Team in 1993.)

Figure 4.2.6	STIFF DIAGRAMS OF NONTHABURI AQUIFER
THE STUDY ON MANAGEMENT OF GROUNDWATER AND LAND SUBSIDENCE IN THE BANGKOK METROPOLITAN AREA AND ITS VICINITY	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	KOKUSAI KOGYO CO., LTD.



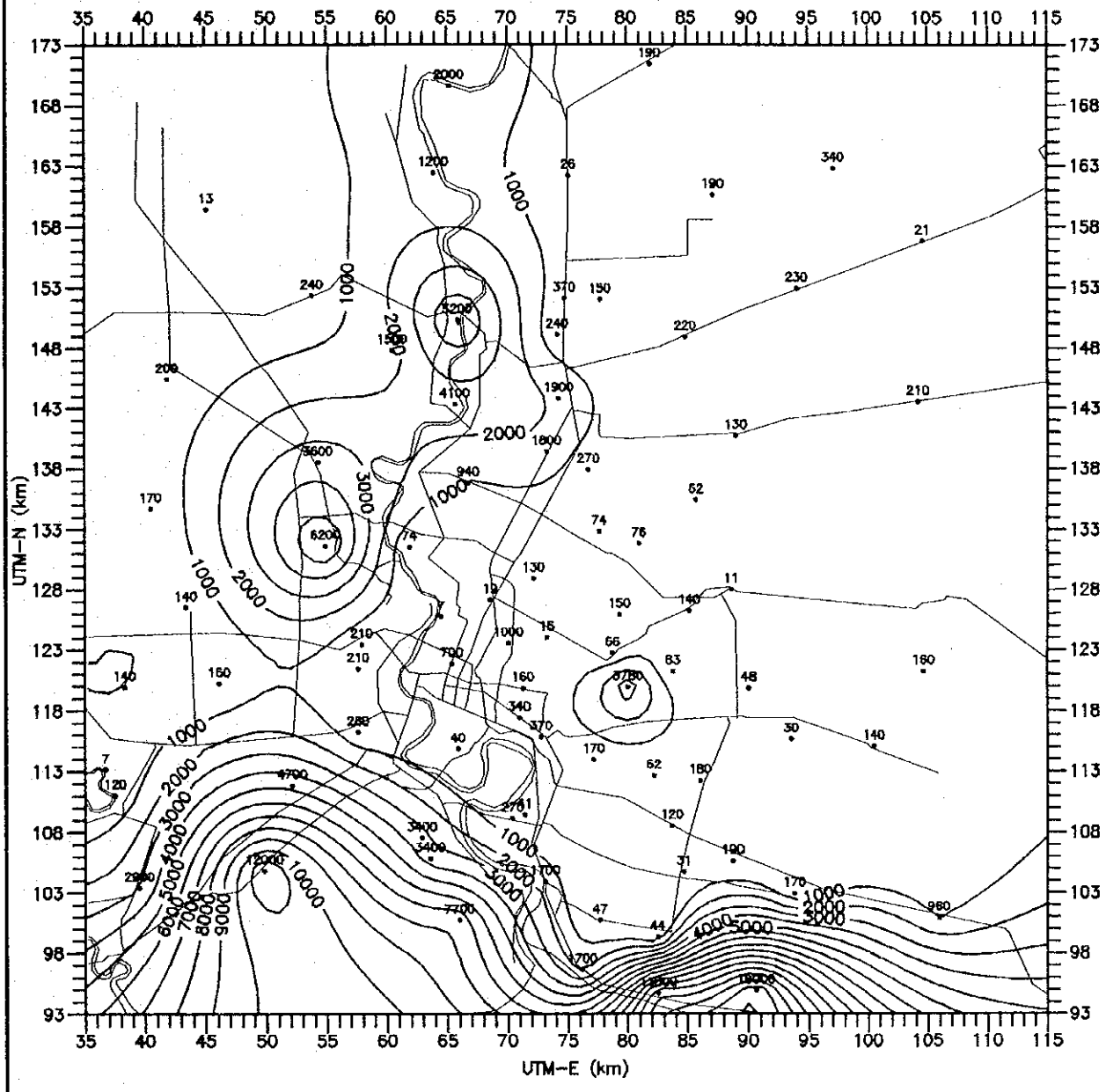
LEGEND

——— LINE OF EQUAL Cl^- CONCENTRATION (mg/L)

1500 DMR MONITORING WELL WITH Cl^- CONCENTRATION (mg/L)

(Water samples were collected by the Study Team in 1993.)

Figure 4.3.1	CHLORIDE CONCENTRATION OF PHRA PRADAENG AQUIFER
THE STUDY ON MANAGEMENT OF GROUNDWATER AND LAND SUBSIDENCE IN THE BANGKOK METROPOLITAN AREA AND ITS VICINITY	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	KOKUSAI KOGYO CO., LTD.



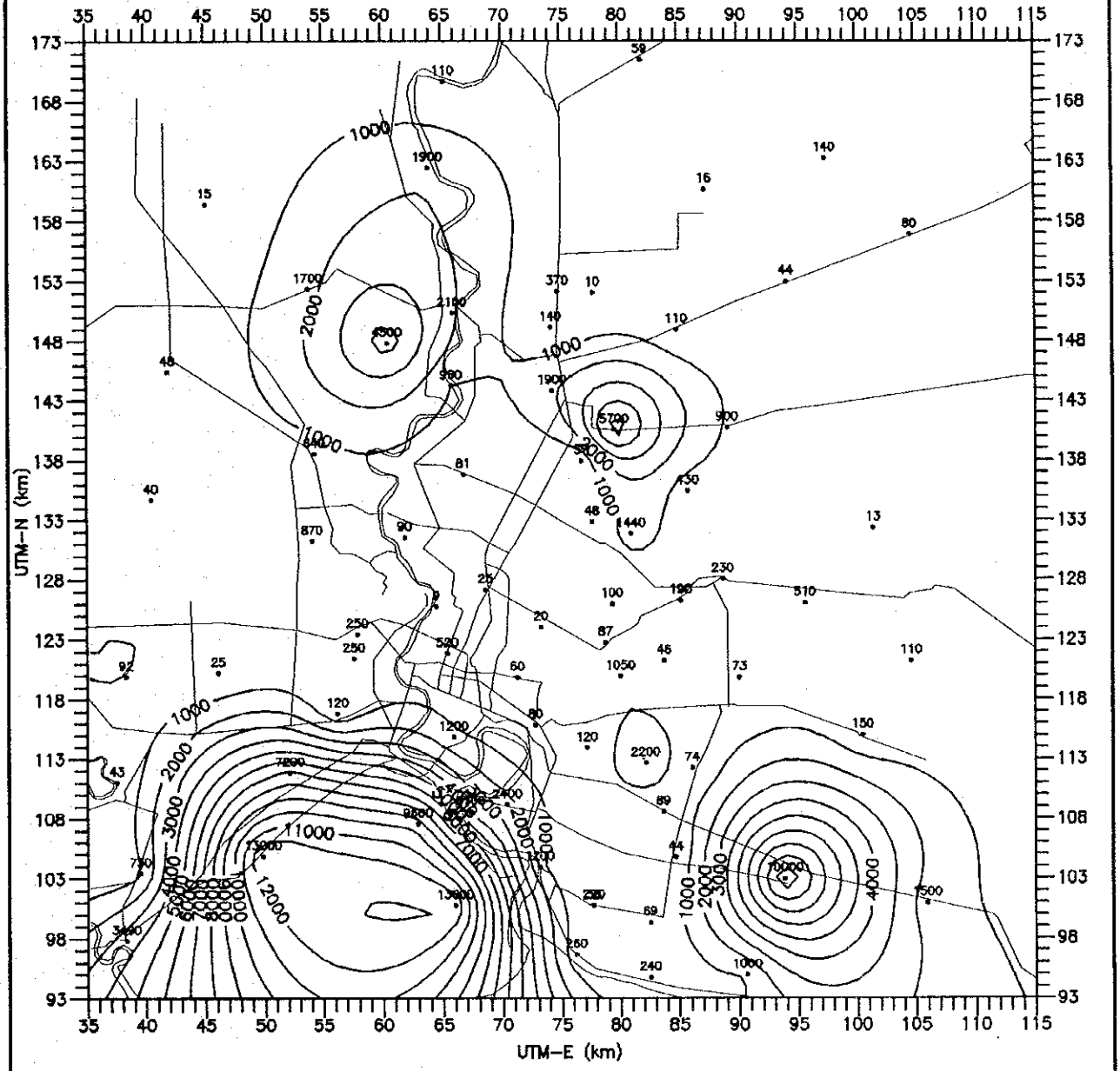
LEGEND

——— LINE OF EQUAL Cl^- CONCENTRATION (mg/L)

1500 DMR MONITORING WELL WITH Cl^- CONCENTRATION (mg/L)

(Water samples were collected by the Study Team in 1993.)

Figure 4.3.2	CHLORIDE CONCENTRATION OF NAKHON LUANG AQUIFER
THE STUDY ON MANAGEMENT OF GROUNDWATER AND LAND SUBSIDENCE IN THE BANGKOK METROPOLITAN AREA AND ITS VICINITY	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	KOKUSAI KOGYO CO., LTD.



LEGEND

——— LINE OF EQUAL Cl^- CONCENTRATION (mg/L)

1500 DMR MONITORING WELL WITH Cl^- CONCENTRATION (mg/L)

(Water samples were collected by the Study Team in 1993.)

Figure 4.3.3	CHLORIDE CONCENTRATION OF NONTHABURI AQUIFER
THE STUDY ON MANAGEMENT OF GROUNDWATER AND LAND SUBSIDENCE IN THE BANGKOK METROPOLITAN AREA AND ITS VICINITY	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	KOKUSAI KOGYO CO., LTD.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 5 GROUNDWATER PUMPAGE

5.1 Background

This chapter presents the results of the estimations of year-1992 groundwater abstractions and historical groundwater pumpage records (1983-1992) based on the compilation of well inventories of both private and public wells in the Bangkok Metropolitan Area and its vicinity. **Private wells** are those wells registered at DMR for water rights, while **public wells** are those wells constructed or managed (or both) by DMR, PWD, MWA, PWA, DOH, ARD and IEAT. Public wells are usually not registered with DMR for water rights.

The groundwater pumpage estimations basically relied on the Groundwater Database System prepared by the Study Team, specifically on the system's well inventory database which stores all the different well inventories collected from the said agencies during the Study. These well inventories contain 11,222 private wells, 2,475 public wells and 258 groundwater observation wells for a total of 13,955 wells as of 1992, encompassing active, inactive and abandoned wells.

5.2 Well Inventory

The results of the compilation of well inventories of both private and public wells in the Bangkok Metropolitan Area and its vicinity are presented in the following subsections.

In the subsequent discussions, the **Whole Area** shall include wholly the eight provinces containing the 11,222 private wells and 2,475 public wells. Inside the Whole Area is the **Study Area** which covers wholly Bangkok, Nonthaburi, Pathum Thani, and Samut Prakan and partly Samut Sakhon, Ayutthaya, Nakhon Pathum and Chachoengsao, i.e., between 35°E and 115°E and between 93°N and 173°N, and locates the 10,772 private wells and 884 public wells.

5.2.1 Private wells

Table 5.2.1 and Figure 5.2.1 show the distribution of the 11,222 inventoried private wells by changwat, by aquifer and by type of user. More than 75% of the private wells are located in Bangkok (4,853 wells) and Samut Prakan (3,669 wells), and more than 45% (5,140 wells), 37% (4,189 wells) and 14% (1,667 wells) are tapping Nakhon Luang, Phra Pradaeng and Nonthaburi Aquifers, respectively.

Note that the well screen position or the well depth was used to determine the aquifer from which a well is withdrawing groundwater. Otherwise, the most tapped aquifer in the vicinity of the well was assumed. Aquifers were identified using the Study Team's prepared isopachs of the eight aquifer units.

Nakhon Luang Aquifer is giving out groundwater to 52.5% of the wells in Bangkok, 57.2% of the wells in Pathum Thani, 52.9% of the wells in Samut Sakhon and 72.4% of the wells in Ayutthaya. In Samut Prakan, 62.2% of the wells are tapping Phra Pradaeng Aquifer. More than 72.4% of the wells in Nonthaburi province are withdrawing from a deeper aquifer, Nonthaburi.

Around 45.3% (5,088 wells) of the 11,222 private wells are for domestic consumption. The distributions of the rest consist of 4.2% (478 wells) for institutional use; 10.6% (1,186 wells) for commercial use; and 39.8% (4,470 wells) for industrial use.

Most of the 5,088 domestic wells are situated in Bangkok (2600), followed by Samut Prakan (1,452) and Samut Sakhon (452). Around 47% of the 5,088 domestic wells are abstracting from Nakhon Luang Aquifer, and 39.3% from Phra Pradaeng Aquifer. Most of the wells tapping Nakhon Luang Aquifer for domestic use are located in Bangkok. While most of the domestic wells using Phra Pradaeng Aquifer are found in Samut Prakan.

Institutional use is topped by Bangkok with 285 wells (of the 478-total). Two hundred fifty (250) of the total number of institutional wells are withdrawing groundwater from Nakhon Luang Aquifer.

Of the 1,186 commercial wells, 667 are drilled in Bangkok and 231 in Samut Prakan. Around 672 commercial wells are tapping Nakhon Luang Aquifer and 301 wells are using Phra Pradaeng Aquifer.

Of the 4,470 industrial wells, 42.4% are concentrated in Samut Prakan, and others are located in Bangkok (29.1%) and Pathum Thani (13.7%). The largest number of industrial wells, 1,129, are pumping from Phra Pradaeng Aquifer in Samut Prakan. The second largest number (645 wells), which is also situated in Samut Prakan, is withdrawing groundwater from Nakhon Luang Aquifer. The third largest number (553 wells) is drilled in Bangkok and tapping the Phra Pradaeng Aquifer. The fourth one (525 wells) is using Nakhon Luang Aquifer also in Bangkok.

5.2.2 Public wells

The distribution of the 2,475 inventoried public wells by changwat, by agency and by aquifer are shown in Table 5.2.2 and Figure 5.2.2. Of these 2,475 public wells, 1,019 (41.2%) were constructed by DMR, 932 (37.7%) by PWD, 157 (6.3%) by MWA, 111 (4.5%) by PWA, 83 (3.4%) by DOH, 93 (3.7%) by ARD, and 80 (3.2%) by IEAT. Wells constructed or managed (or both) by DMR, PWD, PWA, DOH, and ARD are specifically for domestic use. MWA well productions are largely for domestic consumption, while IEAT wells are utilized for industries.

More than 6.6% (163) of the 2,475 public wells are located in Bangkok, 3.2% (79) in Nonthaburi, 8% (198) in Pathum Thani, 7.1% (175) in Samut Prakan, 12.2% (303) in Samut Sakhon, 34.3% (847) in Ayutthaya, 14.3% (355) in Nakhon Pathum and 14.3% (355) in Chachoengsao.

Of the 2,475 inventoried public wells, 1,110 (44.8%) are pumping out from Nakhon Luang Aquifer, 602 (24.3%) from Phra Pradaeng Aquifer, and 534 (21.6%) from Nonthaburi Aquifer. Most of the public wells tapping Nakhon Luang Aquifer are located in Ayutthaya with 415 wells, followed by Samut Sakhon with 249 wells. Percentage-wise, DMR and IEAT constructed wells are mostly tapping Phra Pradaeng and Nakhon Luang Aquifers. While the rest are mostly abstracting from the deeper Nakhon Luang and Nonthaburi Aquifers.

5.2.3 Total number of private and public wells in the Study Area

Of the 11,222 private wells gathered from the DMR's Groundwater Division, 10,772 are located in the Study Area. The distribution of the 10,772 private wells in the Study Area by changwat, by aquifer and by type of user are shown in Table 5.2.3. Out of the 1,159 inventoried wells in

Samut Sakhon, only 883 are inside the Study Area. Ayutthaya has 116 inventoried wells inside the Study Area and 174 wells outside.

As shown in Table 5.2.4, more than 60.6% of the inventoried public wells in the Study Area are located in Bangkok, Pathum Thani and Samut Prakan, and more than 46.4% were constructed by PWD.

The combined total of the inventoried number of private and public production wells in the Study Area is 11,656. Of this total, public wells represent only 7.6%.

On the other hand, the number of private wells with active water permits was estimated at 4,141 for the year-1992 based on the years of the issuance, expiration and extension of water permits. Of this total, 4,132 wells are located in the Study Area.

Table 5.2.1 DISTRIBUTION OF 11,222 PRIVATE WELLS IN THE WHOLE AREA BY CHANGWAT, BY AQUIFER, AND BY TYPE OF USER.

Changwat	Total Number of Wells	AQUIFER Bangkok	Phra Pradaeng	Nakhon Luang	Nontha-buri	Samkhok	Phyathai	Thonburi	Pak Nam
Bangkok	4,853	443	1,615	2,547	528	9	1	11	5
Domestic	2600	238	838	1,416	284	3	1	6	1
Institutional	285	7	66	164	58	2	0	1	0
Commercial	667	31	158	442	71	4	0	2	0
Industrial	1301	167	553	525	115	0	0	2	4
Nonthaburi	395	19	4	102	286	16	0	0	0
Domestic	202	3	2	65	150	5	0	0	0
Institutional	24	1	0	11	14	0	0	0	0
Commercial	37	0	0	6	28	5	0	0	0
Industrial	132	15	2	20	94	6	0	0	0
Pathum Thani	856	1	29	490	279	97	24	3	1
Domestic	293	0	7	197	98	14	0	0	0
Institutional	43	0	4	28	10	3	1	0	0
Commercial	123	1	2	65	49	14	1	0	0
Industrial	397	0	16	200	122	66	22	3	1
Samut Prakan	3,669	288	2,284	1,178	141	17	1	2	15
Domestic	1452	117	967	421	36	4	0	0	0
Institutional	89	5	56	25	4	0	0	0	4
Commercial	231	23	132	87	4	0	0	0	0
Industrial	1897	143	1,129	645	97	13	1	2	11
Samut Sakhon	1,159	1	242	613	367	11	4	6	0
Domestic	452	0	182	225	87	1	0	1	0
Institutional	22	0	3	11	9	0	0	0	0
Commercial	73	0	6	36	33	0	0	2	0
Industrial	612	1	51	341	238	10	4	3	0
Ayutthaya	290	3	15	210	66	5	1	0	1
Domestic	89	0	3	69	20	0	0	0	0
Institutional	15	0	1	11	2	2	0	0	0
Commercial	55	2	3	36	15	0	1	0	0
Industrial	131	1	8	94	29	3	0	0	1
Whole Area	11,222	755	4,189	5,140	1,667	155	31	22	22
Domestic	5,088	358	1,999	2,393	675	27	1	7	1
Institutional	478	13	130	250	97	7	1	1	4
Commercial	1,186	57	301	672	200	23	2	4	0
Industrial	4,470	327	1,759	1,825	695	98	27	10	17

Note: No private well was inventoried in Nakhon Pathom and Chachoengsao.

Table 5.2.2 DISTRIBUTION OF 2,475 PUBLIC WELLS IN THE WHOLE AREA BY CHANGWAT, BY AQUIFER, AND BY AGENCY.

Changwat	Total Number of Wells	AQUIFER Bangkok	Phra Pradaeng	Nakhon Luang	Nontha-buri	Samkhok	Phyathai	Thonburi	Pak Nam
Bangkok	163	1	25	100	41	1	0	0	1
DMR	14	0	4	9	2	0	0	0	0
PWD	13	1	1	6	5	1	0	0	1
MWA	122	0	8	82	34	0	0	0	0
PWA	0	0	0	0	0	0	0	0	0
DOH	0	0	0	0	0	0	0	0	0
ARD	0	0	0	0	0	0	0	0	0
IEAT	14	0	12	3	0	0	0	0	0
Nonthaburi	78	0	1	19	60	3	0	0	0
DMR	5	0	1	2	2	0	0	0	0
PWD	55	0	0	13	44	2	0	0	0
MWA	18	0	0	3	14	1	0	0	0
PWA	1	0	0	1	0	0	0	0	0
DOH	0	0	0	0	0	0	0	0	0
ARD	0	0	0	0	0	0	0	0	0
IEAT	0	0	0	0	0	0	0	0	0
Pathum Thani	198	1	28	80	56	28	3	2	0
DMR	64	1	22	33	5	8	2	0	0
PWD	81	0	4	35	29	14	1	2	0
MWA	0	0	0	0	0	0	0	0	0
PWA	42	0	2	12	22	6	0	0	0
DOH	0	0	0	0	0	0	0	0	0
ARD	0	0	0	0	0	0	0	0	0
IEAT	11	0	0	0	0	0	0	0	0
Samut Prakan	175	11	119	47	8	0	0	0	0
DMR	26	4	18	5	0	0	0	0	0
PWD	109	7	78	28	2	0	0	0	0
MWA	17	0	8	8	2	0	0	0	0
PWA	0	0	0	0	0	0	0	0	0
DOH	0	0	0	0	0	0	0	0	0
ARD	0	0	0	0	0	0	0	0	0
IEAT	23	0	15	6	4	0	0	0	0
Samut Sakhon	303	1	21	249	46	1	0	0	0
DMR	10	0	1	6	3	0	0	0	0
PWD	258	1	20	217	34	1	0	0	0
MWA	0	0	0	0	0	0	0	0	0
PWA	20	0	0	11	9	0	0	0	0
DOH	0	0	0	0	0	0	0	0	0
ARD	0	0	0	0	0	0	0	0	0
IEAT	15	0	0	15	0	0	0	0	0
Ayutthaya	847	2	171	415	270	16	2	0	0
DMR	323	1	168	157	16	0	0	0	0
PWD	416	1	3	188	218	12	1	0	0
MWA	0	0	0	0	0	0	0	0	0
PWA	25	0	0	20	5	1	0	0	0
DOH	9	0	0	3	5	2	0	0	0
ARD	57	0	0	30	26	1	1	0	0
IEAT	17	0	0	17	0	0	0	0	0
Nakhon Pathom	355	21	145	159	49	1	1	1	1
DMR	222	19	116	85	16	0	0	0	0
PWD	0	0	0	0	0	0	0	0	0
MWA	0	0	0	0	0	0	0	0	0
PWA	23	0	3	8	12	0	0	0	0
DOH	74	2	15	47	15	1	1	1	1
ARD	36	0	11	19	6	0	0	0	0
IEAT	0	0	0	0	0	0	0	0	0
Chachoengsao	355	0	92	41	4	0	0	0	0
DMR	355	0	92	41	4	0	0	0	0
PWD	0	0	0	0	0	0	0	0	0
MWA	0	0	0	0	0	0	0	0	0
PWA	0	0	0	0	0	0	0	0	0
DOH	0	0	0	0	0	0	0	0	0
ARD	0	0	0	0	0	0	0	0	0
IEAT	0	0	0	0	0	0	0	0	0
Whole Area	2,474	37	602	1,110	534	50	6	3	2
DMR	1,019	25	422	338	48	8	2	0	0
PWD	932	10	106	487	332	30	2	2	1
MWA	157	0	16	93	50	1	0	0	0
PWA	111	0	5	52	48	7	0	0	0
DOH	83	2	15	50	20	3	1	1	1
ARD	93	0	11	49	32	1	1	0	0
IEAT	80	0	27	41	4	0	0	0	0

Table 5.2.3 DISTRIBUTION OF 10,772 PRIVATE WELLS IN THE STUDY AREA BY CHANGWAT, BY AQUIFER, AND BY TYPE OF USER.

Changwat	Total Number of Wells	AQUIFER Bangkok	Phra Pradaeng	Nakhon Luang	Nontha-buri	Samkhok	Phyathai	Thonburi	Pak Nam
Bangkok	4,853	443	1,615	2,547	528	9	1	11	5
Domestic	2600	238	838	1,416	284	3	1	6	1
Institutional	285	7	66	164	58	2	0	1	0
Commercial	667	31	158	442	71	4	0	2	0
Industrial	1301	167	553	525	115	0	0	2	4
Nonthaburi	395	19	4	102	286	16	0	0	0
Domestic	202	3	2	65	150	5	0	0	0
Institutional	24	1	0	11	14	0	0	0	0
Commercial	37	0	0	6	28	5	0	0	0
Industrial	132	15	2	20	94	6	0	0	0
Pathum Thani	856	1	29	490	279	97	24	3	1
Domestic	293	0	7	197	98	14	0	0	0
Institutional	43	0	4	28	10	3	1	0	0
Commercial	123	1	2	65	49	14	1	0	0
Industrial	397	0	16	200	122	66	22	3	1
Samut Prakan	3,669	288	2,284	1,178	141	17	1	2	15
Domestic	1452	117	967	421	36	4	0	0	0
Institutional	89	5	56	25	4	0	0	0	4
Commercial	231	23	132	87	4	0	0	0	0
Industrial	1897	143	1,129	645	97	13	1	2	11
Samut Sakhon	883	1	101	473	338	10	4	5	0
Domestic	261	0	49	145	79	0	0	0	0
Institutional	18	0	2	8	9	0	0	0	0
Commercial	66	0	6	29	32	0	0	2	0
Industrial	538	1	44	291	218	10	4	3	0
Ayutthaya	116	1	7	95	15	1	0	0	0
Domestic	36	0	1	31	4	0	0	0	0
Institutional	2	0	1	0	1	1	0	0	0
Commercial	24	0	0	20	5	0	0	0	0
Industrial	54	1	5	44	5	0	0	0	0
Study Area	10,772	753	4,040	4,885	1,587	150	30	21	21
Domestic	4,844	358	1,864	2,275	651	26	1	6	1
Institutional	461	13	129	236	96	6	1	1	4
Commercial	1,148	55	298	649	189	23	1	4	0
Industrial	4,319	327	1,749	1,725	651	95	27	10	16

Note: No private well was inventoried in Nakhon Pathom and Chachoengsao.

Table 5.2.4 DISTRIBUTION OF PUBLIC WELLS IN THE STUDY AREA BY CHANGWAT, BY AQUIFER, AND BY AGENCY.

Changwat	Total Number of Wells	AQUIFER Bangkok	Phra Pradaeng	Nakhon Luang	Nontha-buri	Samkhok	Phyathai	Thonburi	Pak Nam
Bangkok	163	1	25	98	41	1	0	0	1
DMR	14	0	4	7	2	0	0	0	0
PWD	13	1	1	6	5	1	0	0	1
MWA	122	0	8	82	34	0	0	0	0
PWA	0	0	0	0	0	0	0	0	0
DOH	0	0	0	0	0	0	0	0	0
ARD	0	0	0	0	0	0	0	0	0
IEAT	14	0	12	3	0	0	0	0	0
Nonthaburi	78	0	1	19	59	3	0	0	0
DMR	5	0	1	2	1	0	0	0	0
PWD	55	0	0	13	44	2	0	0	0
MWA	18	0	0	3	14	1	0	0	0
PWA	1	0	0	1	0	0	0	0	0
DOH	0	0	0	0	0	0	0	0	0
ARD	0	0	0	0	0	0	0	0	0
IEAT	0	0	0	0	0	0	0	0	0
Pathum Thani	198	1	14	60	53	22	1	2	0
DMR	64	1	8	13	2	2	0	0	0
PWD	81	0	4	35	29	14	1	2	
MWA	0	0	0	0	0	0	0	0	0
PWA	42	0	2	12	22	6	0	0	0
DOH	0	0	0	0	0	0	0	0	0
ARD	0	0	0	0	0	0	0	0	0
IEAT	11	0	0	0	0	0	0	0	0
Samut Prakan	175	11	115	46	8	0	0	0	0
DMR	26	4	14	4	0	0	0	0	0
PWD	109	7	78	28	2	0	0	0	0
MWA	17	0	8	8	2	0	0	0	0
PWA	0	0	0	0	0	0	0	0	0
DOH	0	0	0	0	0	0	0	0	0
ARD	0	0	0	0	0	0	0	0	0
IEAT	23	0	15	6	4	0	0	0	0
Samut Sakhon	145	1	10	106	36	1	0	0	0
DMR	6	0	1	2	2	0	0	0	0
PWD	123	1	9	95	27	1	0	0	0
MWA	0	0	0	0	0	0	0	0	0
PWA	16	0	0	9	7	0	0	0	0
DOH	0	0	0	0	0	0	0	0	0
ARD	0	0	0	0	0	0	0	0	0
IEAT	0	0	0	0	0	0	0	0	0
Ayutthaya	94	0	18	62	12	0	1	0	0
DMR	41	0	16	16	8	0	0	0	0
PWD	29	0	2	24	3	0	0	0	0
MWA	0	0	0	0	0	0	0	0	0
PWA	4	0	0	4	0	0	0	0	0
DOH	0	0	0	0	0	0	0	0	0
ARD	11	0	0	9	1	0	1	0	0
IEAT	9	0	0	9	0	0	0	0	0
Nakhon Pathom	27	0	6	19	2	0	0	0	0
DMR	16	0	4	11	1	0	0	0	0
PWD	0	0	0	0	0	0	0	0	0
MWA	0	0	0	0	0	0	0	0	0
PWA	4	0	2	4	1	0	0	0	0
DOH	4	0	0	4	0	0	0	0	0
ARD	0	0	0	0	0	0	0	0	0
IEAT	0	0	0	0	0	0	0	0	0
Chachoengsao	4	3	0	0	1	0	0	0	0
DMR	4	3	0	0	1	0	0	0	0
PWD	0	0	0	0	0	0	0	0	0
MWA	0	0	0	0	0	0	0	0	0
PWA	0	0	0	0	0	0	0	0	0
DOH	0	0	0	0	0	0	0	0	0
ARD	0	0	0	0	0	0	0	0	0
IEAT	0	0	0	0	0	0	0	0	0
Study Area	884	17	189	410	212	27	2	2	1
DMR	176	8	48	55	17	2	0	0	0
PWD	410	9	94	201	110	18	1	2	1
MWA	157	0	16	93	50	1	0	0	0
PWA	70	0	4	30	30	6	0	0	0
DOH	4	0	0	4	0	0	0	0	0
ARD	11	0	0	9	1	0	1	0	0
IEAT	57	0	27	18	4	0	0	0	0

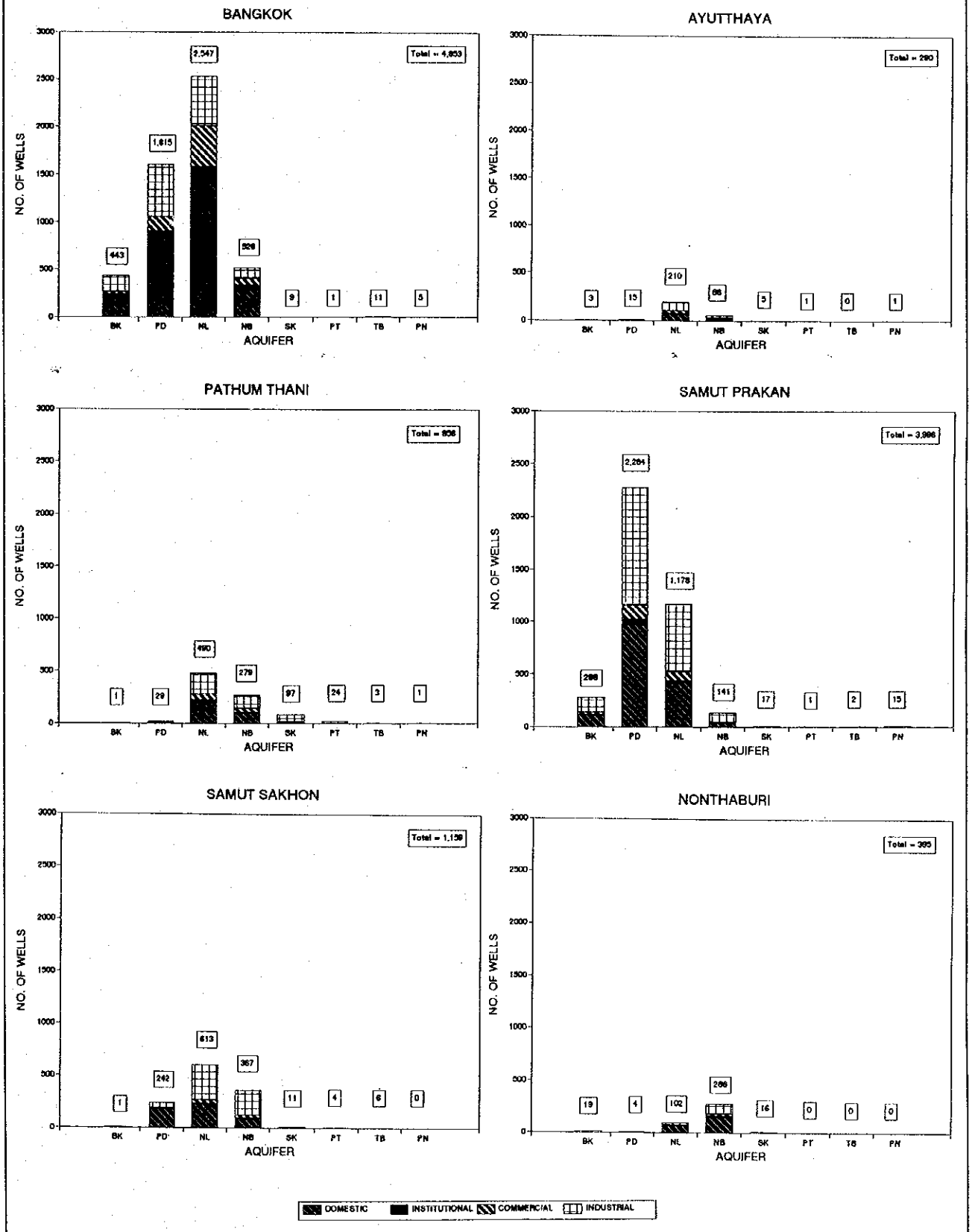


Figure 5.2.1	DISTRIBUTION OF PRIVATE WELLS IN THE WHOLE AREA
THE STUDY ON MANAGEMENT OF GROUNDWATER AND LAND SUBSIDENCE IN THE BANGKOK METROPOLITAN AREA AND ITS VICINITY	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	KOKUSAI KOGYO CO., LTD.

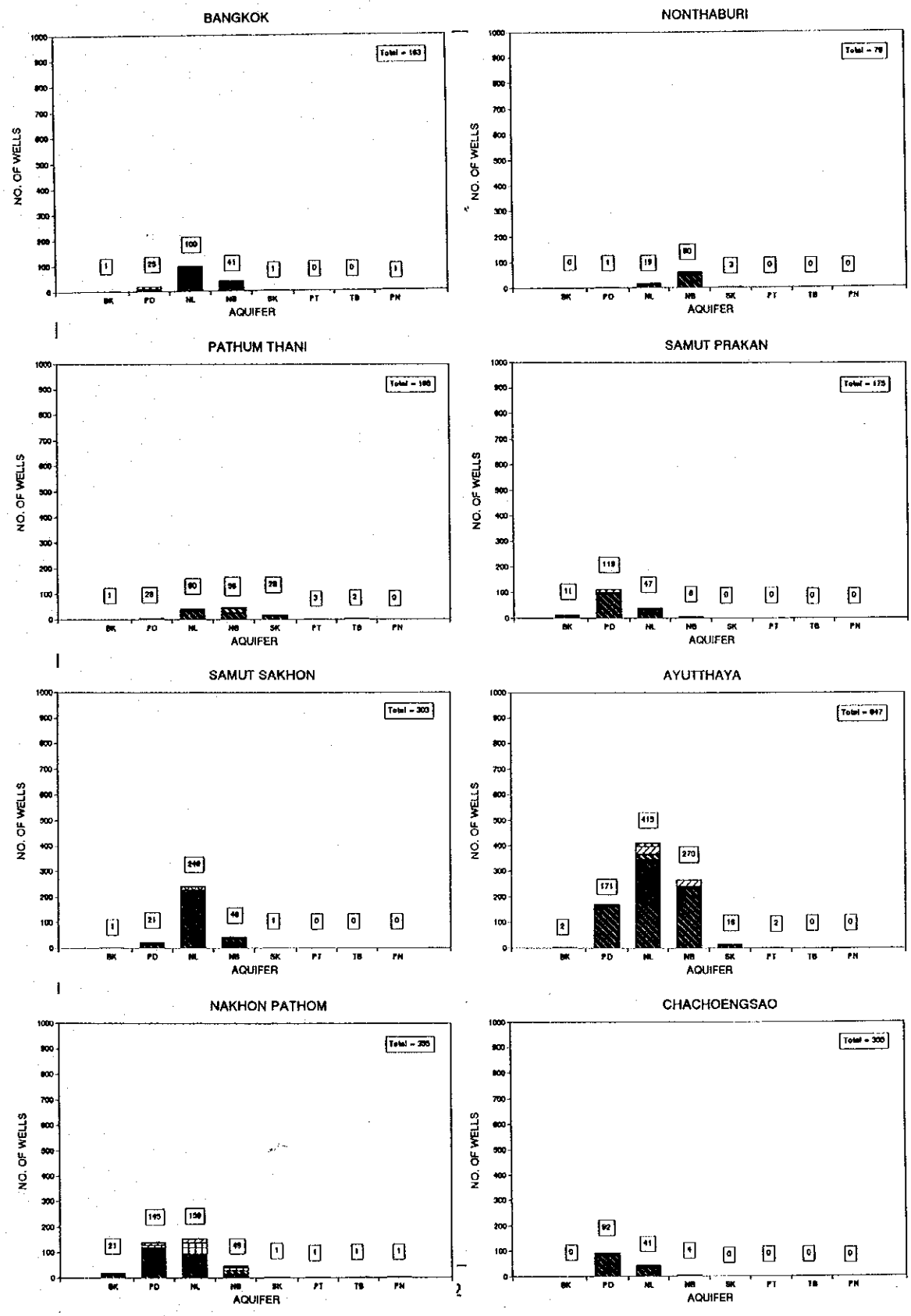


Figure 5.2.2 DISTRIBUTION OF PUBLIC WELLS IN THE WHOLE AREA

THE STUDY ON MANAGEMENT OF GROUNDWATER AND LAND SUBSIDENCE IN THE BANGKOK METROPOLITAN AREA AND ITS VICINITY

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA) | KOKUSAI KOGYO CO., LTD.

5.3 Historical Groundwater Pumpage Estimations

5.3.1 Objective

The 1983-1992 historical groundwater pumpage records were estimated to provide basic data for groundwater simulation studies, i.e. for the calibration and verification of groundwater model, and also for generation of future pumpage scenarios.

5.3.2 Methodology

For private wells, the volume of groundwater permitted by the Groundwater Committee, as stipulated in the water rights, multiplied by a certain groundwater pumpage coefficient (GPC) which depends on the type of groundwater use, gives the daily pumpage estimates. This GPC is the average ratio of the actual pumpage to the volume permitted. Actual pumpage data were obtained from metered private wells. Table 5.3.1 shows the GPCs derived for every type of groundwater use. Overall average of GPCs is 0.66.

Two (2) cases of historical daily groundwater pumpage estimates were considered for private wells:

Case 1: Assumes that all private wells with permits that have expired and have not been extended shall become inactive or abandoned. Estimates are based on the years of issuance, expiration and extension of water rights and the volume permitted multiplied by the GPC.

Case 2: Considers that well owners shall continue using groundwater even after the expiration of their water rights for there is still an inadequate supply of surface water. Estimates are based on either the year of issuance of water permit or the year of completion of well construction and the volume permitted multiplied by the GPC.

In making *Case 1*, the Study Team basically considered the Thai Government's policy concerning the issuance of water rights to private well owners, i.e., private well owners are allowed to use their wells for only ten years. While the Study Team considered three (3) factors in making *Case 2*: first, the historical behavior of most groundwater levels in the Study Area, which were monitored in areas outside central Bangkok to be continuously declining since 1987; second, the inadequacy of surface water supply as mentioned above; and third, the high rate of economic growth being experienced by Thailand since 1987.

On the other hand, the unknown actual number of abandoned or inactive wells should compensate the unknown number of active unregistered private wells. For this reason, it was assumed that all inventoried private deep wells were operational in both *Cases 1* and *2*.

For public wells, monthly discharge records stored in the well inventory database were used for the computation of historical groundwater pumpage. In the absence of actual pumpage records, historical daily pumpage was estimated using the well yield data obtained during pumping test, the number of hours of operation per day, and the year the well was constructed.

5.3.3 Results of Estimations

The results presented in this chapter are limited to the distributions of groundwater pumpage estimates by changwat and by type of users. The distributions by aquifer type and by x and y coordinates are given and discussed in Chapter 7 for the groundwater simulation studies.

(1) Private Wells

Case 1:

Comparing the results shown in Table 5.3.2 for the Whole Area and Table 5.3.3 for the Study Area, the difference which represents the pumpage estimates outside the Study Area is less than 7% of the pumpage estimates for the Study Area. Except for this difference, the year-to-year pattern of groundwater withdrawals for the Study Area is similar to that for the Whole Area, as shown in Figure 5.3.1.

The groundwater withdrawals for the Whole Area increased steadily from 640,375 CMD (630,619 CMD for the Study Area) in 1980, peaked to 838,610 CMD (821,952 CMD) in 1988, started declining in 1989, and decreased abruptly between 1989 and 1990 by 22.1% (23.4% for the Study Area) mainly due to the supposed abandonment of wells with expired water permits. By the year-1992, the groundwater pumpage was estimated at 645,053 CMD for the Whole Area and 603,588 CMD for the Study Area. For the Study Area, the pumpage estimate for year-1992 is lower than that for year-1983. On the contrary, the pumpage estimates for the Whole Area has risen for the same period because of the contributions outside the Study Area. Among user-types, only industrial wells had shown a rise in pumpage between 1983 and 1992.

Figure 5.3.2 indicates that most private wells with expired water permits were located in Bangkok and Samut Prakan, with pumpage in Bangkok decreasing by 55% and in Samut Prakan by 24% between 1988 and 1990. However, the historical trend of groundwater use in other provinces had continued to rise even after 1988, and the effect of retiring expired wells was not as significant as in Bangkok and Samut Prakan.

All user-types in Bangkok indicated a decline in abstractions of more than 50% in the period 1983-1992. In Nonthaburi and Samut Prakan, commercial and industrial groundwater uses had increased, while domestic and institutional uses had decreased for the same period. However, groundwater withdrawals by all user-types had risen more than double in Pathum Thani, Samut Sakhon and Ayutthaya.

Case 2:

The historical records of groundwater pumpage as calculated using *Case 2* for both Whole Area and Study Area had patterns similar to the one shown in Figure 5.3.3. As in *Case 1*, they differed only in the pumpage volume outside the Study Area, which is the pumpage for the Whole Area minus the pumpage for the Study Area.

As shown in Table 5.3.4 and Figure 5.3.3, the rate of increase in the total groundwater withdrawal is higher after 1987 (about 7.5%) than before 1987 (about 5%). This phenomenon after 1987 can be attributed to the fact that Thailand experienced an unexpected high economic growth.

The total groundwater withdrawals for the Whole Area increased from 640,375 CMD in 1983 to 1,171,321 CMD in 1992. In the Study Area, the total use of groundwater had increased 177.8% (or by 490,685 CMD) from 630,620 CMD to 1,121,305 CMD for the same period. About 61.4% of this increase was contributed by Samut Prakan (167,859 CMD) and Pathum Thani (133,196 CMD). The total industrial use increased 182.6% (or by 329,758 CMD) from 398,997 CMD in 1983 to 728,755 CMD in 1992. While the total domestic use had risen 175.5% (or by 115,089 CMD), the total institutional use 145.2% (or by 14,936 CMD) and the total commercial use 167% (or by 30,902 CMD).

As shown in Figure 5.3.4, Bangkok registered the lowest rate of increase in pumpage with 131.1% between 1983 and 1992, while the other provinces increased more than 150%. Ayutthaya and Samut Sakhon had the first two highest rates of increase with 522.4% and 334%, respectively, which were largely contributed by industries. Samut Prakan registered the highest increase in pumpage volume at 167,859 CMD; 83.6% of which was contributed by industries. The heavy industrial use of groundwater after 1987 was dominant in Samut Prakan, Pathum Thani and Samut Sakhon.

The inactivation or abandonment of wells with expired water permits as assumed in *Case 1* should have indicated a recovery of groundwater levels in or after 1989. On the contrary, groundwater level records in 67% of the 84 DMR monitoring stations have shown a steady decline in groundwater levels since 1987, 18% a recovery in 1990-91 but a decline after 1991, and 15% neither a decline nor a recovery from 1987 to 1991 but a decline after 1991. As presented in Table 5.3.6, recoveries were indicated only in 14 out of 34 monitoring stations in Bangkok, while only declines, except for one well, were observed in the other provinces. These statistics have shown that groundwater withdrawal is continuously increasing as assumed in *Case 2*. Since it was also in good agreement with the results of the groundwater simulation studies, *Case 2* therefore was considered as the most probable historical pattern of groundwater withdrawal in the Study Area.

(2) Public Wells

For both the Whole Area and Study Area, the groundwater pumpage estimates for DMR, PWD, PWA, IEAT, DOH, and ARD showed a year-to-year increasing pattern, while MWA showed a historical decreasing trend. This is shown in Tables 5.3.7 and 5.3.8 and Figures 5.3.5 and 5.3.6. Combined withdrawals of all public wells reflected the historical trend of that of MWA because its withdrawals as compared with those of other agencies were much larger.

The historical decline of MWA pumpage was due to the Cabinet Resolution of March 1983 directing MWA to phase out all public wells in the defined Critical Zones 1 and 2 by the end of 1987. The MWA had substantially reduced the use of groundwater from 1983 to 1990. The amount of groundwater phased out was replaced by treated surface water. However, the 1991 to 1993 records showed that MWA had increased again its groundwater abstraction to meet the increasing water demands.

In the Study Area, PWD wells pumped out groundwater heavily in Samut Sakhon amd Samut Prakan for domestic use. MWA supplies Bangkok, Samut Prakan and Nonthaburi with groundwater. It is noted however that beginning 1989 in the Study Area, the withdrawal of PWD was higher than that of MWA. PWA withdrew heavily in Samut Sakhon and Pathum

Thani, while IEAT exploited groundwater in Bangkok, Samut Prakan, Pathum Thani and Ayutthaya for industrial purpose. The combined pumpage of DOH and ARD was small as compared with those of other agencies.

The DMR, PWD, PWA, DOH and ARD wells produced much more groundwater outside than inside the Study Area (266,249 CMD against 177,127 CMD).

(3) Combined total groundwater pumpage of both private and public wells

The combined total historical groundwater withdrawals of both private and public wells were generated using *Case 2*. They are shown in Table 5.3.9 and Figure 5.3.7.

The historical patterns for the Whole Area and the Study Area showed a drop in groundwater withdrawal between 1985 and 1986 as influenced by the abrupt decline of MWA extraction in the same period for the reason mentioned above.

The total groundwater withdrawals for the Whole Area increased from 1,277,499 CMD in 1983 to 1,799,596 CMD in 1992. In the Study Area, the total use of groundwater had increased 132.6% from 1,117,028 CMD to 1,481,061 CMD for the same period.

Table 5.3.1 GROUNDWATER PUMPAGE COEFFICIENTS

Code		Type of User	No. of Wells	Ave. Coef.	Std. Dev.
11	DOMESTIC	: Residences, dormitories, courts, subdivisions, condominiums	38	0.621	0.582
21	INSTITUTIONAL	: Schools, public administration buildings, hospitals, etc.	16	0.443	0.307
31	COMMERCIAL	: Office buildings, malls, hotels, clubs, etc.	42	0.746	0.556
41	INDUSTRIAL	: Basic factory requirement for drinking and sanitation	5	0.741	0.358
42	INDUSTRIAL	: Manufacture of soft drinks	8	0.472	0.166
43	INDUSTRIAL	: Food processing and icemaking	55	0.790	1.041
44	INDUSTRIAL	: Textile industry, nylons	71	0.648	0.656
45	INDUSTRIAL	: Wearing apparels, garments	15	0.741	0.366
46	INDUSTRIAL	: Manufacture of leather products	3	0.755	0.331
47	INDUSTRIAL	: Manufacture of wood products	10	0.780	0.417
48	INDUSTRIAL	: Manufacture of paper and paper products	9	0.495	0.287
49	INDUSTRIAL	: Printing	1	0.700	
50	INDUSTRIAL	: Chemical industry and chemical products	56	0.554	0.510
51	INDUSTRIAL	: Rubber industry and rubber products	15	0.604	0.339
52	INDUSTRIAL	: Plastic products, footwear, insulators, carpets	19	0.466	0.322
53	INDUSTRIAL	: Manufacture of non-metal products, fibers, etc.	38	0.552	0.324
54	INDUSTRIAL	: Manufacture of basic metal products, steel bars	11	0.788	0.380
55	INDUSTRIAL	: Manufacture of metal products	20	0.416	0.225
56	INDUSTRIAL	: Manufacture of mechanical, electrical, and computer products	28	0.673	0.754
57	INDUSTRIAL	: Manufacture, assembly and repair of vehicles	11	0.881	1.631
58	INDUSTRIAL	: Manufacture of grain mill products	2	0.624	0.083
59	INDUSTRIAL	: Agriculture and farm products	14	0.840	0.738
60	INDUSTRIAL	: Industrial estates	3	0.666	0.215
61	INDUSTRIAL	: Tobacco	1	0.477	
62	INDUSTRIAL	: Power plant	1	1.094	
63	INDUSTRIAL	: Others	59	0.587	0.457

BASIS: DMR-registered private wells quarterly groundwater pumpage records and volume permitted data from from the database

Table 5.3.2 CASE 1 HISTORICAL PUMPAGE ESTIMATES FOR PRIVATE WELLS IN THE WHOLE AREA

Changwat	Type of User	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Bangkok	Domestic	103,618	111,875	115,392	117,387	121,198	124,145	104,543	45,844	47,792	43,590
	Institutional	25,996	27,885	30,264	33,126	33,330	33,977	28,146	18,812	17,969	11,717
	Commercial	37,064	37,431	38,204	38,679	38,810	38,999	31,689	15,625	14,170	9,925
	Industrial	103,080	105,362	108,579	110,649	111,473	114,607	94,034	59,983	57,681	50,132
	TOTAL	269,758	282,553	292,439	299,841	304,811	311,728	258,412	140,264	137,612	115,364
Nonthaburi	Domestic	12,853	14,192	14,630	15,531	16,731	17,662	16,345	13,480	14,092	11,360
	Institutional	2,126	2,126	2,126	2,126	2,161	2,166	1,807	831	814	741
	Commercial	272	272	292	328	373	425	374	1,600	1,981	2,126
	Industrial	8,446	9,301	10,036	11,006	11,042	11,924	9,467	8,273	8,788	9,468
	TOTAL	23,697	25,891	27,084	28,991	30,307	32,177	27,993	24,184	25,675	23,695
Pathum Thani	Domestic	6,118	7,267	8,269	10,991	12,757	20,753	24,185	25,181	34,182	38,923
	Institutional	2,412	3,415	3,415	3,424	4,416	4,474	4,694	3,777	4,313	4,321
	Commercial	1,501	2,721	2,758	3,150	3,177	4,214	8,525	8,545	9,130	11,278
	Industrial	73,834	77,223	80,850	85,124	87,707	94,196	105,304	99,583	104,469	93,446
	TOTAL	83,865	90,626	95,292	102,689	108,057	123,637	142,708	137,086	152,094	147,968
Samut Prakan	Domestic	28,316	29,558	30,578	33,950	36,052	38,415	33,366	19,889	22,263	20,036
	Institutional	2,355	2,837	3,900	3,900	3,999	4,079	3,827	2,162	2,236	1,962
	Commercial	6,444	6,837	7,297	7,436	7,859	7,997	7,529	4,924	6,996	7,455
	Industrial	182,341	207,495	219,083	226,385	236,419	244,282	238,657	195,582	200,807	190,257
	TOTAL	219,456	246,727	260,858	271,671	284,329	294,773	283,379	222,557	232,302	219,710
Samut Sakhon	Domestic	2,113	2,152	2,186	2,601	3,234	4,063	3,773	4,524	8,802	10,395
	Institutional	255	274	299	299	299	312	175	194	1,575	1,575
	Commercial	353	476	789	1,259	1,361	1,399	1,535	2,002	3,267	4,795
	Industrial	35,710	38,230	43,452	47,342	52,541	59,559	69,454	70,302	70,472	79,188
	TOTAL	38,431	41,132	46,726	51,501	57,435	65,333	74,937	77,022	84,116	95,953
Ayutthaya	Domestic	211	228	228	310	310	502	593	1,718	4,508	4,795
	Institutional	27	71	71	122	432	432	462	462	618	618
	Commercial	654	676	836	1,373	1,376	1,559	1,803	1,652	1,726	3,127
	Industrial	4,276	4,937	6,475	7,801	7,913	8,469	10,459	18,867	31,653	33,823
	TOTAL	5,168	5,912	7,610	9,606	10,031	10,962	13,317	22,699	38,505	42,363
Whole Area	Domestic	153,229	165,272	171,283	180,770	190,282	205,540	182,805	110,636	131,639	129,099
	Institutional	33,171	36,608	40,075	42,997	44,637	45,440	39,111	26,238	27,525	20,934
	Commercial	46,288	48,413	50,176	52,225	52,956	54,593	51,455	34,348	37,270	38,706
	Industrial	407,687	442,548	468,475	488,307	507,095	533,037	527,375	452,590	473,870	456,314
	TOTAL	640,375	692,841	730,009	764,299	794,970	838,610	800,746	623,812	670,304	645,053

Note: No private well was inventoried in Nakhon Pathom and Chachoengsao.
UNITS: PUMPAGE IN CUBIC METERS PER DAY (CMD)

Table 5.3.3 CASE 1 HISTORICAL PUMPAGE ESTIMATES FOR PRIVATE WELLS IN THE STUDY AREA

Changwat	Type of User	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Bangkok	Domestic	103,618	111,875	115,392	117,387	121,198	124,145	104,543	45,844	47,792	43,590
	Institutional	25,996	27,885	30,264	33,126	33,330	33,977	28,146	18,812	17,969	11,717
	Commercial	37,064	37,431	38,204	38,679	38,810	38,999	31,689	15,625	14,170	9,925
	Industrial	103,080	105,362	108,579	110,649	111,473	114,607	94,034	59,983	57,681	50,132
	TOTAL	269,758	282,553	292,439	299,841	304,811	311,728	258,412	140,264	137,612	115,364
Nonthaburi	Domestic	12,853	14,192	14,630	15,531	16,731	17,662	16,345	13,480	14,092	11,360
	Institutional	2,126	2,126	2,126	2,126	2,161	2,166	1,807	831	814	741
	Commercial	272	272	292	328	373	425	374	1,600	1,981	2,126
	Industrial	8,446	9,301	10,036	11,006	11,042	11,924	9,467	8,273	8,788	9,468
	TOTAL	23,697	25,891	27,084	28,991	30,307	32,177	27,993	24,184	25,675	23,695
Pathum Thani	Domestic	6,118	7,267	8,269	10,991	12,757	20,753	24,185	25,182	34,182	38,923
	Institutional	2,412	3,415	3,415	3,424	4,416	4,474	4,694	3,777	4,313	4,321
	Commercial	1,501	2,721	2,758	3,150	3,177	4,214	8,525	8,545	9,130	11,278
	Industrial	73,834	77,223	80,850	85,124	87,707	94,196	105,304	99,583	104,469	93,446
	TOTAL	83,865	90,626	95,292	102,689	108,057	123,637	142,708	137,087	152,094	147,968
Samut Prakan	Domestic	28,316	29,558	30,578	33,950	36,052	38,415	33,368	19,890	22,263	20,036
	Institutional	2,355	2,837	3,900	3,900	3,999	4,079	3,827	2,162	2,236	1,962
	Commercial	6,444	6,837	7,297	7,436	7,859	7,997	7,529	4,924	6,996	7,455
	Industrial	182,341	207,495	218,083	226,385	236,419	244,282	238,657	195,583	200,807	190,257
	TOTAL	219,456	246,727	259,858	271,671	284,329	294,773	283,381	222,559	232,302	219,710
Samut Sakhon	Domestic	1,409	1,427	1,460	1,859	2,476	3,212	3,252	4,206	8,021	9,453
	Institutional	119	119	144	144	144	157	152	176	1,557	1,557
	Commercial	349	472	778	1,248	1,350	1,388	1,513	1,980	3,233	4,264
	Industrial	28,182	29,705	33,078	36,869	41,593	47,654	55,448	55,606	59,418	63,779
	TOTAL	30,059	31,723	35,460	40,120	45,563	52,411	60,365	61,968	72,229	79,053
Ayutthaya	Domestic	166	166	166	173	173	279	285	1,300	3,719	3,847
	Institutional	0	44	44	44	44	44	354	354	361	383
	Commercial	504	504	504	810	814	870	927	778	815	1,481
	Industrial	3,114	3,438	4,406	5,483	5,595	6,033	7,020	10,241	12,205	12,087
	TOTAL	3,784	4,152	5,120	6,510	6,626	7,226	8,586	12,673	17,100	17,798
Study Area	Domestic	152,480	164,485	170,495	179,891	189,387	204,466	181,978	109,902	130,069	127,209
	Institutional	33,008	36,426	39,893	42,764	44,094	44,897	38,980	26,112	27,250	20,681
	Commercial	46,134	48,237	49,833	51,651	52,383	53,893	50,557	33,452	36,325	36,529
	Industrial	398,997	432,524	455,032	475,516	493,829	518,696	509,930	429,269	443,368	419,169
	TOTAL	630,619	681,672	715,253	749,822	779,693	821,952	781,445	598,735	637,012	603,588

Note: No private well was inventoried in Nakhon Pathom and Chachoengsao.
UNITS: PUMPAGE IN CUBIC METERS PER DAY (CMD)

Table 5.3.4 CASE 2 HISTORICAL PUMPAGE ESTIMATES FOR PRIVATE WELLS IN THE WHOLE AREA

Changwat	Type of User	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Bangkok	Domestic	103,621	111,877	115,395	117,389	121,200	124,148	127,882	130,524	137,558	141,631
	Institutional	25,996	27,885	30,264	33,126	33,330	33,977	34,056	34,118	34,287	34,318
	Commercial	37,064	37,431	38,204	38,679	38,810	38,999	39,778	39,881	41,352	42,867
	Industrial	103,081	105,362	108,579	110,649	111,473	114,608	120,903	126,773	132,083	134,755
	TOTAL	269,762	282,556	292,442	299,844	304,813	311,731	322,620	331,295	345,280	353,570
Nonthaburi	Domestic	12,853	14,192	14,630	15,531	16,731	17,662	19,434	20,980	21,703	22,542
	Institutional	2,126	2,126	2,126	2,126	2,161	2,166	2,166	2,166	2,211	2,211
	Commercial	272	272	292	328	373	425	463	1,730	2,110	2,271
	Industrial	8,446	9,301	10,036	11,006	11,042	11,924	12,215	13,461	14,616	16,186
	TOTAL	23,697	25,890	27,084	28,992	30,308	32,178	34,278	38,337	40,640	43,209
Pathum Thani	Domestic	6,118	7,267	8,269	10,991	12,757	20,753	24,961	27,975	37,013	41,902
	Institutional	2,412	3,415	3,415	3,424	4,416	4,474	4,713	4,793	5,329	5,373
	Commercial	1,501	2,721	2,758	3,150	3,177	4,214	8,545	8,948	10,155	12,431
	Industrial	73,834	77,223	80,850	85,124	87,707	94,196	112,454	124,849	143,255	157,355
	TOTAL	83,865	90,626	95,292	102,689	108,058	123,637	150,672	166,564	195,752	217,061
Samut Prakan	Domestic	28,318	29,559	30,579	33,952	36,054	38,417	40,219	42,856	46,208	47,022
	Institutional	2,355	2,837	3,900	3,900	3,999	4,079	4,123	4,136	4,264	4,300
	Commercial	6,444	6,837	7,297	7,436	7,859	7,997	8,158	9,079	11,713	13,256
	Industrial	182,341	207,495	219,084	226,385	236,420	244,283	260,566	287,465	315,423	322,787
	TOTAL	219,458	246,728	260,860	271,673	284,332	294,776	313,065	343,535	377,608	387,364
Samut Sakhon	Domestic	2,113	2,152	2,186	2,602	3,235	4,063	4,316	5,960	10,400	12,180
	Institutional	257	274	299	299	299	312	312	400	1,831	1,831
	Commercial	353	476	789	1,259	1,361	1,399	1,561	2,255	3,520	5,084
	Industrial	35,710	38,230	43,452	47,342	52,541	59,559	72,695	84,056	93,760	104,917
	TOTAL	38,432	41,132	46,726	51,502	57,436	65,333	78,884	92,671	109,511	124,013
Ayutthaya	Domestic	211	228	228	310	310	502	593	1,893	4,691	4,994
	Institutional	27	71	71	122	432	432	462	462	622	645
	Commercial	654	676	836	1,373	1,376	1,559	1,805	1,869	1,943	3,367
	Industrial	4,276	4,937	6,475	7,801	7,913	8,469	12,403	21,057	33,926	37,098
	TOTAL	5,167	5,912	7,609	9,606	10,032	10,962	15,264	25,281	41,182	46,104
Whole Area	Domestic	153,234	165,276	171,287	180,776	190,287	205,545	217,404	230,186	257,573	270,271
	Institutional	33,172	36,608	40,075	42,996	44,638	45,439	45,832	46,076	48,545	48,678
	Commercial	46,287	48,412	50,176	52,225	52,957	54,594	60,311	63,762	70,793	79,275
	Industrial	407,688	442,548	468,476	488,309	507,097	533,039	591,238	657,660	733,062	773,098
	TOTAL	640,381	692,844	730,014	764,305	794,979	838,617	914,784	997,684	1,109,973	1,171,321

Note: No private well was inventoried in Nakhon Pathom and Chachoengsao.
UNITS: PUMPAGE IN CUBIC METERS PER DAY (CMD)

Table 5.3.5 CASE 2 HISTORICAL PUMPAGE ESTIMATES FOR PRIVATE WELLS IN THE STUDY AREA

Changwat	Type of User	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Bangkok	Domestic	103,619	111,875	115,392	117,387	121,198	124,145	127,879	130,521	137,555	141,628
	Institutional	25,996	27,885	30,264	33,126	33,330	33,977	34,056	34,118	34,287	34,318
	Commercial	37,064	37,431	38,204	38,679	38,810	38,999	39,778	39,881	41,352	42,867
	Industrial	103,080	105,362	108,579	110,649	111,473	114,607	120,903	126,773	132,083	134,755
	TOTAL	269,759	282,553	292,439	299,841	304,811	311,728	322,616	331,293	345,277	353,568
Nonthaburi	Domestic	12,853	14,192	14,630	15,531	16,731	17,662	19,433	20,980	21,703	22,542
	Institutional	2,126	2,126	2,126	2,126	2,161	2,166	2,166	2,166	2,211	2,211
	Commercial	272	272	292	328	373	425	463	1,730	2,110	2,270
	Industrial	8,446	9,301	10,036	11,006	11,042	11,924	12,215	13,461	14,616	16,186
	TOTAL	23,697	25,891	27,084	28,991	30,307	32,177	34,277	38,337	40,640	43,209
Pathum Thani	Domestic	6,118	7,267	8,269	10,991	12,757	20,753	24,961	27,975	37,012	41,902
	Institutional	2,412	3,415	3,415	3,424	4,416	4,474	4,713	4,793	5,329	5,373
	Commercial	1,501	2,721	2,758	3,150	3,177	4,214	8,545	8,948	10,155	12,431
	Industrial	73,834	77,223	80,850	85,124	87,707	94,196	112,454	124,848	143,255	157,355
	TOTAL	83,865	90,626	95,292	102,689	108,057	123,637	150,673	166,564	195,751	217,061
Samut Prakan	Domestic	28,316	29,558	30,578	33,950	36,052	38,415	40,217	42,854	46,206	47,020
	Institutional	2,355	2,837	3,900	3,900	3,999	4,079	4,123	4,136	4,264	4,300
	Commercial	6,444	6,837	7,297	7,436	7,859	7,997	8,158	9,079	11,713	13,256
	Industrial	182,341	207,495	218,083	226,385	236,419	244,282	260,514	287,412	315,370	322,734
	TOTAL	219,456	246,727	259,858	271,671	284,329	294,773	313,012	343,481	377,553	387,310
Samut Sakhon	Domestic	1,409	1,427	1,460	1,859	2,476	3,212	3,448	5,089	9,033	10,609
	Institutional	119	119	144	144	144	157	157	245	1,676	1,676
	Commercial	349	472	778	1,248	1,350	1,388	1,535	2,229	3,482	4,550
	Industrial	28,182	29,705	33,078	36,869	41,593	47,654	58,417	68,984	76,865	83,556
	TOTAL	30,059	31,723	35,460	40,120	45,563	52,411	63,557	76,547	91,056	100,391
Ayutthaya	Domestic	166	166	166	173	173	279	279	1,446	3,748	3,869
	Institutional	0	44	44	44	44	44	44	44	44	66
	Commercial	504	504	504	810	814	870	915	944	982	1,662
	Industrial	3,114	3,438	4,406	5,483	5,595	6,033	8,830	11,390	13,437	14,169
	TOTAL	3,784	4,152	5,120	6,510	6,626	7,226	10,068	13,824	18,211	19,766
Study Area	Domestic	152,481	164,485	170,495	179,891	189,387	204,466	216,217	228,865	255,257	267,570
	Institutional	33,008	36,426	39,893	42,764	44,094	44,897	45,259	45,502	47,811	47,944
	Commercial	46,134	48,237	49,833	51,651	52,383	53,893	59,394	62,811	69,794	77,036
	Industrial	398,997	432,524	455,032	475,516	493,829	518,696	573,333	632,868	695,626	728,755
	TOTAL	630,620	681,672	715,253	749,822	779,693	821,952	894,203	970,046	1,068,488	1,121,305

Note: No private well was inventoried in Nakhon Pathom and Chachoengsao.
UNITS: PUMPAGE IN CUBIC METERS PER DAY (CMD)

Table 5.3.6 GROUNDWATER LEVEL STATISTICS FROM 84 DMR MONITORING STATI

Changwat	Recover* in 1990-91	Decline after 1987	Neither Recover nor Decline* after 1987	Total
Bangkok	14 (41%)	13 (38%)	7 (21%)	34 (100%)
Nonthaburi		5 (100%)		5 (100%)
Pathum Thani		15 (94%)	1 (6%)	16 (100%)
Samut Prakan	1 (5%)	17 (77%)	4 (18%)	22 (100%)
Samut Sakhon		1 (50%)	1 (50%)	2 (100%)
Ayutthaya		3 (100%)		3 (100%)
Nakhon Pathom		2 (100%)		2 (100%)
Total	15 (18%)	56 (67%)	13 (15%)	84 (100%)

*Decline after 1991

Table 5.3.7 HISTORICAL PUMPAGE ESTIMATES FOR PUBLIC WELLS IN THE WHOLE AREA

Changwat	Agency	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Bangkok	DMR	2,636	2,636	2,636	2,636	2,636	2,636	2,636	2,636	2,636	2,636
	PWD	1,600	1,600	1,600	1,600	2,350	2,350	2,350	2,350	2,800	4,110
	MWA	313,946	271,513	232,598	176,251	183,472	155,776	94,664	56,070	66,009	79,937
	PWA	0	0	0	0	0	0	0	0	0	0
	DOH	0	0	0	0	0	0	0	0	0	0
	ARD	0	0	0	0	0	0	0	0	0	0
	IEAT	7,978	7,978	10,916	10,916	10,916	10,916	17,216	17,216	18,476	18,476
	TOTAL	326,160	283,727	247,750	191,403	199,374	171,678	116,866	78,272	89,921	105,159
Nonthaburi	DMR	1,023	1,023	1,023	1,023	1,023	1,023	1,023	1,023	1,023	1,023
	PWD	7,630	11,340	14,320	14,970	16,920	17,220	18,420	19,100	20,300	20,300
	MWA	48,841	49,807	34,942	1,225	1,045	1,742	2,706	3,962	4,977	5,197
	PWA	0	0	0	0	0	0	0	0	0	0
	DOH	0	0	0	0	0	0	0	0	0	0
	ARD	0	0	0	0	0	0	0	0	0	0
	IEAT	0	0	0	0	0	0	0	0	0	0
	TOTAL	57,494	62,170	50,285	17,218	18,988	19,985	22,149	24,085	26,300	26,520
Pathum Thani	DMR	1,096	1,405	1,568	1,568	1,916	1,916	2,251	2,723	3,849	5,066
	PWD	8,850	9,510	13,190	14,970	16,670	16,970	18,065	18,065	19,765	19,765
	MWA	0	0	0	0	0	0	0	0	0	0
	PWA	3,013	4,377	5,905	6,133	6,127	6,250	9,374	14,850	17,168	19,487
	DOH	0	0	0	0	0	0	0	0	0	0
	ARD	0	0	0	0	0	0	0	0	0	0
	IEAT	0	0	0	0	4,960	10,520	16,080	21,640	27,200	28,600
	TOTAL	12,959	15,292	20,663	22,671	29,673	35,656	45,770	57,278	67,983	72,918
Samut Prakan	DMR	2,450	2,450	2,450	2,450	2,450	2,450	2,577	2,699	2,699	2,790
	PWD	15,750	20,005	27,965	31,215	32,415	32,965	33,165	33,365	33,945	33,945
	MWA	28,523	35,447	32,187	16,166	22,949	24,382	13,060	12,966	17,236	20,892
	PWA	0	0	0	0	0	0	0	0	0	0
	DOH	0	0	0	0	0	0	0	0	0	0
	ARD	0	0	0	0	0	0	0	0	0	0
	IEAT	3,759	3,759	3,759	9,079	11,585	14,091	20,356	29,127	29,127	29,127
	TOTAL	50,482	61,661	66,361	58,910	69,399	73,888	69,158	78,157	83,007	86,754
Samut Sakhon	DMR	828	828	828	828	828	828	828	828	890	890
	PWD	40,163	53,113	60,423	66,723	76,563	81,368	83,408	83,408	85,468	85,468
	MWA	0	0	0	0	0	0	0	0	0	0
	PWA	9,722	9,722	9,457	10,008	9,594	9,348	9,377	9,396	9,140	9,871
	DOH	0	0	0	0	0	0	0	0	0	0
	ARD	0	0	0	0	0	0	0	0	0	0
	IEAT	0	0	0	0	0	0	0	0	0	370
	TOTAL	52,696	65,647	72,693	79,545	88,972	93,532	95,602	95,622	97,489	98,591
Ayutthaya	DMR	4,227	4,592	5,331	5,846	8,019	10,058	11,732	12,614	16,416	20,012
	PWD	101,320	110,835	118,710	126,490	147,297	156,477	158,497	161,197	170,157	170,157
	MWA	0	0	0	0	0	0	0	0	0	0
	PWA	10,346	12,438	7,957	12,438	7,957	8,255	9,948	8,772	9,657	9,948
	DOH	89	89	89	89	89	169	169	216	361	361
	ARD	0	0	0	0	0	0	0	254	386	681
	IEAT	0	0	0	0	0	0	0	0	0	2,300
	TOTAL	115,982	127,954	132,087	144,863	163,362	174,959	180,346	183,053	196,997	203,479
Nakhon Pathom	DMR	9,903	10,223	10,308	10,696	10,696	11,009	12,549	13,570	15,210	16,372
	PWD	0	0	0	0	0	0	0	0	0	0
	MWA	0	0	0	0	0	0	0	0	0	0
	PWA	11,574	11,574	11,254	11,915	11,421	11,127	11,162	11,184	10,880	11,749
	DOH	1,091	1,497	1,720	1,856	1,919	2,070	2,277	2,458	2,664	2,994
	ARD	0	0	0	0	0	0	0	342	342	363
	IEAT	0	0	0	0	0	0	0	0	0	0
	TOTAL	22,568	23,294	23,282	24,467	24,036	24,206	25,988	27,554	29,096	31,478
Chachoengsao	DMR	697	992	1,387	2,171	2,545	2,901	3,092	3,787	4,559	5,367
	PWD	0	0	0	0	0	0	0	0	0	0
	MWA	0	0	0	0	0	0	0	0	0	0
	PWA	0	0	0	0	0	0	0	0	0	0
	DOH	0	0	0	0	0	0	0	0	0	0
	ARD	0	0	0	0	0	0	0	0	0	0
	IEAT	0	0	0	0	0	0	0	0	0	0
	TOTAL	697	992	1,387	2,171	2,545	2,901	3,092	3,787	4,559	5,367
Whole Area	DMR	22,860	24,149	25,531	27,218	30,113	32,821	36,688	39,880	47,282	54,156
	PWD	175,313	206,403	236,208	255,968	292,214	307,350	313,905	317,485	332,435	333,745
	MWA	391,310	356,767	299,727	193,642	207,466	181,900	110,430	72,998	88,222	106,026
	PWA	34,655	38,111	34,573	40,494	35,099	34,980	39,861	44,202	46,845	51,055
	DOH	1,180	1,586	1,809	1,945	2,008	2,239	2,446	2,674	3,046	3,376
	ARD	0	0	0	0	0	0	0	596	728	1,044
	IEAT	11,737	11,737	14,675	19,995	27,461	35,527	53,652	67,983	74,803	78,873
	TOTAL	639,038	640,737	614,507	541,248	596,349	596,804	558,970	547,807	595,351	630,267

UNITS: PUMPAGE IN CUBIC METERS PER DAY (CMD)

Table 5.3.8 HISTORICAL PUMPAGE ESTIMATES FOR PUBLIC WELLS IN THE STUDY AREA

Changwat	Agency	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Bangkok	DMR	2,516	2,516	2,516	2,516	2,516	2,516	2,516	2,516	2,516	2,516
	PWD	1,600	1,600	1,600	1,600	2,350	2,350	2,350	2,350	2,800	4,110
	MWA	313,946	271,513	232,598	176,251	183,472	155,776	94,664	56,070	66,009	79,937
	PWA	0	0	0	0	0	0	0	0	0	0
	DOH	0	0	0	0	0	0	0	0	0	0
	ARD	0	0	0	0	0	0	0	0	0	0
	IEAT	7,978	7,978	10,916	10,916	10,916	10,916	17,216	17,216	18,476	18,476
	TOTAL	326,040	283,607	247,630	191,283	199,254	171,558	116,746	78,152	89,801	105,039
Nonthaburi	DMR	750	750	750	750	750	750	750	750	750	750
	PWD	7,630	11,340	14,320	14,970	16,920	17,220	18,420	19,100	20,300	20,300
	MWA	48,841	49,807	34,942	1,225	1,065	1,742	2,706	3,962	4,977	5,197
	PWA	0	0	0	0	0	0	0	0	0	0
	DOH	0	0	0	0	0	0	0	0	0	0
	ARD	0	0	0	0	0	0	0	0	0	0
	IEAT	0	0	0	0	0	0	0	0	0	0
	TOTAL	57,221	61,897	50,012	16,945	18,715	19,712	21,876	23,812	26,027	26,247
Pathum Thani	DMR	1,096	1,405	1,568	1,568	1,861	1,861	1,964	1,964	1,964	2,391
	PWD	8,850	9,510	13,190	14,970	16,670	16,970	18,065	18,065	19,765	19,765
	MWA	0	0	0	0	0	0	0	0	0	0
	PWA	3,013	4,377	5,905	6,133	6,127	6,250	9,374	14,850	17,168	19,487
	DOH	0	0	0	0	0	0	0	0	0	0
	ARD	0	0	0	0	0	0	0	0	0	0
	IEAT	0	0	0	0	4,960	10,520	16,080	21,640	27,200	28,600
	TOTAL	12,959	15,292	20,663	22,671	29,618	35,601	45,483	56,519	66,098	70,243
Samut Prakan	DMR	2,450	2,450	2,450	2,450	2,450	2,450	2,577	2,699	2,699	2,699
	PWD	15,750	20,005	27,965	31,215	32,415	32,965	33,165	33,365	33,945	33,945
	MWA	28,523	35,447	32,187	16,166	22,949	24,382	13,060	12,966	17,236	20,892
	PWA	0	0	0	0	0	0	0	0	0	0
	DOH	0	0	0	0	0	0	0	0	0	0
	ARD	0	0	0	0	0	0	0	0	0	0
	IEAT	3,759	3,759	3,759	9,079	11,585	14,091	20,356	29,127	29,127	29,127
	TOTAL	50,482	61,661	66,361	58,910	69,399	73,888	69,158	78,157	83,007	86,663
Samut Sakhon	DMR	459	459	459	459	459	459	459	459	459	459
	PWD	21,230	27,330	31,870	34,790	38,900	40,300	42,140	42,140	43,510	43,510
	MWA	0	0	0	0	0	0	0	0	0	0
	PWA	9,722	9,722	9,457	10,008	9,594	9,348	9,377	9,396	9,140	9,871
	DOH	0	0	0	0	0	0	0	0	0	0
	ARD	0	0	0	0	0	0	0	0	0	0
	IEAT	0	0	0	0	0	0	0	0	0	0
	TOTAL	33,394	39,495	43,771	47,243	50,940	52,095	53,965	53,985	55,100	55,832
Ayutthaya	DMR	819	1,015	1,015	1,015	1,246	1,246	1,509	1,509	2,020	3,375
	PWD	5,120	5,820	7,570	8,530	8,530	9,210	9,210	9,710	10,810	10,810
	MWA	0	0	0	0	0	0	0	0	0	0
	PWA	994	1,195	765	1,195	765	793	956	843	928	956
	DOH	0	0	0	0	0	0	0	0	0	0
	ARD	0	0	0	0	0	0	0	64	73	118
	IEAT	0	0	0	0	0	0	0	0	0	400
	TOTAL	6,933	8,030	9,350	10,740	10,541	11,249	11,675	12,126	13,831	15,659
Nakhon Pathum	DMR	1,154	1,154	1,205	1,360	1,360	1,360	1,360	1,451	1,532	1,632
	PWD	0	0	0	0	0	0	0	0	0	0
	MWA	0	0	0	0	0	0	0	0	0	0
	PWA	208	208	202	214	205	200	200	201	195	211
	DOH	0	0	64	64	64	64	64	104	136	136
	ARD	0	0	0	0	0	0	0	0	0	0
	IEAT	0	0	0	0	0	0	0	0	0	0
	TOTAL	1,362	1,362	1,471	1,638	1,629	1,624	1,624	1,756	1,863	1,979
Chachoengsao	DMR	0	5	66	66	66	66	77	77	86	86
	PWD	0	0	0	0	0	0	0	0	0	0
	MWA	0	0	0	0	0	0	0	0	0	0
	PWA	0	0	0	0	0	0	0	0	0	0
	DOH	0	0	0	0	0	0	0	0	0	0
	ARD	0	0	0	0	0	0	0	0	0	0
	IEAT	0	0	0	0	0	0	0	0	0	0
	TOTAL	0	5	66	66	66	66	77	77	86	86
Study Area	DMR	9,244	9,754	10,029	10,184	10,708	10,708	11,212	11,425	12,026	13,908
	PWD	60,180	75,605	96,515	106,075	115,785	119,015	123,350	124,730	131,130	132,440
	MWA	391,310	356,767	299,727	193,642	207,466	181,900	110,430	72,998	88,222	106,026
	PWA	13,937	15,502	16,329	17,550	16,691	16,591	19,907	25,290	27,431	30,525
	DOH	0	0	64	64	64	64	64	104	136	136
	ARD	0	0	0	0	0	0	0	64	73	118
	IEAT	11,737	11,737	14,675	19,995	27,461	35,527	53,652	67,983	74,803	76,603
	TOTAL	488,391	471,349	439,323	349,496	380,161	365,792	320,604	304,583	335,812	361,749

UNITS: PUMPAGE IN CUBIC METERS PER DAY (CMD)

Table 5.3.9 COMBINED HISTORICAL PUMPAGE ESTIMATES FOR PRIVATE (USING CASE 2) AND PUBLIC WELLS

Changwat	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Bangkok	595,922	566,283	540,192	491,247	504,187	483,409	439,486	409,567	435,201	458,729
Nonthaburi	81,191	88,060	77,369	46,210	49,296	52,163	56,427	62,422	66,940	69,729
Pathum Thani	96,888	105,918	115,955	125,360	137,731	159,293	196,442	223,842	263,734	289,979
Samut Prakan	269,940	308,389	327,221	330,583	353,731	368,664	382,223	421,692	460,615	474,118
Samut Sakhon	89,145	104,795	117,434	129,061	144,421	156,876	172,497	186,303	205,009	220,611
Ayutthaya	121,149	133,866	139,696	154,469	173,394	185,921	195,609	208,334	238,179	249,583
Nakhon Pathom	22,568	23,294	23,282	24,467	24,036	24,206	25,988	27,554	29,096	31,478
Chachoengsao	697	992	1,387	2,171	2,545	2,901	3,092	3,787	4,559	5,367
WHOLE AREA	1,277,499	1,331,597	1,342,536	1,303,567	1,389,340	1,433,434	1,471,765	1,543,501	1,703,334	1,799,596
Bangkok	595,799	566,160	540,069	491,124	504,065	483,286	439,362	409,445	435,078	458,607
Nonthaburi	80,918	87,788	77,096	45,936	49,022	51,889	56,153	62,149	66,667	69,456
Pathum Thani	96,824	105,918	115,955	125,360	137,675	159,238	196,156	223,083	261,849	287,304
Samut Prakan	269,938	308,388	326,219	330,581	353,728	368,661	382,170	421,638	460,560	473,973
Samut Sakhon	61,470	69,234	77,246	85,377	94,516	102,518	115,533	128,542	144,165	154,231
Ayutthaya	10,717	12,182	14,470	17,250	17,167	18,475	21,743	25,950	32,042	35,425
Nakhon Pathom	1,362	1,362	1,471	1,638	1,629	1,624	1,624	1,756	1,863	1,979
Chachoengsao	0	5	66	66	66	66	77	77	86	86
STUDY AREA	1,117,028	1,151,037	1,152,592	1,097,332	1,157,868	1,185,757	1,212,818	1,272,640	1,402,310	1,481,061

UNITS: PUMPAGE IN CUBIC METERS PER DAY (CMD)

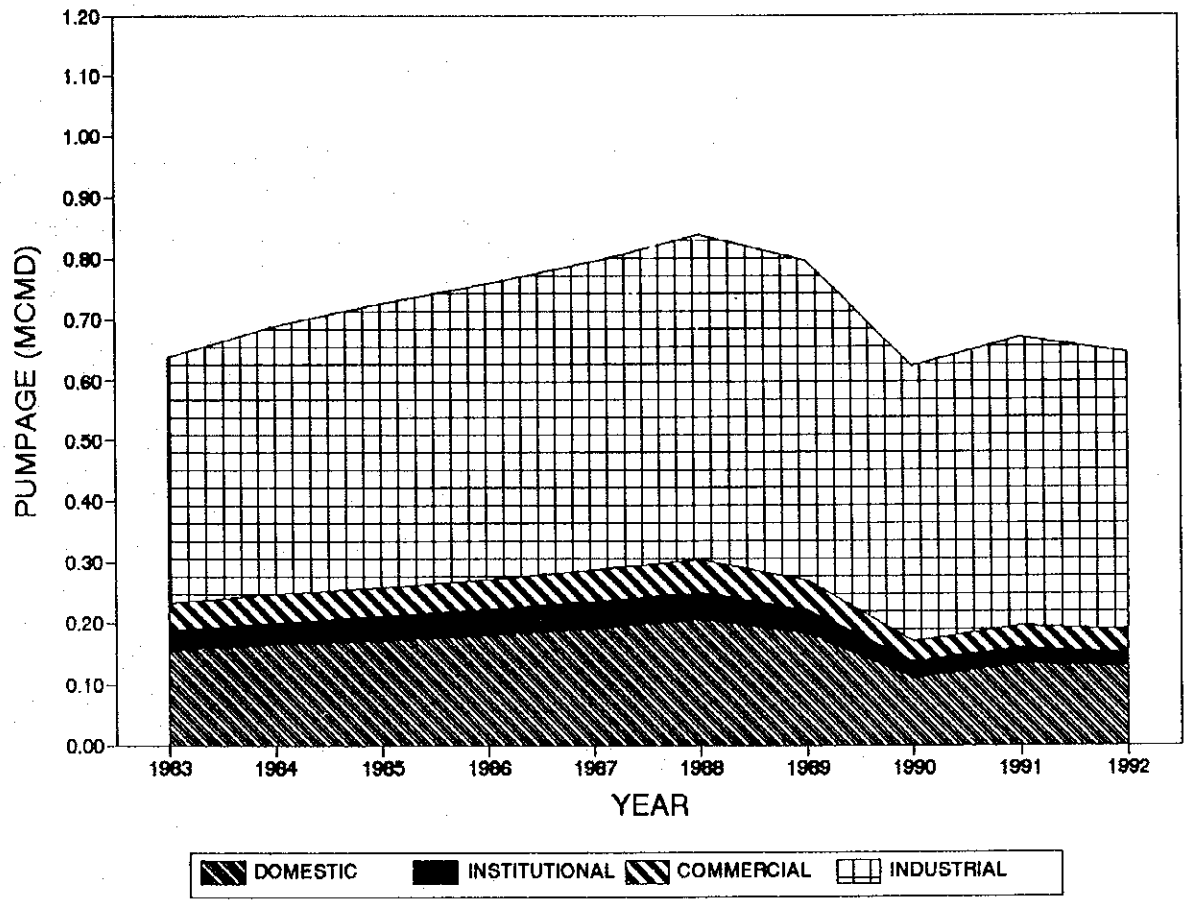


Figure 5.3.1	CASE 1 HISTORICAL PUMPAGE ESTIMATES FOR PRIVATE WELLS IN THE WHOLE AREA
THE STUDY ON MANAGEMENT OF GROUNDWATER AND LAND SUBSIDENCE IN THE BANGKOK METROPOLITAN AREA AND ITS VICINITY	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	KOKUSAI KOGYO CO., LTD.

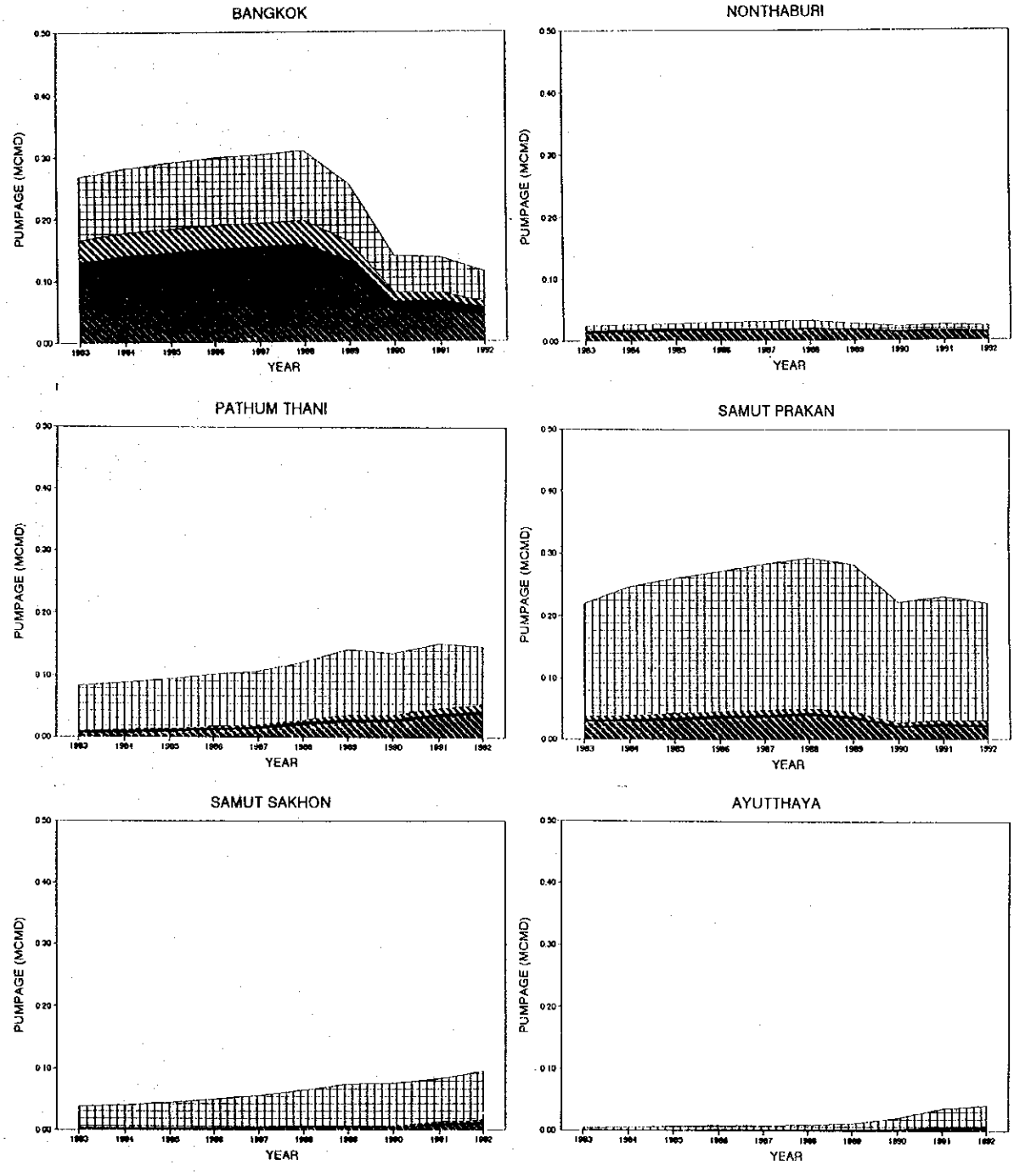


Figure 5.3.2	CASE 1 HISTORICAL PUMPAGE ESTIMATES FOR PRIVATE WELLS IN THE WHOLE AREA BY CHANGWAT
THE STUDY ON MANAGEMENT OF GROUNDWATER AND LAND SUBSIDENCE IN THE BANGKOK METROPOLITAN AREA AND ITS VICINITY	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	KOKUSAI KOGYO CO., LTD.

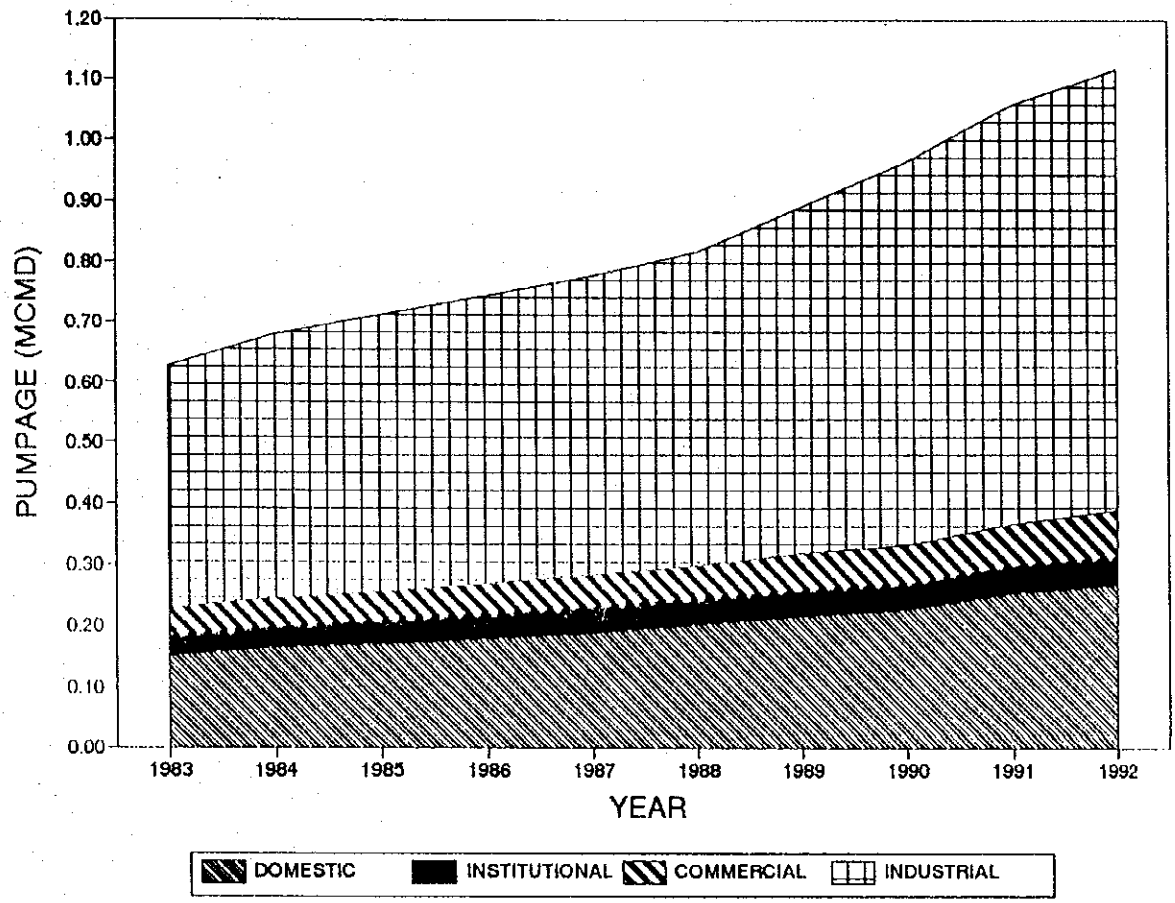


Figure 5.3.3	CASE 2 HISTORICAL PUMPAGE ESTIMATES FOR PRIVATE WELLS IN THE STUDY AREA
THE STUDY ON MANAGEMENT OF GROUNDWATER AND LAND SUBSIDENCE IN THE BANGKOK METROPOLITAN AREA AND ITS VICINITY	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	KOKUSAI KOGYO CO., LTD.

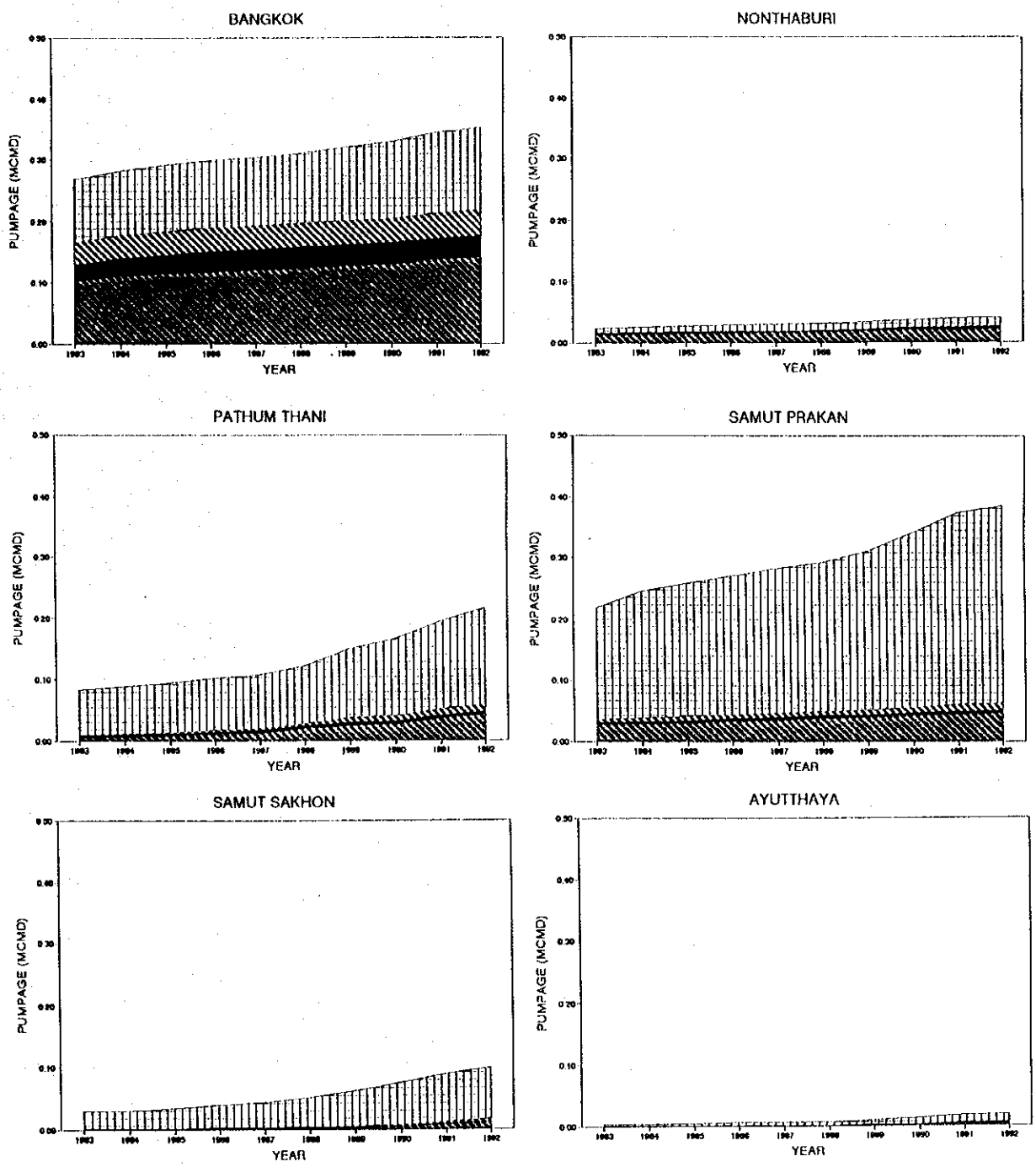


Figure 5.3.4	CASE 2 HISTORICAL PUMPAGE ESTIMATES FOR PRIVATE WELLS IN THE STUDY AREA BY CHANGWAT
THE STUDY ON MANAGEMENT OF GROUNDWATER AND LAND SUBSIDENCE IN THE BANGKOK METROPOLITAN AREA AND ITS VICINITY	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	KOKUSAI KOGYO CO., LTD.

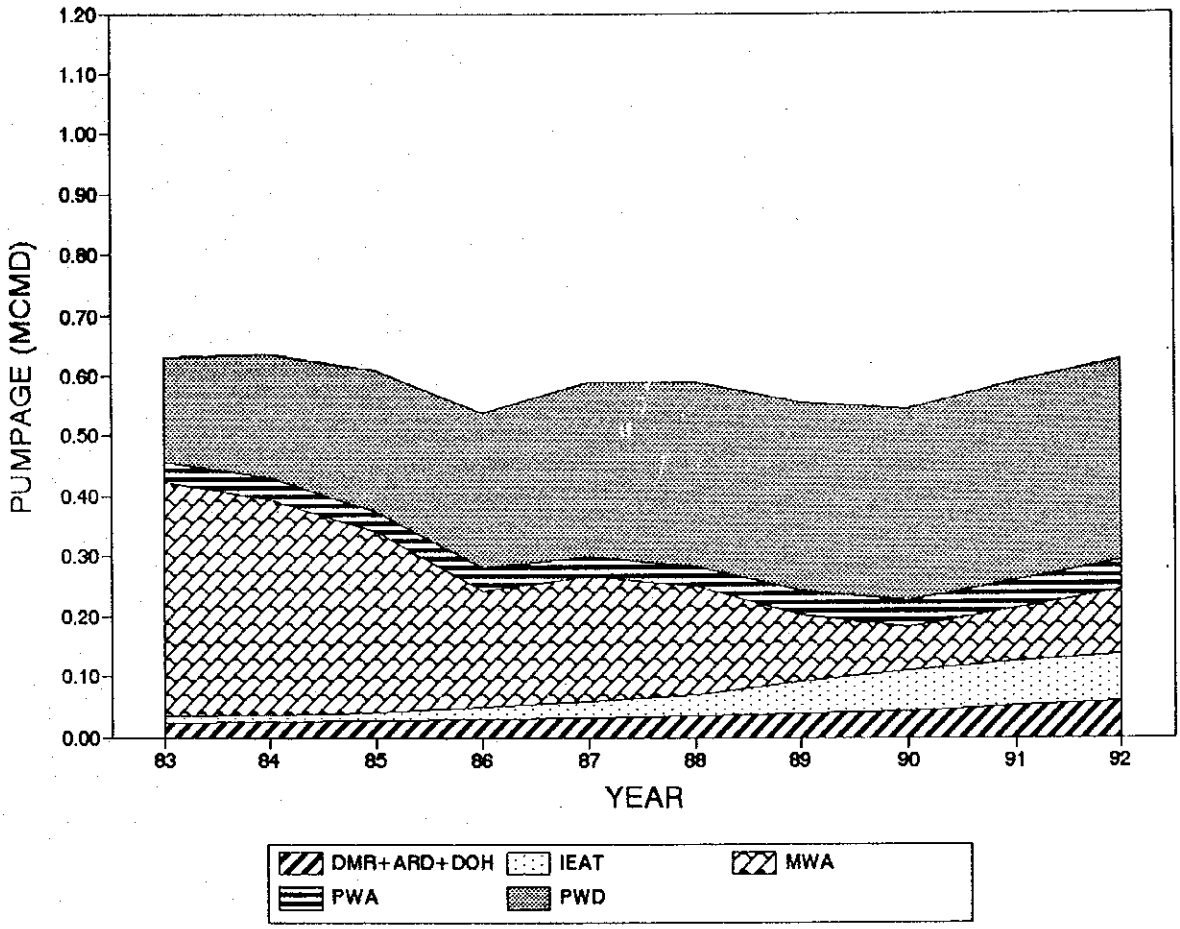


Figure 5.3.5	HISTORICAL PUMPAGE ESTIMATES FOR PUBLIC WELLS IN THE WHOLE AREA
THE STUDY ON MANAGEMENT OF GROUNDWATER AND LAND SUBSIDENCE IN THE BANGKOK METROPOLITAN AREA AND ITS VICINITY	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	KOKUSAI KOGYO CO., LTD.

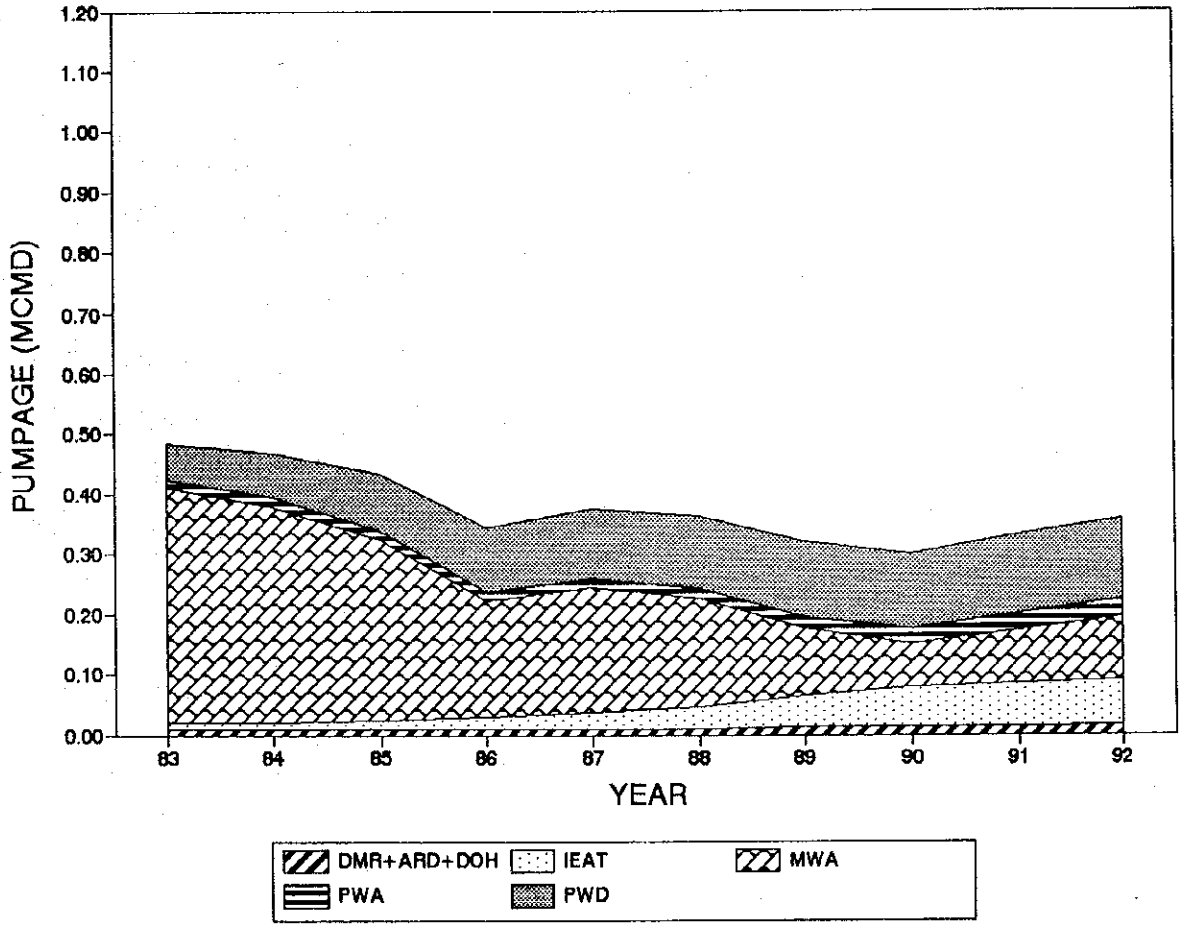
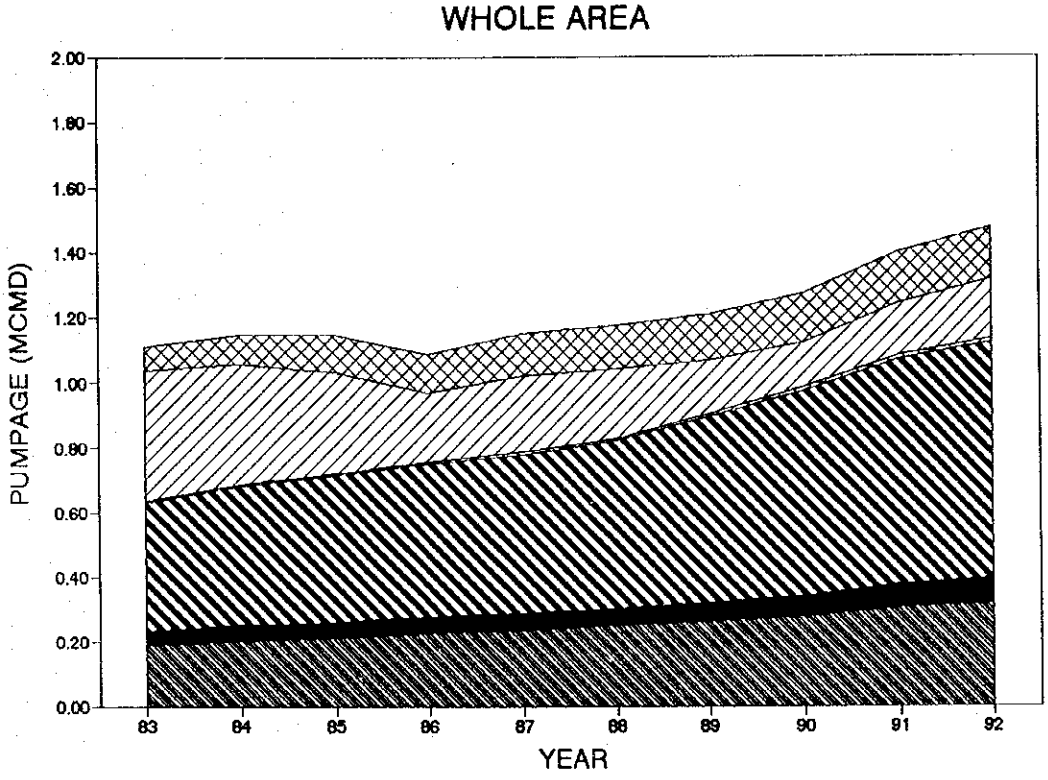


Figure 5.3.6	HISTORICAL PUMPAGE ESTIMATES FOR PUBLIC WELLS IN THE STUDY AREA
THE STUDY ON MANAGEMENT OF GROUNDWATER AND LAND SUBSIDENCE IN THE BANGKOK METROPOLITAN AREA AND ITS VICINITY	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	KOKUSAI KOGYO CO., LTD.



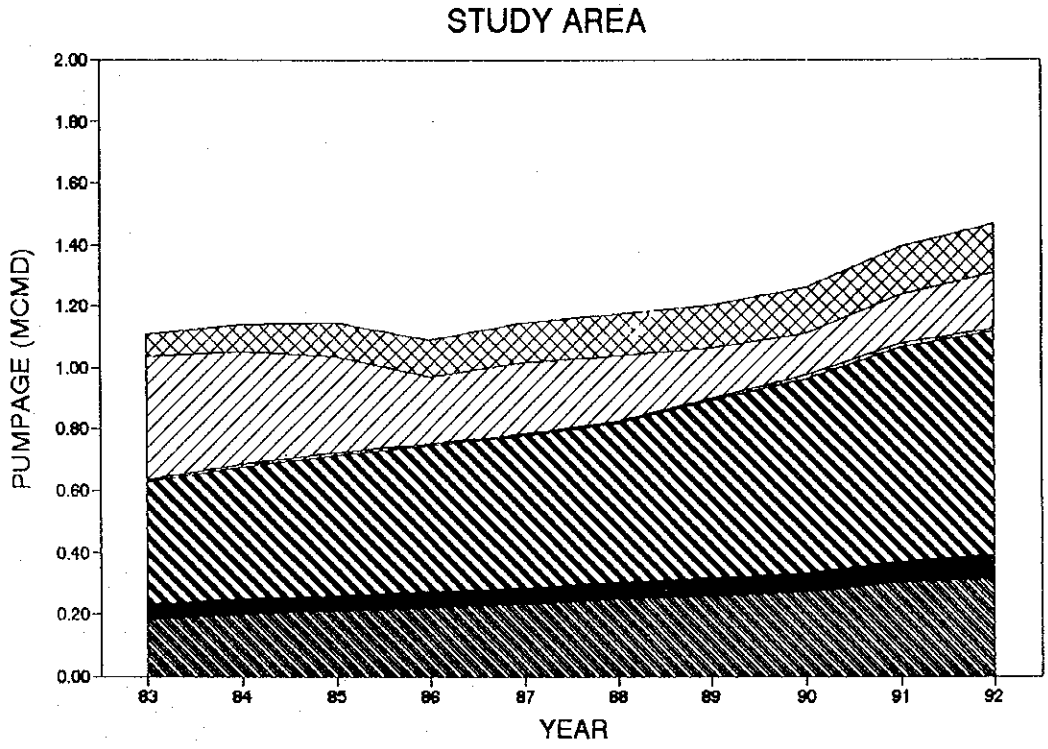


Figure 5.3.7	CASE 2 COMBINED HISTORICAL PUMPAGE ESTIMATES FOR PRIVATE AND PUBLIC WELLS

THE STUDY ON MANAGEMENT OF GROUNDWATER AND LAND SUBSIDENCE IN THE BANGKOK METROPOLITAN AREA AND ITS VICINITY

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	KOKUSAI KOGYO CO., LTD.

5.4 Year-1992 Total Groundwater Pumpage in the Study Area

The year-1992 groundwater pumpage for the private wells in the Study Area are discussed below based on the results of *Case 2*. The combined total pumpage of both private and public wells shows the approximate picture of the year-1992 groundwater pumpage in the Study Area.

5.4.1 Year-1992 groundwater pumpage of private wells

The year-1992 pumpage level generated by private wells in the Study Area was 1,121,305 CMD as computed using *Case 2* in Table 5.4.1. Figure 5.4.1 shows the distributions of this total pumpage as 23.8% for domestic supplies, 4.3% for institutional uses, 6.9% for commercial purposes and 65% for industries.

Table 5.4.1 gives the total daily pumpage of each changwat in terms of domestic, institutional, commercial and industrial uses. As shown in this table, Samut Prakan and Bangkok posted the highest shares at 34.5% and 31.5% in the total pumpage, respectively. Pathum Thani came in next with a 19.4% share, followed by Samut Sakhon with 9%. The high pumpage shares of Samut Prakan, Bangkok and Pathum Thani could be attributed to the concentration of industries in these areas. Bangkok had the highest share of pumpage for domestic and institutional purposes. Commercial use was also topped by Bangkok, followed by Samut Prakan.

Table 5.4.2 shows the year-1992 total daily withdrawals of the 26 different user-types. Around 728,755 CMD, which represented 65% of the total average daily pumpage in the Study Area, were used by industries. Of this amount of pumpage, textile industry got the biggest share at 30.6%, followed by food processing industry with 11.5%. Of the 26 user-types, the share of textile industry (19.9%) was next only to that of domestic users (23.9%) in the total daily abstractions in the Study Area. The share of chemical industry amounted to 7% or 50,709 CMD and paper industry shared 5.9% or 42,739 CMD to the total industrial pumpage. In terms of average pumping rate, industrial estates and power plants ranked first (2,220 CMD) and second (1,553 CMD), respectively, among the 26 user-types. While paper, textile and soft drink industries placed third (555 CMD), fourth (485 CMD) and fifth (342 CMD), respectively.

5.4.2 Year-1992 groundwater pumpage of public wells

As presented in Table 5.4.1, the year-1992 groundwater production of public wells in the Study Area totaled 359,756 CMD. In Figure 5.4.1, this total was divided into 78.7% for domestic use and 21.3% for industrial use.

The highest pumpage (105,039 CMD) by public wells was reflected by Bangkok, which was largely due to pumpage by MWA wells. The next highest pumpage (86,663 CMD) was shown by Samut Prakan, which was consumed by PWD, MWA and IEAT. The third one (70,243 CMD) was in Pathum Thani, which was pumped out for domestic purposes by PWD and PWA wells and for industrial uses by IEAT.

PWD was pumping out a total of 132,440 CMD of groundwater, the highest among the seven (7) agencies. This was followed by MWA with 106,026 CMD.

For domestic use, public wells produced more groundwater than private wells (283,153 CMD against 267,570 CMD). While abstraction for industrial use by public wells represented only 10.5% of the total industrial production of private wells.

5.4.3 Year-1992 total groundwater pumpage

Combined total of the estimated groundwater withdrawals of private and public wells in the Study Area amounted to 1,481,061 CMD. Of this total, public wells used 24.3%.

The combined total withdrawals were distributed as: 550,723 CMD for domestic uses; 47,944 CMD for institutional uses; 77,036 CMD for commercial uses; and 805,358 CMD for industrial uses. Combined distributions were 37.2% for domestic supplies, 3.2% for institutional uses, 5.2% for commercial supplies and 54.4% for industries. This is shown in Figure 5.4.1.

The distributions of this total abstraction by changwat and by type of user are presented in Table 5.4.2. A total of 473,973 CMD was withdrawn in Samut Prakan. Of this total, 74.2% or 351,861 CMD were abstracted for industries, and 22.1% or 104,556 CMD for water supplies. Next to Samut Prakan was Bangkok which was getting 458,607 CMD. The top two (2) groundwater abstractors were domestic users with 228,191 CMD and industrial users with 153,231 CMD.

Groundwater withdrawals of 287,304 CMD in Pathum Thani were largely used by industries which amounted to 185,955 CMD of the daily total. Most of the pumpage (154,231 CMD) in Samut Sakhon were largely by industries (54.1%). In other provinces, groundwater were used mostly for water supplies.

Figure 5.4.2 plots the spatial distribution of pumpage in the Study Area in year-1992.

Table 5.4.1 YEAR-1992 COMBINED GROUNDWATER PUMPAGE ESTIMATES FOR PRIVATE AND PUBLIC WELLS IN THE STUDY AREA

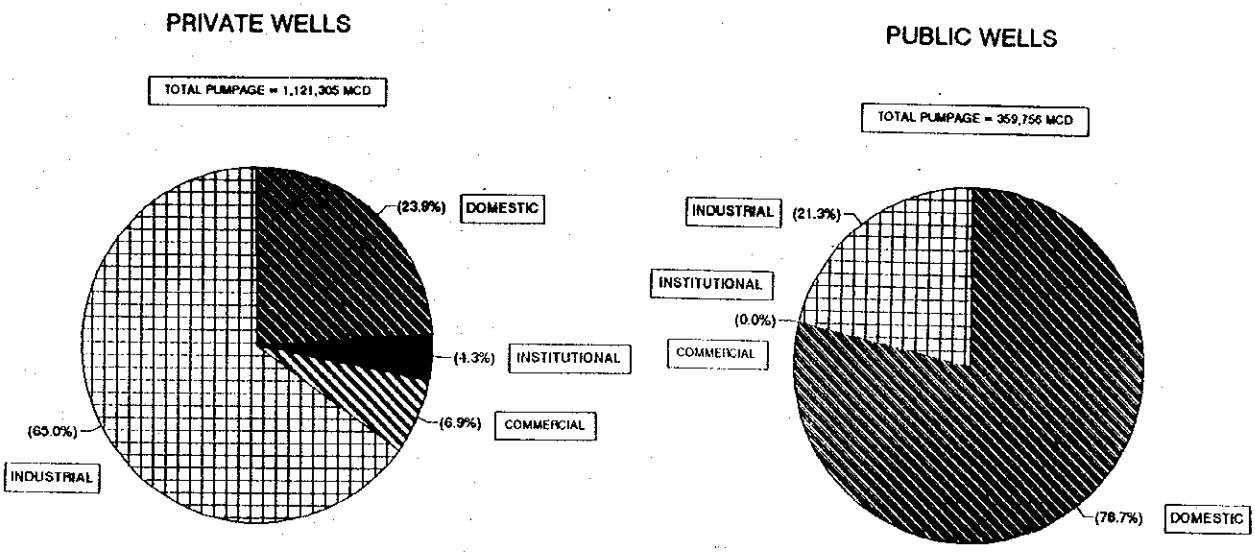
Changwat	Type of User	Private Total	DMR	PWD	MWA	PWA	DOH	ARD	IEAT	Public Total	Combined Total
Bangkok	Domestic	141,628	2,516	4,110	79,937	0	0	0	0	86,563	228,191
	Institutional	34,318								0	34,318
	Commercial	42,867								0	42,867
	Industrial	134,755							18,476	18,476	153,231
	TOTAL	353,568	2,516	4,110	79,937	0	0	0	18,476	105,039	458,607
Nonthaburi	Domestic	22,542	750	20,300	5,197	0	0	0		26,247	48,789
	Institutional	2,211								0	2,211
	Commercial	2,270								0	2,270
	Industrial	16,186							0	0	16,186
	TOTAL	43,209	750	20,300	5,197	0	0	0	0	26,247	69,456
Pathum Thani	Domestic	41,902	2,391	19,765	0	19,487	0	0		41,643	83,545
	Institutional	5,373								0	5,373
	Commercial	12,431								0	12,431
	Industrial	157,355							28,600	28,600	185,955
	TOTAL	217,061	2,391	19,765	0	19,487	0	0	28,600	70,243	287,304
Samut Prakan	Domestic	47,020	2,699	33,945	20,892	0	0	0	0	57,536	104,556
	Institutional	4,300								0	4,300
	Commercial	13,256								0	13,256
	Industrial	322,734							29,127	29,127	351,861
	TOTAL	387,310	2,699	33,945	20,892	0	0	0	29,127	86,663	473,973
Samut Sakhon	Domestic	10,609	459	43,510	0	9,871	0	0	0	53,840	64,449
	Institutional	1,676								0	1,676
	Commercial	4,550								0	4,550
	Industrial	83,556								0	83,556
	TOTAL	100,391	459	43,510	0	9,871	0	0	0	53,840	154,231
Ayutthaya	Domestic	3,869	3,375	10,810	0	956	0	118		15,259	19,128
	Institutional	66								0	66
	Commercial	1,662								0	1,662
	Industrial	14,169							400	400	14,569
	TOTAL	19,766	3,375	10,810	0	956	0	118	400	15,659	35,425
Nakhon Pathom	Domestic		1632	0	0	211	136	0	0	1,979	1,979
	Institutional									0	0
	Commercial									0	0
	Industrial									0	0
	TOTAL	0	1,632	0	0	211	136	0	0	1,979	1,979
Chachoengsao	Domestic		86							86	86
	Institutional									0	0
	Commercial									0	0
	Industrial									0	0
	TOTAL	0	86	0	0	0	0	0	0	86	86
Study Area	Domestic	267,570	13,908	132,440	106,026	30,525	136	118	0	283,153	550,723
	Institutional	47,944	0	0	0	0	0	0	0	0	47,944
	Commercial	77,036	0	0	0	0	0	0	0	0	77,036
	Industrial	728,755	0	0	0	0	0	0	76,603	76,603	805,358
	TOTAL	1,121,305	13,908	132,440	106,026	30,525	136	118	76,603	359,756	1,481,061

Note: No private well was inventoried in Nakhon Pathom and Chachoengsao.
UNITS: PUMPAGE IN CUBIC METERS PER DAY (CMD)

TABLE 5.4.2 GROUNDWATER PUMPAGE OF PRIVATE WELLS BY TYPE OF USER

Code		Type of User	No. of Wells	Pumpage	Percent Share in Total*	Share in Industrial Total**	Average Pumping Rate	Rank
11	DOMESTIC	: Residences, dormitories, courts, subdivisions, condominiums	4,844	267,575	23.9		55	22
21	INSTITUTIONAL	: Schools, public administrations hospitals, etc.)	461	47,945	4.3		104	17
31	COMMERCIAL	: Office buildings, malls, hotels, clubs, etc.	1,148	77,036	6.9		67	20
41	INDUSTRIAL	: Basic factory requirement for drinking and sanitation	352	6,104	0.5	0.8	17	26
42	INDUSTRIAL	: Manufacture of soft drinks	38	18,436	1.6	2.5	485	4
43	INDUSTRIAL	: Food processing and icemaking	452	83,885	7.5	11.5	186	10
44	INDUSTRIAL	: Textile industry, nylons	652	223,206	19.9	30.6	342	5
45	INDUSTRIAL	: Wearing apparels, garments	78	17,486	1.6	2.4	224	7
46	INDUSTRIAL	: Manufacture of leather products	154	9,313	0.8	1.3	60	21
47	INDUSTRIAL	: Manufacture of wood products	134	5,982	0.5	0.8	45	23
48	INDUSTRIAL	: Manufacture of paper and paper products	77	42,739	3.8	5.9	555	3
49	INDUSTRIAL	: Printing	44	9,125	0.8	1.3	207	8
50	INDUSTRIAL	: Chemical industry and chemical products	348	50,709	4.5	7.0	146	13
51	INDUSTRIAL	: Rubber industry and rubber products	107	15,105	1.3	2.1	141	14
52	INDUSTRIAL	: Plastic products, footwear, insulators, carpets	211	16,910	1.5	2.3	80	19
53	INDUSTRIAL	: Manufacture of non-metal products, fibers, etc.	287	45,128	4.0	6.2	157	12
54	INDUSTRIAL	: Manufacture of basic metal products, steel bars	206	40,194	3.6	5.5	195	9
55	INDUSTRIAL	: Manufacture of metal products	153	5,958	0.5	0.8	39	25
56	INDUSTRIAL	: Manufacture of mechanical, electrical and computer products	193	25,503	2.3	3.5	132	15
57	INDUSTRIAL	: Manufacture , assembly and repair of vehicles	166	27,904	2.5	3.8	168	11
58	INDUSTRIAL	: Manufacture of grain mill products	23	6,260	0.6	0.9	272	6
59	INDUSTRIAL	: Agriculture and farm products	155	6,430	0.6	0.9	41	24
60	INDUSTRIAL	: Industrial estates	6	13,320	1.2	1.8	2,220	1
61	INDUSTRIAL	: Tobacco	4	372	0.0	0.1	93	18
62	INDUSTRIAL	: Power plants	5	7,767	0.7	1.1	1,553	2
63	INDUSTRIAL	: Others	474	50,969	4.5	7.0	108	16
		*Total	10,772	1,121,361				
		**Total Industrial Pumpage		728,805				

UNITS: PUMPAGE IN CUBIC METERS PER DAY (CMD)
AVERAGE PUMPING RATE IN CMD/WELL



PRIVATE AND PUBLIC WELLS

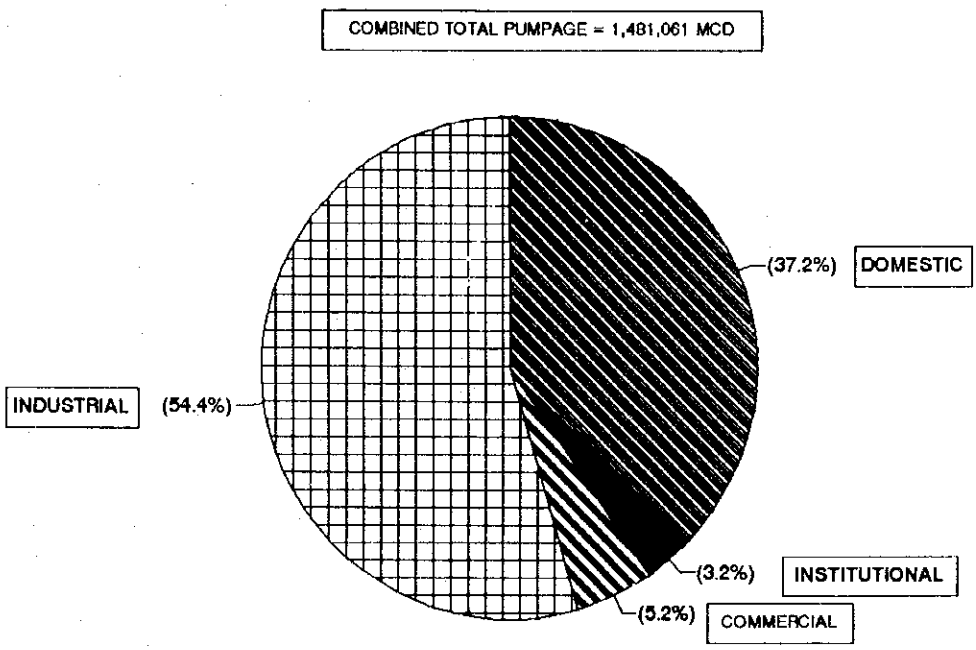
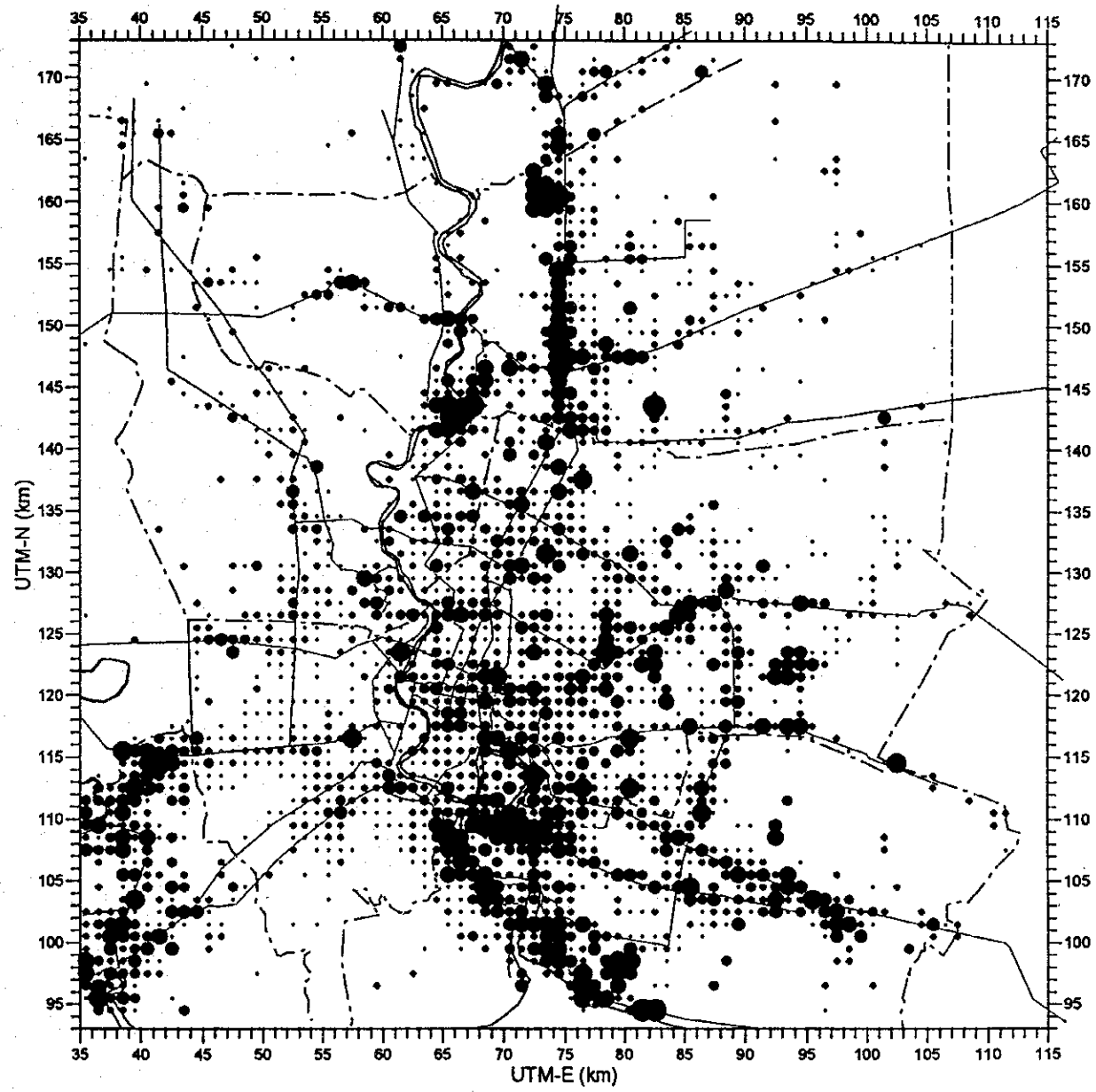


Figure 5.4.1	YEAR-1992 GROUNDWATER USE DISTRIBUTIONS OF PRIVATE AND PUBLIC WELLS IN THE STUDY AREA
THE STUDY ON MANAGEMENT OF GROUNDWATER AND LAND SUBSIDENCE IN THE BANGKOK METROPOLITAN AREA AND ITS VICINITY	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	KOKUSAI KOGYO CO., LTD.



LEGEND

Groundwater Pumpage (m^3 /day) per 1km x 1km grid

- 1 to 99
- 100 to 499
- 500 to 999
- 1,000 to 1,999
- 2,000 to 4,999
- 5,000 to 9,999
- More than 10,000

Total Pumpage in Study Area in 1992 = 1,481,061 m^3/day

Figure 5.4.2	DISTRIBUTION OF GROUNDWATER PUMPAGE IN THE STUDY AREA IN 1992
THE STUDY ON MANAGEMENT OF GROUNDWATER AND LAND SUBSIDENCE IN THE BANGKOK METROPOLITAN AREA AND ITS VICINITY	
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)	KOKUSAI KOGYO CO., LTD.

CONTENTS

LIST OF TABLES

LIST OF FIGURES