5. CONCEPTUAL SEWERAGE MASTER PLAN

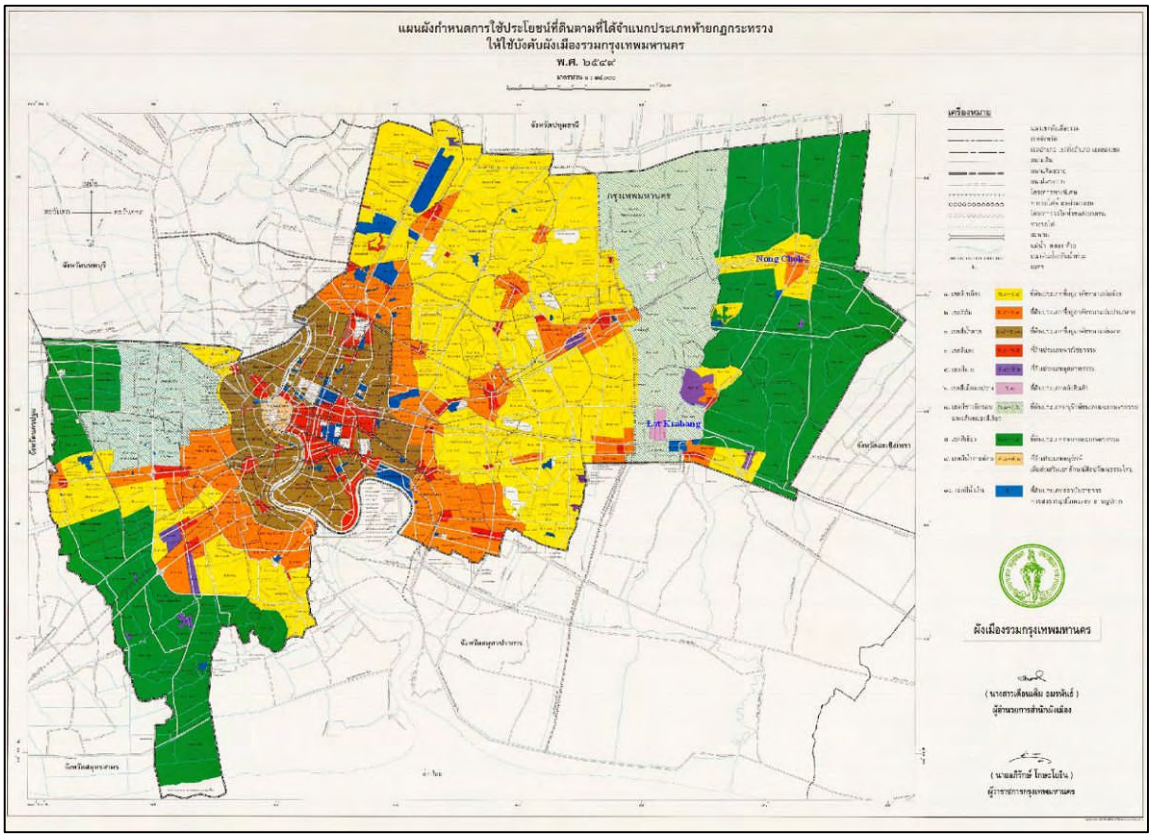
5.1 Target Year and Sewerage Service Area

In the Master Plan prepared in 1999, 20 WWTPs are planed in total in BMA. Comparing these treatment areas with urbanized areas planed in Land Use Plan prepared in 2006, treatment areas do not cover all of the urbanized areas, viz. residential, commercial, institutional and Thai culture conservation (Palace and surrounding area) areas. At present seven (7) WWTPs are in operation and approximately 40 % of wastewater generated in BMA is considered to be treated. According to Performance Plan of Bangkok Metropolitan Administration 2009 – 2012, prepared in 2008, treatment ratio of wastewater was targeted to be 60 % in 2020.

The target year of this conceptual master plan is set as 2040, which is approximately 30 years from now, with consultation with DDS. Year 2020 is considered to be target year of medium term. In this Conceptual Master Plan, treatment ratio is considered to be raised gradually and objective treatment ratio in 2040 is targeted to be 80 %.

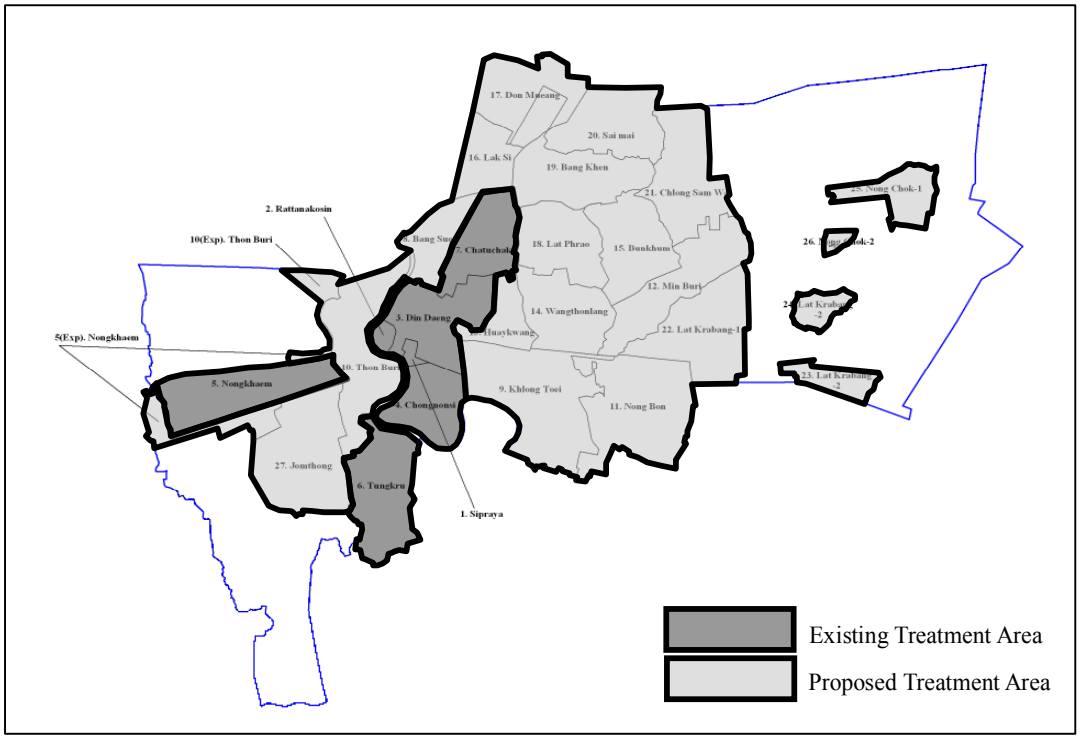
To achieve this objective, entire urbanized area designated under land use plan (target year is 2020) will be included in the treatment area principally except for agriculture conservation area and agricultural area. Although, some agricultute conservation areas and agricultural areas which are already included in current sewerage areas are considered to be treatment areas. Some of isolated insudtrial, warehouse and government office areas surrounded by agricultural area are excluded from treatment area.

Figure 5.1.1 shows Land Use Plan of BMA prepared in 2006, and treatment area proposed in this conceptual master plan is shown in Figure 5.1.2.



Source: City Planning Department, BMA

Figure 5.1.1 Land Use Plan of BMA



Source: JST

Figure 5.1.2 Treatment Area of Sewerage System

Ten (10) land use categories shown in Table 5.1.1 are specified in the Land Use Plan prepared in 2006. Table 5.1.1 also shows estimated population and population share by the category. Population in the proposed treatment area is estimated to be 7,318,000 which accounts for 96% of the BMA population. Assuming that sewer coverage ratio will be 90% in 2040, population served by sewerage system is calculated to be 86% of total population which is sufficient for the master plan target.

Table 5.1.1 Land Use Categories and Estimated Population in 2040

(1) By Land Use Categories

Land Use	Area (ha)	Estimated Population (person)			Population Density (person/ha)
		Inside of Treatment Area	Outside of Treatment Area	Total	
1. Low density residential area	47,473	2,941,900	0	2,941,900	62.0
2.. Medium density residential area	17,314	1,297,900	0	1,297,900	75.0
3. High density residential area	13,302	1,724,100	0	1,724,100	129.6
4. Commercial area	5,677	1,131,900	0	1,131,900	199.4
5. Industrial area	1,297	18,800	3,400	22,200	17.1
6. Warehouse area	224	0	500	500	2.2
7. Agricultural conservation area	18,463	9,100	24,400	33,500	1.8
8. Agricultural area	43,135	400	251,800	252,200	5.8
9. Thai culture and art conservation area	454	55,800	0	55,800	122.9
10. Government office area	2,965	164,100	1,900	166,000	56.0
11. Other area	6,686	0	0	0	0.0
Total	156,990	7,344,000	282,000	7,626,000	48.6
		(96%)	(4%)	(100%)	

Areas by land use categories are tabulated based on the data of City Planning Department, BMA by JST.

(2) By Inside/Outside of Tratment Area

	Area (ha)	Estimated Population (person)			Population Density (person/ha)
		Inside of Treatment Area	Outside of Treatment Area	Total	
Inside of Treatment Area	92,519	7,344,000	0	7,344,000	79.4
Outside of Treatment Atrea	62,939	0	282,000	282,000	4.5
Subtotal	155,458	7,344,000	282,000	7,626,000	49.1
Area of Chao Phraya River	1,532	0	0	0	0
Total	156,990	7,344,000	282,000	7,626,000	48.6

Areas of inside/outside treatment area are measured by JST

Source: JST

In addition to expansion of treatment area, rearrangement of treatment area will be considered based on comparison of projected wastewater flow and design capacities of the existing WWTPs, and availability of land for construction of WWTP (refer to Section 5.7).

In areas outside of treatment area, small scale wastewater treatment systems (community plants) or on –site treatment systems should be provided since population estimated in 2040 accounts for only 4 % of total population as shown in Table 5.1.1, and sewerage system is not efficient in these areas.

5.2 Population Projection

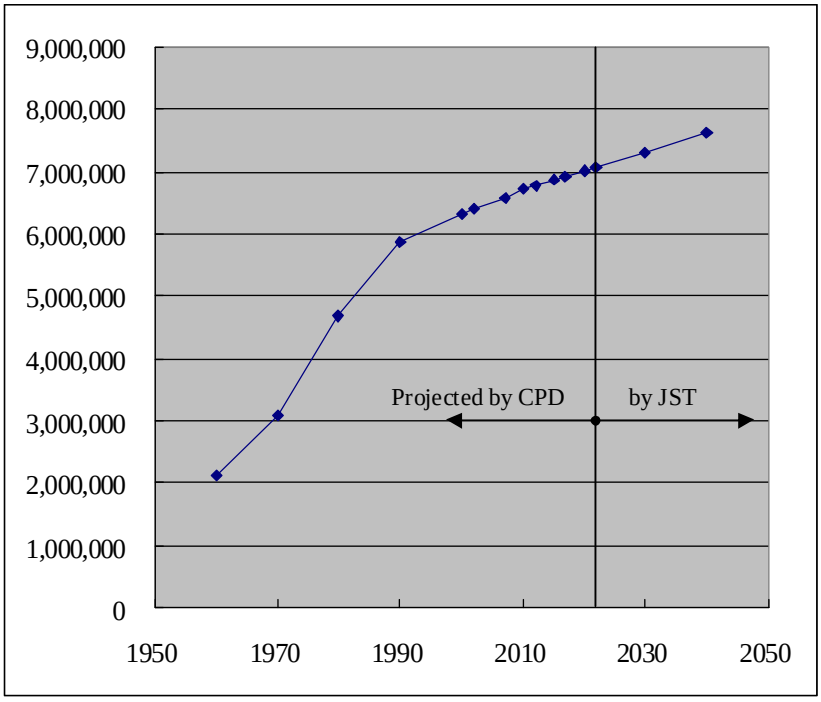
5.2.1 Population of BMA

City Planning Department estimated future population of BMA up to 2022 based on the census data. Their population projection is shown in Table 5.2.1 and Figure 5.2.1. According to the projection annual increase of approximately 30,400 people was estimated from 2010 to 2022 (linear equation).

Table 5.2.1 Population Projection by City Planning Department and JST

Year	Census Population	Year	Projected Population
1960	2,136,435	2012	6,775,676
1970	3,077,336	2015	6,866,758
1980	4,697,071	2017	6,927,480
1990	5,882,411	2020	7,018,563
2000	6,320,174	2022	7,079,285
2002	6,399,130	Projected by Survey Team	
2007	6,596,520	2030	7,322,390
2010	6,714,954	2040	7,626,000

Source: City Planning Department, BMA and JST



Source: JST and City Planning Department, BMA and JST

Figure 5.2.1 Population Projection by City Planning Department and JST

Population in 2030 and 2040 was estimated by extrapolation on the assumption that this tendency would continue until 2040. Population projection up to 2040 is shown in Table 5.2.2, since population growth was stabilized from 1990 after rapid increase during 70s' and 80s'.

Table 5.2.2 Projected Population (2030 and 2040)

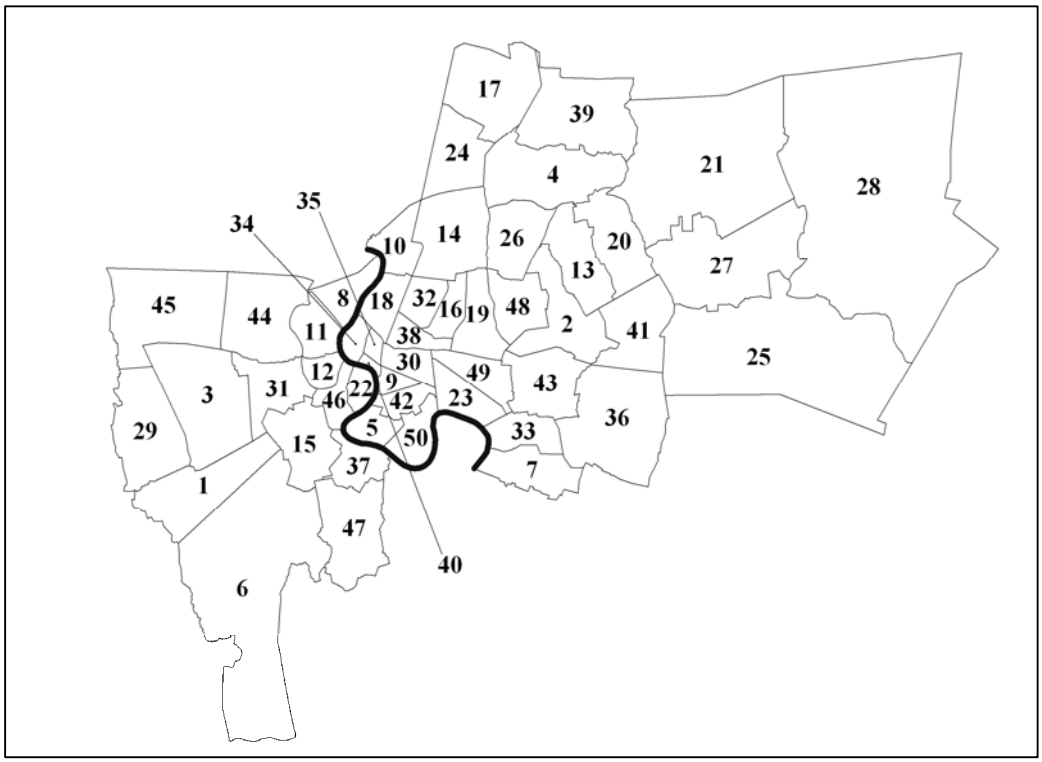
Year	Projected Population	Population Increment	Growth Rate	Remarks
2010	6,714,954	30,361 person/year	0.44%/year (an average for 12 years)	City planning Department
2012	6,775,676			
2017	6,927,480			
2020	7,018,563			
2022	7,079,285			
2030	7,322,390	Same as above	-	JICA Survey Team
2040	7,626,000			

Source: JST and City Planning Department, BMA and JST

5.2.2 Population Projection by Administrative Districts

(1) Administrative Districts

Administrative district of BMA is shown in Figure 5.2.2 and Table 5.2.3.



Source: JST

Figure 5.2.2 Administrative Districts of BMA

Table 5.2.3 Administrative Districts of BMA

No.	Name of District	No.	Name of District	No.	Name of District
1	Bang Bon	18	Dusit	35	Pom Prap Sattru Phai
2	Bang Kapi	19	Huai Khwang	36	Prawet
3	Bang Khae	20	Khan Na Yao	37	Rat Burana
4	Bang Khen	21	Klong Sam Wa	38	Ratchathewi
5	Bang Kho Laem	22	Klong San	39	Sai Mai
6	Bang Khun Thian	23	Klong Toei	40	Samphanthawong
7	Bang Na	24	Lak Si	41	Saphan Sung
8	Bang Phlat	25	Lat Krabang	42	Sathon
9	Bang Rak	26	Lat Phrao	43	Suan Luang
10	Bang Sue	27	Min Buri	44	Taling Chan
11	Bangkok Noi	28	Nong Chok	45	Thawi Watthana
12	Bangkok Yai	29	Nong Khaem	46	Thon Buri
13	Bueng Kum	30	Phathum Wan	47	Tung Khru
14	Chatuchak	31	Phasi Charoen	48	Wang Thonglang
15	Chom Thong	32	Phaya Thai	49	Wattana
16	Din Daeng	33	Phra Khanong	50	Yan Nawa
17	Don Mueang	34	Pra Nakhon		

Source: JST

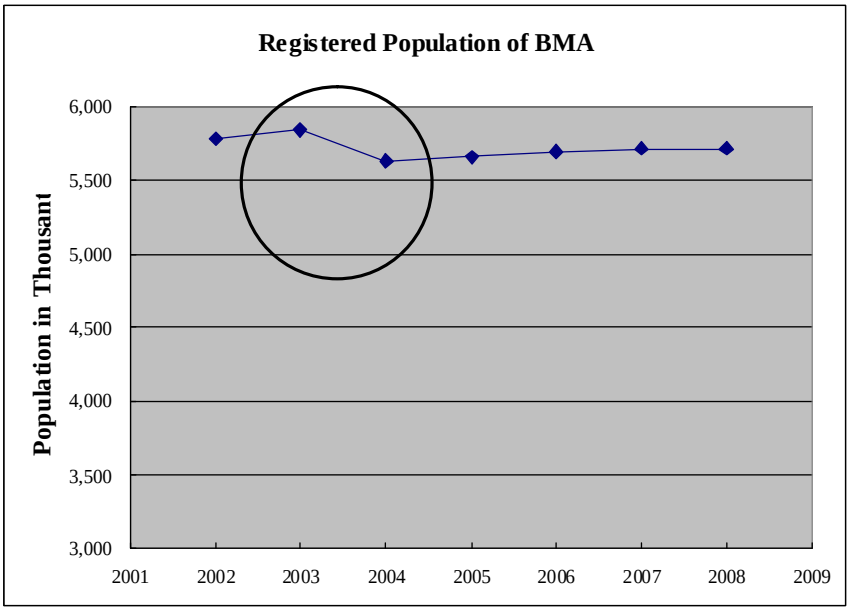
(2) Population Figure Published by DOLA

City Planning Department estimated total population of BMA, but did not estimate district-wise population. Therefore, population projection by districts has been made by the Survey Team based on those published by Department of Local Administration (DOLA), Ministry of Interior. Population figures published by DOLA are shown in Table 5.2.4 and Figure 5.2.3. There is a drop between populations in 2003 and in 2004, and therefore population figures from 2004 have been utilized for the projection. Table 5.2.4 also shows census population with registered population. It is clear that there is some difference between the two. Therefore, registered population figures have been used only for distribution to district purpose.

Table 5.2.4 Comparison of Census Population and Registered Population

Year	Registered Population (person)	Census Population (person)	Deference (person)	Registered/ Census
2000		6,320,174		
2002	5,782,159	6,399,130	616,971	0.903
2003	5,844,607			
2004	5,634,132			
2005	5,658,953			
2006	5,695,956			
2007	5,716,248	6,596,520	800,272	0.867
2008	5,710,883			

Source: JST



Source: JST

Figure 5.2.3 Registered Population of BMA by DOLA

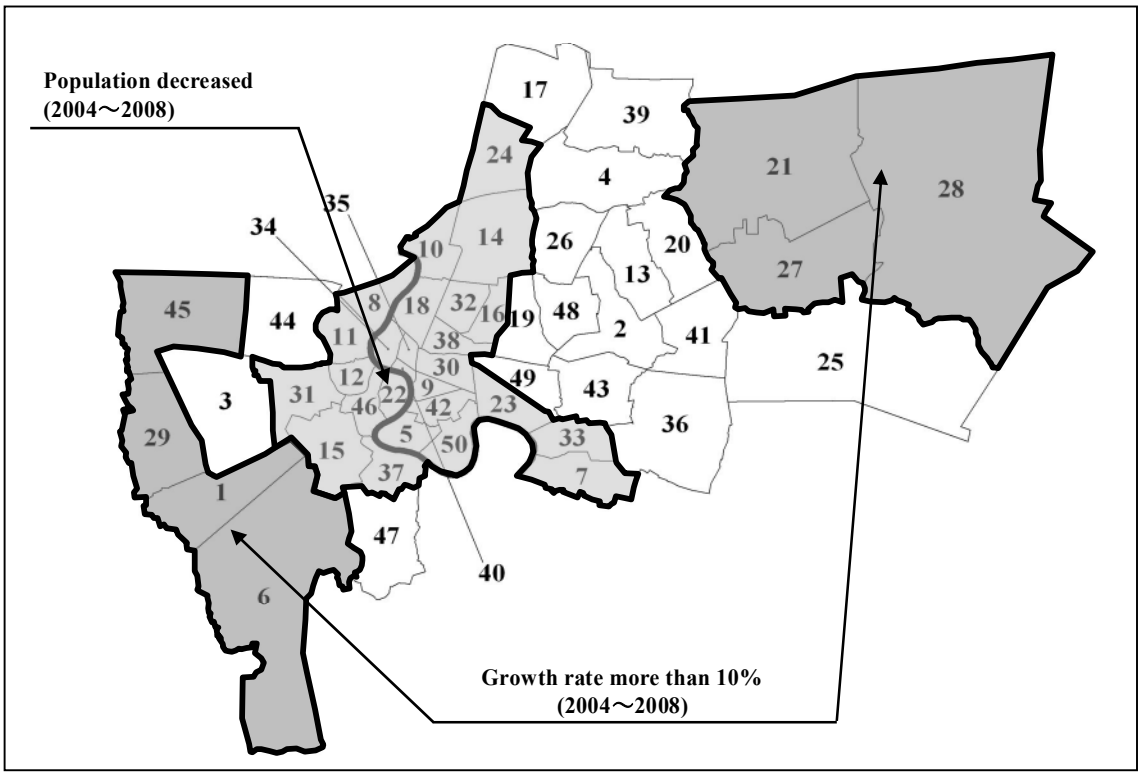
(3) Population by Administrative District by DOLA

Populations by administrative districts which was published by DOLA are shown in Table 5.2.5. Looking into changes of population from 2004 to 2008 by districts, it became clear that population in the districts located in the central part of Bangkok facing Chao Phraya River has decreased. Population in the districts located in eastern and western parts of BMA which are mainly agriculture areas increased significantly. Distribution of population growth rates by districts is shown in Figure 5.2.4.

Table 5.2.5 Registered Population by Districts

		2004	2005	2006	2007	2008	Remarks
1	Bang Bon	93,225	96,723	99,348	101,263	102,963	
2	Bang Kapi	147,694	149,093	149,860	150,139	150,286	
3	Bang Khae	186,744	189,257	191,521	192,597	193,449	
4	Bang Khen	177,062	178,986	181,390	182,335	183,836	
5	Bang Kho Laem	106,499	105,685	104,479	103,391	101,862	Decreasing
6	Bang Khun Thian	127,697	132,313	137,934	141,698	145,294	
7	Bang Na	101,737	101,667	101,695	101,360	100,474	Decreasing
8	Bang Phlat	110,331	108,597	107,139	105,347	103,852	Decreasing
9	Bang Rak	50,735	50,023	49,730	49,124	48,506	Decreasing
10	Bang Sue	154,079	151,788	150,547	147,797	145,671	Decreasing
11	Bangkok Noi	135,944	133,669	132,394	130,540	129,401	Decreasing
12	Bangkok Yai	82,676	81,727	80,863	79,637	78,307	Decreasing
13	Bueng Kum	138,340	138,501	140,580	145,172	147,466	
14	Chatuchak	169,983	169,113	167,837	166,581	165,438	Decreasing
15	Chom Thong	167,794	167,175	166,377	165,070	163,846	Decreasing
16	Din Daeng	147,398	146,031	144,461	141,765	139,322	Decreasing
17	Don Mueang	157,989	159,506	161,600	163,080	164,570	
18	Dusit	123,282	121,336	119,927	117,867	116,742	Decreasing
19	Huai Khwang	76,452	76,213	76,402	77,033	76,948	
20	Khan Na Yao	83,611	84,080	84,562	85,027	85,586	
21	Klong Sam Wa	124,476	132,172	138,962	144,423	149,776	
22	Klong San	89,200	87,853	86,163	84,821	82,824	Decreasing
23	Klong Toei	125,254	122,919	121,504	119,909	118,412	Decreasing
24	Lak Si	117,163	116,713	116,922	116,055	115,518	Decreasing
25	Lat Krabang	134,834	138,327	142,460	144,800	147,482	
26	Lat Phrao	116,305	117,711	119,168	120,417	121,366	
27	Min Buri	115,212	118,019	122,825	127,727	131,035	
28	Nong Chok	117,385	126,126	133,415	138,667	143,675	
29	Nong Khaem	125,545	128,493	131,344	135,554	139,585	
30	Pathum Wan	64,168	63,192	62,102	61,040	60,275	Decreasing
31	Phasi Charoen	137,473	136,240	135,149	134,407	133,622	Decreasing
32	Phaya Thai	78,294	77,232	77,343	77,202	76,477	Decreasing
33	Phra Khanong	98,957	98,564	98,096	98,496	97,794	Decreasing
34	Phra Nakhon	69,188	67,357	65,835	64,356	62,966	Decreasing
35	Pom Prap Sattru Phai	61,220	60,001	58,768	57,461	56,464	Decreasing
36	Prawet	139,009	142,633	146,401	149,883	152,669	
37	Rat Burana	95,041	94,097	93,548	92,929	92,094	Decreasing
38	Ratchathewi	103,086	99,827	98,601	97,747	78,147	Decreasing
39	Sai Mai	161,749	165,491	169,109	173,076	176,376	
40	Samphanthawong	32,194	31,674	31,142	30,646	30,088	Decreasing
41	Saphan Sung	81,784	83,147	84,934	86,043	87,082	
42	Sathon	96,714	95,089	93,808	92,021	90,937	Decreasing
43	Suan Luang	114,940	115,120	115,490	116,293	116,067	
44	Taling Chan	104,680	105,730	106,811	107,812	107,513	
45	Thawi Watthana	64,220	66,354	68,423	70,196	72,026	
46	Thon Buri	139,573	136,971	134,589	132,034	129,662	Decreasing
47	Thung Khru	104,827	107,609	110,469	111,621	113,008	
48	Wang Thonglang	113,166	114,132	114,950	114,984	115,685	
49	Watthana	80,217	80,121	80,596	80,744	81,053	
50	Yan Nawa	88,986	88,556	88,383	88,061	87,386	Decreasing
	Total	5,634,132	5,658,953	5,695,956	5,716,248	5,710,883	

Source: DOLA



Source: JST

Figure 5.2.4 Distribution of Population Growth Rates by Districts

(4) Population Projection by Administrative Districts

Population projection by districts has been carried out taking into account projected future population of BMA (Cunsus Base) shown in Table 5.2.2 and population growth tendencies of districts (Registered Base) shown in Table 5.2.5. Future populations of districts whose population has decreased are assumed to maintain present population (2008).

Population decrease in 38 Rachathewi District in 2008 was extordinary large (19,600 persons/year) comparing to other years from 2004 to 2007 (refer to Table 5.2.5). It may be too low if future population is fixed at population in 2008. Therefore, future population of the district is fixed at population in 2007.

And those of other districts will increase depending on population growth tendency. Table 5.2.6 shows projected population (Census Base) by administrative districts.

Table 5.2.6 Projection of Future Population by Districts

(person)

		2008	2020	2030	2040	Remarks
1	Bang Bon	118,758	131,190	139,790	148,750	
2	Bang Kapi	173,340	184,060	191,780	199,500	
3	Bang Khae	223,125	249,270	269,430	289,630	
4	Bang Khen	212,037	238,590	258,900	279,240	
5	Bang Kho Laem	117,488	117,550	117,550	117,550	Population fixed
6	Bang Khun Thian	167,582	196,680	217,190	237,080	
7	Bang Na	115,887	115,950	115,950	115,950	Population fixed
8	Bang Phlat	119,783	119,840	119,840	119,840	Population fixed
9	Bang Rak	55,947	55,980	55,980	55,980	Population fixed
10	Bang Sue	168,017	168,100	168,100	168,100	Population fixed
11	Bangkok Noi	149,251	149,330	149,330	149,330	Population fixed
12	Bangkok Yai	90,319	90,370	90,370	90,370	Population fixed
13	Bueng Kum	170,088	173,720	178,980	185,670	
14	Chatuchak	190,817	190,910	190,910	190,910	Population fixed
15	Chom Thong	188,980	189,080	189,080	189,080	Population fixed
16	Din Daeng	160,694	160,780	160,780	160,780	Population fixed
17	Don Mueang	189,815	216,010	236,080	256,190	
18	Dusit	134,651	134,720	134,720	134,720	Population fixed
19	Huai Khwang	88,752	91,650	93,990	96,320	
20	Khan Na Yao	98,715	107,120	113,110	119,090	
21	Klong Sam Wa	172,752	222,450	256,700	288,550	
22	Klong San	95,529	95,580	95,580	95,580	Population fixed
23	Klong Toei	136,577	136,650	136,650	136,650	Population fixed
24	Lak Si	133,239	133,310	133,310	133,310	Population fixed
25	Lat Krabang	170,106	183,530	193,930	205,090	
26	Lat Phrao	139,984	159,870	175,240	190,640	
27	Min Buri	151,136	177,420	196,930	215,730	
28	Nong Chok	165,715	219,560	256,120	289,880	
29	Nong Khaem	160,998	178,450	192,340	206,390	
30	Pathum Wan	69,521	69,560	69,560	69,560	Population fixed
31	Phasi Charoen	154,120	154,200	154,200	154,200	Population fixed
32	Phaya Thai	88,209	88,250	88,250	88,250	Population fixed
33	Phra Khanong	112,796	112,850	112,850	112,850	Population fixed
34	Phra Nakhon	72,625	72,660	72,660	72,660	Population fixed
35	Pom Prap Sattru Phai	65,126	65,160	65,160	65,160	Population fixed
36	Prawet	176,089	191,670	203,770	216,470	
37	Rat Burana	106,221	106,280	106,280	106,280	Population fixed
38	Ratchathewi	90,135	112,800	112,800	112,800	Population fixed
39	Sai Mai	203,433	217,700	229,290	241,890	
40	Samphanthawong	34,704	34,720	34,720	34,720	Population fixed
41	Saphan Sung	100,441	101,570	103,690	106,790	
42	Sathon	104,887	104,940	104,940	104,940	Population fixed
43	Suan Luang	133,872	140,820	145,170	149,510	
44	Taling Chan	124,006	137,070	146,450	155,840	
45	Thawi Watthana	83,075	93,290	101,510	109,670	
46	Thon Buri	149,552	149,630	149,630	149,630	Population fixed
47	Thung Khru	130,344	135,210	140,180	146,110	
48	Wang Thonglang	133,431	142,960	150,190	157,420	
49	Watthana	93,487	98,670	101,590	104,510	
50	Yan Nawa	100,791	100,840	100,840	100,840	
Total		6,586,947	7,018,570	7,322,390	7,626,000	

Population: Census population base

Source: JST

5.3 Water Supply Plan of MWA

5.3.1 Water Supply Plan

Water supply in BMA is solely managed by Metropolitan Waterworks Authority (MWA). Service area of MWA covers BMA area and neighboring provinces. Amounts of supplied water from 2000 to 2009 were obtained from the annual reports. Projection of water production until 2057 was also obtained in interview with the authority. These figures are shown in Table 5.3.1.

Table 5.3.1 Water Supply of MWA

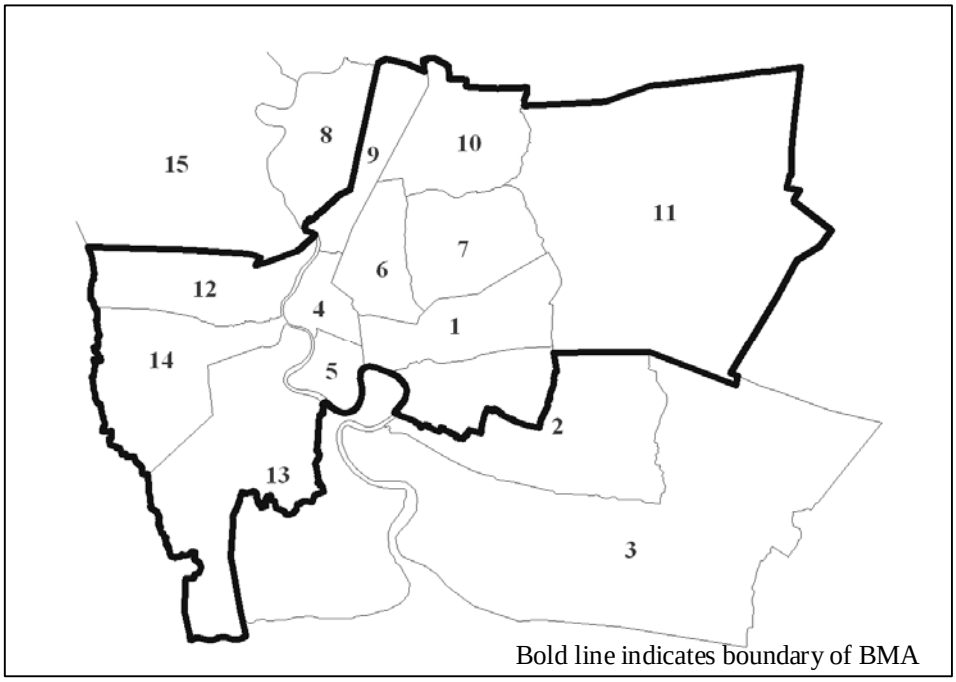
Year	Served Population (person)	Water Production (Mm^3/y)	Supply/ Product Ratio (%)	Water Supply (Mm^3/y)	Water Supply (m^3/d)	Unit Water Supply (lpcd)	Remarks
2000	7,535,825	1,438.6	61.2	880.3	2,411,781	320	Actual
2001	7,621,972	1,481.6	62.7	929.5	2,546,575	334	
2002	7,715,075	1,505.0	64.4	969.4	2,655,890	344	
2003	7,815,347	1,516.2	66.9	1,013.9	2,777,808	355	
2004	7,625,840	1,538.4	69.9	1,076.0	2,947,945	387	
2005	7,708,756	1,628.0	69.5	1,131.0	3,098,630	402	
2006	7,802,639	1,699.7	69.0	1,173.0	3,213,699	412	
2007	7,867,379	1,739.4	70.4	1,224.0	3,353,425	426	
2008	7,910,699	1,765.7	70.8	1,250.6	3,426,301	433	
2009	7,958,163	1,736.4	72.0	1,250.3	3,425,479	430	
2010	8,253,151	1,800.8	72.1	1,299.2	3,559,485	431	Planned
2020	8,799,507	2,184.1	73.6	1,607.0	4,402,692	500	
2030	9,382,031	2,350.4	75.0	1,762.8	4,829,517	515	
2040	10,003,118	2,500.5	75.0	1,875.4	5,138,018	514	

Source: MWA

5.3.2 Water Supply by MWA Branches and by Uses

(1) MWA Branches

Figure 5.3.1 shows service area of MWA covered by fifteen (15) branches listed in Table 5.3.2. Service areas of branch Nos.3, 8 and 15 cover entirely out of BMA area. And, service areas of branch Nos. 2 and 13 cover both BMA area and out of BMA area.



Source: JST, MWA

Figure 5.3.1 Water Supply Branch Area of MWA

Table 5.3.2 List of MWA Branch

No.	Branch Name	No.	Branch Name	No.	Branch Name
1	Sukhumvit	6	Prayathai	11	Minburi
2	Prakanong	7	Lad prao	12	Bangkoknoi
3	Samut prakarn	8	Nongthabuti	13	Taksin
4	Mensri	9	Prachachuan	14	Paseecharoen
5	Tung mahamek	10	Bangkhen	15	Bangbuathong

Source: JST, MWA

(2) Water Supply by MWA Branches and by Uses

Water supply data by MWA braches and uses of 2007, 2008 and 2009 were obtained from MWA. Water supply by detailed uses is obtained only from data of 2009. Data of 2007 and 2008 are categorized barely into two uses, viz. residential and non-residential uses. These figures are shown in Table 5.3.3 and Table 5.3.4.

Ratios of residential use, commercial use and industrial use to total are 47.6%, 32.3% and 4.0% respectively, as shown in Table 5.3.3. Ratios of commercial use to residential use of 2007 to 2009 do not vary substantially, but it varies by MWA branches significantly. In branch Nos. 4 and 5 which cover Thai cultural conservation area and commercial area mainly, water supply for non-residential use is more than double of residential use. Distribution of ratios of non-residential use to residential use is shown in Figure 5.3.2.

Table 5.3.3 Water Supply by MWA Branches and by Uses in 2009 (Detailed)

(Million m^3/year)

MWA Branch		Residential	Non-residential								Total	Ratio Non-residential /Residential
			Commercial Business	Govern. Office	Industrial Sector	Temporary Use	Bulk (Residential)	Bulk (Commercial)	Public Use	Sub Total		
1	Sukhumvit	42.21	44.72	2.62	1.82	4.84	6.53	1.14	2.76	64.43	106.64	1.53
2	Prakanong	51.67	33.11	1.13	5.96	4.36	7.23	0.97	2.38	55.14	106.81	1.07
3	Samut prakarn	45.29	35.91	1.64	13.72	2.63	3.17	15.54	1.35	73.96	119.25	1.63
4	Mensri	27.11	45.14	11.55	0.42	1.98	3.21	0.35	0.99	63.64	90.75	2.35
5	Tung mahamek	21.40	33.61	1.07	1.17	1.82	2.02	1.37	0.70	41.76	63.16	1.95
6	Prayathai	33.56	34.33	6.44	0.26	4.18	6.48	1.23	1.07	53.99	87.55	1.61
7	Lad prao	44.46	26.66	0.48	0.91	4.17	4.90	1.26	0.96	39.34	83.80	0.88
8	Nongthabuti	37.18	15.31	2.77	0.28	2.08	4.41	0.20	0.41	25.46	62.64	0.68
9	Prachachuan	29.01	11.74	5.21	0.09	1.66	3.85	0.32	0.40	23.27	52.28	0.80
10	Bangkhen	31.07	11.61	3.89	2.77	2.45	4.15	0.15	2.08	27.10	58.17	0.87
11	Minburi	39.08	12.81	6.29	2.83	4.11	4.82	7.90	0.48	39.24	78.32	1.00
12	Bangkoknoi	36.19	14.53	0.86	0.50	2.15	1.18	0.00	1.22	20.44	56.63	0.56
13	Taksin	69.82	43.45	1.03	14.86	3.52	4.37	0.15	2.96	70.34	140.16	1.01
14	Paseecharoen	42.74	28.20	1.07	2.68	2.06	1.03	0.68	1.45	37.17	79.91	0.87
15	Bangbuathong	44.25	12.10	0.33	1.44	3.45	1.77	0.07	0.77	19.93	64.18	0.45
	Total	595.04	403.23	46.38	49.71	45.46	59.12	31.33	19.98	655.21	1,250.25	1.10
		47.6%	32.3%	3.7%	4.0%	3.6%	4.7%	2.5%	1.6%	52.4%		

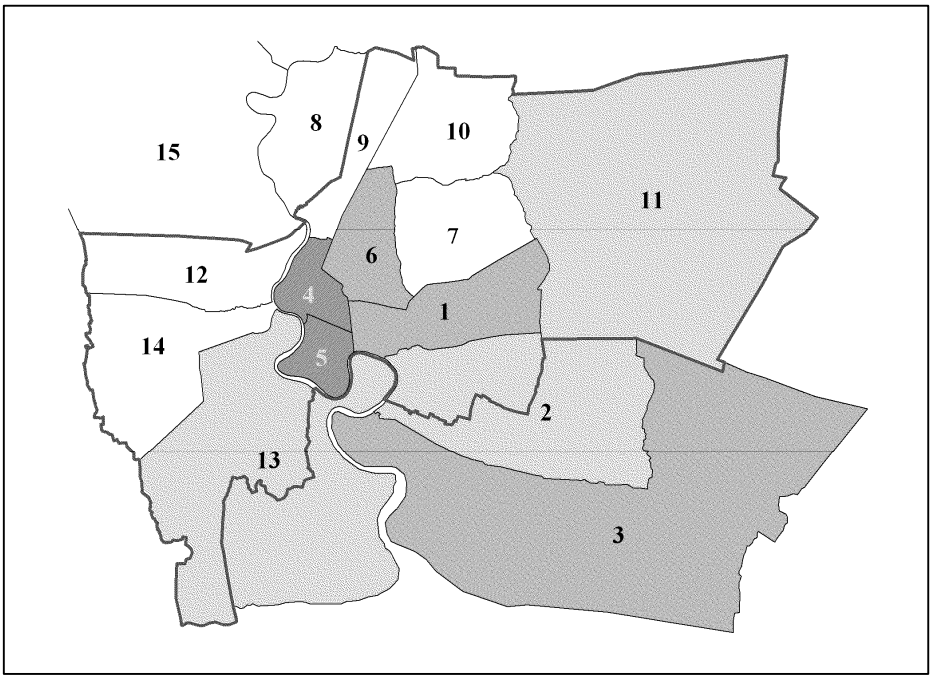
Source: MWA

Table 5.3.4 Water Supply by MWA Branches and by Uses in 2007 to 2009

MWA Branch		2007			2008			2009			N-R / Residential Ratio (Average)	Remarks
		Residential (Mm^3/y)	Non Residential (Mm^3/y)	N-R / Residential Ratio	Residential (Mm^3/y)	Non Residential (Mm^3/y)	N-R / Residential Ratio	Residential (Mm^3/y)	Non Residential (Mm^3/y)	N-R / Residential Ratio		
1	Sukhumvit	40.97	65.20	1.59	41.95	65.28	1.56	42.21	64.43	1.53	1.56	
2	Prakanong	47.21	56.24	1.19	49.06	57.89	1.18	51.67	55.15	1.07	1.15	Including out of BMA
3	Samut prakarn	39.50	76.72	1.94	41.81	82.57	1.97	45.29	73.96	1.63	1.85	Out of BMA Area
4	Mensri	26.78	64.18	2.40	27.17	64.45	2.37	27.11	63.65	2.35	2.37	
5	Tung mahamek	21.57	45.05	2.09	21.14	44.70	2.11	21.40	41.76	1.95	2.05	
6	Prayathai	33.62	53.51	1.59	33.48	53.69	1.60	33.56	54.00	1.61	1.60	
7	Lad prao	42.20	41.14	0.97	42.75	40.93	0.96	44.46	39.35	0.88	0.94	
8	Nongthabuti	36.13	24.67	0.68	36.71	24.51	0.67	37.18	25.45	0.68	0.68	Out of BMA Area
9	Prachachuan	27.91	25.96	0.93	28.09	24.15	0.86	29.01	23.27	0.80	0.86	
10	Bangkhen	28.44	27.70	0.97	29.09	27.79	0.96	31.07	27.11	0.87	0.93	
11	Minbuti	30.72	38.16	1.24	33.85	40.57	1.20	39.08	39.22	1.00	1.15	
12	Bangkoknoi	35.02	21.69	0.62	35.36	21.17	0.60	36.19	20.44	0.56	0.59	
13	Taksin	65.71	73.77	1.12	67.83	74.36	1.10	69.82	70.34	1.01	1.08	Including out of BMA
14	Paseecharoen	40.24	40.30	1.00	40.79	39.85	0.98	42.74	37.17	0.87	0.95	
15	Bangbuathong	36.12	19.01	0.53	39.30	20.26	0.52	44.25	19.94	0.45	0.50	Out of BMA Area
計		552.14	673.30	1.22	568.38	682.17	1.20	595.06	655.25	1.10	1.17	
		1,225.44			1,250.55			1,250.30				

Note:Residential and non-residential classification by MWA (refer to Table 5.3.3)

Source: MWA



Category	Non-Residential /Residential Ratio	MWA Branch No.
A	More than 2.0	4, 5
B	Between 1.5 and 2.0	1, 3, 6
C	Between 1.0 and 1.5	2, 11, 13
D	Less than 1.0	7, 8, 9, 10,12,14,15

Source: JST

Figure 5.3.2 Distribution of Non-Residential/Residential Ratio of Water Supply by MWA Branch

(3) Water Supply to BMA Area

As data on water supply to BMA area is not available, Survey Team estimated that by following steps.

i)	Population in BMA area in 2008	6,586,947 (Table 5.2.6)
ii)	Water supply coverage ratio in BMA area	estimated to be 90%
iii)	Water served population in BMA area	5,928,252
iv)	Water served population in whole MWA area	7,910,699 (Table 5.3.1)
v)	Served population ratio of BMA to whole MWA	75%
vi)	Water supply ratio of BMA to whole MWA	75%

(Assuming unit water supply of BMA area equals to that of whole MWA area)

Table 5.3.5 shows water supply to BMA area estimated by above steps.

Table 5.3.5 Estimated Water Supply to BMA Area

Year	Total Water Supply	To Out of BMA Area (25%)	Water Supply to BMA Area (75%)	
	(Mm^3/y)	(Mm^3/y)	(Mm^3/y)	(m^3/d)
2007	1,224.0	306.0	918.0	2,515,068
2008	1,250.6	312.6	938.0	2,569,863
2009	1,250.3	312.6	937.7	2,569,041
2010	1,299.2	324.8	974.4	2,669,589
2020	1,607.0	401.8	1,205.2	3,301,918
2030	1,762.8	440.7	1,322.1	3,622,192
2040	1,875.4	468.9	1,406.5	3,853,425

Source: JST

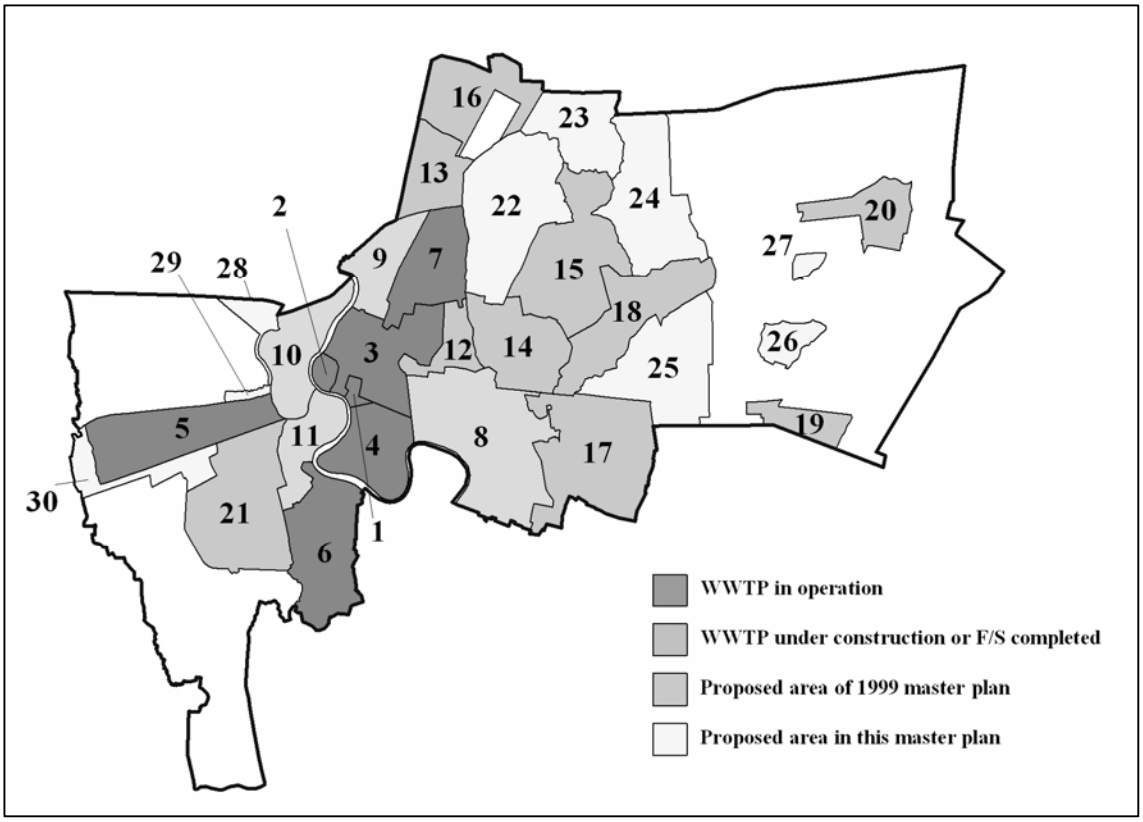
5.4 Proposal on Treatment Areas

At present seven (7) WWTPs are in operation and Bang Sue WWTP is under construction. Feasibility study on Klong Toei and Thong Buri Sewerage Projects were completed. In addition to these WWTPs, other ten (10) WWTPs were proposed in mater plan prepared in 1999. In this conceptual Master Plan, first additional nine (9) new treatment areas are proposed to cover urbanized area of BMA in addition to dividing Thon Buri area into two. These newly proposed treatment areas are set as temporary ones for case study on treatment area rearrangement. These will be checked against wastewater generation and current plants capacity before concluding new treatment areas. Proposed temporary treatment areas are shown in Table 5.4.1 and Figure 5.4.1.

Table 5.4.1 List of Proposed Temporary Treatment Areas

Treatment Area	Status
1. Si Praya	WWTP in operation
2. Rattanakosin	WWTP in operation
3. Din Daeng	WWTP in operation
4. Chong Nonsi	WWTP in operation
5. Nong Khaem	WWTP in operation
6. Thung Khru	WWTP in operation
7. Chatuchak	WWTP in operation
8. Klong Toei	F/ S Completed
9. Bang Sue	WWTP under construction
10. Thon Buri North	Ex-Thon Buri treatment will be divided into two areas,
11. Thon Buri South	DDS will start F/S for both Thon Buri North and South soon.
12. Huaykwan	1999 Sewerage master plan area
13. Lak Si	1999 Sewerage master plan area
14. Wanghthonglang	1999 Sewerage master plan area
15. Bunkhum	1999 Sewerage master plan area
16. Don Mueang	1999 Sewerage master plan area
17. Nong Bon	1999 Sewerage master plan area
18. Ming Buri	1999 Sewerage master plan area
19. Lat Krabang -1	1999 Sewerage master plan area
20. Nong Chok -1	1999 Sewerage master plan area
21. Jomthong	1999 Sewerage master plan area
22. Lat Phrao	Newly proposed area
23. Sai Mai	Newly proposed area
24. Klong Sam Wa	Newly proposed area
25. Lat Krabang -2	Newly proposed area
26. Lat Krabang -3	Newly proposed area
27. Nong Chok -2	Newly proposed area
28. Taling Chan	Newly proposed area
29. Nong Khaem North	Newly proposed area
30. Nong Khaem South	Newly proposed area

Source: JST



Source: JST

Figure 5.4.1 Proposed Treatment Areas

5.5 Population by Proposed Temporary Treatment Areas

Table 5.5.1 shows population by proposed treatment areas which is calculated based on population by administrative districts shown in Table 5.2.5 considering land use plan and estimated population density of land use categories set by city planning department.

Table 5.5.1 Population by Treatment Areas

	Treatment Area	2008	2020	2030	2040	Remarks
1	Si Praya	57,466	57,495	57,495	57,495	WWTP in operation
2	Rattanakosin	49,457	49,480	49,480	49,480	WWTP in operation
3	DinDaeng	498,402	513,145	513,145	513,145	WWTP in operation
4	ChongNonsi	372,765	372,960	372,960	372,960	WWTP in operation
5	Nong Khaem	335,240	362,659	384,017	405,487	WWTP in operation
6	ThungKhru	240,207	245,134	250,104	256,033	WWTP in operation
7	Chatuchak	209,055	209,316	209,446	209,575	WWTP in operation
8	KhlongToei	554,373	566,270	572,976	579,670	FS completed
9	Bang Sue	228,951	229,063	229,063	229,063	WWTP under construction
10	Thon Buri North	359,355	359,542	359,542	359,542	Ex-Thon Buri treatment will be divided into two areas
11	Thon Buri South	333,533	333,707	333,707	333,707	
12	Huaykwang	97,056	106,322	107,842	109,358	Propsed area of 1999 master plan
13	Lak Si	133,238	133,310	133,310	133,310	Propsed area of 1999 master plan
14	Wangthonlang	269,239	287,070	300,183	313,296	Propsed area of 1999 master plan
15	Bunkhum	295,586	311,145	325,092	340,430	Propsed area of 1999 master plan
16	DonMueang	210,468	238,112	259,359	280,749	Propsed area of 1999 master plan
17	Nong Bon	222,293	238,863	251,574	264,883	Propsed area of 1999 master plan
18	Min Buri	216,007	239,043	256,620	274,182	Propsed area of 1999 master plan
19	Lat Krabang-1	49,352	53,246	56,265	59,502	Propsed area of 1999 master plan
20	Nong Chok-1	119,272	158,022	184,339	208,634	Propsed area of 1999 master plan
21	Jomthong	373,336	406,973	430,547	453,938	Propsed area of 1999 master plan
22	Lat Phrao	361,083	405,888	440,489	475,384	Newly proposed area
23	Sai Mai	133,035	142,368	149,949	158,188	Newly proposed area
24	KhlongSamWa	189,057	241,080	277,130	310,738	Newly proposed area
25	Lat Krabang-2	177,038	189,773	200,197	211,457	Newly proposed area
26	Lat Krabang-3	23,332	25,173	26,600	28,129	Newly proposed area
27	Nong Chok-2	11,952	15,837	18,472	20,908	Newly proposed area
28	Taling Chan	119,252	131,814	140,835	149,866	Newly proposed area
29	Nong KhaemNorth	17,365	17,374	17,374	17,374	Newly proposed area
30	Nong KhaemSouth	129,952	144,600	156,071	167,622	Newly proposed area
Sub-total		6,386,717	6,784,784	7,064,183	7,344,105	
31	Out of Treatment Area	200,230	233,786	258,207	281,895	Agricutual area
Total		6,586,947	7,018,570	7,322,390	7,626,000	

Source: JST

5.6 Wastewater Generation

5.6.1 Present Wastewater Generation

(1) Water Supply to BMA by MWA Branches

Table 5.6.1 shows water supply by MWA branches assuming ratio of BMA/ MWA is 75% as discussed in Section 5.3.

(2) Water Supply by Proposed Treatment Areas

Table 5.6.2 shows water supply by proposed treatment areas. Ratios of non-residential use to residential use vary by treatment areas significantly depending on commercial activity of each treatment area. Maximum aggregate unit water supply is 572 lpcd of Rattanakosin treatment area and minimum one is 284 lpcd of Sai Mai and some other treatment areas.

Table 5.6.1 Water Supply to BMA Area by MWA Branches

(m^3/day)

	MWA Branch	Whole MWA			BMA Area			Related Treatment Area
		Domestic	Commercial	Total	Domestic	Commercial	Total	
1	Sukhmvit	114,923	178,855	293,779	114,923	178,855	293,779	Klong Toei, Wangthonlang, Nong Bon, Min Buri, Lat Krabang -2
2	Phrakanong	134,420	158,602	293,021	98,893	116,684	215,577	
3	Samut Prakarn	114,550	226,226	340,776	0	0	0	Out of BMA Area
4	Mansri	74,440	176,574	251,013	74,440	176,574	251,013	Si Praya, Rattanakosin, Din Daeng
5	Tung Mahamak	57,927	122,469	180,396	57,927	122,469	180,396	Chong Nonsi
6	Praya Thai	91,732	147,106	238,839	91,732	147,106	238,839	Din Daeng, Chatuchak, Huaykwang
7	Lad Phrao	117,132	112,131	229,262	117,132	112,131	229,262	
8	Non Taburi	100,560	67,157	167,717	0	0	0	Out of BMA Area
9	Pracha Chuan	76,954	66,149	143,103	76,954	66,149	143,103	
10	Bang Khaen	79,707	76,132	155,839	79,707	76,132	155,839	
11	Minbri	92,731	111,156	203,887	92,731	111,156	203,887	
12	Bankok Noi	96,880	57,995	154,876	96,880	57,995	154,876	
13	Taksin	185,838	203,721	389,559	136,866	150,036	286,902	
14	Pasee Charoen	111,750	109,177	220,926	111,750	109,177	220,926	
15	Bang Bua Thong	107,657	55,504	163,161	0	0	0	Out of BMA Area
		1,557,201	1,868,954	3,426,154	1,149,935	1,424,464	2,574,399	

Note: Commercial includes commercial, government office, industrial,
large scale residential, large scale commercial and public uses

Source: JST

Table 5.6.2 Water Supply and Unit Water Supply by Treatment Areas

	Treatment Area	Population	Water Supply			Per Capita Water Supply			Non-R / Residential Ratio
			Residential	Non Residential	Total	Residential	Non Residential	Total	
		(person)	(m^3/d)			(lpcd)			
1	Si Praya	57,466	9,411	21,695	31,106	164	378	541	2.31
2	Rattanakosin	49,457	8,394	19,910	28,303	170	403	572	2.37
3	DinDaeng	498,402	85,854	179,877	265,731	172	361	533	2.10
4	ChongNonsi	372,765	55,489	117,314	172,803	149	315	464	2.11
5	Nong Khaem	335,240	59,355	57,988	117,343	177	173	350	0.98
6	ThungKhru	240,207	35,556	38,978	74,534	148	162	310	1.10
7	Chatuchak	209,055	36,995	59,328	96,323	177	284	461	1.60
8	Klong Toei	554,373	119,166	163,738	282,904	215	295	510	1.37
9	Bang Sue	228,951	41,745	42,791	84,536	182	187	369	1.03
10	Thon Buri North	359,355	77,873	51,683	129,555	217	144	361	0.66
11	Thon Buri South	333,533	49,371	54,121	103,492	148	162	310	1.10
12	Huaykwang	97,056	17,175	27,543	44,719	177	284	461	1.60
13	Lak Si	133,238	23,390	20,511	43,901	176	154	329	0.88
14	Wangthonlang	269,239	53,863	62,602	116,465	200	233	433	1.16
15	Bunkhum	295,586	56,554	54,123	110,676	191	183	374	0.96
16	Don Mueang	210,468	35,020	31,437	66,457	166	149	316	0.90
17	Nong Bon	222,293	51,014	64,164	115,178	229	289	518	1.26
18	Min Buri	216,007	37,558	50,124	87,682	174	232	406	1.33
19	Lat Krabang-1	49,352	6,387	7,656	14,044	129	155	285	1.20
20	Nong Chok-1	119,272	15,437	18,504	33,940	129	155	285	1.20
21	Jomthong	373,336	56,703	61,111	117,814	152	164	316	1.08
22	Lat Phrao	361,083	59,394	56,783	116,178	164	157	322	0.96
23	Sai Mai	133,035	19,344	18,477	37,821	145	139	284	0.96
24	Klong Sam Wa	189,057	24,468	29,330	53,798	129	155	285	1.20
25	Lat Krabang-2	177,038	26,855	36,265	63,121	152	205	357	1.35
26	Lat Krabang-3	23,332	3,020	3,620	6,639	129	155	285	1.20
27	Nong Chok-2	11,952	1,547	1,854	3,401	129	155	285	1.20
28	Taling Chan	119,252	27,102	16,224	43,327	227	136	363	0.60
29	Nong Khaem North	17,365	3,075	3,004	6,078	177	173	350	0.98
30	Nong Khaem South	129,952	23,008	22,479	45,487	177	173	350	0.98
Sub-total		6,386,717	1,120,123	1,393,234	2,513,356	175	218	394	1.24
31	Out of Service Area	200,230	29,812	31,230	61,043	149	156	305	1.05
BMA Area		6,586,947	1,149,935	1,424,464	2,574,399	175	216	391	1.24

Source: JST

(3) Wastewater Generation

Table 5.6.3 shows wastewater generation and estimated flow at existing seven WWTP. Sewage return ratio from water supply is assumed to be 0.80, which was adopted in F/S of Bang Sue and Klong Toei. Sewer coverage ratio is assumed to be 0.80 in this Survey considering actual condition that some wastewater is discharging into Klong even in an area where interceptors are installed. Here "Sewer Coverage Ratio" is defined as a ratio of wastewater collected by sewer to wastewater generated.

Table 5.6.3 Wastewater Generation and Estimated Flow at WWTP

	Treatment Area	Area	Population	Water Supply	Return Ratio	Wastewater Generation	Sewer Coverage Ratio	Estimated Flow
		(ha)	(person)	(m^3/d)		(m^3/d)		(m^3/d)
1	Si Praya	270.0	57,466	31,106	0.80	24,885	0.80	19,678
2	Rattanakosin	414.2	49,457	28,303	0.80	22,642	0.80	18,270
3	DinDaeng	2,700.0	498,402	265,731	0.80	212,585	0.80	171,480
4	ChongNonsi	2,850.0	372,765	172,803	0.80	138,242	0.80	109,447
5	Nong Khaem	4,400.0	335,240	117,343	0.80	93,874	0.80	66,951
6	ThungKhru	4,200.0	240,207	74,534	0.80	59,627	0.80	54,187
7	Chatuchak	3,340.0	209,055	96,323	0.80	77,058	0.80	62,101
Total		18,174.2	1,762,592	786,143		628,913		502,114

Source: JST

(4) Ground Water and Infiltration Flow from Klong

Inflow to WWTP includes flow from Klong through interceptor chambers in addition to ground water infiltration in Bangkok. Therefore, infiltration in this M/P includes ground water and klong water. Table 5.6.4 shows estimated wastewater and actual recorded flow at WWTPs. The difference between estimated wastewater and recorded flows can be assumed as infiltration here. Table 5.6.4 also shows "infiltration ratio 1" and "infiltration ratio 2" which are calculated by treatment areas and calculated based on estimated wastewater flow.

Average infiltration ratios (1) and (2) are around 10 m^3/d/ha and 40% respectively excepting Si Praya WWTP whose infiltration ratios are minus. These ratios vary significantly by treatment areas.

Table 5.6.4 Estimated Flow and Infiltration Flow

(1) Year 2008

	Treatment Area	Area	Estimated					Actual Flow			Infiltration Flow	Infiltration Flow Ratio (1)	Infiltration Flow Ratio (2)
			Water Supply Amount	Return Ratio	Wastewater Generated	Sewer Coverage Ratio	Estimated Flow WWTP			Average			
		(ha)	(m^3/d)		(m^3/d)		(m^3/d)			(m^3/d)	(m^3/d)	(m^3/d/ha)	(%)
1	Si Praya	270.0	30,746	0.80	24,597	0.80	19,678			13,306	-6,372	-23.60	-32.38
2	Rattanakosin	414.2	28,546	0.80	22,837	0.80	18,270			28,720	10,450	25.23	57.20
3	Din Daeng	3,700.0	267,937	0.80	214,350	0.80	171,480			204,496	33,016	8.92	19.25
4	Chong Nonsi	2,850.0	171,011	0.80	136,809	0.80	109,447			124,282	14,835	5.21	13.55
5	Nong Khaem	4,400.0	104,611	0.80	83,689	0.80	66,951			132,605	65,654	14.92	98.06
6	Thung Khru	4,200.0	84,667	0.80	67,734	0.80	54,187			62,791	8,604	2.05	15.88
7	Chatuchak	3,340.0	97,032	0.80	77,626	0.80	62,101			124,325	62,224	18.63	100.20
	Total (2-7)	18,904.2	753,804		603,045		482,436			677,219	194,783	10.30	40.37

(2) Year 2009

	Treatment Area	Area	Estimated					Actual Flow			Infiltration Flow	Infiltration Flow Ratio (1)	Infiltration Flow Ratio (2)
			Water Supply Amount	Return Ratio	Wastewater Generated	Sewer Coverage Ratio	Estimated Flow WWTP	Dry Season	Rainy Season	Average			
		(ha)	(m^3/d)		(m^3/d)		(m^3/d)	(m^3/d)	(m^3/d)	(m^3/d)	(m^3/d)	(m^3/d/ha)	(%)
1	Si Praya	270.0	30,163	0.80	24,130	0.80	19,304	18,363	18,061	18,213	-1,091	-4.04	-5.65
2	Rattanakosin	414.2	28,278	0.80	22,622	0.80	18,098	28,719	28,864	28,791	10,693	25.82	59.08
3	Din Daeng	3,700.0	266,543	0.80	213,234	0.80	170,587	216,893	192,968	204,931	34,344	9.28	20.13
4	Chong Nonsi	2,850.0	164,047	0.80	131,238	0.80	104,990			124,282	19,292	6.77	18.38
5	Nong Khaem	4,400.0	103,675	0.80	82,940	0.80	66,352	116,411	150,420	132,605	66,253	15.06	99.85
6	Thung Khru	4,200.0	83,456	0.80	66,765	0.80	53,412	55,087	72,873	63,980	10,568	2.52	19.79
7	Chatuchak	3,340.0	97,464	0.80	77,971	0.80	62,377	120,327	120,593	120,470	58,093	17.39	93.13
	Total (2-7)	18,904.2	743,463		594,770		475,816			675,059	199,243	10.54	41.87

Note: Infiltration flow ratio (1) = Infiltration Flow / Treatment area Area
Infiltration flow ratio (2) = Infiltration Flow / Estimated flow based on water supply
Actual flow of Chong Nonsi is 2007's. Data of 2008 and 2009 are not available
Si Praya is excluded from calculation of infiltration flow ratio

Source: JST

5.6.2 Estimated Flow at WWTP in 2040

(1) Population by Treatment areas

Population by treatment areas in 2040 is shown in Table 5.5.1.

(2) Unit Per Capita Water Supply

Wastewater flow to WWTP is estimated based on water supply. Water supply is broadly classified into two categories, such as residential and non-residential. Non-residential category includes commercial, government office, industrial, large scale residential, large scale commercial and public uses. There are more than 17,000 factories in BMA and their wastewater flow totals approximately 40,000 m^3/day according to data obtained from MOIn (refer to Table 3.4.11). This quantity accounts for only 1.5 % of total water supply of 2,574,000 m^3/day in BMA. Therefore, industrial water supply is considered to be a part of non-residential category.

Unit per capita water supply for residential use is assumed to be 200 lpcd. Non-residential unit water supply is divided into four levels based on degree of commercial activity in treatment areas shown in Table 5.6.5. Quantity of water supply calculated based on these unit water supply is well agree with estimated total water supply in BMA.

Table 5.6.5 Unit Water Supply by Category (2040)

(lpcd)

	Non-R /Residential Ratio	Residential	Non-Residential	Total	Particular Treatment area
A	2.5	200	500	700	Si Praya, Rattanakosin, Chong Nonsi,
B	2.0	200	400	600	Dig Daeng, Klong Toei
C	1.5	200	300	500	Refer to Table 5.6.6.
D	1.0	200	200	400	Refer to Table 5.6.6.

Source: JST

(3) Return Ratio

Sewage return ratio from water supply in 2040 is set to be 0.80 same as present condition.

(4) Sewer Coverage Ratio

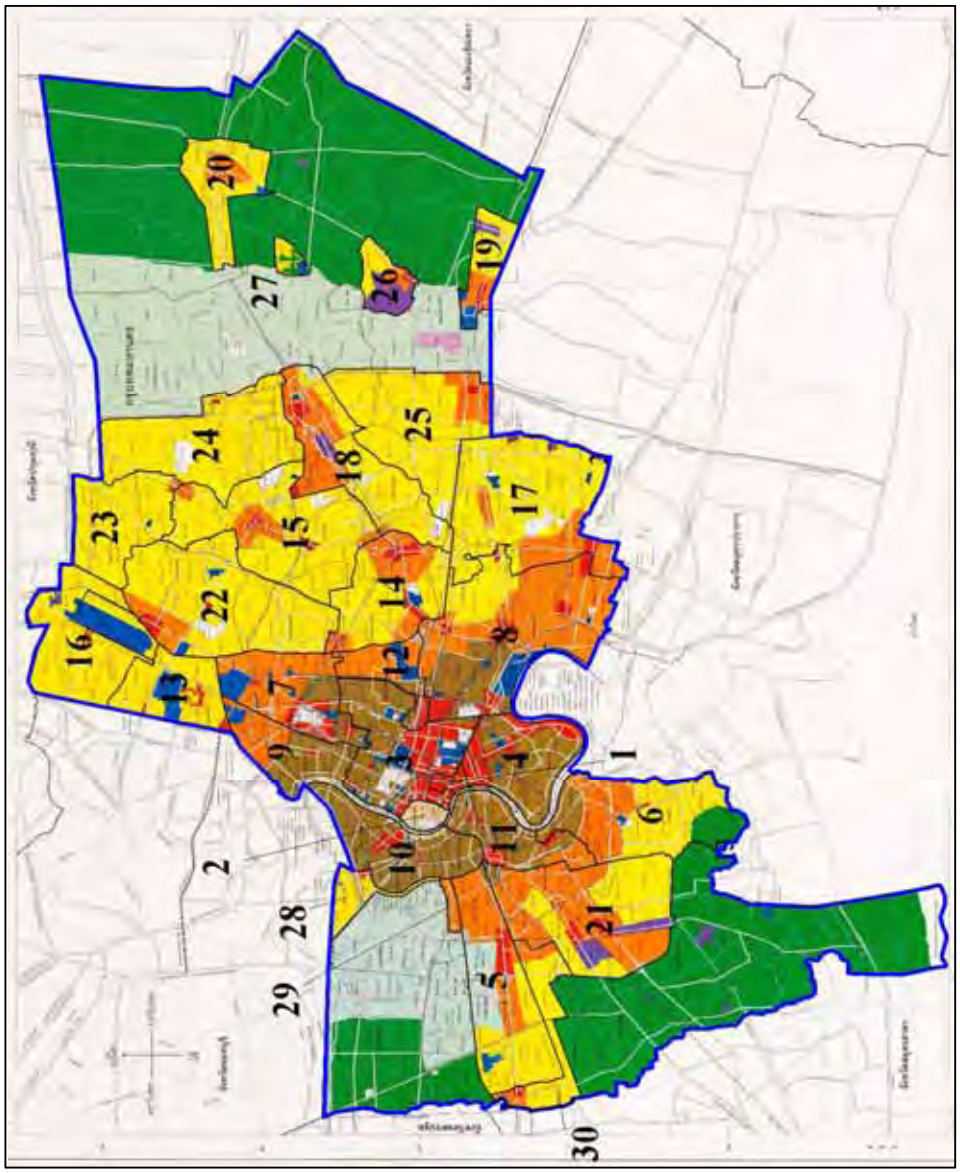
Sewer coverage ratio in 2040 is set to be 0.90.

(5) Infiltration Flow

Infiltration flow is assumed to be principally proportional to area of each treatment area and infiltration ratio is set to be 10 m^3/d/ha considering present condition of existing seven WWTPs as shown in Table 5.6.4. However, there are many vacant spots in new treatment areas, and infiltration flow calculated based on the above rule may be excessively high. Thus infiltration flow should be calculated based on effective treatment area excluding park, open space, water surface and so on. Therefore, limit for infiltration flow is set to be 40% of wastewater flow to avoid excessively high infiltration flow in this M/P.

(6) Estimated Flow at WWTP in 2040

Figure 5.6.1 shows proposed treatment area and estimated flows at WWTP in 2040 by treatment areas are shown in Table 5.6.6.



Source: JST

Figure 5.6.1 Proposed Treatment Area Arrangement (Based on Existing Treatment Area)

Table 5.6.6 Estimated Flow at WWTP by Treatment Areas in 2040

Sr. No.	Tratment Area	Area	Person in Sewer District	Unit Water Supply				Unit Sewage Generation	Water Supply Amount	Sewage Generated	Flow at WWTP	UKF1 Ratio	UKF1	UKF2 (Limit)	UKF Adopted	Total Inflow
				Ratio Category	Commercial / Residential Ratio	Residential	Commercial	Total								
		(ha)				lpcd	lpcd	lpcd	lpcd	(m^3/d)	(m^3/d)	(m^3/d)	(m^3/d/ha)	(m^3/d)	(m^3/d)	(m^3/d)	(m^3/d)
1	Si Praya	226	57,495	A	2.50	200	500	700	560	40,247	32,197	28,977	5	1,130	11,591	1,130	30,107
2	Rattanakosin	367	49,480	A	2.50	200	500	700	560	34,636	27,709	24,938	10	3,670	9,975	3,670	28,608
3	Din Daeng	3,923	513,145	B	2.00	200	400	600	480	307,887	246,310	221,679	10	39,230	88,672	39,230	260,909
4	Chong Nonsi	2,872	372,960	A	2.50	200	500	700	560	261,072	208,858	187,972	5	14,360	75,189	14,360	202,332
5	Nong Khaem	4,384	405,487	D	1.00	200	200	400	320	162,195	129,756	116,780	10	43,840	46,712	43,840	160,620
6	Thung Khru	4,447	256,033	C	1.50	200	300	500	400	128,017	102,413	92,172	5	22,235	36,869	22,235	114,407
7	Chatuchak	3,073	209,575	B	2.00	200	400	600	480	125,745	100,596	90,536	10	30,730	36,214	30,730	121,266
8	Klong Toei	7,309	579,670	B	2.00	200	400	600	480	347,802	278,242	250,418	10	73,090	100,167	73,090	323,508
9	Bang Sue	2,095	229,063	C	1.50	200	300	500	400	114,532	91,625	82,463	10	20,950	32,985	20,950	103,413
10	Thon Buri North	2,922	359,542	C	1.50	200	300	500	400	179,771	143,817	129,435	10	29,220	51,774	29,220	158,655
11	Thon Buri South	2,087	333,707	C	1.50	200	300	500	400	166,854	133,483	120,135	10	20,870	48,054	20,870	141,005
12	Huaykwang	1,333	109,358	B	2.00	200	400	600	480	65,615	52,492	47,243	10	13,330	18,897	13,330	60,573
13	Lak Si	2,263	133,310	C	1.50	200	300	500	400	66,655	53,324	47,992	10	22,630	19,197	19,197	67,189
14	Wangthonlang	3,547	313,296	C	1.50	200	300	500	400	156,648	125,318	112,786	10	35,470	45,114	35,470	148,256
15	Bunkhum	5,639	340,430	D	1.00	200	200	400	320	136,172	108,938	98,044	10	56,390	39,218	39,218	137,262
16	Don Mueang	3,250	280,749	D	1.00	200	200	400	320	112,300	89,840	80,856	10	32,500	32,342	32,342	113,198
17	Nong Bon	6,385	264,883	C	1.50	200	300	500	400	132,442	105,953	95,358	10	63,850	38,143	38,143	133,501
18	Min Buri	4,165	274,182	C	1.50	200	300	500	400	137,091	109,673	98,706	10	41,650	39,482	39,482	138,188
19	Lat Krabang-1	1,258	59,502	C	1.50	200	300	500	400	29,751	23,801	21,421	10	12,580	8,568	8,568	29,989
20	Nong Chok-1	2,109	208,634	C	1.50	200	300	500	400	104,317	83,454	75,109	10	21,090	30,044	21,090	96,199
21	Jomthong	5,816	453,938	C	1.50	200	300	500	400	226,969	181,575	163,418	10	58,160	65,367	58,160	221,578
22	Lat Phrao	6,206	475,384	D	1.00	200	200	400	320	190,154	152,123	136,911	10	62,060	54,764	54,764	191,675
23	Sai Mai	2,958	158,188	D	1.00	200	200	400	320	63,275	50,620	45,558	10	29,580	18,223	18,223	63,781
24	Klong Sam Wa	5,015	310,738	C	1.50	200	300	500	400	155,369	124,295	111,866	10	50,150	44,746	44,746	156,612
25	Lat Krabang-2	4,959	211,457	C	1.50	200	300	500	400	105,729	84,583	76,125	10	49,590	30,450	30,450	106,575
26	Lat Krabang-3	988	28,129	C	1.50	200	300	500	400	14,065	11,252	10,127	10	9,880	4,051	4,051	14,178
27	Nong Chok-2	309	20,908	C	1.50	200	300	500	400	10,454	8,363	7,527	10	3,090	3,011	3,011	10,538
28	Taling Chan	759	149,866	D	1.00	200	200	400	320	59,946	47,957	43,161	10	7,590	17,264	7,590	50,751
29	Nong Khaem North	208	17,374	C	1.50	200	300	500	400	8,687	6,950	6,255	10	2,080	2,502	2,080	8,335
30	Nong Khaem South	1,647	167,622	D	1.00	200	200	400	320	67,049	53,639	48,275	10	16,470	19,310	16,470	64,745
	Sub-total	92,519	7,344,105							3,711,446	2,969,156	2,672,243				785,710	3,457,953
	Out of Service Area	62,939	281,895	D	1.00	200	200	400	320	112,758	90,206	81,185	10	629,390	32,474	32,474	113,659
	Total / Average	155,458	7,626,000							3,824,204	3,059,362	2,753,428				818,184	3,571,612

Note: Treatment Area is measured on a drawing

Source: JST

(7) Estimated Flow in 2040 and Treatment Capacity

Table 5.6.7 shows estimated flow in 2040 and treatment capacity of existing WWTPs, WWTPs under construction or for which F/S was completed. Din Daeng, Chong Nonsi and Chatuchak WWTPs have capacity margin in 2040. At the same time, Thung Khru WWTP lacks treatment capacity in 2040. If treatment area of Nong Khaem will be expanded to nearby urbanized area, Nong Kheam WWTP will lack treatment capacity in 2040.

Current treatment capacity of Chong Nonsi WWTP is 200,000 m^3/day. Site for expansion to 400,000 m^3/day is secured. However, site for the expansion is rented currently to Bangkok Mass Transit Authority (BMTA) for their parking area for rapid buses (BRT). It is somewhat risky to to assume that design capacity will be 400,000 m^3/day since return of the site is not certain at present. Therefore, it is assumed that design capacity of the WWTP will be 200,000 m^3/day in 2040. Although design capacity is less than projected wastewater flow of 202,000 m^3/day by 1 %, design capacity is judged to be sufficient.

Din Daeng and Chatuchak WWTPs are considered to have marginal capacities compared to projected wastewater flow in 2040. On the contrary, Thung Khru and Nong Khaem WWTPs are short of their design capacities.

There is no room for expansion in surrounding areas of Thung Khru WWTP, and therefore increase of capacity is difficult. It is necessary to divide a part of its treatment area and to integrate it to other treatment area(s) or to be independent new treatment area. For Nong Khaem treatment area, expansion of the WWTP site is possible. In addition, it is considered appropriate that urbanized areas in neighborhood of the current treatment area (Nos. 29 and 30 in Figure 5.6.1) are integrated into Nong Khaem treatment area.

Table 5.6.7 Estimated Flow at WWTP and Treatment Capacity of WWTP

(m^3/d)

	Treatment Area	Estimated Flow	Capacity		Evaluation of Capacity
			Current	Future	
1	Si Praya	30,107	30,000	30,000	Adequate
2	Rattanakosin	28,608	40,000	40,000	Adequate
3	Din Daeng	260,909	350,000	350,000	Large margin
4	Chong Nonsi	202,332	200,000	200,000	Adequate
5	Nong Khaem	160,620	157,000	157,000	Inadequate
6	Thung Khru	114,407	65,000	65,000	Inadequate
7	Chatuchak	121,266	150,000	150,000	Large margin
8	KhlongToei	323,508	360,000	360,000	Adequate
9	Bang Sue	103,413	120,000	120,000	Adequate
10	Thon Buri North	158,655			F/S in progess
11	Thon Buri South	141,005			F/S in progess

Source: JST

5.7 Rearrangement of Treatment Areas

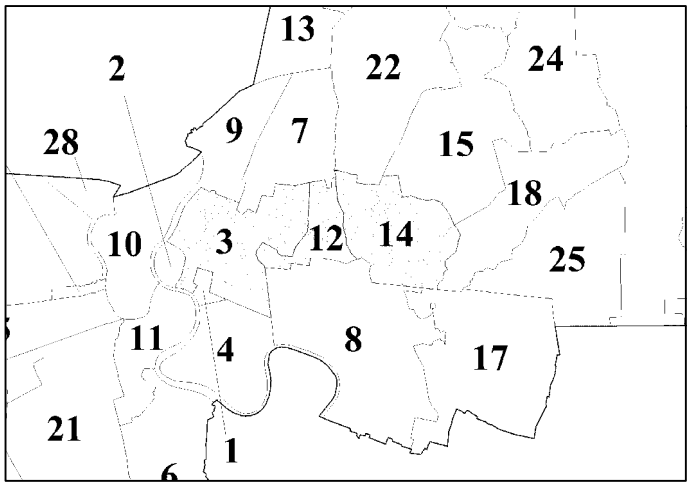
In Din Daeng and Chatuchak treatments areas treatment capacities have some margins. On the contrary, there are shortage of treatment capacities in Thung Khru and Nong Khaem treatment areas. Rearrangement of treatment areas is considered to mitigate this imbalance.

Among 11 treatment areas, 5 treatment areas, i.e. Si Praya, Rattanakosin, Chong Nonsi, Klong Toei and Bang Sue in which design treatment capacities in 2040 are judged to be appropriate are excluded from rearrangement of treatment areas. F/S for Thon Buri treatment area was completed, however, site for WWTP could not be secured and updating of F/S is currently underway by dividing the area into two treatment areas, viz. Thon Buri North and Thon Buri South.

5.7.1 Rearrangement of Din Daeng and Nearby Treatment Areas

(1) Estimated Flows and Treatment Capacities of WWTPs in 2040

To utilize treatment capacity margin of Din Daeng, WWTP effectively, expansion of of the treatment area is considered. Treatment areas surrounding Din Daeng treatment area is shown in Figure 5.7.1 and Table 5.7.1. In the surrounding areas, four WWTPs such as Si Praya, Rattanakosin, Chong Nonsi and Chatuchak WWTPs are in operation, and F/S were completed for Klong Toei and Bang Sue treatment areas. Therefore, expansion of the Din Daeng treatment area is limited to Huaykwang and Wangthonlang treatment areas as shown in Figure 5.7.1.



Source: JST

Figure 5.7.1 Current Situation of Din Daeng and Nearby Treatment Areas

Table 5.7.1 Present Treatment Area Arrangement, Din Daeng and Nearby Treatment Areas

	Treatment Area	Condition
1	Si Praya	Existing, adequate capacity, excluded from rearrangement
2	Rattanakosin	Existing, adequate capacity, excluded from rearrangement
3	Din Daeng	Existing, large margin, Rearrangement to be considered
4	Chong Nonsi	Existing, adequate capacity, excluded from rearrangement
7	Chatchuk	Existing, large margin, To be considered separately
8	Khlong Toei	F/S finished, appropriate design capacity, excluded from rearrangement
9	Nong Bon	Proposed, excluded from rearrangement
12	Huaykwang	Proposed, Rearrangement to be considered
14	Wangthonlang	Proposed, Rearrangement to be considered

Source: JST

Table 5.7.2 shows estimated wastewater flows and treatment capacities in 2040 of 3 treatment areas for rearrangement. Margin of the treatment capacity in Din Daeng treatment area is 89,100 m^3/day.

Table 5.7.2 Estimated Flow and Treatment Capacity of Din Daeng and Nearby Treatment Areas in 2040

(m^3/d)

Treatment Area	Population (person)	Flow	Potential Maximum Capacity	Capacity Margin	Remarks
Din Daeng	513,100	260,900	350,000	89,100	Existing
Huaykwang	109,400	60,600	-	-	Planned
Wangthonlang	313,300	148,300	-	-	Planned
計	935,800	469,800	-	-	

Source: JST

(2) Proposed Treatment Area Boundary for Din Daeng, Huaykwang and Wangthonlang

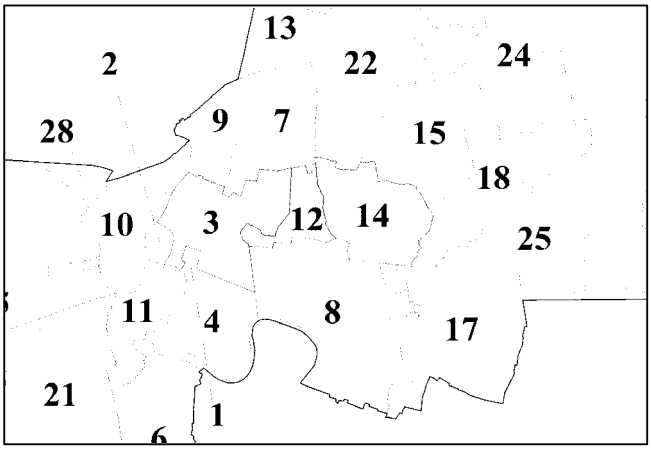
Rearrangement of boundaries of three treatment areas, viz. Din Daeng, Huaykwang and Wangthonlang is shown in Figure 5.7.2.

Rearrangement option 1 is that Huaykwang treatment area is integrated into Din Daeng treatment area. There is no change for Wangthonlang treatment area. In this option, wastewater flow to Din Daeng WWTP is 321,600 m^3/day, with a margin of 28,400 m^3/day to the design capacity of 350,000 m^3/day.

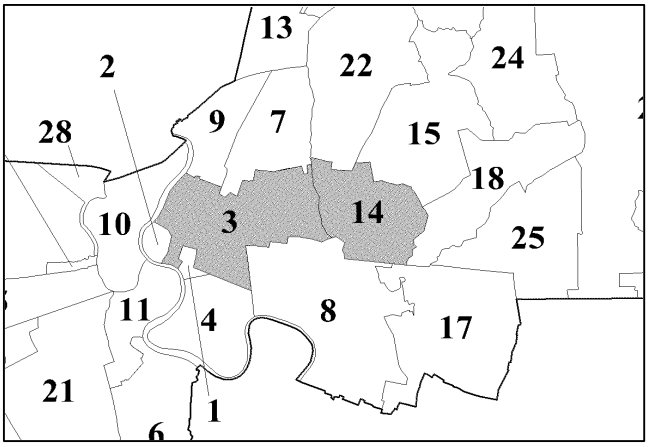
Rearrangement option 2 is that western part of Wangthonlang treatment area is integrated into

Din Daeng treatment area in addition to Huaykwang treatment area to increase flow to Din Daeng WWTP. Boundary of Din Daeng and Wangthonlang treatment areas is highway between them. In this option, design capacity of Din Daeng WWTP is almost equal to wastewater flow in the treatment area. Table 5.7.2 shows comparison of two options.

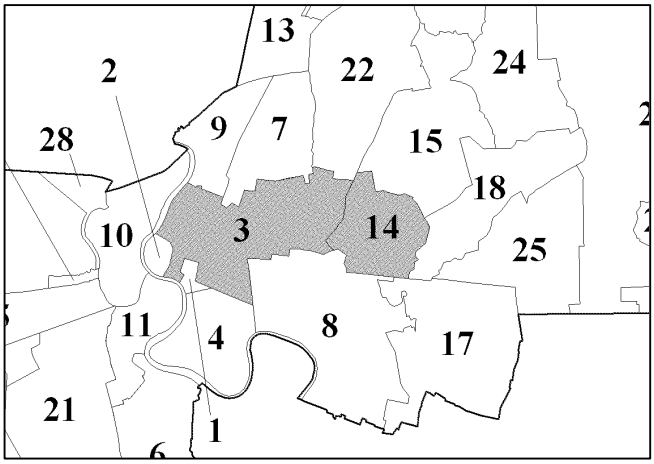
(A) Proposal on Treatment Area Arrangement



(B) Rearrangement of Treatment Area, Option 1



(C) Rearrangement of Treatment Area, Option 2



3: Din Daeng
12: Huaykwang
14: Wangthonlang

Source: JST

Figure 5.7.2 Rearrangement of Treatment Area by Two Options

Table 5.7.3 Estimated Flow and Treatment Capacity of Option 1

(m^3/d)

	Treatment Area	Population (person)	Flow	Capacity Required	Remarks
3	Din Daeng	622,500	321,600	350,000	Divert from whole Huaykwang, Treatment capacity unchanged Capacity margin is about 28,400 m^3/d
12	Huaykwang	0	0	-	Diverted to Din Daeng totally
14	Wangthonlang	313,300	148,200	-	Unchanged
	Total	935,800	469,800	-	

Source: JST

Table 5.7.4 Estimated Flow and Treatment Capacity of Option 2

(m^3/d)

	Treatment Area	Population (person)	Flow	Capacity Required	Remarks
3	Din Daeng	689,700	353,400	350,000	Divert from whole Huaykwang, and part of Wangthonlang Treatment capacity unchanged
12	Huaykwang	0	0	-	Diverted to Din Daeng totally
14	Wangthonlang	246,100	116,400	-	Diverted to Din Daeng partly
	Total	935,800	469,800	-	

Source: JST

Table 5.7.5 Comparison of Two Options

	Treatment Area	Option 1	Option 2
3	Din Daeng	Current design capacity of 350,000 m^3/day should not be changed. These is still margin of capacity of 28,500 m^3/d which can not be used	Design capacity is almost equal to wastewater flow. Therefore, no need to expand the current capacity of 350,000 m^3/d.
12	Huaykwang	None, because of integration into Din Daeng Treatment area.	None, because of integration into Din Daeng Treatment area.
14	Wangthonlang	New WWTP with 149,000 m^3/d design capacity	New WWTP with 117,000 m^3/d design capacity
Adopted or not			Adopted

Source: JST

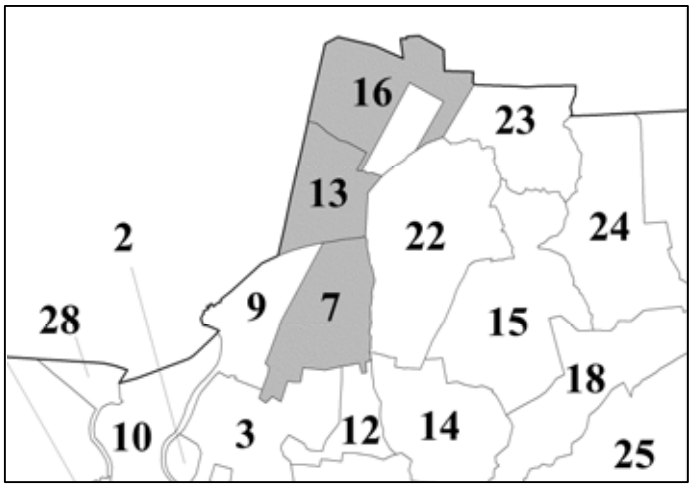
5.7.2 Rearrangement of Chatuchak and Nearby Treatment Areas

(1) Estimated Flows and Treatment Capacities of WWTPs

To utilize treatment capacity margin of Chatuchak WWTP effectively, expansion of Chatuchak treatment area is considered.

Current status of treatment areas around Chatuchak treatment area is shown in Figure 5.7.3 and Table 5.7.6. In the surrounding areas of Chatuchak treatment area, Din Daeng WWTP is in operation and WWTP is under construction in Bang Sue treatment area. Huaykwang and Wangthonlang treatment areas are proposed to be integrated into Din Daeng treatment area as described in the previous section. Therefore these two treatment areas are excluded from consideration here.

Expansion of Chatuchak treatment area is considered in two treatment areas, viz. Lak Si and Don Mueang as shown in Figure 5.7.3.



7	Chatuchak	16	Don Mueang
13	Lak Si		

Source: JST

Figure 5.7.3 Current Situation of Chatuchak and NearbyTreatment Areas

Table 5.7.6 Current Situation of Chatuchak and Nearby Treatment Areas

	Treatment Area	Condition
3	Din Daeng	Already considered, excluded from rearrangement
7	Chatuchak	Existing, treatment capacity margin, rearrangement to be considered
9	Bang Sue	WWTP under construction, adequate capacity, excluded from

	Treatment Area	Condition
		rearrangement
12	Huaykwang	Already considered, excluded from rearrangement
13	Lak Si	Proposed, rearrangement to be considered
14	Wangthonlang	Already considered, excluded from rearrangement
16	Dong Mueang	Proposed, rearrangement to be considered

Source: JST

Table 5.7.7 shows estimated wastewater flows and treatment capacities of Chatuchak, Lak Si and Don Mueang treatment areas in 2040. Treatment capacity of Chatuchak WWTP is 150,000 m^3/d and with a margin of 28,700 m^3/d.

Table 5.7.7 Estimated Flow and Treatment Capacity of Related Treatment Areas

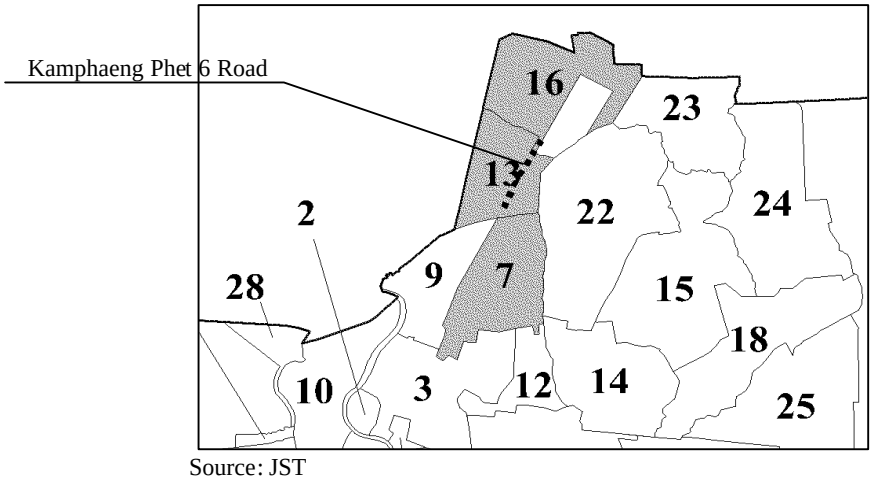
(m^3/d)

	Treatment Area	Population (person)	Flow	Treatment Capacity	Capacity Margin	Remarks
7	Chatuchak	209,600	121,300	150,000	28,700	Existing
13	Lak Si	133,300	67,200	-	-	
16	Don Mueang	280,700	133,200	-	-	
	Total	623,600	301,700	-	-	

Source: JST

(2) Proposed Treatment Area Boundary for Chatuchak Nearby Treatment Areas

Chatuchak WWTP can accommodate an additional flow of 28,700 m^3/day, thus it is proposed that a part of Lak Si treatment area located in eastern side of Kamphaeng Phet 6 street in which wastewater flow seems to be equal to a margin is integrated to Chatuchak treatment area. Remaining part is integrated to Don Mueang treatment area. Figure 5.7.4 rearrangement of treatment areas. Table 5.7.8 shows design population, wastewater flow and design treatment capacities of WWTPs.



Source: JST

Figure 5.7.4 Proposed Treatment Area Arrangement

Table 5.7.8 Estimated Flow and Treatment Capacity in Proposed Arrangement

(m^3/d)

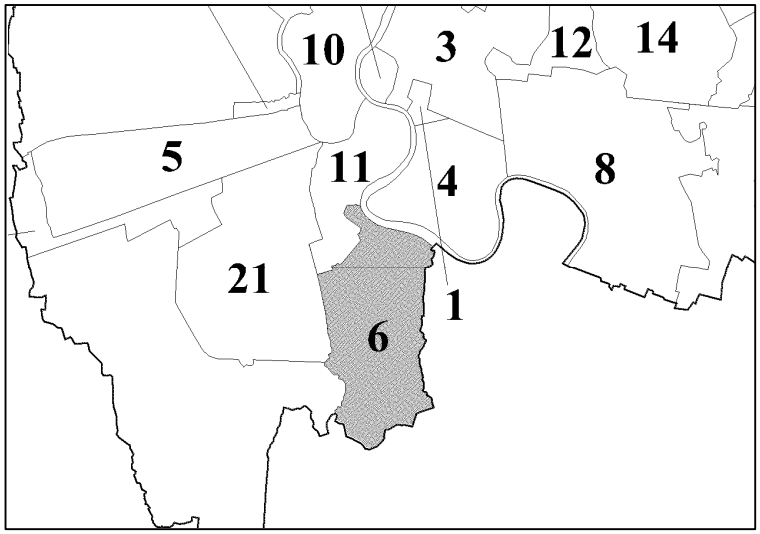
	Treatment Area	Population (person)	Flow	Capacity Required	Remarks
7	Chatuchak	239,700	136,400	140,000	Divert from part of Lak Si Capacity unchanged
13	Lak Si	0	0	0	Not necessary
16	Don Mueang	384,000	165,200	170,000	Divert from part of Lak Si New WWTP
	Total	623,700	301,600	310,000	

Source: JST

5.7.3 Rearrangement of Thung Khru Treatment Area

(1) Estimated Flow and Treatment Capacity of Thung Khru WWTP

Current design capacity of Thung Khru WWTP is 65,000 m^3/day. Wastewater flow estimated in 2040 reaches 114,400 m^3/day, and shortage of treatment capacity is 49,400 m^3/day. Expansion of the treatment facility is very difficult because Thung Khru WWTP is located in a densely built up area. It is necessary to divide and reduce the treatment area to match the design capacity. Current situation of Thung Khru and nearby treatment areas is shown in Figure 5.7.5 and Table 5.7.9.



Source: JST

Figure 5.7.5 Present Treatment Area Arrangement ofThung Khru Treatment Area

Table 5.7.9 Current Situation of Thung Khru and Nearby Treatment Areas

	Treatment Area	Condition
6	Thung Khru	Existing, inadequate capacity, divide into north and south parts
11	Thon Buri South	F/S finished, excluding from arrangement
21	Jomthong	Proposed

Source: JST

Table 5.7.10 shows estimated wastewater flow and treatment capacity in 2040 of Thung Khru treatment area.

Table 5.7.10 Estimated Flow and Treatment Capacity of Thung Khru Treatment Area

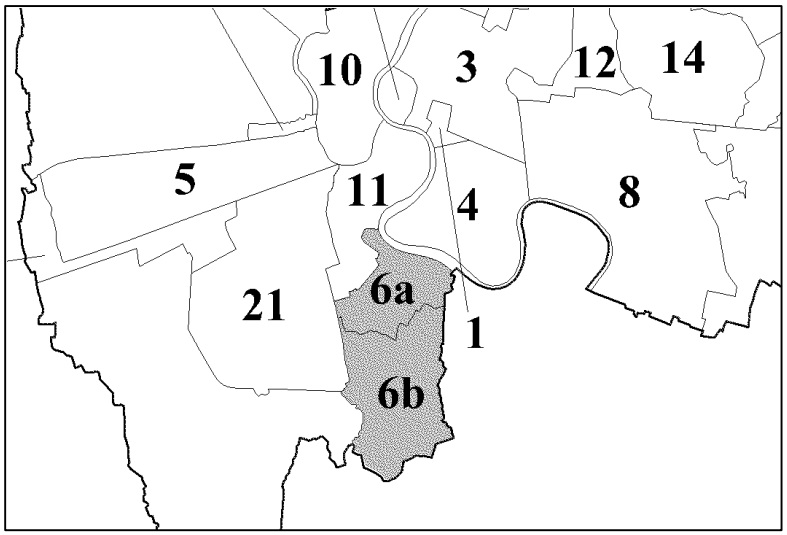
(m^3/d)

	Treatment Area	Population (person)	Flow	Capacity	Shortage	Remarks
6	Thung Khru	256,000	114,400	65,000	-49,400	Existing

Source: JST

(2) **Proposed Treatment Area Boundary for Thug Khru Treatment Area**

To resolve shortage of treatment capacity, Thung Khru treatment area is proposed to be divided into two areas, viz. Thung Khru North and Thung Khru South. Boundary of the two areas is set to match its wastewater flow to the design capacity. Division of the treatment area is shown in Figure 5.7.6. Estimated population, wastewater flow, and treatment capacity are shown in Table 5.7.11.



Source: JST

Figure 5.7.6 Proposed Division of Thung Khru Treatment Area

Table 5.7.11 Estimated Flow and Treatment Capacity in Proposed Arrangement

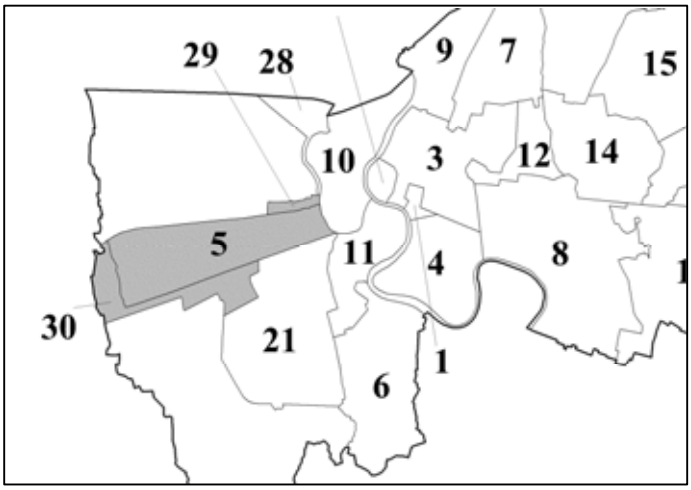
(m^3/d)

	Treatment Area	Population (person)	Flow	Capacity Required	Remarks
6a	Thung Khru North	128,600	53,900	-	To be independet treatment area, divided from Thung KhruTreatment Area
6b	Thung Khru South	127,400	60,500	65,000	Southern part of Thung KhruTreatment Area Existing WWTP, capacity unchanged
	Total	256,000	114,400	-	

Source: JST

5.7.4 Rearrangement of Nong Khaem Treatment Area

Urbanized area located south and north of Nong Khaem treatment area is out of sewerage service area presently as shown in Figure 5.7.7. As this master plan targets to cover almost all urbanized area as sewerage service area, it is proposed to extend existing Nong Khaem treatment area to cover these nearby urbanized areas. Table 5.7.9 shows estimated sewage flows after merging nearby urbanized areas and required treatment capacity of Nong Khaem WWTP. Treatment capacity of this WWTP is necessary to be increased to 235,000 m^3/d.



Source: JST

Figure 5.7.7 Present Treatment Area Arrangement near Nong Khaem Treatment Area

Table 5.7.12 Current Situation of Nong Khaem and Nearby Treatment Areas

	Treatment Area	Condition
5	Nong Khaem	Existing, rearrangement to be considered
29	Nong Khaem North	Proposed, rearrangement to be considered
30	Nong Khaem South	Proposed, rearrangement to be considered

Source: JST

Table 5.7.13 Estimated Flow and Treatment Capacity of Nong Khaem Treatment Area

(m^3/d)

	Treatment Area	Population (person)	Flow	Capacity Required	Remarks
5	Nong Khaem	405,500	160,600	-	
29	Nong Khaem North	17,400	8,300	-	
30	Nong Khaem South	167,600	64,700	-	
	計	590,500	233,600	235,000	Current capacity 157,000 m^3/d

Source: JST

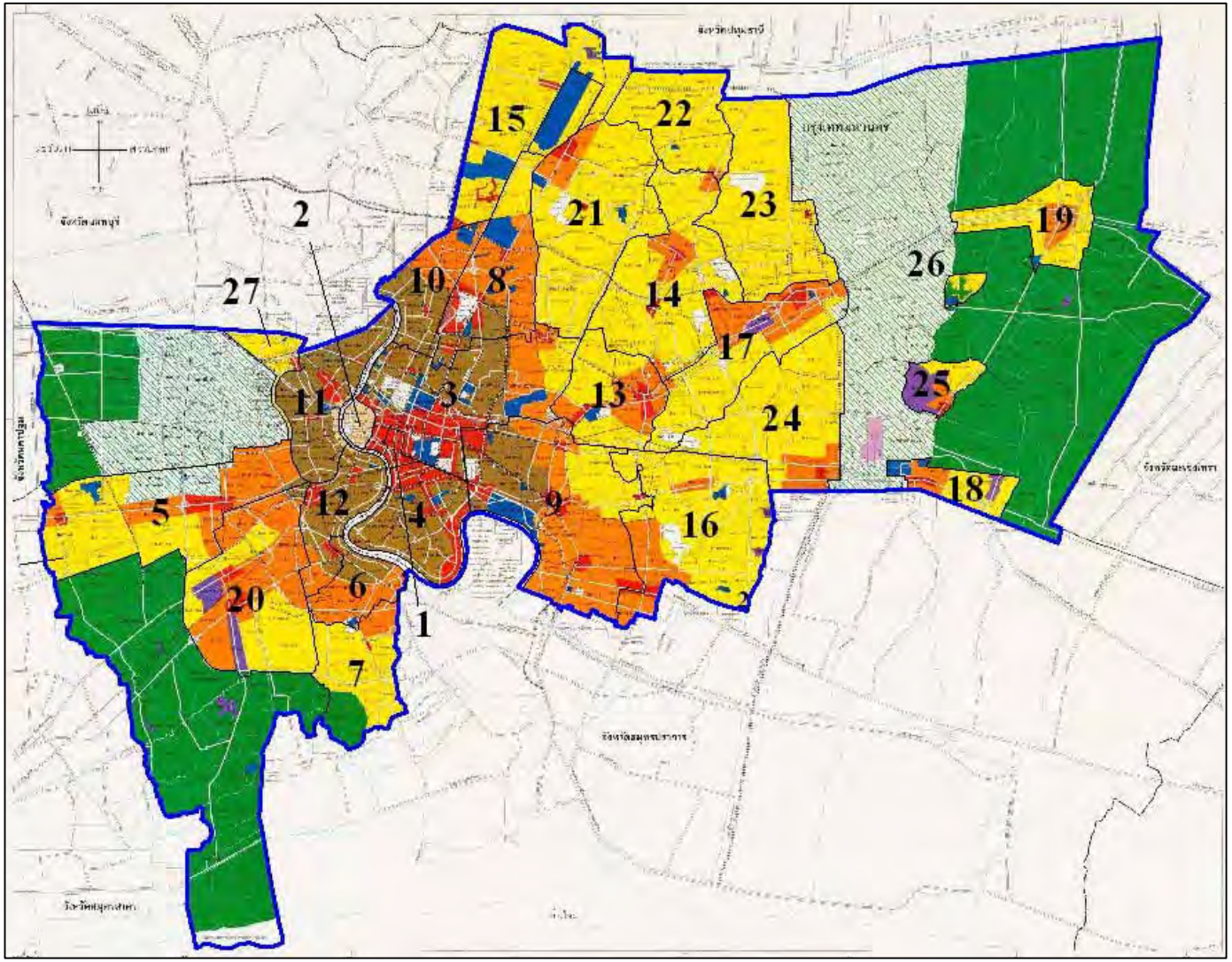
5.7.5 Summary of Treatment Area Rearrangement

Table 5.7.14 shows outlines of proposed rearrangement. Figure 5.7.8 shows rearrangement of treatment areas, Table 5.7.15 shows population and wastewater projection in 2040 by treatment area.

Table 5.7.14 Summary of Treatment Area Rearrangement

	Original	Rearranged	Remarks
1	Din Daeng	Din Daeng	Divert to Chong Nonsi partly Integrate whole Huaykwang and part of Wangthonlang
	Chong Nonsi	Chon Nonsi	Integrate part of Din Daeng
	Huaykwang	-	Divert to Din Daeng totally
	Wangthonlang	Wangthonlang	Divert to Din Daeng partly
2	Chatuchak	Chatuchak	Integrate part of Lak Si
	Lak Si	-	Divert to Chatuchak and Don Mueang totally
	Don Muaeng	Chatuchak	Integrate part of Lak Si
3	Thung Khru	Thung Khru	Divert to Jomthong partly
	Thon Buri South	-	Divert to Jomthong totally
	Jomthong	Jomthong	Integrate whole Thon Buri South and part of Thug Khru
4	Nong Khem	Nong Khaem	Integrate whole Nong Khaem North and South
	Nong Khaem North	-	Divert to Nong Khaem totally
	Nong Khaem South	-	Divert to Nong Khaem totally

Source: JST



Source: JST

Figure 5.7.8 Proposed Treatment Area Rearrangement

Table 5.7.15 Estimated Flow at WWTP by Treatment Area in 2040

No.	Treatment Area	Area	Population	Inflow to WWTP		
				Watewater	Infiltration	Total
		(ha)	(Person)	(m^3/d)		
1	Si Praya	226	57,495	28,977	1,130	30,107
2	Rattanakosin	367	49,480	24,938	3,670	28,608
3	Din Daeng	5,931	689,699	297,950	59,310	357,260
4	Chong Nonsi	2,872	372,960	187,972	14,360	202,332
5	Nong Khaem	6,239	590,483	170,060	62,390	232,450
6	Thung Khru North	1,513	128,637	46,310	7,565	53,875
7	Thung Khru South	2,934	127,396	45,862	14,670	60,532
8	Chatuchak	3,645	239,653	103,530	36,450	139,980
9	KhlongToei	7,309	579,670	250,418	73,090	323,508
10	Bang Sue	2,095	229,063	82,463	20,950	103,413
11	Thon Buri North	2,922	359,542	129,435	29,220	158,655
12	Thon Buri South	2,087	333,707	120,135	20,870	141,005
13	Wangthonlang	2,872	246,098	88,595	28,720	117,315
14	Bunkhum	5,639	340,430	98,044	39,218	137,262
15	Don Mueang	4,941	383,983	110,587	44,235	154,822
16	Nong Bon	6,385	264,883	95,358	38,143	133,501
17	Min Buri	4,165	274,182	98,706	39,482	138,188
18	Lat Krabang-1	1,258	59,502	21,421	8,568	29,989
19	Nong Chok-1	2,109	208,634	75,109	21,090	96,199
20	Jomthong	5,816	453,938	163,418	58,160	221,578
21	Lat Phrao	6,206	475,384	136,911	54,764	191,675
22	Sai Mai	2,958	158,188	45,558	18,223	63,781
23	KhlongSam Wa	5,015	310,738	111,866	44,746	156,612
24	Lat Krabang-2	4,959	211,457	76,125	30,450	106,575
25	Lat Krabang-3	988	28,129	10,127	4,051	14,178
26	Nong Chok-2	309	20,908	7,527	3,011	10,538
27	Taling Chan	759	149,866	43,161	7,590	50,751
Sub-total		92,519	7,344,105	2,670,563	784,126	3,454,689
	Out ofService Area	62,939	281,895	81,186	32,474	113,660
Total		155,458	7,626,000	2,751,749	816,600	3,568,349

Note: Treatment Area is measured on a drawing

Total wastewater flows in Tables 5.6.6 and 5.6.15 are slightly different because infiltration rates of treatment areas are different. Boundary of treatment areas was changed by rearrangement of treatment areas.

Source: JST

Planning of WWTPs and interceptors could not be done because sites for WWTPs were not determined for new treatment areas.

5.8 Construction Cost

Construction cost for sewerage system to be implemented was estimated by using unit costs of Bang Sue and Klong Toei sewerage projects. Unit costs including construction costs for interceptors, pumping stations and WWTPs per treatment area, population and wastewater flow were worked out. Construction cost for each treatment area was calculated as an average of those estimated by three unit costs. Construction costs for treatment areas are shown in Table 5.8.1. A total construction cost including Bang Sue and Klong Toei sewerage systems is estimated to be 102 billion Baht, and that excluding two sewerage systems is to be 86 billion Baht

Table 5.8.1 Construction Cost

No.	Treatment Area	Area	Population	Wastewater Flow	Construction Cost				
					(area)	(population)	(wastewater)	(average)	
		(ha)	(person)	(m^3/day)	(milliom Baht)	(milliom Baht)	(milliom Baht)	(milliom Baht)	
1	Si Praya	226	57,495	30,107	-	-	-	-	
2	Rattanakosin	367	49,480	28,608	-	-	-	-	
3	Din Daeng	5,931	689,699	357,260	-	-	-	-	
4	Chong Nonsi	2,872	372,960	202,332	-	-	-	-	
5	Nong Khaem	6,239	590,483	232,450	-	-	-	-	
6	Thung Khru North	1,513	128,637	53,875	2,515	2,486	1,972	2,324	
7	Thung Khru South	2,934	127,396	60,532	-	-	-	-	
8	Chatuchak	3,645	239,653	139,980	-	-	-	-	
9	KhlongToei	7,309	579,670	323,508	-	-	-	11,046	*1
10	Bang Sue	2,095	229,063	103,413	-	-	-	4,584	*2
11	Thon Buri North	2,922	359,542	158,655	4,857	6,949	5,809	5,871	
12	Thon Buri South	2,087	333,707	141,005	3,469	6,449	5,162	5,027	
13	Wangthonlang	2,872	246,098	117,315	4,773	4,756	4,295	4,608	
14	Bunkhum	5,639	340,430	137,262	9,372	6,579	5,025	6,992	
15	Don Mueang	4,941	383,981	154,822	8,212	7,421	5,668	7,100	
16	Nong Bon	6,385	264,883	133,501	10,612	5,119	4,888	6,873	
17	Min Buri	4,165	274,182	138,188	6,922	5,299	5,059	5,760	
18	Lat Krabang-1	1,258	59,502	29,989	2,091	1,150	1,098	1,446	
19	Nong Chok-1	2,109	208,634	96,199	3,505	4,032	3,522	3,686	
20	Jomthong	5,816	453,938	221,578	9,667	8,773	8,112	8,851	
21	Lat Phrao	6,206	475,384	191,675	10,315	9,188	7,017	8,840	
22	Sai Mai	2,958	158,188	63,781	4,916	3,057	2,335	3,436	
23	KhlongSam Wa	5,015	310,738	156,612	8,335	6,005	5,734	6,691	
24	Lat Krabang-2	4,959	211,457	106,575	8,242	4,087	3,902	5,410	
25	Lat Krabang-3	988	28,129	14,178	1,642	544	519	902	
26	Nong Chok-2	309	20,908	10,538	514	404	386	434	
27	Taling Chan	759	149,866	50,751	1,262	2,896	1,858	2,005	
	Total	92,519	7,344,103	3,454,689	101,221	85,195	72,362	101,889	

Note: *1 estimated by F/S
*2 contract price
Source: JST

5.9 Simple Analysis of Water Pollution

5.9.1 Outline of Simple Analysis of Water Pollution

The purpose of this simple analysis of water pollution is to evaluate approximately the effects of sewerage projects proposed in the Master Plan on the water environment.

(1) Object Water Bodies and Points of Water Quality Estimation

Object water bodies are Chao Phraya River and main klongs in the Survey Area. The points of water quality estimation have been selected among the existing monitoring points of DDS, BMA. At each of these points of water quality estimation, future water quality parameter such as BOD will be estimated for both cases of 'with' or 'without' project. Thus effects of the sewerage project to the river and klongs can be evaluated comparing values of both cases.

Thirty two (32) water quality estimation points have been selected among monitoring points of DDS. These points are shown in Table 5.9.1 and Figures 5.9.1 and 5.9.2. Reasons for selection are described below.

Chao Phraya River

- Monitoring point R01 is the most upstream of BMA administration area, and this point is regarded as boundary point of pollution model. Therefore water quality at the point will be given and not estimated.
- Most downstream monitoring point R09 is outside of BMA administration area, and therefore this point is excluded from pollution model.
- Seven (7) points, viz. R02 to R08 are selected for water pollution analysis as shown in Figure 5.9.1.

Klongs on the East Bank

- Monitoring points located at major klongs such as Klong Lad Phrao, Klong Saen Saep, Klong Prawetburiom and Klong Phra Khanong are selected. Monitoring points in the central district of Bangkok are located within existing treatment areas, and water quality at these points will not be changed significantly even with new sewerage project. Therefore, these points are excluded from pollution model.

Klongs on the West Bank

- Three points (3) in the existing urbanized area are selected to evaluate effects of new sewerage project. These are monitoring points Nos. 252, 261 and 393.
- Three points along the main klong, Klong Sanamchai are selected to evaluate effects of sewerage project on the west bank entirely.

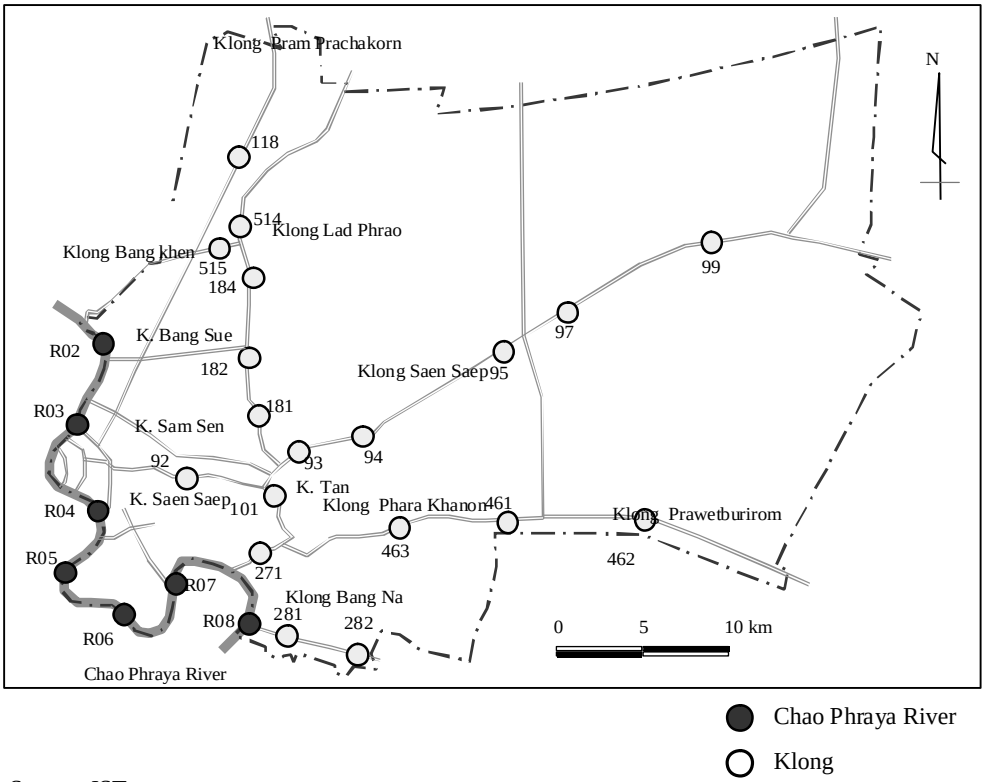
- A total of six points are selected as shown in Figure 5.9.2.

Table 5.9.1 Points of Water Quality Estimation

No.	Monitoring Point	Name of River /Klong	BOD Concentration (mg/l)				Name of District
			Av-1	Av-2	Av-3	Median	
1	R02	Chao Phraya River	4	4	4	4	-
2	R03	Chao Phraya River	4	4	5	4	-
3	R04	Chao Phraya River	5	5	5	4	-
4	R05	Chao Phraya River	6	6	6	4	-
5	R06	Chao Phraya River	6	5	6	5	-
6	R07	Chao Phraya River	6	6	6	5	-
7	R08	Chao Phraya River	6	5	7	5	-
8	99	Klong Saen Saep	4	3	4	4	Nong Chok
9	97	Klong Saen Saep	4	5	3	3	Min Buri
10	95	Klong Saen Saep	7	8	6	6	Min Buri
11	94	Klong Saen Saep	11	12	10	9	Bang Kapi
12	93	Klong Saen Saep	12	18	7	9	Wang Thonglang
13	101	Klong Tan	12	8	16	10	Watthana
14	271	Klong Phra Khanong	8	8	8	8	Klong Toei
15	462	K. Prawetburirom	5	6	4	5	Prawet
16	461	K. Prawetburirom	7	8	5	5	Prawet
17	463	K. Prawetburirom	8	9	7	6	Prawet
18	92	Klong Saen Saep	9	6	11	8	Watthana
19	514	Klong Bang Khen	10	11	8	10	Bang Khen
20	515	Klong Bang Khen	9	12	7	10	Lak Si
21	184	Klong Lad Phrao	9	11	8	8	Lat Phrao
22	182	Klong Lad Phrao	10	11	10	10	Wang Thonglang
23	181	Klong Lad Phrao	10	10	10	11	Huai Khwang
24	118	K. Prem Prachakorn	13	15	11	12	Lak Si
25	261	Klong Bangkok Noi	8	6	9	8	Bangkok Noi
26	394	Klong Bangkok Yai	5	4	6	5	Bangkok Noi
27	252	Klong Mon	6	6	6	6	Bangkok Noi
28	671	Klung Dan	5	5	4	3	Phasi Charoen
29	431	Klong Sanam Chai	5	5	5	6	Chom Thong
30	433	Klong Sanam Chai	9	9	9	9	Bang Khun Thian
31	282	Klong Bang Na	13	15	10	12	Bang Na
32	281	Klong Bang Na	20	14	9	20	Bang Na

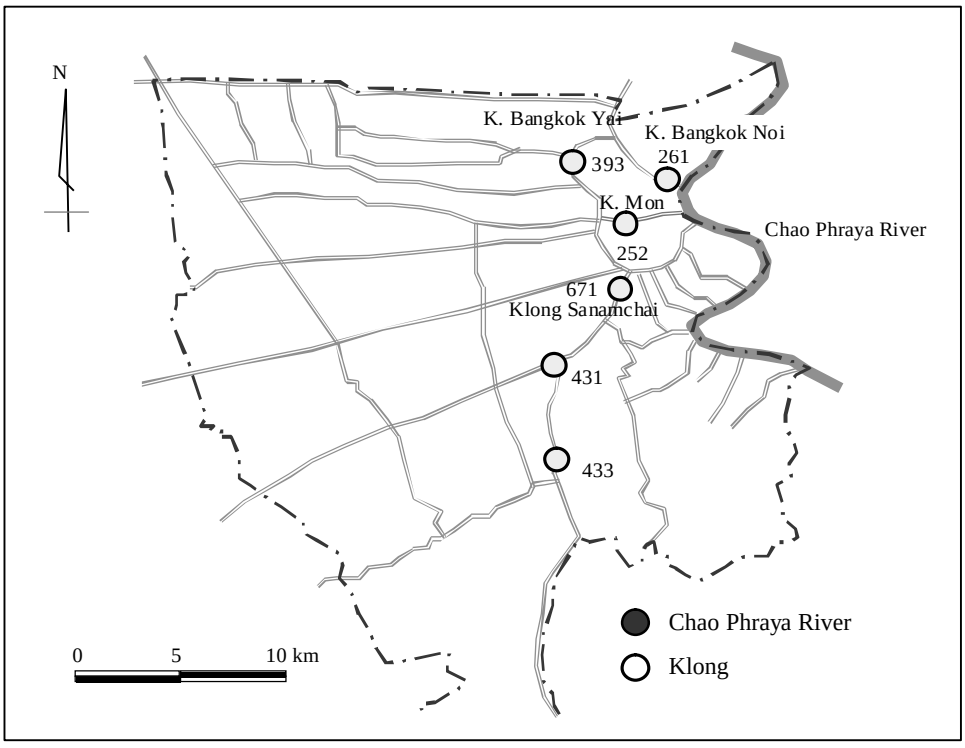
- Av-1: Annual average in 2009
- Av-2: Average during dry season (from November to April) in 2009
- Av-3: Average during rainy season (from May to October) in 2009

Source: JST



Source: JST

Figure 5.9.1 Points of Water Quality Estimation (Chao Phraya River and Klongs on the East Bank)



Source: JST

Figure 5.9.2 Points of Water Quality Estimation (Klongs on the West Bank)

(2) Flow Direction of Klongs for Pollution Model

Topography of the Survey Area is generally flat, and flow in klongs is affected by tide and also influenced strongly by pump and gate operation in wet weather. Flow is often stagnated and sometimes reverse flow may occur. For simplification of pollution model, regular flow direction is assumed for each klong. Regular flow directions are determined based on flow control policy described in purification water introduction plan shown in Figure 5.9.3. On the east bank, the main klongs are controlled to flow into Klong Phra Khanong, then pumped to Chao Phraya River through Phra Khanong pumping station.

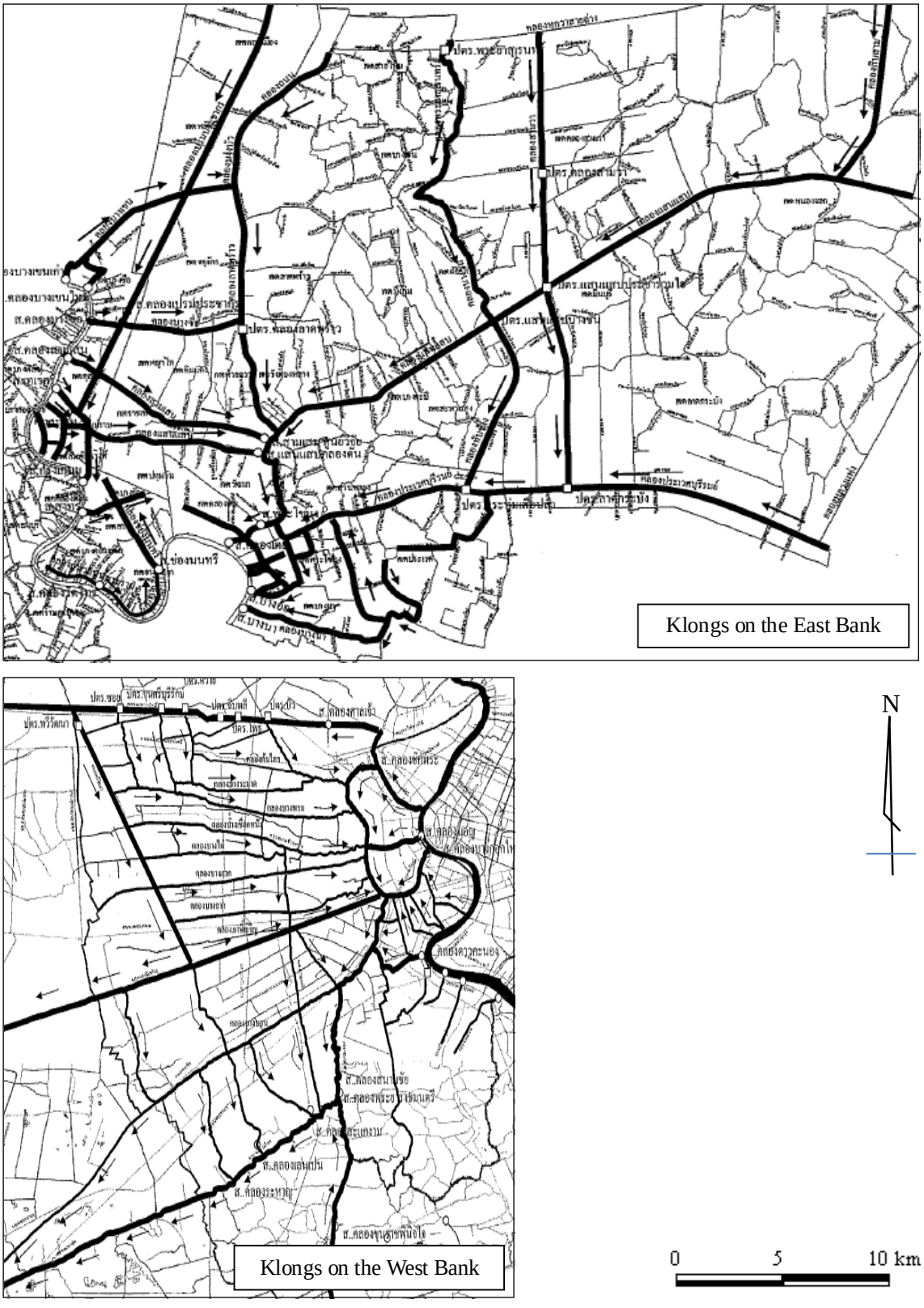
On the west bank, control policy is that purification water is introduced from Chao Phraya River to klongs and klongs discharge to other basins instead of returning to Chao Phraya River. Therefore, flows in these klongs are regular and steady. However, some klongs which are affected strongly by water level of Chao Phraya River are excluded from the above mentioned assumption because flow directions change by tidal effects. Excluded klongs which are affected by tide are described in the following section.

(3) Water Quality Items to be Evaluated

Water quality item to be estimated is Biochemical Oxygen Demand (BOD). Dissolved Oxygen (DO) is affected by various factors and can not be estimated from pollution load only. It is difficult to estimate by simplified model. Therefore, DO is omitted from evaluation. However, DO level will be improved as BOD concentration become low.

(4) Representative BOD Values for Pollution Model

Representative BOD values for pollution analysis are determined to be annual average values in 2009. BOD concentrations obtained at three representative points in Klong Saen Saep, Klong Lad Phrao and Klong Prawetburirom are shown in Figure 5.9.4. From this figure, it can be seen the tendency that BOD concentrations in dry season are generally higher than those in wet season. However this tendency can not always be recognized clearly. It should be noticed that longitudinal continuation of BOD concentrations along a steady flow klong is a key point for developing simplified pollution model. If BOD values in dry season are adopted as representative values, longitudinal continuation can not be assured because higher BOD concentrations appear in dry season at some points and this occur in wet season at other points. This phenomenon can not be described by a simplified pollution model. Based on the consideration mentioned above, annual average value is adopted as representative value. BOD concentrations at other points are shown in Appendix-4 for reference.

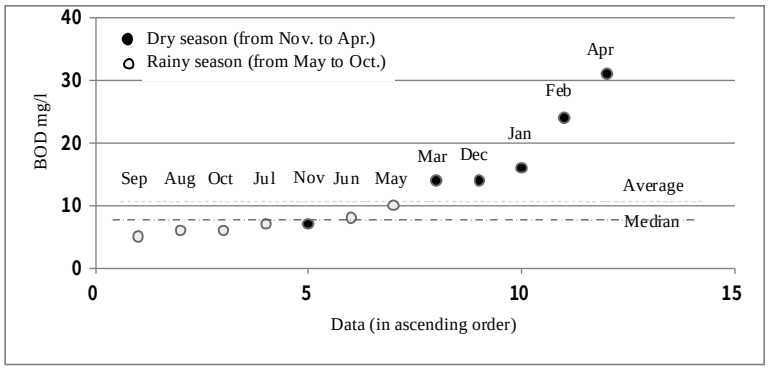


Source: DDS

Figure 5.9.3 Flow Directions in the Main Klongs
(Based on Purification Water Introduction Plan)

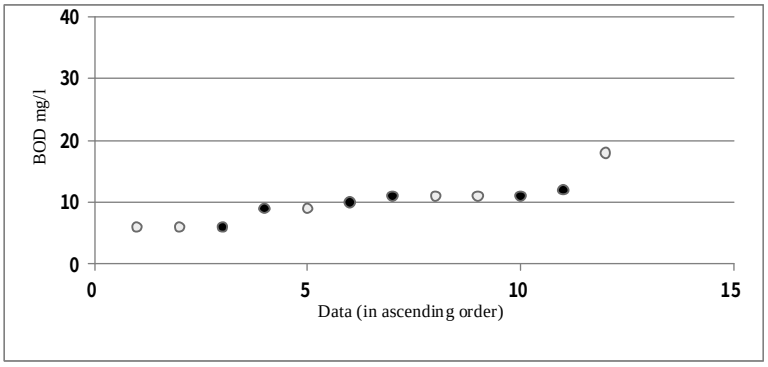
Point No.: 93 (Klong Saen Saep)

Date	Ranking	BOD mg/l
2009/9/3	1	5
2009/8/5	2	6
2009/10/5	3	6
2009/7/13	4	7
2009/11/4	5	7
2009/6/3	6	8
2009/5/21	7	10
2009/3/4	8	14
2009/12/1	9	14
2009/1/6	10	16
2009/2/3	11	24
2009/4/3	12	31
Average		12
Median		9



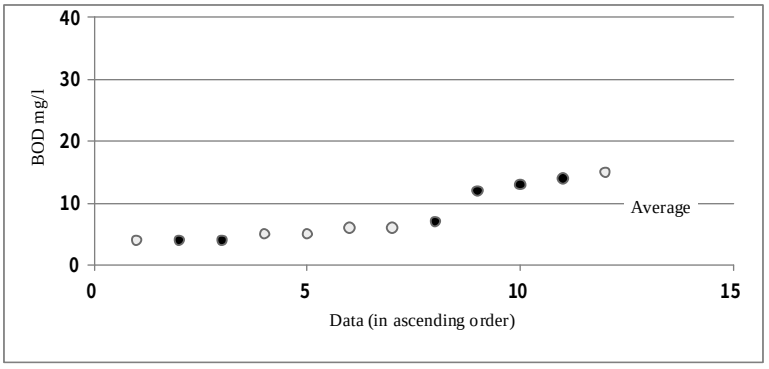
Point No.: 181(Klong Lad Phrao)

Date	Ranking	BOD mg/l
2009/5/4	1	6
2009/7/13	2	6
2009/12/1	3	6
2009/4/20	4	9
2009/9/8	5	9
2009/3/4	6	10
2009/1/13	7	11
2009/6/12	8	11
2009/8/11	9	11
2009/11/4	10	11
2009/2/11	11	12
2009/10/5	12	18
Average		10
Median		11



Point No.: 463 (K. Prawetburirom)

Date	Ranking	BOD mg/l
2009/8/19	1	4
2009/11/3	2	4
2009/12/2	3	4
2009/7/28	4	5
2009/9/2	5	5
2009/6/3	6	6
2009/10/6	7	6
2009/1/5	8	7
2009/3/3	9	12
2009/4/2	10	13
2009/2/2	11	14
2009/5/1	12	15
Average		8
Median		6



Source: JST

Figure 5.9.4 BOD Concentrations in Klongs (2009)

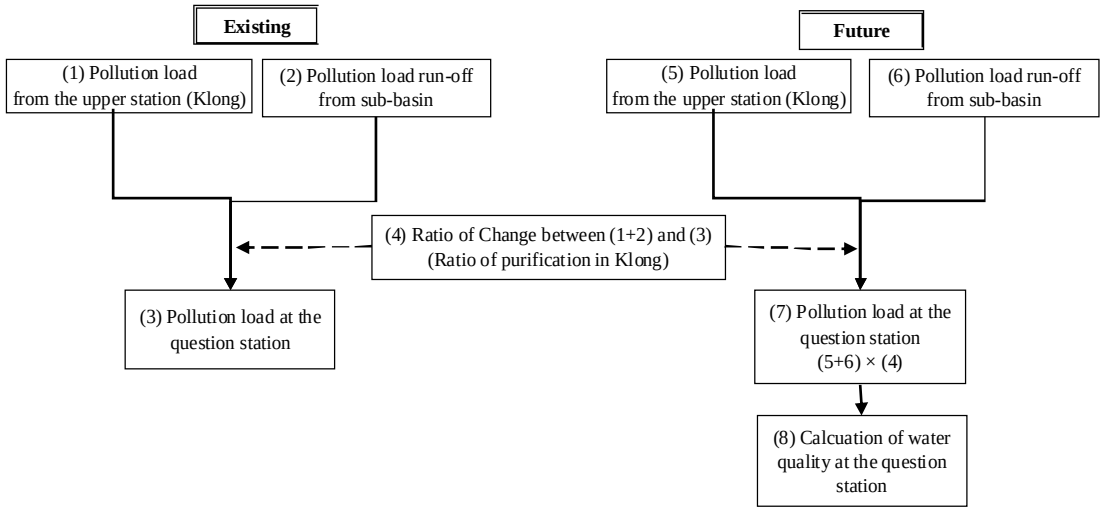
(5) Estimation of BOD Concentration

Different methods of estimation of BOD concentration are considered for steady flow klongs and for klongs affected by tide. Steady flow klongs are defined as klongs of which flow directions are determined. On the other hand, there are some klongs on the west bank for which flow directions can not be determined. These klongs, viz. Klong Bangkok Noi, Klong Bangkok Yai, and Klong Mon are defined as klong affected by tide. Chao Phraya River is also affected by tide and it is categorized as river affected by tide. Two methods are described below.

(A) Estimation Method for Steady Flow Klongs

BOD concentration of a certain section of klong is calculated by water flow and pollution load from upstream point and wastewater and pollution load from tributary basin (sub-basin). Organic pollution load in terms of BOD is reduced in natural water environment by many factors. This phenomenon is expressed as overall reduction or purification rate in a pollution model. Reduction rate of pollution load obtained from analysis of current water pollution mechanism is assumed to be unchanged in future. BOD concentration in future is estimated based on future wastewater flow, pollution load, and reduction rate.

Procedures are broadly divided into two steps. At the first step, reduction rate is analyzed from the current conditions (flow rate, representative BOD concentration, pollution load and wastewater flow). At the second step, future BOD concentration is estimated based on future conditions and reduction rate which is obtained at the first step. Procedures for estimation are shown in the following Figure 5.9.5 and Table 5.9.2.



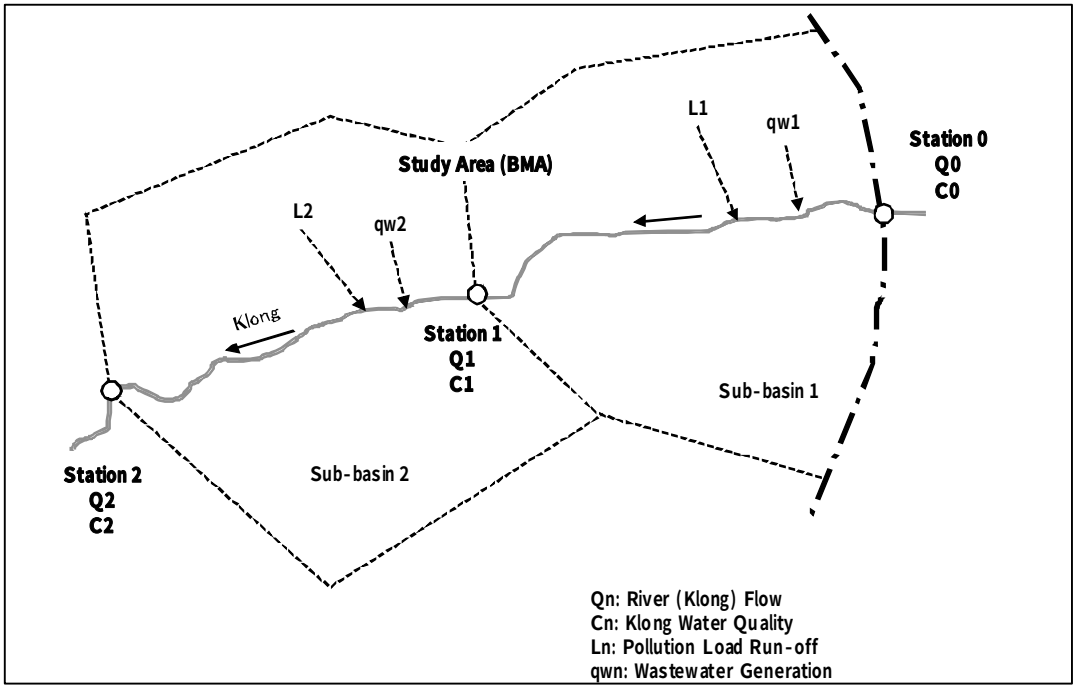
Source: JST

Figure 5.9.5 Calculation Flow for BOD Concentration

Table 5.9.2 Procedures for Calculation of BOD Concentration

		Items	Station-0	Sub-basin-1	Station-1	Sub-basin-2	Station-2
			from upper Station	From sub-baisn		From sub-baisn	
Existing	Q	Flow rate (m^3/sec.)	Q_0		$Q_1 = Q_0 + (qw_1/86,400)$		$Q_2 = Q_1 + (qw_2/86,400)$
	C	Existing water quality (mg/l-BOD)	C_0		C_1		C_2
	LK	Pollution load at station (kg/day-BOD)	$LK_0 = Q_0 \times C_0 \times 86.4$		$LK_1 = Q_1 \times C_1 \times 86.4$		$LK_2 = Q_2 \times C_2 \times 86.4$
	L	Pollution load run-off from sub-basin (kg/day-BOD)		L_1		L_2	
	qw	Wastewater from sub-basin (m^3/day)		qw_1		qw_2	
	k	Ratio of purification in Klong			$k_{0-1} = 1.0 - LK_1/(LK_0 + L_1)$		$k_{1-2} = 1.0 - LK_2/(LK_1 + L_2)$
Future (without project)	fQ	Flow rate (Q= m^3/sec.)	Q_0		$Qf_1 = Q_0 + (qwf_1/86,400)$		$Qf_2 = Qf_1 + (qwf_2/86,400)$
	C	Existing water quality (mg/l-BOD)	C_0				
	LKf	Pollution load at station (kg/day-BOD)	$LK_0 = Q_0 \times C_0 \times 86.4$		$LKf_1 = (LK_0 + Lf_1) \times (1.0\text{-}k_{0-1})$		$LKf_2 = (LKf_1 + Lf_2) \times (1.0\text{-}k_{1-2})$
	Lf	Pollution load run-off from sub-basin (kg/day-BOD)		Lf_1		Lf_2	
	qwf	Wastewater from sub-basin (m^3/day)		qwf_1		qwf_2	
	Cf	Calculated water quality (mg/l-BOD)			$Cf_1 = (LKf_1/86.4) / Qf_1$		$Cf_2 = (LKf_2/86.4) / Qf_2$
Future (with project)	fQ	Flow rate (Q= m^3/sec.)	Q_0		$Qf_1 = Q_0 + (qwf_1/86,400)$		$Qf_2 = Qf_1 + ((qwf_2 + qwTf_2)/86,400)$
	C	Existing water quality (mg/l-BOD)	C_0				
	LKf	Pollution load at station (kg/day-BOD)	$LK_0 = Q_0 \times C_0 \times 86.4$		$LKf_1 = (LK_0 + Lf_1) \times (1.0\text{-}k_{0-1})$		$LKf_2 = (LKf_1 + Lf_2 + LTf_2) \times (1.0\text{-}k_{1-2})$
	Lf	Pollution load run-off from outside of treatment area in sub-basin (kg/day-BOD)		Lf_1		Lf_2	
	LTf	Pollution load from wastewater treatment plant in sub-basin (kg/day-BOD)		-		LTf_2	
	qwf	Wastewater from sub-basin (m^3/day)		qwf_1		qwf_2	
	qwTf	Wastewater from wastewater treatment plant (m^3/day)		-		$qwTf_2$	
	Cf	Calculated water quality (mg/l-BOD)			$Cf_1 = (LKf_1/86.4) / Qf_1$		$Cf_2 = (LKf_2/86.4) / Qf_2$

Source: JST



Source: JST

Figure 5.9.6 Concept of Pollution Model

(B) Estimation Method for Chao Phraya River and Klongs Affected by Tide

Flow direction in Chao Phraya River and in klongs affected by tide changes as tide turns. Therefore estimation method for steady flow klongs mentioned above can not be adopted. More simplified estimation method is adopted for calculation of future BOD concentration. The following is the estimation method for Chao Phraya River and three klongs on the west bank, viz. Klong Bangkok Noi, Klong Bangkok Yai and Klong Mon.

Chao Phraya River

Chao Phraya River in BMA administration area is affected by tide from Bangkok Bay, and flow direction changes with high and low tide. Thus BOD concentration of an estimation point is affected not only by pollution loads from upstream point and sub-basin but also by that from downstream point. Judging from current pollution situation described in the previous section and estimation of pollution load, Chao Phraya River is thought to be affected mostly by pollution load discharged from Klong Phrakanong. Therefore, BOD concentrations in Chao Phraya River are estimated by pollution load from Klong Phrakanong. BOD concentrations are calculated by the following formula.

$$C_c = (Ce - C_0) \times (L_f / L_e)$$

Where

C_c: Future BOD concentration
C_e: Current BOD concentration (representative value)
C_0: Base BOD concentration (representative BOD value at upstream point R01)
L_e: Current BOD load from Klong Phra Khanong
L_f: Future BOD load from Klong Phara Khanong

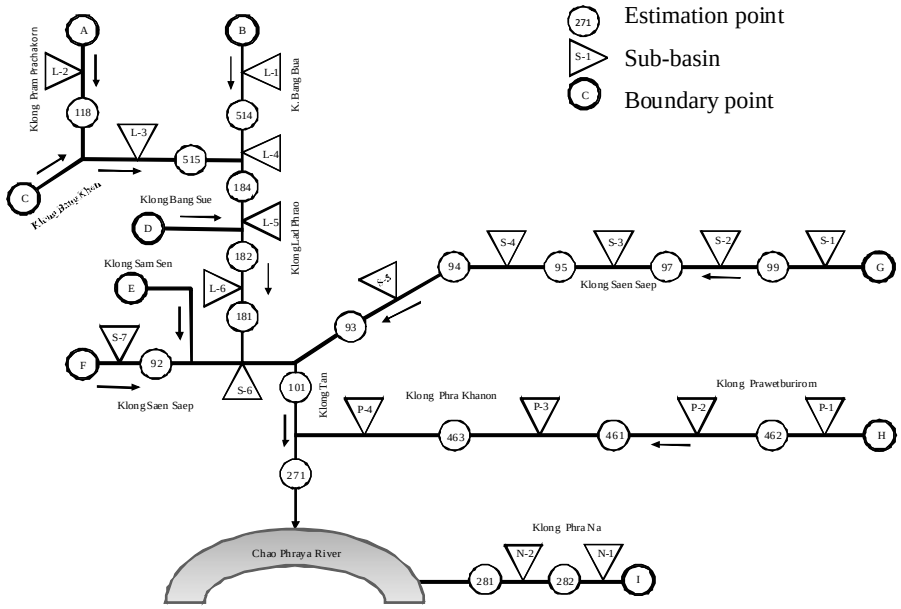
BOD load from Klong Phra Khanong is calculated at monitoring point No. 271. Chao Phraya River receives pollution load from small tributary areas on both sides of a section from R01 to R08, and Si Praya WWTP and Chong Nonsi WWTP. However, it is very difficult to analyze influence of these pollution loads to water quality in the river. Considering flow directions in klongs on both banks, i.e. most of klong water flow in to Klong Phra Khanong on the east bank and most of klong water flow to outside of the BMA area on the west bank, pollution load from Klong Phara Khanong can be considered to be representative pollution load for pollution model. (C_e -C_0) in the above formula means increment of BOD concentration due to discharged pollution load from BMA. Base BOD concentration at monitoring point R01 is assumed to be unchanged throughout the section and also in future.

Klongs on the West Bank

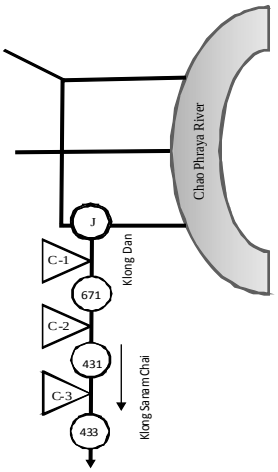
Three klongs, viz. Klong Bangkok Noi, Klong Bangkok Yai and Klong Mon are influenced by klong water from upstream, water from Chao Phraya River and discharge from their sub-basins. Therefore, pollution model for steady flow klong can not be applied for these klongs. The same method as for Chao Phraya River is used for estimation of future BOD concentration. Base BOD concentration is assumed to be that of monitoring points R03, and pollution load is assumed to be that of contributing sub-basin.

Pollution Model for Steady Flow

Pollution models for steady flow are shown in Figure 5.9.7 together with selected estimation points. Pollution model for the east bank is composed with 9 boundary points, 19 estimation points and 19 sub-basins. Pollution model for the west bank is composed with 1 boundary point, 3 estimation points and 3 sub-basins. Boundaries of sub-basins are shown in Appendix-4.



(Klongs on the Eest Bank)



(Klongs on the West Bank)

Source: JST

Figure 5.9.7 Pollution Models

(6) Other Elements for Pollution Model and Conditions for Estimation

Other elements necessary for simplified pollution model are as follows and explained here.

- Flow rate in steady flow klong
- Discharging pollution load and wastewater flow (by district/land use category/sub-basin)
- Discharging ratio (by land use category)
- Conditions at boundary point (BOD, flow rate)

Flow Rate in Steady Flow Klong

Flow rate at each estimation point is calculated by adding flow from sub-basin to flow rate at upstream point.

Pollution Load Discharged and Wastewater Flow (by District/land use category /sub-basin)

Pollution load and wastewater flow used for pollution model are estimated as follows.

- Wastewater flow: This is calculated district-wise based on population in each land use category and per capita wastewater flow. All of wastewater generated is assumed to discharge into klongs.
- Pollution load generated: Pollution load generated at each pollution source
- Pollution load discharged to klongs: Pollution load discharged is calculated considering removal at pollution source, e.g. septic tank.
- Pollution load arrived: This is a load which arrives at a certain estimation point. This is calculated based on pollution load discharged to klongs and reduction rate.

Wastewater flow and pollution load generated are described in the previous section of this report.

Pollution Load Discharged to Klongs

Generally pollution load discharged to klongs varies depending on the urbanization of the area, and discharging ratio to klong is considered to be larger as urbanization advanced or in other word, as provision of drainage system advanced. Discharging ratio used in this simplified pollution model is established for each land use category. Discharging pollution load is therefore estimated by land use category based on discharging ratio and pollution load generated. Urbanization of BMA area has been progressing in accordance with land use pattern indicated on land use plan. The same discharging rates by land use category are used for estimation of future discharging loads.

Table 5.9.3 Discharging Ratios by Land Use Category

Land Use Category	Discharging Rate	Planning Population Density (Average)
1. Low density residential area	60 %	62.0 person/ha
2. Medium density residential area	70 %	75.0 person/ha
3. High density residential area	80 %	129.6 person/ha
4. Commercial area	90 %	199.4 person/ha
5. Industrial area	20 %	17.1 person/ha
6. Warehouse area	10 %	2.2 person/ha
7. Agriculture conservation area	10 %	1.8 person/ha
8. Agriculture area	20 %	5.8 person/ha
9. Thai culture and art conservation area	80 %	122.9 person/ha
10. Institutional and public facilities area	60 %	56.0 person/ha

Source: JST

Conditions at Boundary Points

At every boundary point of pollution model i.e. A to J in Figure 5.9.7, incipient conditions such as BOD concentration and flow rate should be given. There are 10 boundary points, 4 are for klongs which flow from outside of BMA area, and 6 boundary points are located within BMA area. Representative BOD values at these points are determined by using those of nearby monitoring points or those of klongs of similar nature. On the other hand, data about flow rates of klongs are very limited and these are estimated as described in Table 5.9.4 below.

Table 5.9.4 Establishment of Conditions at Boundary Points

Boundary Point	BOD (mg/l)	Flow Rate (m^3/s)	Estimation Method
A (K. Pramprachakorn)	11	1.0	BOD: Monitoring point (No.119) Flow Rate: No data, minimum flow rate of 1.0 m^3/s is assumed
B (K. Bang Bua)	8	1.0	BOD: Monitoring point (No.1321) Flow Rate: No data, minimum flow rate of 1.0 m^3/s is assumed
C (K. Bang Khen)	5	1.5	BOD: Monitoring point (No.511) Flow Rate: Based on data 1)
D (K. Bang Sue)	9	2.6	BOD: Monitoring point (No.123) Flow Rate: Based on data 1)
E (K. Sam Sen)	9	1.4	BOD: Monitoring point (No.85) Flow Rate: Based on data 1)
F (K. Sansab)	9	2.8	BOD: Monitoring point (No.98) Flow Rate: Based on data 1)
G (K. Sansab)	4	4.6	BOD: Monitoring point (No.99.1) Flow Rate: Based on data 1)
H (K. Prawetburirom)	4	8.6	BOD: Assumed to be the same as point G, 4 mg/l Flow Rate: Based on data 1)
I (K. Bang Na)	7	1.0	BOD: Monitoring point (No.1101) Flow Rate: No data, minimum flow rate of 1.0 m^3/s is assumed
J (K. Sanamchai)	5	1.0	BOD: Monitoring point (No.393) Flow Rate: No data, minimum flow rate of 1.0 m^3/s is assumed

Note: Data 1) The Feasibility Study of Purification of Klong Water in Bangkok, 1990 JICA
Source: JST

5.9.2 Results of Pollution Analysis

Based on the explanation given above, an Excel based simplified model was developed by the JST. Using the model, BOD concentrations in Chao Phraya River and klongs in future are estimated for the flowing two cases.

i) Without project case

Sewerage system in BMA will remain the same as it is at present until 2040.

ii) With project case

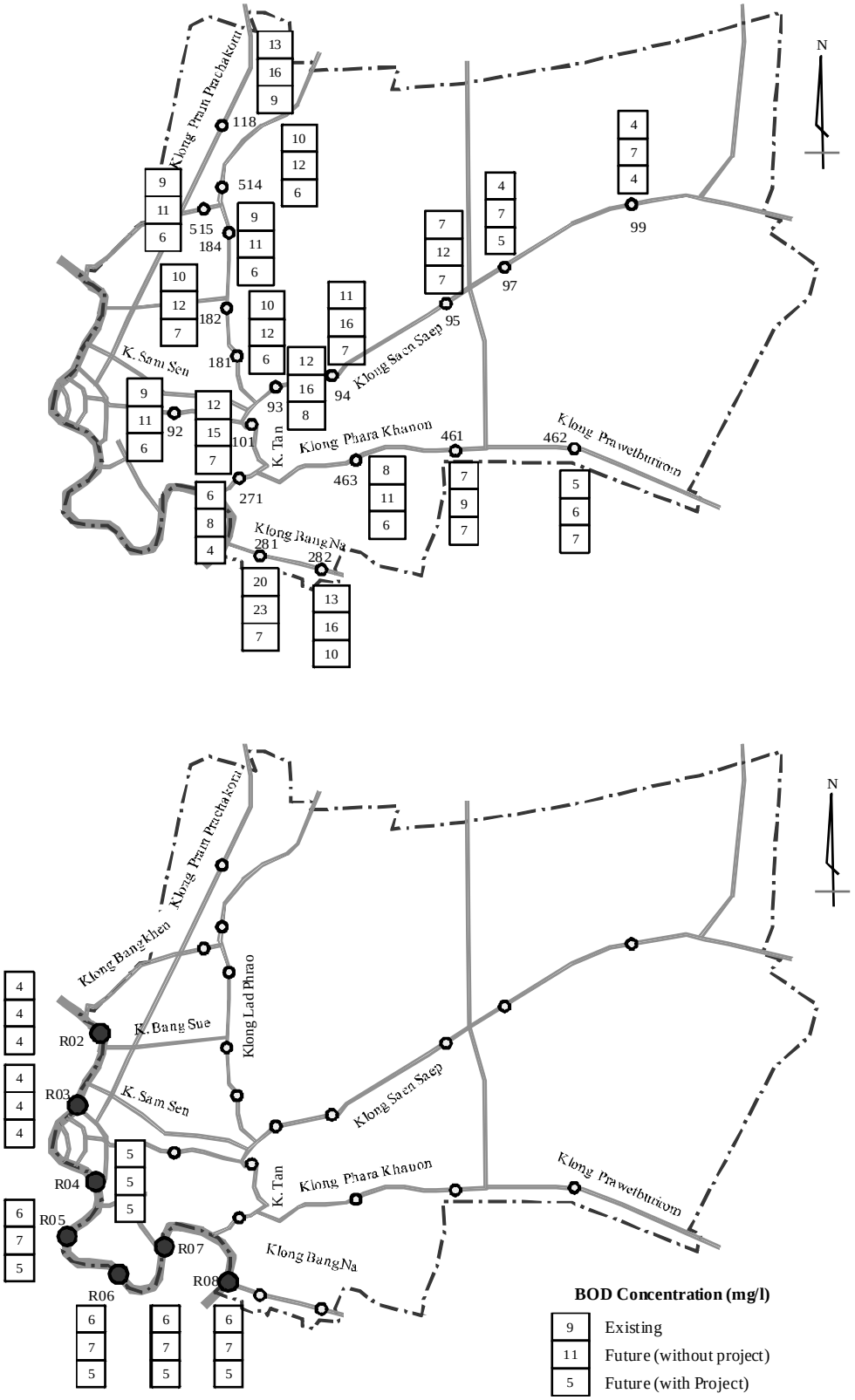
Sewerage system will be developed as proposed in this Master Plan.

Results of the estimation are shown in Table 5.9.5 and Figure 5.9.8

Table 5.9.5 BOD Concentrations Estimated by Simplified Pollution Model

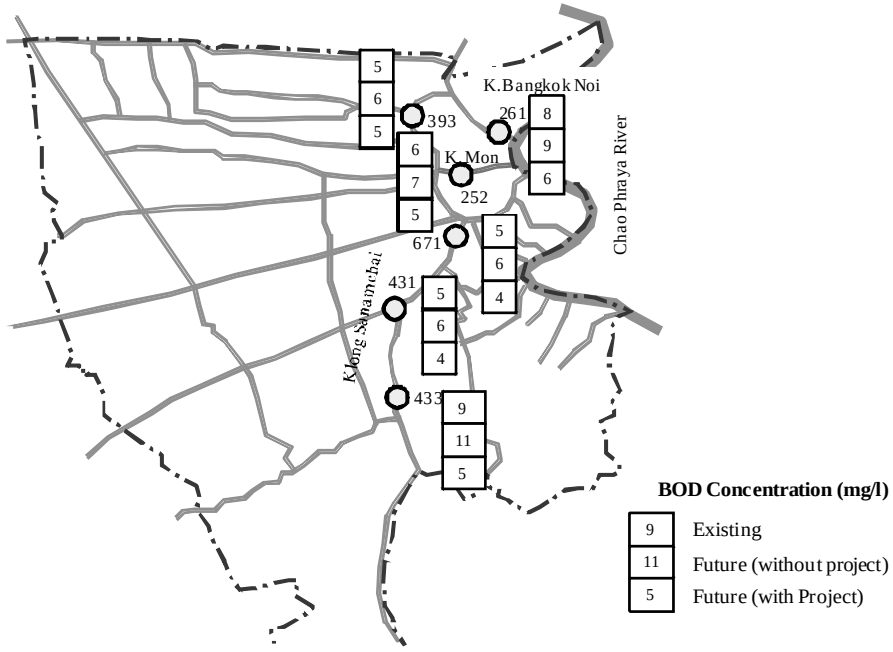
No.	Monitoring Point No.	Name of River /Klong	Representative BOD Concentration (mg/l)	Estimated BOD Concentration (mg/l)	
				Without Project (2040)	With Project (2040)
1	R02	Chao Phraya River	4	4	4
2	R03	Chao Phraya River	4	4	4
3	R04	Chao Phraya River	5	5	5
4	R05	Chao Phraya River	6	7	5
5	R06	Chao Phraya River	6	7	5
6	R07	Chao Phraya River	6	7	5
7	R08	Chao Phraya River	6	7	5
8	99	Klong Saen Saep	4	7	4
9	97	Klong Saen Saep	4	7	5
10	95	Klong Saen Saep	7	12	7
11	94	Klong Saen Saep	11	16	7
12	93	Klong Saen Saep	12	16	7
13	101	Klong Tan	12	15	7
14	271	Klong Phra Khanong	6	8	4
15	462	K. Prawetburirom	5	6	6
16	461	K. Prawetburirom	7	9	7
17	463	K. Prawetburirom	8	11	7
18	92	Klong Saen Saep	9	11	7
19	514	Klong Bang Khen	10	12	6
20	515	Klong Bang Khen	9	11	6
21	184	Klong Lad Phrao	9	11	5
22	182	Klong Lad Phrao	10	12	7
23	181	Klong Lad Phrao	10	12	6
24	118	K. Prem Prachakorn	13	16	9
25	261	Klong Bangkok Noi	8	9	6
26	394	Klong Bangkok Yai	5	6	5
27	252	Klong Mon	6	7	5
28	671	Klung Dan	5	6	4
29	431	Klong Sanam Chai	5	6	4
30	433	Klong Sanam Chai	9	11	5
31	281	Klong Bang Na	20	33	7
32	282	Klong Bang Na	13	21	8

Source: JST



Source: JST

Figure 5.9.8 (1) Results of Estimation of BOD Concentrations by Simplified Pollution Model (1/2)



Source: JST

Figure 5.9.8 (2) Results of Estimation of BOD Concentrations by Simplified Pollution Model (2/2)

The results of the estimation are summarized as follows.

- BOD concentrations in main klongs on the east bank, viz. Klong Saen Saep, Klong Lad Phrao, Klong Prawetburirom and Klong Phra Khanong will rise to 1.4 times the current values on average (1.2 to 1.7 times) if sewerage system remains the same as it is now.
- BOD concentrations in the same klongs as mentioned above will be less than 10 mg/l if sewerage system is developed as proposed.
- If BOD concentrations are less than 10 mg/l, conservation of ecosystem and prevention of emission of foul smell from sediments can be assured in klongs since a certain DO level is maintained (refer to Table 3.5.7 in Section 3.5.3, average DO value is 1.9 mg/l if BOD concentrations are less than 10 mg/l, and DO values of 73 % of total samples exceed 1.0 mg/l.)
- If sewerage system remains the same as it is now, BOD pollutant load is estimated to increase to 1.3 times the current level (2008). As a result, BOD concentrations in Chao Phraya River (R05 to R08) will increase to 7 mg/l from current 6 mg/l.
- On the other hand, if sewerage system is developed as proposed in this Master Plan, BOD concentrations in Chao Phraya River will be improved to 5 mg/l from 7 mg/l in case of without project.
- Based on the results of simplified pollution analysis, environmental standard for Chao Phraya River (BOD 4 mg/l) can not be satisfied by sewerage system development. More

detailed model which covers more extensive area beyond BMA area should be developed to estimate future water quality in Chao Phraya River.

Water quality in klong shows significant changes seasonally and also hourly in a day. Monthly changes at monitoring point No. 93 in Klong Sansab are shown in previous Figure 5.9.4. Hourly changes in a day are presented by results of water quality test conducted in former JICA Study shown in Table 5.9.6. From the table, ratios between maximum BOD and average BOD are 1.7 to 2.0 (number of samples 6 each), which indicates significant change.

Table 5.9.6 Results of Water Quality Test
(24 hour consecutive measurement at Klong Tan)

Date of Observation	Average BOD	Maximum BOD	Note
3-4/ Feb. /1988	15 mg/l	26 mg/l	n=6, Max/Av= 1.7
16-17/ Jul. /1988	7 mg/l	14 mg/l	n=6, Max/Av= 2.0

Source: The Feasibility Study on Purification of Klong Water in Bangkok, 1990, JICA

Various causes for these seasonally and hourly changes can be considered. However the following factors can be considered as main causes.

i) Hourly changes of discharging wastewater (wastewater flow changes due to daily life and commercial activities)
ii) Storm water flow in wet weather (first flush of highly contaminated CSO and dilution by storm water)
iii) Changes of flow in klong (pump operation, gate operation, and introduction of purification water)

Changes caused by factors i) and ii), particularly high BOD concentration, are considered to be mitigated by provision of sewerage system, because wastewater in dry weather and combined sewage up to a certain quantity (e.g. 3.5 DWF) in wet weather are intercepted by sewerage system. However, intercepted wastewater is transferred to WWTP and is not discharged to klongs, flow rates in some small klongs are considered to reach to almost zero. Water quality in these klongs can not be improved or even will worsen by uncollected wastewater discharged into klongs.

In order to evaluate effects of each sewerage system, water quality monitoring should be carried out and more precise pollution model should be developed based on the results of that. For klongs of which water quality has not been improved by sewerage system, reasons for that should be identified. Other measures to improve water quality, such as introduction of purification water from Chao Phraya River, use of treated effluent, and purification plant in klong should be considered.

5.10 Selection of Priority Project

5.10.1 Candidate Treatment Areas for Priority Project

Wastewater treatment facilities are indispensable infrastructure for a large city like Bangkok. It is most appropriate that wastewater generated in BMA except for agricultural and agricultural conservation areas is treated by sewerage system. Water quality in klongs in BMA has been deteriorated significantly by wastewater discharge and it is apparent that water quality will be further deteriorated unless provision of the sewerage system is implemented.

Sewerage system has been provided or projects are expected to be started shortly in 11 treatment areas in BMA as shown in Table 5.10.1 and 7 WWTPs are currently in operation. In addition to 7 WWTPs, Bang Sue WWTP is under construction, F/S for Klong Toei was completed and F/S for Thon Buri North and Thon Buri South is currently being carried out.

Table 5.10.1 Existing and Near Future Treatment Areas

	Treatment area	Current situation	Remarks
1	Si Praya	WWTP in operation	Excluded from selection of priority project
2	Rattanakosin	WWTP in operation	
3	Din Daeng	WWTP in operation	
4	Chong Nonsi	WWTP in operation	
5	Nong Kheam	WWTP in operation	
6	Thung Khru North	WWTP in operation	
7	Chatuchak	WWTP in operation	
8	Khlong Toei	F/S completed, to be started shortly	
9	Bang Sue	F/S completed, WWTP under construction	
10	Thon Buri North	F/S completed, to be started shortly	
11	Thon Buri South	F/S completed, to be started shortly	

Source: JST

Candidates of priority project are selected from the treatment areas except treatment areas listed in Table 5.10.1. Huaykwang sub-treatment area (former Huaykwang treatment area) shall be one of the candidates of priority project, because the area is one of the pollution sources of Klong Lad Phrao, though the area became a part of Din Daeng treatment area as the result of rearrangement of treatment areas. In case that the Huaykwang sub-treatment area is selected as the priority project, only interceptors connected with Din Daeng WWTP will be constructed but no additional construction of WWTP.

Eight (8) treatment areas which satisfy the criteria shown in Table 5.10.2 were selected as candidate areas for selection of priority project as shown in Table 5.10.3. Outlines of treatment areas and result of the selection are shown in Table 5.10.4, and their locations are shown in Figure 5.10.1. Figure 5.10.2 shows klongs related to selection of candidate treatment areas.

Table 5.10.2 Evaluation Criteria for Selecting Candidate Treatment Area

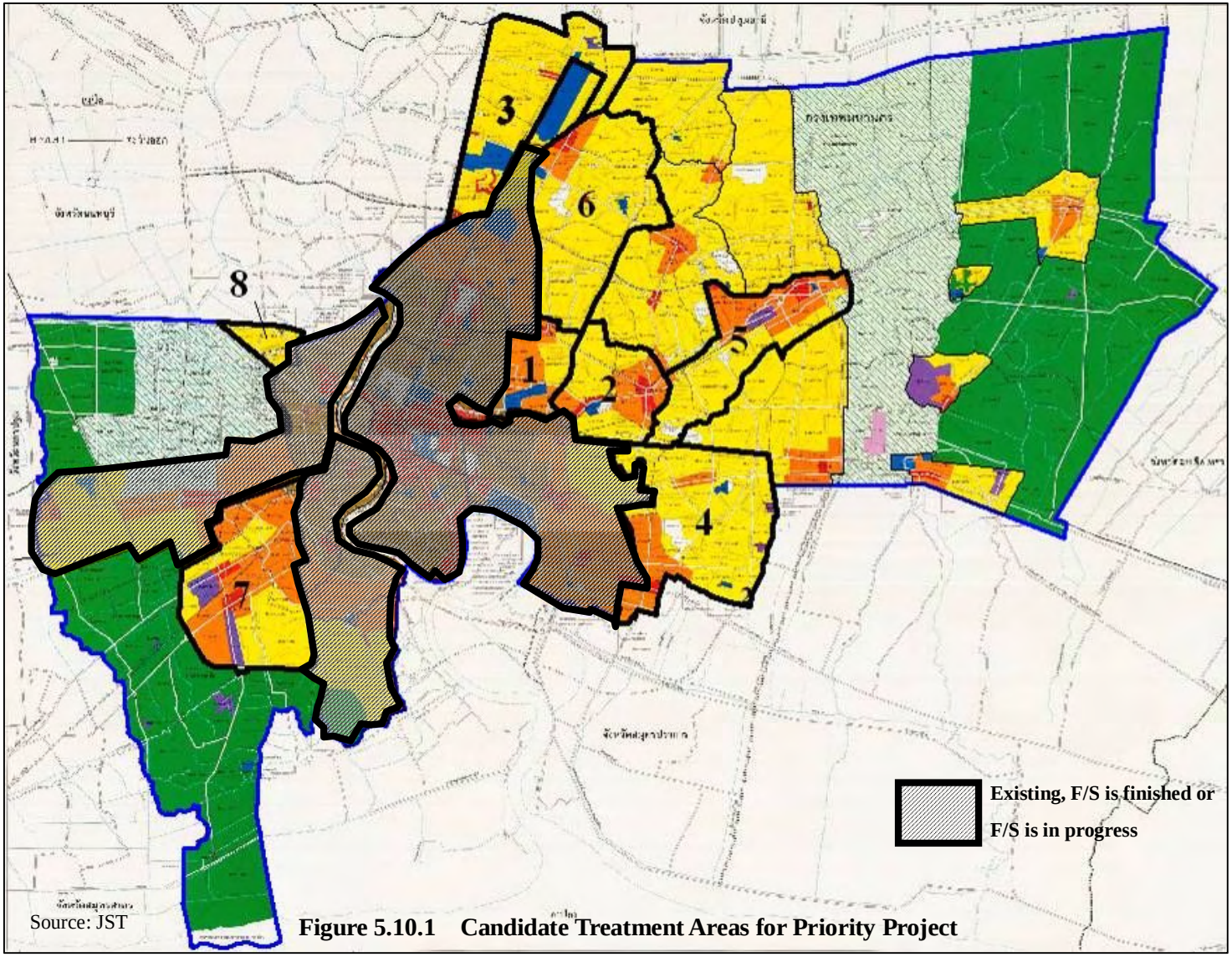
	Item	Explanation
1	Klong Water Quality Improvement	Treatment areas of which wastewater are discharged into the following klongs, Lat Phrao, Saen Saep, Phra Khanon, Bang Na, Sanamchai, Bangkok Noi, Bangkok Yai
2	Urbanized Area	Treatment areas adjacent to existing treatment area, and which include urbanized area in their treatment area
3	Developing Area	Treatment areas which are expected to be developed rapidly due to housing developments and new mass transit services etc.

Source: JST

Table 5.10.3 Outlines of Treatment Areas and Result of the Selection

Treatment Area	Main Klongs	Water quality in Klong		Population Density		Situation in Treatment Area	Criteria and Judge			
		Current	Future	Current	Future		C1	C2	C3	Judge
Huaykwang sub-tratment area	Downstream of Klong Lat Phrao	10-12	12-16	73	82	Sub-treatment area of Din Daeng treatment area Medium- to High-density residential areas Water quality in Klong Lat Phrao is deteriorated	○	○		◎
Wangthonlang	Downstream of Klong Saen Saep	11-12	12-16	74	86	Medium- to Low-density residential areas next to Huaykwang sub-treatment area of Din Daeng treatment area Water quality in Klong Saen Saep is deteriorated	○	○		◎
Bunkhum	Upstream of Klong Saen Saep	4	7	52	60	Population density is low, and many agriculture areas。 Water quality in upstream of Klong Saen Saep is and will be good				
Don Mueang	Upstream of Klong Pram Prachakom, Upstream of Klong Lat Phrao	13 10	16 12	63	78	Urbanized area Water quality in Klong Lat Phrao is deteriorated	○	○		◎
Nong Bon	Upstream of Klong Bang Na, Downstream of Klong Phra Khanong	13-20 7-8	16-23 9-11	35	41	Near Suvarnabhumi International Airport. Airport link is a factor for development. Developed as comparatively high quality residential areas with low population density. Water quality in Klong Bang Na, and Klong Phra Khanong is deteriorated.	○	○	○	◎
Ming Buri	Upstream of Klong Saen Saep	7-11	12-16	52	66	Water quality in Klong Saen Saep is deteriorated	○			◎
Lat Krabang -1	-			39	47	Low population density at present, many agricultural areas				
Nong Chok -1	-			57	99	Low population density at present, many agricultural areas				
Jomthong	Klong Sanamchai	5-9	6-11	64	78	West bank of Chao Phraya River, Population increase in future		○	○	◎
Lat Phrao	Upstream of Klong Lat Phrao	9-10	11-12	58	77	Water quality in Klong Lat Phrao is deteriorated	○	○		◎
Sai Mai	-			45	53	Low population density at present, many agricultural areas				
Khlong Sam Wa	-			38	62	Low population density at present, many agricultural areas				
Lat Krabang -2	-			36	43	Low population density at present, many agricultural areas				
Lat Krabang -3	-			24	28	Low population density at present, many agricultural areas				
Nong Chok -2	-			39	68	Low population density at present, many agricultural areas				
Taling Chan	Klong Bangkok Noi Klong Bangkok Yai	8 5-6	9 6-7	157	197	West bank of Choa Phraya River, Existing urbanized areas Extension of metro line is planed		○	○	◎

Note: Water quality in klong is indicated in terms of BOD (mg/l), current means year 2008 and future means estimation in year 2040 without project
Unit of population density is persons /ha, current means year 2008, and future means estimation in year 2040
Source: JST



Source: JST

Figure 5.10.1 Candidate Treatment Areas for Priority Project

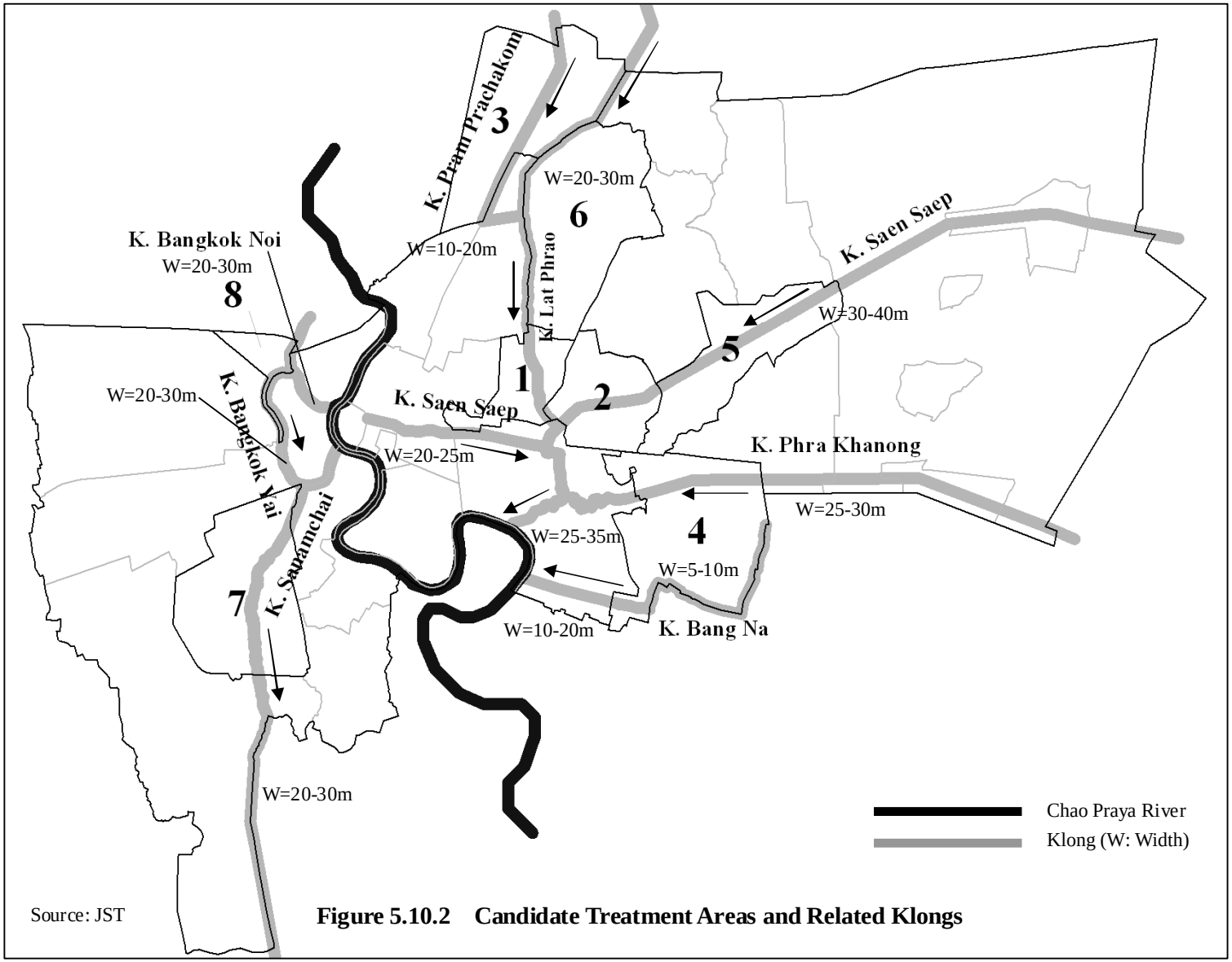


Figure 5.10.2 Candidate Treatment Areas and Related Klongs

Table 5.10.4 Outlines of Candidate Treatment Areas for Priority Project

	Candidate treatment area	Location	Area (ha) Population in 2040 (persons) Population density (persons /ha)	Tendency of population growth (2004-08)	Land use plan (Dominant land use)	Receiving klong	Reasons for candidate area
1	Huaykwang sub-tratment area	East bank of Chao Phraya River	2,008 164,800 82	Increase 0 - 10%/year	Medium- and high-density residential Commercial	Downstream of Klong Lat Phrao	Existing urbanized area Water quality deterioration in Klong Lat Phrao
2	Wangthonlang		2,872 246,100 86	Increase 0 - 10%/year	Low- and medium-density residential Commercial	Downstream of Klong Saen Saep	Existing urbanized ares Water quality deterioration in Klong Saen Saep
3	Dong Mueang		4,941 384,000 78	Decrease	Low-density residential Public (airport)	Upstream of Klong Pram Prachakom, and Klong Lat Phrao	Existing urbanized area Water quality deterioration in Klong Lat Phrao
4	Nong Bon		6,385 264,900 41	Increase 0 - 10%/year	Low- and medium-density residential Commercial	Upstream of Klong Bang Na Downstream of Klong Phra Khanong	Existing urbanized area Population growth due to development Closeness to international airport Water quality deterioration in Klong Bang Na, and Klong Phra Khanong
5	Min Buri		4,165 274,200 66	Increase 0 - 10%/year	Low- and medium-density residential Commercial	Upstream of Klong Saen Seap	Existing urbanized area Water quality deterioration in Klong Saen Saep
6	Lat Phrao		6,206 475,400 77	Increase 0 - 10%/year	Low- and medium-density residential Commercial	Upstream of Klong Lat Phrao	Existing urbanized area Water quality deterioration in Klong Lat Phrao
7	Jomthong	West bank of Chao Phraya River	5,816 453,900 78	Increase, an area with 10%/year is included	Low- and medium-density residential Commercial	Klong Sanamchai	Existing urbanized are, population growth expected
8	Taling Chan		759 149,900 197	Increase 0 - 10%/year	Low-density residential	Klong Bangkok Noi and Klong Bangkok Yai	Existing urbanized are, population growth expected

Note: Location of treatment areas, refer to Figure 5.10.1

Source: JST

5.10.2 Evaluation of Priority Treatment Area

Priority project is selected from among eight (8) treatment areas shown in Table 5.10.4 taking into account the various factors comprehensively such as future situation of the area, current water pollution in klongs, improvement effects of water pollution due to provision of sewerage system, availability of land for WWTP, and DDS's intention

(1) Situation of Water Pollution in Receiving Klongs and Urgency of Sewerage System

Urgency of sewerage system is evaluated based on the current situation of water pollution in receiving klongs. Water quality standards are not stipulated for klongs in BMA. However, BMA established Performance Plan (2009 – 2012) and strove to improve water quality in klongs. According to the plan, target of the improvement is determined in terms of DO concentration. In order to achieve this, wastewater characteristics for treated effluent from WWTPs are determined in terms of BOD as follows.

Year 2009: BOD less than 15 mg/l
Years 2012, 2020: BOD less than 10mg/l

Criteria for evaluation of urgency of provision of sewerage system are established as shown in Table 5.10.5 considering that BOD concentrations mentioned above substitute those of klong water.

Table 5.10.5 Evaluation Criteria for Urgency of Provision of Sewerage System

Urgency	Water quality in klong (BOD)	Explanation
High	More than 15mg/l	Target of BMA Performance Plan (2009) is not achieved Urgency is determined to be high
Medium	10～15 mg/l	Target of BMA Performance Plan (2009) is achieved Urgency is determined to be medium
Low	10 mg/l 以下	Target of BMA Performance Plan (2020) is achieved Urgency is determined to be low

Source: JST

Results of the evaluation of candidate treatment areas by the above criteria is shown in Table 5.10.6.

Table 5.10.6 Results of the Evaluation regarding Urgency of Provision of Sewerage System

	Candidate treatment area	Receiving klong	Current water quality (BOD)	Urgency
1	Huaykwang sub-tratment area	Downstream of Klong Lat Phrao	10 mg/l	Medium
2	Wangthonlang	Downstream of Klong Sean Seap	11～12 mg/l	Medium
3	Dong Mueang	Upstream of Klong Pram Prachakom Upstream of Klong Lat Phrao	13 mg/l 10 mg/l	Medium
4	Nong Bon	Klong Bang Na Klong Phra Khanon	13～20 mg/l 7～8 mg/l	High /Low
5	Min Buri	Upstream of Klong Sean Seap	7～11 mg/l	Medium
6	Lat Phrao	Upstream of Klong Lat Phrao	9～13 mg/l	Medium
7	Jomthong	Klong Sanamchai	5～6 mg/l	Low
8	Taling Chan	Klong Bangkok Noi Klong Bangkok Yai	5～9 mg/l	Low

Source: JST

Urgency of Nong Bon treatment area is determined to be low for Klong Phra Khanon, but to be high for Klong Bang Na.

(2) Improvement Effects on Water Quality due to Provision of Sewerage System

Improvement effects on water quality in klongs due to provision of sewerage system are evaluated by comparing water quality at present and that in future in case sewerage projects are implemented. Evaluation criteria are shown in Table 5.10.7, and results of the evaluation are shown in Table 5.10.8.

Table 5.10.7 Evaluation Criteria for Effects due to Provision of Sewerage System

Effect on water quality	Achievement of water quality	Explanation
High	Achieve less than BOD 10mg/l due to provision of sewerage system	Target of BMA Performance Plan (2009) is achieved
Medium	Water quality improved, but not achieve less than BOD 10mg/l	Target of BMA Performance Plan (2009) is achieved
Low	Significant effects are not recognized	Target of BMA Performance Plan (2009) is not achieved

Source: JST

Table 5.10.8 Results of Evaluation of Effects due to Provision of Sewerage System

	Candidate Treatment Area	Receiving Klong	Effects on water quality		Results of evaluation
			Current (BOD) (mg/l)	Effects due to Provision of Sewerage System	
1	Huaykwang sub-tratment area	Downstream of Klong Lat Phrao	10	Less than 10 mg/l	Medium Provision of sewerage systems in upstream areas is necessary to improve water quality
2	Wangthonlang	Downstream of Klong Sean Saep	11～12	Same as at present	Low
3	Dong Mueang	Upstream of Klong Pram Prachakom Upstream of Klong Lat Phrao	13 10	Less than 10 mg/l Less than 10 mg/l	Medium
4	Nong Bon	Klong Bang Na	13～20	Less than 10 mg/l	High
		Klong Phara Khanon	7～8	Improve	
5	Min Buri	Upstream of Klong Sean Saep	7～11	Less than 10 mg/l	Medium Provision of sewerage systems in upstream areas is necessary to improve water quality
6	Lat Phrao	Upstream of Klong Lat Phrao	9～10	Less than 10 mg/l	High
7	Jomthong	Klong Sanamchai	5～9	Improve	Low Target of BMA Performance Plan (2009) is achieved
8	Taling Chan	Klong Bangkok Noi Klong Bangkok Yai	5～6	Improve	Low Target of BMA Performance Plan (2009) is achieved

Source: JST

Catchment areas of Klong Saen Saep and Klong Lat Phrao cover several treatment areas, and therefore, improvement effect on water quality due to provision of sewerage system in an individual treatment area is not significant. Development of sewerage system should be implemented all together. Evaluation of individual treatment areas located in the downstream of Klong Saen Saep and Klong Lat Phrao is determined to be slightly lower than the criteria shown in Table 5.10.7.

(3) Availability of Land for Construction of WWTP

Construction site for WWTP must be secured to conduct feasibility study of sewerage system. Construction sites are secured by BMA for only two treatment areas at present, viz. Nong Bon and Min Buri treatment areas except for treatment areas for which F/S was already completed.

Construction sites are not determined for the remaining treatment area. For Min Buri treatment area for which the construction site for WWTP is secured, F/S is to be started by DDS shortly. Availability of land for WWTPs is shown in Table 5.10.9.

Table 5.10.9 Availability of Land for WWTP

	Candidate treatment area	Construction site for WWTP	Remarks
1	Huaykwang sub-tratment area	-	Sub-treatment area of Din Daeng treatment area. No need to prepare the land
2	Wangthonlang	Not determined	
3	Dong Mueang	Not determined	
4	Nong Bon	Secured	Near Rama IX Park
5	Min Buri	Secured	DDS will start F/S shortly
6	Lat Phrao	Not determined	
7	Jomthong	Not determined	
8	Taling Chan	Not determined	

Source: JST

(4) Summary of Evaluation

There are many reaches in Klong Bang Na, Klong Lat Phrao and Klong Saen Saep where BOD concentrations exceed 10 mg/l, in particular in Klong Bang Na BOD concentrations exceed 15 mg/l. This means that urgency of implementation sewerage project is obvious in these treatment areas related to the above klongs.

As for improvement effects on water quality in klongs, effect of an individual treatment area is not so significant for large klongs such as Klong Lat Phrao and Klong Saen Saep because catchment areas of these klongs cover many treatment areas. On the other hand, Klong Bang Na is a small klong flowing through congested residential areas. Improvement effect on water quality due to implementation of sewerage project can be expected to be significant. Among the candidate treatment areas only Nong Bon treatment area is included in catchment area of Klong Bang Na.

To conduct F/S, construction site for WWTP must be secured beforehand, because preliminary design of sewerage facilities such as trunk sewers and WWTP is indispensable element of the study. Treatment areas which satisfy this requirement are Nong Bon and Min Buri treatment areas.

DDS's intention is that sewerage system will be provided in all urbanized areas except for

agricultural areas. To realize the aim, DDS will implement the sewerage projects as soon as possible from where preparation for implementation is completed.

DDS's thought was that implementation of sewerage projects for Klong Toie, Thon Buri North and Thon Buri South for which F/S was completed would be followed by implementation of sewerage projects in Min Buri and Nong Bon treatment areas. Currently budget for F/S, detailed design and construction for Min Buri project was secured by DDS and F/S for Nong Bon is desired.

5.10.3 Strategic Environmental Assessment for Selection of Priority Project

(1) Purpose of Strategic Environmental Assessment

In the previous section, priority project was selected based on the criteria, such as urgency of implementation, effects of the project and availability of construction site. However, at F/S or implementation stage, some obstacles to delay or to make project implementation difficult may occur. These are supposed to be prolonged land acquisition, involuntary resettlement of residents, or opposition of residents against socio-environmental problems. It is therefore required that these obstacles should be avoided by conducting strategic environmental assessment at M/P stage. In this section, strategic environmental assessment is conducted for 8 treatment areas which were selected as candidate treatment areas in the previous section.

(2) Assessment Items and Judgment Criteria

Assessment items and their judgment criteria are shown in Table 5.10.10.

Table 5.10.10 Assessment Items and Judgment Criteia

Assessment item	Major effects	Judgment criteria	
＜Social Environment＞ Site for WWTP	Effects on life of residents and prolonged land acquisition	○ △ ×	Site is owned by DDS/BMA Site is unused land (private) Site is private land and occupied by resident or other religious or business establishments
＜Social Environment＞ Traffic and living environment	Effects on access road to WWTP and on residents living along the road at construction stage	○ △ ×	Site faces to main road Access road is living road Access road is living road in congested area
＜Social Environment＞ Traffic obstacle	Traffic obstacle due to construction of interceptors	○ △ ×	Interceptor route is on roads without traffic jam A part of interceptor route is on roads with traffic jam Interceptor route is on roads with traffic jam

Assessment item	Major effects	Judgment criteria	
＜Social Environment＞ Heritage, cultural properties (including tourism)	Effects due to construction and operation of WWTP	○ △ ×	No heritage nor cultural properties in the project site There are heritage or cultural properties but not in the neighborhood of sewerage facilities Construction site is in the neighborhood of heritage or cultural properties
＜Social Environment＞ Landscape	Effects on landscape caused by WWTP (including tourism)	○ △ ×	No facility nor area to be considered for landscape There are facilities or areas to be considered for landscape, but not in the neighborhood of WWTP WWTP site is in the neighborhood of facilities or areas to be considered for landscape
＜Natural Environment＞ Natural reserve (including important bird habitat and national park)	Effects on flora and fauna, and birds	○ △ ×	No natural reserve There is natural reserve(s), but not in the neighborhood of sewerage facilities WWTP site is in the neighborhood of natural reserve
＜Pollution and contamination＞ Noise	Effects on residents living in the neighborhood of WWTP	○ △ ×	Nearest residential area is more than 300 m from WWTP (boundary of the site) Nearest residential area is more than 100 m from WWTP (boundary of the site) Residential area is less than 100 m from WWTP (boundary of the site)
＜Pollution and contamination＞ Odor	Effects on residents living in the neighborhood of WWTP (dominant direction of wind in BMA is south or north)	○ △ ×	Nearest residential area is more than 300 m from WWTP (boundary of the site) (south and north in particular) Nearest residential area is more than 100 m from WWTP (boundary of the site) Residential area is less than 100 m from WWTP (boundary of the site)

Note:
○: No obstacles to make implementation difficult
△: There are obstacles for implementation, but can be avoided
×: There are obstacles for implementation
Source: JST

(3) Results of Strategic Environment Assessment

Results of the strategic environment assessment are presented in Table 5.10.11. Construction sites for WWTP are determined in only two treatment areas, i.e. Nong Bon and Min Buri treatment areas. Construction site for WWTP has not been determined in the remaining 6 treatment areas.

All assessment items have been evaluated to be “No obstacles for smooth implementation of the project” or “There are obstacles for implementation of the project, but these can be avoided” in Nong Bon and Min Buri treatment areas. For the remaining 6 treatment areas in which site for WWTP can not be determined, items such as “Heritage and cultural properties”, “Natural reserve (including important bird habitat and national park), and “Landscape” were

judged to be “No obstacles for smooth implementation of the project”, but assessment could not be done for other items because of the reasons mentioned in notes for Table 5.10.11. Therefore general evaluation of 6 treatment areas could not be done.

From the above, it is judged that there is no obstacles to prevent smooth implementation of the project in both Nong Bon and Min Buri treatment areas.

Table 5.10.11 Results of Strategic Environmental Assessment

Assessment item / Treatment area		Acquisition of land for WWTP	Traffic and living environment (1)	Traffic obstacle (2)	Heritage, cultural properties (3)	Landscape	Natural reserve	Noise	Odor	General evaluation	**Remark**
1	Huaykwang sub-treatment area	＝	＝	＝	○	○	○	＝	＝	-	General evaluation can not be done since some items can not be evaluated
2	Wangthonlang	＝	＝	＝	○	○	○	＝	＝	-	ditto
3	Dong Mueang	＝	＝	＝	○	○	○	＝	＝	-	ditto
4	Nong Bon	○ (4)	△	△ (5)	○	○ (6)	○	○	○	No problem ○	
5	Min Buri	○ (7)	△	△	○	○	○	△	△	No problem ○	
6	Lat Phrao	＝	＝	＝	○	○	○	＝	＝	-	General evaluation can not be done since some items can not be evaluated
7	Jomthong	＝	＝	＝	○	○	○	＝	＝	-	ditto
8	Taling Chan	＝	＝	＝	○	○	○	＝	＝	-	ditto

○: No obstacles for smooth implementation
△: Some obstacles for smooth implementation, but can be avoided
×: Obstacles for smooth implementation
＝: Evaluation can not be done due to lack of information

Note:
(1) Heritage and cultural properties item is evaluated whether there is “Thai culture and art conservation area” which is designated under land use plan by city planning department. This kind of areas are located in Pra Nakon district and 5 districts on the opposite side of Chao Phraya River, and is not located in the above 8 areas.
(2) It is difficult to evaluate landscape item unless location is not determined. For example, Din Daeng WWTP which is located in an urbanized area dose not cause any landscape problem because all facilities are contained in buildings. Another example is Bang Sue WWTP which is located in a park and all facilities are constructed underground.

(3) It is judged to be no problem since there is no natural reserve (including important bird habitat and national park) in BMA.
(4) The site is located in DDS's property adjacent to storm water reservoir.
(5) A part of interceptor route passes through congested road.
(6) The site is located in the neighborhood of Rama IX park, but can not be seen from the park.
(7) The site is located in the site of DDS's administration office for flood control for Klong Saen Saep
(8) Reasons for impossibility of general evaluation due to lack of one item are as follows.
- Item "Acquisition of land" can not be evaluated unless the location of the site of WWTP is determined.
- Features of road arrangement in Bangkok is such that road network is composed of main roads and independent living roads (limited access to other main or living roads) which connect to main roads. Item "Transportation and living environment" can not be evaluated unless living road (access road) is identified. Access road can not be identified unless the site for WWTP is determined.
- Item "Transportation obstacle" is not envisaged on main roads where traffic is heavy. There are some possibilities of "Transportation obstacle" at the entrance of access road during construction of WWTP when construction vehicles come to access road. It is necessary to identify access road to evaluate the same as for item "Transportation and living environment".
- Effects on item "Noise and odor" is limited to an area within 300 m radius of WWTP. Therefore, it is necessary to identify location of WWTP to evaluate this item.

Source: JST

5.10.4 Selection of Priority Treatment Area

Evaluation of current water quality in klong, improvement effects on klong water quality, availability of site for construction of WWTP together with strategic environmental assessment was carried out. As a result, Nong Bon treatment area was selected as priority project area where provision of sewerage system is expected to contribute to improvement of water quality in Klong Bang Na and Klong Phra Khanon and site for WWTP was determined. Also no obstruction for implementation of the project was envisaged by strategic environmental assessment (refer to Table 5.10.12).

Therefpore, F/S will be conducted at the second stage of the Survey for selected Nong Bon treatment area.

Table 5.10.12 Selection of Priority Project Area

	Candidate treatment area	Area (ha) Population (persons) Population density (persons/ha)	Land use plan (dominant land use)	Receiving klong	Water quality in klong (BOD mg/l)	(1) Urgency of project	(2) Effects of provision of sewerage system	(3) Construction site for WWTP	(4) Strategic environmental assessment	Remarks
1	Huaykwang sub-treatment area	2,008 164,800 82	Medium- and high-density residential Commercial	Downstream of Klong Lat Phrao	10～12	Medium	Medium	To be integrated to Din Daeng Treatment area	Can not be done	
2	Wangthonlang	2,872 246,100 86	Low- and medium-density residential Commercial	Downstream of Klong Saen Saep	11～12	Medium	Low	Not determined	Can not be done	
3	Dong Mueang	4.941 384,000 78	Low-density residential Public (airport)	Upstream of Klong Pram Prachakom Upstream of Klong Lat Phrao	13 10	Medium	Medium	Not determined	Can not be done	
4	Nong Bon	6,385 264,900 41	Low- and medium-density residential Commercial	Upstream of Klong Bang Na Downstream of Klong Phra Khanong	13～20 7～8	**High**	**High**	**Secured**	**No problem**	**Selected as priority project**
5	Min Buri	4,165 274,200 66	Low- and medium-density residential Commercial	Upstream of Klong Saen Seap	7～11	Medium	Medium	**Secured**	No problem	
6	Lat Phrao	6,206 475,400 77	Low- and medium-density residential Commercial	Upstream of Klong Lat Phrao	9～13	Medium	**High**	Site is under consideration by DDS	Can not be done	
7	Jomthong	5,816 453,900 78	Low- and medium-density residential Commercial	Klongs on the west bank	5～9	Low	Low	Not determined	Can not be done	
8	Taling Chan	5,816 453,900 78	Low- and medium-density residential Commercial	Klongs on the west bank	5～6	Low	Low	Not determined	Can not be done	

Note: Location of treatment areas, refer to Figure 5.10.1
Source: JST

5.10.5 Outlines of Nong Bon Treatment Area

Although population density in Nong Bon treatment area is comparatively low at present, population has been increasing because of opening of airport link which connects central part of the city and a new airport and consequent enhancement of convenience. Many housing developments of relatively high class houses by private companies have been progressing. A new elevated railway line is planned to be constructed along Sri Nakharin Road in the western part of the area resulting in further enhancement of convenience. Nong Bon treatment area is close to the new international airport. Population growth and needs for development are expected in the area. Site for construction of WWTP is located at land owned by DDS adjcant to storm water reservoir in the neighbhood of Rama IX park. However, the area of the site is narrow, only 3.5 ha.

Provision of sewerage facilities will be considered based on the following policies.

- Economical route of interceptors under both klongs and roads will be investigated
- Compact and economic treatment process will be investigated and enegy recovery will be considered
- Treated wastewater will be reused for splinkling for trees, beautification water of Rama IX Park and improvement of water quality in Klong Nong Bon and Klong Bang Na.
- Sludge will be treated at Nong Khaem WWTP for composting and will be reused as soil conditioner

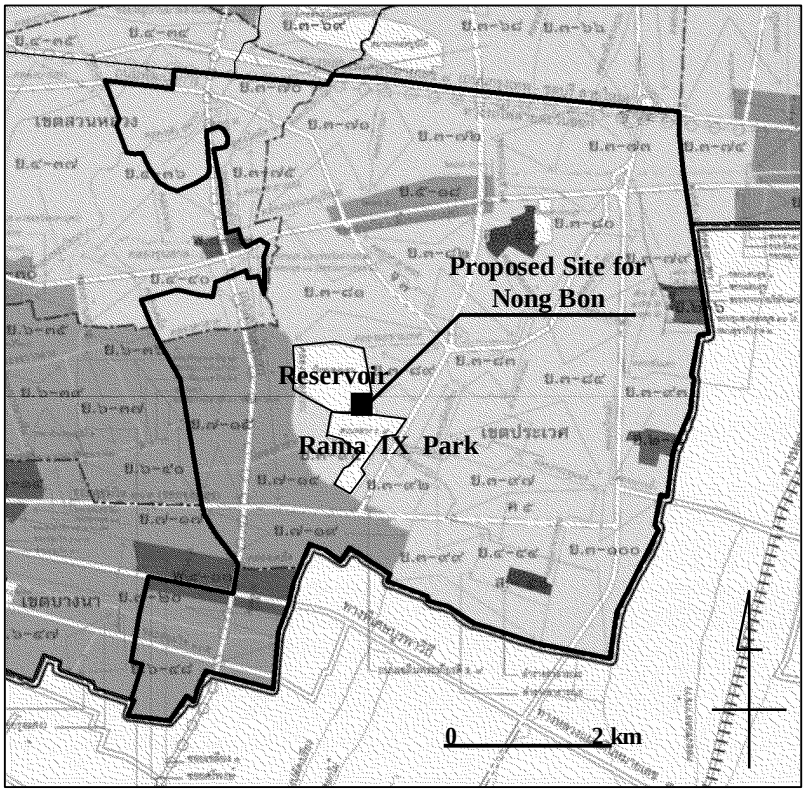
Outlines of Nong Bon treatment area and Nong Bon WWTP are shown in Table 5.10.13. Construction site for WWTP is located in the neighborhood of Rama IX Park, adjacent to storm water reservoir constructed under Monkey Cheek Project. Construction site for WWTP is shown in Figures 5.10.3 and 5.10.4.

Table 5.10.13 Outlines of Nong Bon Treatment Area and Nong Bon WWTP

		Design figure	Remarks
Target year		2040	
Area of treatment area		6,385 ha	Including areas of parks, vacant lands and water surfaces
Collection system		Combined	
Design population (2040)		265,000 persons	
Flow (2040)		133,501 m^3/day	
Design capacity (2040)		135,000 m^3/day	
Target water quality	BOD	20 mg/l	
	SS	30 mg/l	
	T-N	10 mg/l	
	T-P	2 mg/l	

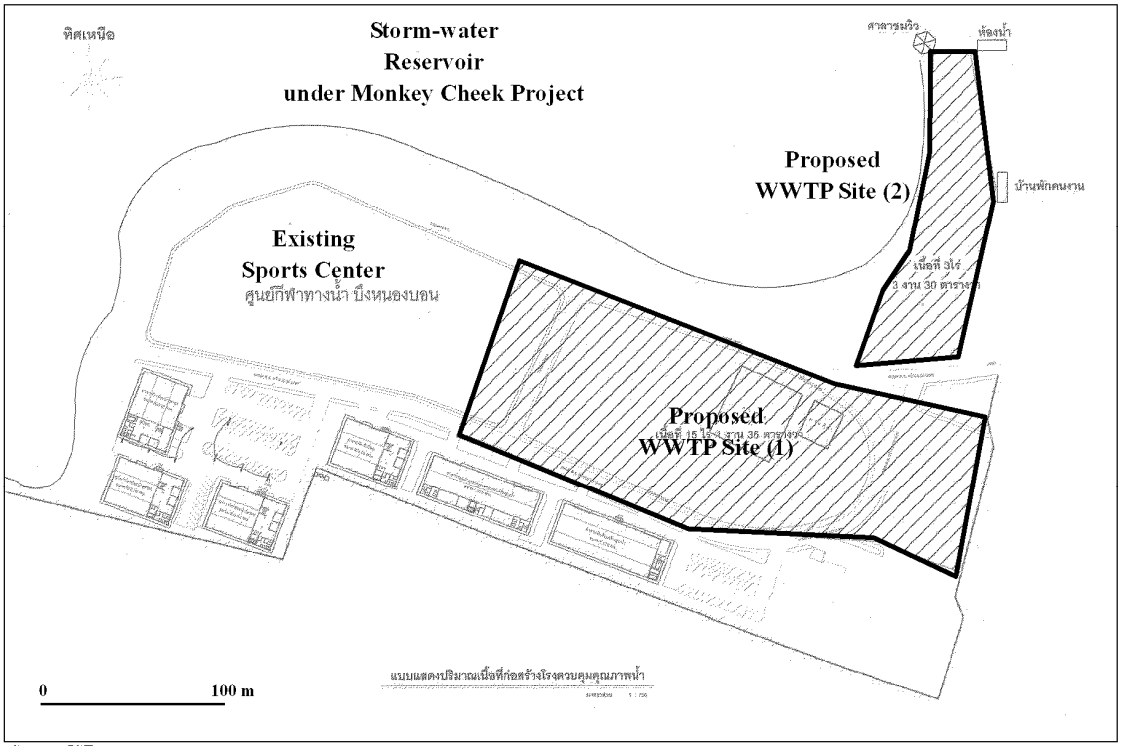
	Design figure	Remarks
Area of WWTP site	3.5 ha (22 Rai) (1.1 ha for above ground facilities)	Adjacent to storm water reservoir constructed under Monkey Cheek Project, in the neighborhood of Rama IX Park Biological treatment: adoption of compact treatment process A part of the facilities is to be constructed underground, administration building is to be constructed above ground

Source: JST



Source: JST

Figure 5.10.3 Location of Nong Bon Treatment Area and WWTP



Source: JST

Figure 5.10.4 Proposed Site for Nong Bon WWTP

5.11 Strategy for Sewerage System Development

5.11.1 Implementation of Sewerage Projects up to 2040

Implementation of sewerage projects up to 2040 was considered. Sewerage projects in Klong Toie, Thon Buri North treatment areas for which DDS is preparing project implementation follow Bang Sue Project which is now under construction. Then Nong Bon Project, which was selected as priority project under this M/P and Min Buri Project for which F/S is to be prepared will follow. Thon Buri South and Thong Kru North are judged to have high priority because these are separated from Thon Buri and existing Thong Kru areas respectively. In addition, the same priority is given to a group of 5 treatment areas for which priority was evaluated to be high in the previous section i.e. Wangthonlang, Don Mueang, Lat Prao, Jomthong and Taling Chan. Sewerage project in these 7 treatment areas will be implemented next. Finally, sewerage projects in the remaining 8 treatment areas, i.e. Bunkhum, Sai Mai, Lat Krabang-2, Lat Krabang-1, Nong Chok-1, Klong Sam Wa, Lat Krabang-3 and Nong Chok-2 will be implemented. Treatment areas classified into four groups according to their implementation priorities are presented below.

Group 1: Existing treatment areas (7)
Si Praya, Rattanakosin, Din Daeng, Chong Nonsi, Nong Khaem, Thung Kru South, and Chatuchak

Group 2: Under construction and F/S to be prepared (5)
Bang Sue, Klong Toei, Thon Buri North, Nong Bon and Min Buri

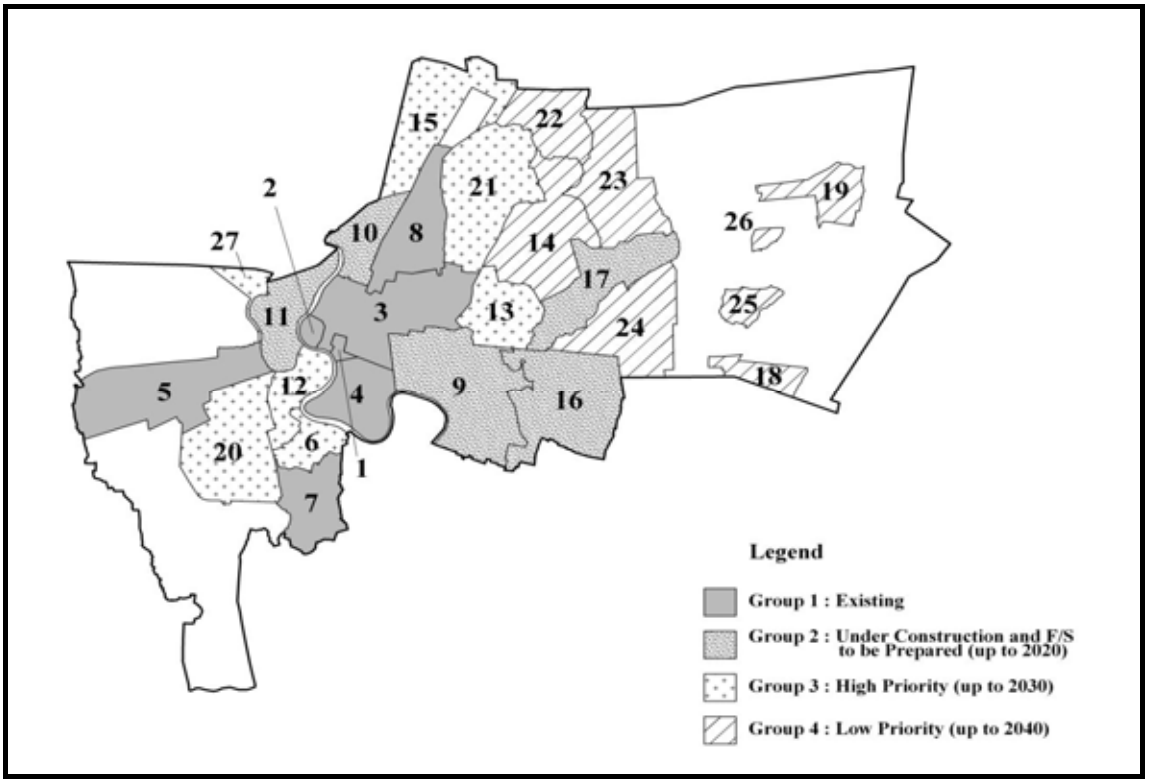
Group 3: High priority treatment areas (7)
Thon Buri South, Thung Kru North, Wangthonlang, Don Muaeng, Lat Prao, Jomthong, and Taling Chan

Group 4: Low priority treatment areas (8)
Bunkhum, Sai Mai, Lat Krabang-2, LatKrabang-1, Nong Chok-1, Klong Sam Wa, Lat Krabang-3, Nong Chok-2

Table 5.11.1 and Figure 5.11.1 show sewerage system development plan based on the classification of treatment areas. Bang Sue WWTP which is currently under construction will be completed in 2012. When four WWTPs for which F/S are to be prepared in addition to Bang Sue WWTP are constructed, total treatment capacity will be 1,983,000 m^3/day increased by 914,000 m^3/day. This will account for 76.0 % of total wastewater generated in BMA, i.e. 2,610,000 m^3/day (assumed that the whole area is provided with sewerage system). This will far exceed the long term target of the Sewerage System Development Plan of BMA that is 60 % in 2020. Figure 5.11.2 illustrates wastewater generated and treatment capacity. Construction cost which is necessary to increase treatment capacity by 914,000 m^3 /day is estimated to be approximately 34.1 billion Baht.

Considering that a total of 5 years DDS's budget from 2007 to 2011 for Water Quality Management Office was 3.9 billion Baht with maximum annual budget of 1.21 billion Baht in 2010 (refer to Table 3.3.3), significant increase of budget is necessary to provide sewerage systems until 2020. Since a total construction cost to complete all the sewerage projects by 2040 is estimated to be 101.9 billion Baht, and an annual average of initial investment is calculated to be 3.4 billion Baht, significant increase of budget is necessary to achieve long term goal of M/P until 2040.

In order to cover a tremendous amount of investment, introduction of loans from bilateral or multilateral financial institutions such as JICA together with increase of budget of BMA and central government is recommended. It is proposed that implementation of sewerage projects in 5 treatment areas including on going project and for which F/S is prepared should be completed by 2020, 7 treatment areas with higher priority by 2030, and the remaining 8 treatment areas by 2040 on an assumption that budget will be significantly increased.



Source: JST

Figure 5.11.1 Implementation Plan of Sewerage Projects

Table 5.11.1 Sewerage System Development Plan

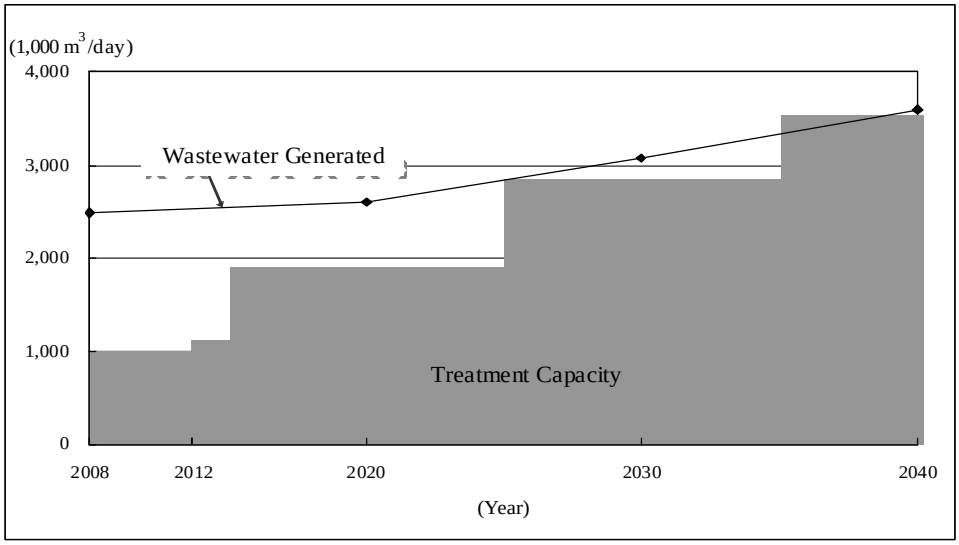
Existing		Under construction and F/S to be prepared (up to 2020)			High priority treatment areas (up to 2030)			Low priority treatment areas (up to 2040)		
Treatment area	Treatment capacity (m^3/day)	Treatment area	Treatment capacity (m^3/day)	Construction cost (million Baht)	Treatment area	Treatment capacity (m^3/day)	Construction cost (million Baht)	Treatment area	Treatment capacity (m^3/day)	Construction cost (million Baht)
1. Si Praya	30,000	10. Bang Sue [2]	120,000	4,584	12. Thon Buri South	142,000	5,027	14. Bunkhum	138,000	6,992
2. Rattanakosin	40,000	9. Klong Toei [3]	360,000	11,046	6. Thung Kru North	54,000	2,324	22. Sai Mai	64,000	3,436
3. Din Daen	350,000	11. Thon Buri North	160,000	5,871	13. Wangthonlang	117,000	4,608	24. Lat Krabang-2	107,000	5,410
4. Chong Nonsi	200,000	16. Nong Bon	134,000	6,873	15. Don Muaeng	155,000	7,100	18. Lat Krabang-1	30,000	1,446
5. Nong Khaem [1]	234,000	17. Min Buri	140,000	5,760	21. Lat Prao	192,000	8,840	19. Nong Chok-1	97,000	3,686
7. Thung Kru South	65,000				20. Jomthong	222,000	8,851	23. Klong Sam Wa	157,000	6,691
8. Chatuchak	150,000				27. Taling Chan	51,000	2,005	25. Lat Krabang-3	15,000	902
								26. Nong Chok-2	11,000	434
Total	1,069,000		914,000	34,134		933,000	38,755		619,000	28,997

Note: 1) Current capacity of 157,000 m^3/day is to be expanded

2) Contract amount

3) Estimated by F/S

Source: JST



Source: JST

Figure 5.11.2 Sewerage Development Plan

5.11.2 Operation and Maintenance Cost

Operation and maintenance (O&M) cost up to 2040 was estimated. WWTPs are considered to be constructed as proposed in the previous section. Unit O&M cost of 2.38 Baht per m^3 was used for estimation (refer to Table 3.4.4). This unit O&M cost does not include depreciation cost. Approximately 3.0 billon Baht per annum will be necessary in 2040 which accounts for 5 times current cost. O&M cost up to 2040 is shown in Table 5.11.2.

Table 5.11.2 O&M Cost

	2008	2020	2030	2040
Wastewater treated (million m^3/year)	247	579	939	1,261
O&M cost (million Baht/year)	587	1,377	2,236	3,001

Source: JST

5.11.3 Rearrangement of Treatment Areas

Huaykwang treatment area designated in the existing M/P is proposed to be integrated to Din Daeng treatment area, and Thon Buri and Thong Kru treatment areas are proposed to be divided into two areas, Thon Buri North and Thon Buri South and Thong Kru North and Thong Kru South. A part of Wangthonglang treatment area is also integrated to Din Daeng treatment area in addition to Huaykwang treatment area. Therefore, it is desirable that integration of Huaykwang treatment area is to be carried out at the same time when integration of a part of Wangthonglang treatment area is

carried out.

Thong Buri South and Thong Kru North both of which are separated from the existing treatment areas lie next to each other, and construction sites for WWTP are required for both of them. It seems to be difficult to find sizable lands for construction of WWTP in both treatment areas since urbanization has already been progressed. Jomthong treatment area where urbanization is expected in the near future and its priority for sewerage project implementation is evaluated to be high is located next to these treatment areas on the west. If a site for WWTP is secured in Jomthong treatment area, these three treatment areas should be integrated into one treatment area. Integration of these treatment areas will result in reduction of construction cost. Therefore, it is recommended that integration of two treatment areas is to be considered when F/S for Jomthong project is carried out.

5.11.4 Securing and Acquisition of Land for WWTP

Construction sites for WWTP for 15 treatment areas except for 7 existing WWTPs and Bang Sue, Klong Toei, Thong Buri North, Nong Bon and Min Buri treatment areas could not be secured regardless of the Survey Team's request. It is most important to determine location of WWTP site for sewerage system planning. Not only design of WWTP but also planning of major facilities of sewerage system including interceptors can not be carried out unless location of WWTP is determined. Sewerage project can not be implemented without determination of WWTP site even high priority for implementation was given. It becomes more difficult in future to obtain a sizable land under the circumstances that urbanization has been progressed every where. Therefore it is recommended that securing and acquisition of lands for construction of WWTPs should be done as soon as possible.

Nutrients removal such as N and P removal should be provided in addition to conventional secondary treatment in BMA. Thus, necessary areas for step feeding multi-staged nitrification and de-nitrification process which requires minimum area are calculated for each of 15 treatment areas, and are shown in Table 5.11.3. Required areas were calculated based on the following formula which is presented in Japanese "Guidelines for Comprehensive Basin-wide Planning of Sewerage Systems". The formula was developed based on typical arrangements of necessary facilities. Required areas range from smallest 2.36 ha for Nong Chok-2 treatment area to largest 9.96 ha for Jomthong treatment area.

Formula:

$A = 7.45\ Q \wedge 0.48$

Where

A: Area (1,000 m^3/day)

Q: Treatment Capacity (1,000 m^3/day)

Table 5.11.3 Required Areas for WWTPs

Treatment Area	Treatment Capacity (m^3/day)	Required Area (m^2)
Thon Buri South	142,000	80,400
Thung Kru North	54,000	50,500
Wangtholang	117,000	73,300
Don Muaeng	155,000	83,900
Lat Prao	192,000	92,900
Jomthong	222,000	99,600
Tailing Chan	51,000	49,200
Bunkhum	138,000	79,300
Sai Mai	64,000	54,800
Lat Krabang-2	107,000	70,200
Lat Krabang-1	30,000	38,100
Nong Chok-1	97,000	67,000
Klong Sam Wa	157,000	84,400
Lat Krabang-3	15,000	27,300
Nong Chok-2	11,000	23,600

Source: JST

APPENDICES

TABLE OF CONTENTS

Appendix-1
Record & List of Documents

1) **Manning Schedule**
2) **DDS Working Group Member List**
3) **100317 1st Working Group Record**
4) **100325 Comment & Discussion with DDS**
5) **100408 Discussion with DDS**
6) **100602 BMA Order Steering Committee**
7) **100615 2nd Working Group Record**
8) **100615 Comments on PR**
9) **100621 Steering Committee Meeting Report**
10) **100705 Progress of Survey**
11) **100825 3rd Working Group Record**
12) **100831 ITR Meeting for Related Organizations**
13) **100928 Discussion Record on ITR**
14) **100930 2nd Steering Committee Meeting Report**
15) **List of Documents Collected**

1) Manning Schedule

Appendix1-2

Position	Name	Organization	2010 MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2011 JAN	FEB	MAR	APR	MAY
Team Leader/Water Pollution Control	MIYAMOTO MASAFUMI	TOKYO ENGINEERING CONSULTANTS Co., Ltd.	(40)			(42)				(40)			(38)		(30)		
Sector Development Strategy/Legal System	INOUE YAKURO	NIPPON KOEI Co., Ltd.	(30)			(50)											
Sewerage Planning	TAKAHASHI HARUKI	TOKYO ENGINEERING CONSULTANTS Co., Ltd.	(40)			(22)		(30)		(21)	(20)			(42)			
Sewer and Pumping Station Design	KAJIURA TAKEKI	NIPPON KOEI Co., Ltd.				(80)				(49)			(56)				
WWTP Design/Water Quality Analysis	IZUMI KUNIMASA	TOKYO ENGINEERING CONSULTANTS Co., Ltd.	(30)					(46)		(35)			(69)				
Mechanical and Electrical Facilities Design	MISAWA YOSHINORI	TOKYO ENGINEERING CONSULTANTS Co., Ltd.								(28)				(37)			
Cost Estimation/Construction Planning	TANAKA NORIO	TOKYO ENGINEERING CONSULTANTS Co., Ltd.								(34)				(41)			
Organization and Business Management	NURUL ISLAM	NIPPON KOEI Co., Ltd.				(30)							(30)				
Economic and Financial Planning	MURAKAMI TAKESHI	NIPPON KOEI Co., Ltd. (KRI International Corp.)												(60)			
Environmental Assessment/Water Pollution Analysis	KAWACHI MASAHIRO	TOKYO ENGINEERING CONSULTANTS Co., Ltd.	(30)				(30)			(31)					(29)		
Report	Submission		△ IC/R			△ P/R		△ IT/R1	△ IC/R2				△ IT/R2			△ DF/R	△ F/R
			Phase 1 : Revision of Master Plan							Phase 2 : Feasibility Study							

Remarks: On-site Work

Home Work

2) DDS Working Group Member List

คณะทำงานสนับสนุนโครงการ Preparatory Survey for Bangkok Wastewater Treatment Project

ชื่อ-สกุล	Name	Position
1. นางสุทธิมล เกษสมบูรณ์	Mrs.Suthimol Kessomboon	Sanitary Engineer 8
2. นางจันทนา ริรัตนพงษ์	Mrs. Chantana Rirattanapong	Scientist 7
3. นางสาวเกศรัชฎา กลั่นกรอง	Ms.Katerachada Klankrong	Sanitary Engineer 7
4. นายกฤชภัทร ยินหิรัญ	Mr.Kitchapat Yinhirun	Civil Engineer 7
5. นายปธาน บรรจงปรู	Mr. Pathan Banjongproo	Sanitary Engineer 6
6. นางสาวโสภา บุราไกร	Ms. Sopa Burakrai	Sanitary Scientist 6
7. นายโอภาส แสงทองประกาย	Mr. Opas Seangtongprakay	Sanitary Scientist 6 Chonnonsi WWTP
8. นายประชา แก้วปรางค์	Mr. Pracha Kaewprang	Sanitary Scientist 6 Chatuchark WWTP
9. นายทรัพย์สิน นนสุราช	Mr. Supsin Nonsurach	Sanitary Scientist 6
10. นายศักดา ประยงค์หอม	Mr. Sakda Prayonghom	Civil Technician 6
11. นายฉมาพรรณ มาศจร	Mr. Chamaphan Masjorn	Sanitary Scientist 4
12. นายธีระสันต์ อมรสิน	Mr. Theerasan Amonsin	Sanitary Scientist 3

3) 100317 1st Working Group Record

1st Working Group Meeting
on JICA Preparatory Survey for Bangkok Wastewater Treatment

Date and time: 13:30 – 15:00 on March 17 (Wed)
Place: 6F, DDS
Participants;

[DDS] Mr. Chainat Niyomtoon: Director of WQMO, DDS (Chairman)
Ms. Sutimol kessomboon: Chief of Project and Sludge Management Section, WQMO
Working Group Members
[MOJ] Mr. Yamamoto Shinichiro: Secretary, Embassy of Japan
[JICA] Ms. Sato Momo: Senior Program Officer, JICA Thailand Office
Ms. Suthasinee: Program Officer, JICA Thailand Office
[Study Team] Mr. Miyamoto Masafumi, TEC (Team Leader)
Mr. Takahashi Haruki, TEC
Mr. Inoue Yakuro, NK

Documents distributed;
Inception Report (English version) & Handout of ppt

Issues discussed at the meeting;

1. Opening
The chairman gave opening remarks.
Ms. Sutimol explained the following organisations and its roles to implement the preparatory study.
- Steering Committee to coordinate the preparatory study headed by Deputy Parmanent Secretary of BMA
- Working Group which is the support team for the preparatory study consisted of DDS staff

2. Explanation of Inception Report
Mr. Miyamoto explained the contents of Inception Report by ppt.

3. Discussion
Comments on the Inception Report and answers to questionare (data and references) would be described in the meeting on 25th March.

4) 100325 Comment & Discussion with DDS

Comments and Discussion on Inception Report

Time and date: at 14:00 on March 25 (Thu)

Place: 6F, DDS

Participants: DDS Working Group (12 members) and JICA Study Team (3 members)

Following points were discussed at the meeting;

- Pollution (P.1): Water pollution in Bangkok appears mainly in klongs.

- JICA ODA Loan (P.1, 13, 33): It should be careful to use a word "JICA ODA Loan".
- ODA (P.1): This stands for "Official Development Assistance".

- Regulation (P.3): "Regulating -----" should be "Coordination between flood/drainage control and water pollution control is inadequate." Water level in rainy season is low but in dry season is high. Improvement of combined sewerage system is important.

- Water quality improvement (P.3): Improvement effect is not tangible; because klongs in sewerage developed area and undeveloped area are connected.

- Sewerage service tariff (P.3): As a personal opinion, the environmental (discharge) load charge may be fair for all residents in Bangkok, because sewerage users have difficulty to recognize the improvement of water environment. But it is not allowed by the BMA Regulation.

- Model separate system (P.5-6, 12, 16): As it is difficult to develop separate system in the existing urbanized area, the pilot area shall be selected in housing estate development areas.
  The size of the housing estate will be of a population of 2,000-5,000 (more than 500 households).
  The separate system can be examined in two community plants transferred from NHA in Bangkok.

- Sewage dilution problem (P.7): New issue of dilution is the presence of "unknown drainage pipe" in household, which raises the sewage dilution through drainage pipes toward both klong and public drainage system under road.
- Intercepting rate (P.7): 3.5DWF should be changed to 2-3 DWF for main interceptors and 5 DWF for branch interceptors, as mentioned in FS Klong Toei, FS Thonburi and Bangsue Wastewater Project.

- Improvement of interceptor (P.7): Structure of interceptors (storm overflow chambers) has

been changed repeatedly, so as fixed weir type, stop log type and flap gate type.

- Target year (P.11): For design of facilities, 20 years for WWTP and 50 years for sewer network have been adopted. Target year will be discussed further after the steering committee meeting.

- Industrial wastewater (P.5, 8): MOI is responsible for installation and monitoring of industrial wastewaters and PCD (MONRE) is responsible for regulation of wastewaters from industries. PWD (BMA) and District Office are responsible for installation and monitoring of wastewaters from buildings, hospitals and small industries.

- Regulation for Septic Tank: It is under PWD/District Office (BMA), PCD (MONRE).
Standard construction (depth, beneath and so on) is considered. Oil trap is usually provided.
There are around 50 examples of exception for obligation of septic tank installation at household.

- 75% value in Table 2 (P.24): This is excess probability in Japan as for environment cost and natural phenomena.
- Level survey (P.29-30): 20km is typical length of level survey for cost estimation proposed to JICA

- Public consultation (P.30-32): Public hearing follows the experience of Bang Sue Project.
- CVM (P.32): Contingent Valuation Method and Willing to Pay (WTP) survey will be explained in detail later on.

- Economic and financial analysis (P.34-36): EIRR is likely to be less than 10% as maximum value. FIRR depends on sewerage service charge. These analyses will be discussed more at later stage.

5) 100408 Discussion with DDS

Discussion points on Strategies for developing the sewerage system

Date and Place: 9:30 on April 8 (Thu) at 6F, DDS

Participants: Head of DDS Working Group and JICA Study Team (5 members)

1. Steering Committee

- Committee Members are Deputy Permanent Secretary of BMA, Inspector of BMA, Director General of DDS, Deputy DG of DDS and Director of WQMO, DDS.
- The 1st Committee meeting will be held in the beginning of June; supposed to be in the second week.

2. Improvement on Interceptor sewerage system in Thailand

- WG headed by Deputy DG is conducting the fact finding survey for (1) comparison between water supply and actual influent to WWTP of DDS, (2) structure of interceptor chamber, (3) klong water level in operation, and (4) other potential reasons of wastewater dilution.

3. Monitoring of septic tank and community plant

- Installation of septic tank and community plant is regulated by PWD, BMA under the Building Control Act and BMA Ordinance.
- Monitoring of septic tank and community plant is regulated by PCD, MONRE under the Enhancement and Conservation of National Quality Act.
- The authority of the above monitoring was transferred to BMA in 1992, and then PCD changed the policy in 2005? and has monitored by himself.

4. Shortage of WWTP land

- Private land is very difficult to purchase for WWTP due to the controversial procedure, such as price explanation and penalty by BMA Inspector.
- The vacant spaces in On Nut relay station are already occupied by several plans on municipal solid waste.

5. Pilot area for separate sewerage system

- It will be proposed at new housing estate (new village) developed by developer.

6. Expanding treatment areas from 20 to 30 in revision of MP

- They will be proposed in the Study without any prejudgment.

7. Target year, 2040 or 2030

- The reference data will be collected in the interview with City Planning Department, BMA and MWA.

6) 100602 BMA Order Steering Committee

Order of Bangkok Metropolitan Administration
No.1482/2553
Subject : Appointment of the Preparatory Survey for Bangkok Treatment Project Steering Committee

Japan International Cooperation Agency has supported Bangkok Metropolitan Administration by Grant Aid to implement the Survey for the review of Bangkok Wastewater Management Master Plant and 1 project of the Feasibility of Wastewater Treatment. By virtue of the provision of Article 49 of the Act of parliament B.E.2528 (1985), the Preparatory Survey for Bangkok Wastewater Treatment Project Steering Committee is hereby appointed with members and authority and duties as follows:

1. Deputy Permanent Secretary — Chair person
   (For Department of Drainage and Sewerage)
2. Mr. Chanchai Vitoonpanyakit — Deputy Chair person
   (Inspector General, Office of the Permanent Secretary for the BMA)
3. Director of Drainage and Sewerage Department — Committee
4. Deputy Director of Drainage and Sewerage Department — Committee
   (For Water Quality Management Office)
5. Assoc. Prof. Sutchai Champa — Committee
   Expert
6. Assist. Prof. Boonyong Lowongwat — Committee
   Expert
7. Director of Economic and Fiscal Office — Committee
   Department of Finance
8. Director of Legal and Litigation Office — Committee
   Office of the Permanent Secretary for the BMA
9. Director of Drainage Information System Division — Committee
   Drainage and Sewerage Department
10. Director of Water Quality Management Office — Committee and Secretary

Drainage and Sewerage Department

11. Ms. Suthimol Kessomboon — Committee and Assist. Secretary
    Drainage and Sewerage Department
12. Ms. Kate-rachada Klankrong — Committee and Assist. Secretary
    Drainage and Sewerage Department

Authority and Duties

(1) Represent for BMA's activities in the implementation of the Survey according to the Terms of Reference and regulations

(2) Consider to give recommendation and suggestion during the review of Wastewater Treatment Management Master Plan and the Feasibility Study

(3) Consult ,suggest and solve problems occurred during the implementation

(4) Consider to suggest the use of the Survey results for Bangkok development

This order shall come into force with immediate effect

Issued on 7 March 2010

MR. Sukhumbhand Paripatra
Governor of Bangkok

7) 100615 2nd Working Group Meeting

on JICA Preparatory Survey for Bangkok Wastewater Treatment
Date and time: 10:00 – 12:00 on June 15 (Tue)
Place: 6F, DDS
Participants;

[DDS] Mr. Chainat Niyomtoon: Director of WQMO, DDS (Chairman)
Ms. Sutimol Kessomboon: Chief of Project and Sludge Management Section, WQMO
Working Group Members（9+7）
[JICA] Ms. Sato Momo: Senior Program Officer, JICA Thailand Office
Ms. Suthasinee: Program Officer, JICA Thailand Office
[Study Team] Mr. Miyamoto Masafumi, TEC (Team Leader)
Mr. Takahashi Haruki, TEC
Mr. Inoue Yakuro, NK
Mr. Kajiura Takeki, NK
Dr. Nurul Islam, NK

Documents distributed;

Progress Report (English version) & Handout of ppt

Issues discussed at the meeting;

1. Opening

The chairman gave opening remarks.

2. Explanation of progress Report

Mr. Miyamoto explained the contents of Progress Report by ppt.

3. Discussion

(1) Projected population

- Three cases of population projection, in particular forecasting pose of donut phenomenon in future, was discussed.
- Construction of condominium is increasing in central Bangkok.
- Projection of water supply for business activities is important for projection of wastewater generation in central Bangkok.

(2) Performance of existing seven WWTPs in 2009

- Performance of existing WWTPs should be indicated on an average to avoid misunderstanding.

Inflow of Chong Nonsi WWTP is abnormal due to extraordinary circumstance in 2009.

(3) Combined sewerage system in Bangkok

- Director raised a possibility to adopt the separate sewerage system in Bangkok, in order to solve some problems arisen from the interceptor combined sewerage system in Bangkok.
- Study Team expressed the difficulty to introduce the separate system into Bangkok where drainage system were already developed, from the view point of experiences of Tokyo and Osaka in Japan where the combined sewerage system have been improved to play a role of wastewater management, and this topic will be discussed in this study in case of newly developed housing estate in Bangkok.

(4) Planning of Sewerage Area in Master Plan

- Study Team raised the necessity of expanding Treatment Area from existing 20 to around 27 areas; boundary and number of treatment areas should be determined, as follows;
- At first the boundary of treatment areas will be discussed, which is proposed to be the same as urbanized area of City Planning of BMA in 2025.
- Then expansion of exiting Treatment Area will be discussed, in order to utilize the margin of existing WWTP capacity, for example; expansion of Chong Nonsi Area to Din Daen Area, expansion of Din Daen Area to Huay Kwang Area and so on.
- DDS requested Study Team that Klong Toei Treatment Area and Bang Sue Treatment Area should not be changed, because the Feasibility Studies for both of the Treatment Areas are already concluded.
- In parallel possible WWTP sites will be found in the undeveloped treatment areas and set each treatment area.
- Outside urbanized area, Agricultural Area and Agricultural Conservation Area, on-site treatment system and communal treatment system of housing estate developed by developers will be adopted.

8) 100615 Comments on Progress Report

Comments and Discussion on Progress Report

Time and date: at 13:00 on June 15 (Tue)

Place: 6F, DDS

Participants: DDS Working Group (5 members) and JICA Study Team (2 members)

Following comments on Progress Report were expressed by DDS working group members;

P16: "4.3.1 Reconnaissance Survey of WWTPs"

The style of explanation should be unified to be the same as "Rattanakosin WWTP".

P16: "1) Rattanakosin WWTP "

Instead of "2.5 DWF" "1.5 DWF is biologically treated and excess 3.5 DWF is discharged" was suggested.

But an explanation of "2.5 DWF is biologically treated" is shown in a broacher of Rattanakosin WWTP.

P37: the reason for delay of sewerage development

It is not only limited WWTP sites, but also the lacking of budget.

P37 and P53: industrial wastewater

This word should be replaced with "business wastewater" which includes commercial, public office and industrial use.

P42: B) Guidance for drainage facilities

"Department of Construction" is "Public Works Department".

P42: C) Monitoring of wastewater from establishment

Last two sentences should be deleted, because DDS does not support MOI.

P52: Institutional requirements ㄱ Guidance of development

This paragraph should be rewritten, because "Land development law" already established, and DDS has no idea to manage those sewerage facilities constructed by developer.

P60: Table 4.11 Pollution of BMA by DORA

"DORA" is "DOLA", that is, Department of Local Administration.

P76: Figure 4.27 Profile of BOD Concentration along Chao Phraya River

It was commented on that the maximum value of R05-09 were abnormal, but it is finally understood as the ranges of fluctuation is shown in table 4.19 and written in detail.

P82: (2) Present Water Pollution Situation

The number of monitoring points in 2009 is 283, not 285 points.

P86: Table 4.23 Monitoring Points which show Obvious Water Quality Improvement

It is doubtful that development of treatment plant is effective to improve water quality in klongs. For example the water quality in Chong Nonsi klong is still bad even if Chong Nonsi WWTP is in operation.

Why these points are selected and how explain the actual situation that four out of ten klongs having the worst water quality in Bangkok are in the existing treatment area.

P92: G) Monitoring Points: No 331, No 332

It was commented on that water quality improvement of these points is caused by flushing project, because these are no gates or gates are “usually closed”, not “usually opened.”

Study Team requested some additional interviews to collect data, as attached file;

9) 100621 Steering Committee Meeting Report 1

Meeting Report 1/2553
The Preparatory Survey for Bangkok Wastewater Treatment Project
Date June,21nd B.E. 2553 13.30-15.30
Nopbhand Room, Drainage and Sewerage Department
3th Floor , Bangkok City Hall 2

Committees who has joined the meeting

1. Mr. Chanchai Vitoonpanyakit — Deputy Chair person
   Inspector General, Office of the Permanent Secretary for the BMA)
2. Mr. Thammanat Chunsano — Committee
   Deputy Director of Drainage and Sewerage Department
   (for Water Quality Management Office)
3. Assoc. Prof. Sutchai Champa — Committee
   Sanitary Engineer Expert
4. Assist. Prof. Boonyong Lowongwat — Committee
   Sanitary Engineer Expert
5. Ms. Darunee Supanai Committee in charge — Committee
   On behalf of Director of Economic and Fiscal Office (Committee)
   Department of Finance
6. Ms. Suwannee Phusuwan — Committee in charge
   On behalf of Director of Legal and Litigation Office (Committee)
   Office of the Permanent Secretary for the BMA
7. Mr. Witchu Sukdhava — Committee in charge
   On behalf of Director of Drainage Information System Division (Committee)
   Drainage and Sewerage Department
8. Mr. Chainat Niyomtooon — Committee and Secretary
   Director of Water Quality Management Office
   Drainage and Sewerage Department
9. Ms. Suthimol Kessomboon — Committee and Assist. Secretary
   Water Quality Management Office
   Drainage and Sewerage Department
10. Ms. Kate-rachada Klankrong — Committee and Assist. Secretary
    Water Quality Management Office
    Drainage and Sewerage Department

Participants who has joined the meeting

1. Mr. Miyamoto Masafumi — JICA STUDY TEAM
2. Mr. Takahashi Haruki — JICA STUDY TEAM

3.	Mr. Nurul Islam	JICA STUDY TEAM
4.	Mr. Inoue Yakoru	JICA STUDY TEAM
5.	Ms. Sayuri Kakimoto	JICA, Tokyo
6.	Ms. Momo Sato	JICA, Thailand
7.	Ms. Suthasinee Boonmeeprasert	JICA, Thailand
8.	Ms. Marisa Kanchana	Economic and Fiscal Office (BMA)

Committees who was absent from the meeting

1. Mr.Chatinai Nauwaphut Chair Person
   Deputy Permanent Secretary (For Department of Drainage and Sewerage)
2. Mr. Sunya Chinimit
   General Director Department of Drainage and Sewerage Committee

Begin at 13.30

Period 1 : Introduction for meeting

Acting chair committee (Mr. Chanchai) has declared to the committee and meeting participants that Order of Bangkok Metropolitan Administration No.1482/2553 on 5th March 2010, Bangkok Governor has appointed the steering committee for the Preparatory Survey for Bangkok Wastewater Treatment Project to supervise the project. The project is financially supported by the Japan International Corporation Agency (JICA) in order to revise the last version of Wastewater Management Master Plan(JICA-Nippon Koei,1999) and to finish a feasibility study on one wastewater treatment project (to be selected later) within 15 months. The project has been carried on for some months and would be represented in this meeting.

Result : The committee and participants noticed and accepted

Period 2 : Approval of the last meeting report

Result : Nothing to be declared.

Period 3 : Agenda for hearing

Result : Nothing to be declared

Period 4 : Progress of the Project

Mr. Miyamoto MASAFUMI has presented the Inception Report and Progress Report to the steering committee and discussed in some topics as follows,

1. Pilot Project on Separated Sewer System

- JICA expert has proposed that the new wastewater project should be installed with partially separated wastewater collection system. A committees (Mr. Boonyong) commented that BMA will have to prepare firstly the main trunk sewer in the service area to allow the separated sewer to connect to

2. Aerosol Control

- The steering committee has guided that the new wastewater project should have to concern about aerosol. Aerosol will be a parameter under control by PCD in the future. The design of covered aeration tank may help reduce aerosol dispersion as an alternative solution

3. Low BOD in Influent

- JICA expert has suggested the way to increase BOD concentration in Influent is to change laws and regulations to allow residential wastewater source to discharge wastewater without passing septic tank (or other pretreatment). Probably, BMA should revise laws and regulations about high rise building located inside wastewater service area, such as Building Control Act BE.2522, Royal Decree on Environmental Enhance and Protection BE.2535. etc.

However, present regulations allow polluter (especially the large scale building under building control act) inside wastewater service area to choose if they want to discharge wastewater directly to wastewater collection system or they have to treat wastewater to meet effluent standard.

4. Infiltration and Inflow

- In this year (2010), salinity of water in Chaophraya river has been increasing for a long period until May 2010 because salinity intrusion effect due to very low flow rate from northern Chaophraya River basin. This shall allow BMA to recheck about Inflow and Infiltration in some wastewater service area. The committee has suggested that salinity and dissolve solids in water example should be analyzed in order to indicate Infiltration and Inflow.
- There should be study of result from tidal effect in the new wastewater project too, the committee has suggested.

5. In the feasibility study of Nongbon Wastewater Treatment Project, the committee suggested the expert to consider the nutrients (Nitrogen and Phosphorus) removal together with separated sewer network.

6. Tariff collection system and alternatives should be included in the revised Wastewater Master Plan

7. The improvement of wastewater collection system and wastewater storage tank (Equalization Tank) should be included in the revised Wastewater Master Plan.

Result : JICA expert should take attention on the comments from the steering committee and working in accordance with the conclusion from this meeting

Meeting Closed at 16.30

Recorded by	(Mr. Chamaphan Masjorn**)**
Translated by	(Mr. Pathan Banjongproo)
Approved by	(Ms. Suthimol Kessomboon)

10) 100705 Progress of Survey

Discussion about Progress of the Survey

Time and date: 13:00, July 5 (Mon.)
Place: 6F, DDS
Participants: (DDS Working Group)
Ms. Suthimol Kessomboon
Ms. Katerachada Rirattanapong
Dr. Pathern Banjongproo
Ms. Sopa Burakrai
Mr. Chamaphan Masjorn
(JICA Survey Team)
Mr. Masafumi Miyamoto
Mr. Yakuro Inoue
Mr. Takeki Kajiura

Discussions were held on the progress of the Survey. Main points are as follows.

1. Site Visits

Survey Team answered that they have not request for additional site visits so far corresponding to DDS's question. Site visits may be requested as study progresses.

2. Pilot Separate System

DDS mentioned that these is one private housing development project in Thongbri that has complete separate system. DDS will look into housing developments which are good example for pilot project.

Survey Team explained their considerations regarding pilot project. It was agreed that amendments of relevant laws are necessary to discharge raw wastewater directly to sewerage system and this will be proposed in the report. Concern about sediments in sewers was expressed because there is no provision to prevent sediments in pipeline inside housing areas. DDS pointed out necessity of providing storage tanks (septic tank, etc) to regulate wastewater flows to sewerage system in case of high rising residence. DDS checked this matter when EIA report is submitted.

3. Plumber Registration

Survey Team explained importance of plumber registration system. They will mention recommendation about the system in the report.

4. Water Pollution in Klogns

Further discussions will be held after Survey Team's expert's arrival on 13 July. Modeling of

water pollution mechanism will be one of the subjects.

5. MWA Data

DDS will confirm with MWA whether service district-wise data for the remaining seven years are available. It was confirmed later that MWA posses these data only for three years and the data for the remaining seven years are not available.

6. Interview with PCD

Survey Team's questionnaire was sent to PCD. We shall wait for their answer with patience.

7. Sewerage Service Tariff

Survey Team explained O&M cost projection and ratio of it against DDS budget, and comparison of water supply tariff and sewerage service tariff in major cities in Asia. It was agreed that recommendations regarding sewerage service tariff will be made based on these analysis.

8. Possible Site for WWTP

DDS informed that they approached Treasury Department (Ministry of Finance) to find out possible sites for construction of WWTP in entire BMA. They also try to find possible sites looking into "monkey cheek projects" which are under DDS and public parks. It will take some time to get results from these enquiries.

9. Klong Water Levels and Interceptor Weir Levels

Survey Team explained the results of analysis of klong water levels and interceptor weir levels. Backwater from klongs can be prevented in some klongs if water level can be lowered in dry seasons. Difficulty to lower the water level in some klongs was expressed. Survey Team recommends storm water pumping area as long term paln.

10. Infiltration

Wastewater generation was estimated based on the assumption that 80% of water consumption is returned to sewerage system and infiltration of 20 m3/ha/day for the latest two F/S i.e. Bang Sue and Klong Toie. It was discussed that the infiltration is too much. DDS and Survey Team will further study on the matter.

11. Rearrangement of Treatment Areas

It was confirmed that the contract period of Chongnonsi WWTP site for BRT motor pool is 5 years, and that after that the site can be used for expansion of WWTP (double the current capacity). DDS and Survey Team will look into rearrangement of treatment areas in detail, in particular such areas as Chonongnonsi, Din Daeng, Nong Bon and Min Buri. Information regarding the existing drainage pipelines are requested in this regards.

12. Deep Tunnels

Information about the existing and future deep tunnels for klong water pumping to Cho Praya river was requested.

11) 100825 3rd Working Group Meeting

on JICA Preparatory Survey for Bangkok Wastewater Treatment

Date and time: 13:30 – 15:00 on August 25 (Wed)
Place: 6F, DDS
Participants;

[DDS] Mr. Chainat Niyomtoon: Director of WQMO, DDS (Chairman)
Ms. Sutimol Kessomboon: Chief of Project and Sludge Management Section, WQMO
Working Group Members（10）
[Study Team] Mr. Takahashi Haruki, TEC
Mr. Izumi Kunimasa, TEC
Mr. Ideta Isao, TEC

Documents distributed;

Draft of Interim Report

Issues discussed at the meeting;

1. Opening

The chairman gave opening remarks.

2. Explanation of Draft of Interim Report

Mr. Takahashi explained the first part (Introduction & Strategy) of Draft of Interim Report.

Mr. Izumi explained the second part (Conceptual Sewerage Master Plan) of Draft of Interim Report.

3. Discussion

(1) Strategy 1.1 (Improvement of interceptor system)

- Director raised a question about the long-term countermeasure (reduction of interceptor chambers & pump drainage system) in strategy 1.1, that it is necessary to discuss more within DDS, because changing drainage system is very sensitive for DDS.
- Din Daen operation officer said that water level at the Pumping Station of WWTP is already controlled lower, and some interceptor chambers are closed and equipped with an adjustable weir.

(2) Strategy 4.3 (Improvement of institution of sewerage works) and 4.4 (Ordinance)

- Project Section Chief (Team Leader of WG) said the proposed institutional improvement draws many obstructions from related organizations (PWD & DOE) for setting of new ordinance on sewerage works.

4. Further discussion with Director, Project Section Chief and key member of WG

(1) Study team explained the concept on “Reduction of interceptor chambers & Pump drainage system” in Rattanakosin Area, as follows;

a) Interceptor chambers should be in principle closed to stop the inflow from klong in dry season.

b) Wastewater up to 5 DWF is conveyed to WWTP through interceptor; there is no change in sewerage system.

c) Rain water will inundate roads or low lands in rainy season due to the close of interceptor chambers.

d) Then the above rain water will be drained through new storm sewer, and pumped up at rain-water pumping station.

e) The concept proposed by study team is based on the existing and planned pump drainage system; utilizing existing and planned drainage system to the fullest extent and only adding certain drainage/pumping capacity to cover the closed interceptor chamber.

d) This means that raised problems will be solved by coordination between wastewater treatment work and rain water drainage work, instead of implementing each project separately.

5. Schedule of next phase

- Comments and questions for Draft of Interim Report will be submitted by September 9th, so that study team will conclude the report.
- The Feasibility Study on Priority Project in BMA will be commenced in the end of September on schedule, because DDS accepts the Conceptual Sewerage Master Plan in Interim Report.
- Presentation of Interim Report to Steering Committee is postponed in the first stage of next survey. Interim Report will be completed after the steering Committee.

12) 100831 ITR Meeting for Related Organizations

31 Aug.2010
Summary of Interim Report
JICA Preparatory Survey for Bangkok Wastewater Treatment

Section 1. Issues for Sewerage Work and Strategy for Sewerage Development in BMA by Mr. Takahashi

Comments

1. BMA (Mr. Chanchai V.) As Mr. Takahashi described, the way to reduce water level in klongs during the dry season seems to be impractical because BMA has to dilute canal water by river water to make better environment. The most possible solution is to install the sophisticate instruments (such as pump...etc.) in the IPC to control of wastewater level.

   Additionally, BMA has to concern about the Institutional Issue; Department of Public Work (DPW), Department of Environment (DOE), Department of Drainage and Sewerage (DDS) still have some sharing legal frame work and fragmented responsibilities. DPW has to control each housing construction project in accordance with Building Control Act, while DOE has to control of the night soil and its treatment plant. At the same time, DDS has to control and operate the wastewater collection and treatment plant. The three departments should join their responsibilities in order to do best benefit to the BMA.

2. NESDB
   About Klong Toey WW Project, NESDB has submitted the project to the Ministry of Interior. At the present time, BMA representative should visit the key persons in the Ministry of Interior to give more details and explanations before Minister of Interior propose the project to the ministry cabinet. (The Klong Toey WW Project had passed three BMA Governors, two minister of Interiors and once in the cabinet and was resubmitted due to the request of chair person (Economic-In-charge Deputy Prime Minister))

   NESDB also has concerned about the wastewater fee and collection if the fees should be from all polluter of Bangkok or only the polluter in the service areas. The answer is; due to the city Ordinance only the polluter in the service areas should be charged for the wastewater fees. If all polluters of the city should have to share the response, then some laws and regulations must be modified such as the MWA act. This is to allow the MWA to offer the water bill included with wastewater tariff.

3. PCD

PCD representative has asked in the meeting about the collection of wastewater that is still leaking into the canal even in the wastewater service areas. BMA has provided in the new wastewater project especially Bang Sue EECP to collect all pipes and drains which help to trap almost all wastewater before it flows into canals. This will help to reduce wastewater leakage inside the wastewater service area as much as possible.

4. MWA

   MWA representative has declared in the meeting that even he is not being in charge for the water supply committee but it is no doubt that the subject of wastewater billing in the water bill is now under consideration due to the Prime Minister's policy. However, MWA can not control for all payment of wastewater tariff and some expenses will be charged for the billings of wastewater.

5. Office of Planning, Ministry of Interior. (MOI)

   MOI representative has suggested in the meeting that, Klong Toey Project was postponed due to the problems of the financial numbers and the wastewater tariff. The Prime Minister has given the policy to apply single bill (for both Water and Wastewater Taffy) and to modified laws and regulations to allow MWA and PWA to issue the bills. At the present time, some municipality issue both water and wastewater tariff on the same bill depends on local regulations.

   However, the rate of charge must be under sharing consideration between the Ministry of Interior and the pollution control department. BMA representative explained in the meetings that according to the City Ordinance, wastewater tariff is now ready to be collected but must wait for some detail declarations (such as where to collect, who will be in charged for the collection…etc.)

6. Department of City Planning (DCP, BMA)

   DCP has declared in the meeting that the population forecast in Bangkok still requires some more explanations. It is true that by registration the population in the City Core area is decreasing at the present time but practically the housing project especially new condominiums on the route of mass transit system are now increasing and lead people to come back and live in the city as non-registered population. These people just stay in the city for the working day and then leave to out skirt of the City during holidays. It was estimated that in the year B.E.2547 the registered was equal to around 4 Millions and the non-registered is equal to around 5 Millions accordingly. Also in B.E.2565, the summation of registered and non-registered is forecasted to be 11 Millions

7. Department of Environment. (DOE) & Department of Budgetary, BMA (DOB)

   Their representatives have no comment.

13) 100928 Discussion Record on ITR

Time and date: 14:00, September 28 (Tue.)
Place: Director's Room, 3F, DDS

Participants:	(DDS Working Group)	(JICA Survey Team)
	Mr. Chainat Niyomtoon, Director of WQMD	Mr. Masafumi Miyamoto
	Ms. Suthimol Kessomboon	Mr. Haruki Takahashi
	Ms. Katerachada Klankrong	Mr. Kunimasa Izumi
	Dr. Pathan Banjongproo	
	Mr. Chamaphan Masjorn	

The following topics were discussed on the Interim Report.

1. Proposals introducing pump drainage system and closing interceptor chambers

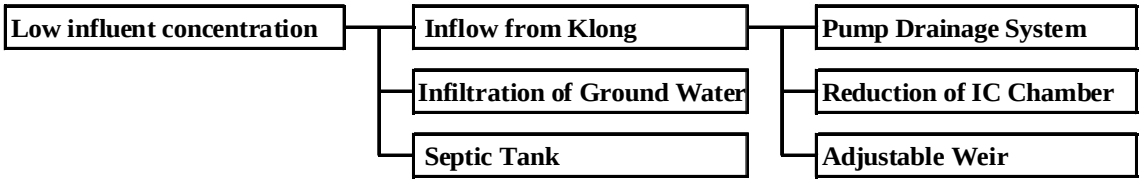
Survey Team explained the concept of introducing pump drainage system and closing interceptor chambers by using experience in Tokyo Metropolis.

Director argued that it is impossible to put these proposals into action because urban drainage and flood protection are given priority to and also difficult to finance high cost pump drainage system due to limited budget.

Survey Team also explained that these proposals intend to improve low concentrations of influent and it is possible to coordinate countermeasures between urban drainage/flood protection and sewage treatment. It is one of long-term countermeasures and its immediate implementation is not needed at present.

Director explained that raising of weir level by stop log will be carried out in Chong Nonsi Treatment Area and adjustment of weir level in dry and wet seasons (adjustable weir level) will be considered.

Finally these proposals are accepted to be described in the Interim Report as one of the alternatives to improve present situation and will be discussed more in the F/S by presenting concrete and detailed approach.



2. Zoning of treatment areas in conceptual master plan

(1) Selection of Priority Project

Director emphasized that criteria for selection of priority treatment area should include effects on improvement of klong water quality (catchment area) and that topographic features (large klong and road) should be considered for zoning of treatment areas.

Zone 21 and 22 located along Klong Lad Phrao should be considered as the candidates for priority project, because Klong Lad Phrao is severely polluted in the central Bangkok.

In the comparison of the candidates for priority project, evaluation will be done preferably by klong water quality improvement, the site for WWTP construction and numeric value (population density, project cost and so on).

(2) Rearrangement of the other zone

- Expansion of Din Daeng Treatment Area is limited up to around Huaykwang Treatment Area.
- Min Buri Treatment Area is expanded to include nearby dense urbanized area in Wangthonlang Treatment Area.
- Thon Buri Treatment Area is divided into two areas; North Thon Buri with possible WWTP site and South Thon Buri which may be combined into nearby Jomthong Treatment Area.

Director asked Survey Team to provide large maps on which he will draw boundary lines of treatment areas mentioned above, which Survey Team agreed to.

14) 100930 2nd Steering Committee

Meeting Report 2/2553
The Preparatory Survey for Bangkok Wastewater Treatment Project
Date September 30nd B.E. 2553 10.00-12.00
Nopbhand Room, Drainage and Sewerage Department
3th Floor , Bangkok City Hall 2

Committees who has joined the meeting

1. Mr. Chanchai Vitoonpanyakit — Deputy Chair person
   Inspector General, Office of the Permanent Secretary for the BMA)
2. Mr. Thammanat Chunsano — Committee
   Deputy Director of Drainage and Sewerage Department
   (for Water Quality Management Office)
3. Assoc. Prof. Sutchai Champa — Committee
   Sanitary Engineer Expert
4. Assist. Prof. Boonyong Lowongwat — Committee
   Sanitary Engineer Expert
5. Ms. Darunee Supanai — Committee in charge
   On behalf of Director of Economic and Fiscal Office (Committee)
   Department of Finance
6. Ms. Suwannee Phusuwan — Committee in charge
   On behalf of Director of Legal and Litigation Office (Committee)
   Office of the Permanent Secretary for the BMA
7. Ms. Ammaraporn Jitpraphai — Committee in charge
   On behalf of Director of Drainage Information System Division (Committee)
   Drainage and Sewerage Department
8. Mr. Chainat Niyomtooon — Committee and Secretary
   Director of Water Quality Management Office
   Drainage and Sewerage Department
9. Ms.Suthimol Kessomboon — Committee and Assist. Secretary
   Water Quality Management Office
   Drainage and Sewerage Department
10. Ms.Kate-rachada Klankrong — Committee and Assist. Secretary
    Water Quality Management Office
    Drainage and Sewerage Department

Participants who has joined the meeting

1.	Mr. Miyamoto	Masafumi	JICA STUDY TEAM
2.	Mr. Takahashi	Haruki	JICA STUDY TEAM
3.	Mr. Izumi	Kunimasa	JICA STUDY TEAM
4.	Ms. Marisa	Kanchana	Economic and Fiscal Office (BMA)

Committees who was absent from the meeting

1. Mr. Chatinai Nauwaphut — Chair Person
   Deputy Permanent Secretary (For Department of Drainage and Sewerage)
2. Mr. Sunya Chinimit — Committee
   General Director Department of Drainage and Sewerage

Begin at 10.00

Period 1 : Introduction for meeting

Acting chair committee (Mr. Chanchai) has explained to the committee that Mr. Chatinai (Chair Person) has another official appointment, so Mr. Chanchai will be the acting chairman.

Result : The committee and participants noticed and accepted

Period 2 : Discussion of the Inception report

The JICA study team has proposed the progress task of the Interim Report "Preparatory Survey for Bangkok Wastewater Treatment Project." and the discussions are as follows.

1. The Steering committees suggest that the conventional (combined) Sewage System is not suitable for BMA because the wastewater has low BOD concentration which leads to high energy consumption and another question is how Japan can solve the problem of low BOD in wastewater and the definition of 3W wastewater (WWW).

The JICA study team declared that in Japan the wastewater treatment plant was designed in smaller size and smaller service area. BMA Wastewater is a 5 unique system with a lot of interceptors and very light capacity. The may leads to high rate of infiltration and lower BOD concentration. For about "3W-Wet Weather Wastewater" is Japanese terms to explain very low BOD concentration occurred after heavy rainfall. The wastewater can be treated by special AS system.

2. The special AS System is such as the "Step feed Aeration" and by design optimum size of aeration tank, the problems of law BOD can be avoided. Also the optional design for such low BOD and SS wastewater are design of WWTP without primary settling tank, using limiting area SBR or Modified Activated Sludge or Membrane System but for the Membrane designer must consider about the unstable of influent wastewater quality.

3. The steering committee suggested that the vicinity at outfall should be designed in harmonized with the public park and beautiful landscape.The outfall structure should be dual drainage options, in dry screen the effluent should be discharge to dilute canal water and to help improve water quality, in rainy season the effluent can be diverted in to Nong bon Reservoir to help reduce drainage capacity of the canal system

4. Chairman has given opinion that the water supply statistics BKK should be higher than 75% (of total MWA) as the JICA study team has presented. The JICA study team said the data was obtained from MWA as separated by branch office area respectively. It was clear for most of area, only Prakanong and Thonburi branch office have the common service area in Bangkok and Samutprakarn. Both of areas can be analyzed and the presented result is reasonable. Anyway Mr.Chairman said the information is critically important and should be rechecked for the certainty.

5. Ms.Supanai D, on behalf of department of finance, BMA has given advice that the study team should present the detail of financial analysis on the three options.

5.1 BMA and Central Government of Thailand invest together

5.2 Soft Loan from JICA, ADB, AFD or the others

5.3 Public Private Partnership (PPP)

Practically, JICA study team have to do the risk assessment on both the financial and technical issues especially in case that government join with private.

6. About the Wastewater Service Area Zoming in the year of 2040 and the Nongkhaem and Tung Kru WWTP which are propored to be expanded , the committee has question on the period of prediction if it is too long or not. Because too long prediction period can lead to higher deviation. The study team has the same opinion that this study is just a master plan that should be revised in every 5-10 years for better solution.

7. The committee offer to the chairman that in strategy 1.2 can not be practically applied.

Consent of Meeting : the study team should have to concern about all suggestion and let this to be implemented.

Period 4 : others

The JICA study team has submitted the plan to do the feasibility study on Non bon Wastewater Project which is as follows

- Area of Study
- Waste Water Treatment Technology (Process and Option)
- Social and Economy study
- Priority of Project
- Cost Estimation and Construction Plan
- Economical Analysis
- Social and Environmental Study

Consent of Meeting : Informed and Accepted

Meeting Closed at 12.00

Recorded by _____
(Mr.Chamaphan Masjorn)

Translated by _____
(Mr.Pathan Banjongproo)

Approved by _____
(Ms.Suthimol Kessomboon)

15) List of Documents Collected

1. Water Quality Management Office – Annual Report 2551 (2008)
2. Performance Plan of BMA 2009-2012 (English Version)
3. Performance Plan of BMA 2009-2012 (Thai Version)
4. Statistical Profile of BMA (2008) (English Version)
5. Statistical Profile of BMA (2008) (Thai Version)
6. The study for the Master Plan on Sewage Sludge Treatment/Disposal and Reclaimed Wastewater Reuse in Bangkok – Vol 1 : Executive Summary (1999)
7. The study for the Master Plan on Sewage Sludge Treatment/Disposal and Reclaimed Wastewater Reuse in Bangkok – Vol 2 : Main Report (1999)
8. The study for the Master Plan on Sewage Sludge Treatment/Disposal and Reclaimed Wastewater Reuse in Bangkok – Vol 3 : Supporting Report (1999)
9. The study for the Master Plan on Sewage Sludge Treatment/Disposal and Reclaimed Wastewater Reuse in Bangkok – Vol 4 : Data Book (1999)
10. Bangkok Metropolitan Region Wastewater Management Action Plan and Feasibility Study – Vol 1 : Executive Summary (1996)
11. Bangkok Metropolitan Region Wastewater Management Action Plan and Feasibility Study – Vol 2 : Main Report (1996)
12. Bangkok Metropolitan Region Wastewater Management Action Plan and Feasibility Study – Vol 3 : Appendices (1996)
13. Bangkok Metropolitan Region Wastewater Management Action Plan and Feasibility Study – Vol 4 : WMA Corporate Plan (1996)
14. Bangkok Metropolitan Region Wastewater Management Plan – Main Report (1996)
15. Bangkok Metropolitan Region Wastewater Management Plan – Appendices : Part I
16. Metropolitan Water Works Authority – Annual Report 2000
17. Metropolitan Water Works Authority – Annual Report 2001
18. Metropolitan Water Works Authority – Annual Report 2002
19. Metropolitan Water Works Authority – Annual Report 2003
20. Metropolitan Water Works Authority – Annual Report 2004
21. Metropolitan Water Works Authority – Annual Report 2006
22. Metropolitan Water Works Authority – Annual Report 2007
23. BOD Loading in the Chaophraya River
24. Dindaeng Water Environment Control Plant – Annual Report 2009
25. Chatujak Water Environment Control Plant – Annual Report 2009
26. Nongkhaem - Tungkru Water Environment Control Plant – Annual Report 2008
27. Bang Sue Feasibility Study Report Volume 1/5 - For executive summary (Thai Ver.) (2006)
28. Bang Sue Feasibility Study Report Volume 2/5 - For executive summary (Eng. Ver.) (2006)
29. Bang Sue Feasibility Study Report Volume 3/5 - Main Report (Thai Ver.) (2006)
30. Bang Sue Feasibility Study Report Volume 4/5 - Appendices (Thai Ver.) (2006)

31. Bang Sue Feasibility Study Report Volume 5/5 – Basic (2006)
32. Wastewater Tariff : Feasibility Study – Main Report (Thai Version) (1998)
33. Feasibility Study of Klong Toey Wastewater Treatment Project Vol.1 : Executive Summary (2001)
34. Feasibility Study of Klong Toey Wastewater Treatment Project Vol.2 : Main Report(2001)
35. Feasibility Study of Klong Toey Wastewater Treatment Project Vol.3 : Appendices (2001)
36. Feasibility Study of Klong Toey Wastewater Treatment Project Vol.4 : Preliminary Design Drawings (2001)
37. Chatuchak WWTP : Diskette #1
38. Din Daeng WWTP : Diskette #7
    Bangkok Wastewater project stage 1 (PART1) 1/2 AS-Built drawing
    Bangkok Wastewater project stage 1 (PART2) 1/1 AS-Built drawing
    Bangkok Wastewater project stage 1 (PART3) 1/4 AS-Built drawing
    Bangkok Wastewater project stage 1 (PART3) 3/4 AS-Built drawing
    Bangkok Wastewater project stage 1 (PART4) 1/1 AS-Built drawing
    Bangkok Wastewater project stage 1 (PART5) 1/3 AS-Built drawing
    Bangkok Wastewater project stage 1 (PART5) 3/3 AS-Built drawing
39. Nong Khaem WWTP : Diskette #4 As-Built drawing
40. Tungklu WWTP : Diskette #6
41. Questionnaire on Technical Survey
42. Presentation Sheet : Summary of Inception Report
43. Bangkok State of Environment Report 2006-2007
44. Water Quality Management Office – Annual Report 2550 (2007)
45. (Diskette #1) Water Quality Management Office – Annual Report 2549-2551 (2006-2008)
46. Major Public Park in Bangkok
47. (Diskette #1) Data of water consumption 2553 (2010) -Transition of water supplied population and water consumption by use (domestic,commercial and industrial)
48. Operation and maintenance data in 2009
    (a) O&M cost and utility consumption for personal, electrical power, chemicals, repair, replacement and so on
    (b) Wastewater flow of influent and effluent
    (c) Treatment performance: Influent and effluent wastewater characteristic and target value
49. (Diskette #1)
    (a) Data of industrial activity, estimated wastewater volume
    (b) Data of livestock
    (c) Journal of infection diseases department
50. (Diskette #1) Factory BMA Sep 2009 (Industrial area)
51. City Planning BMA (Edit #2) and (Diskette #1) Map : landuse,transport and openspace.
52. (Diskette #1) BKK Comprehensive Plan (Regulation)
53. Map and (Diskette #1) (Land use 2006)

54. Long Term Plan 32 years (2010 – 2041) from PCD
55. (a) Wastewater Management in Thailand (Eng Ver.)
    (b) Wastewater Management of community (Thai Ver.)
56. Building Effluent Standards from PCD
57. (a) Water Quality in Chaophraya River (2009 : Jan.-July)
    (b) Water Quality of Khlong in BKK
58. Map and (Diskette #1) Chaophraya River
59. (Diskette #1) Rainfall Data from BMA
60. Map of Nongbon WWTP
61. EIA in Thailand (2007)
62. Guidelines for participation of people and assessment the impact of social environment (EIA) (2006)
63. Strategic Environment Assessment : SEA (2009)
64. Guidelines for heath impact assessment (EIA) (2009)
65. (Diskette #1) Human Development Report 2007
66. (Brochure #3) MWA
    (a) History
    (b) Water Treatment Plant-Bangkhen
    (c) Water Treatment Plant – Mahasawat
67. (Drat) Summary of waterworks improvement project
    And (Demand for water and Capability to produce water)
68. Metropolitan Water Works Authority – Annual Report 2009 (Thai Version)
69. Metropolitan Water Works Authority – Annual Report 2008 (Thai Version)
70. (Diskette #1)
    (a) Strategic Environmental Assessment : SEA (Thai & Eng. Version)
    (b) Announcement – guideline of EIA (Eng. Version)
71. Action Plan for Flooding Prevention (2010) (Thai Version)
72. Comparative study on Integrated Wastewater Management System Model for Developing Countries under Rapid Urbanization (Eng. Version)
73. BMA ordinance : Collection of Wastewater Tariff B.E.2547(2004) (Thai & Eng. Version)
74. Regulation for obstaing the service of sewerage in BKK.(Thai Version)
75. Geology of the lower central Plain. (Eng. Version)
76. (Diskette #1)(Powerpoint) Solid waste management
77. History and organization chart of DDS 2542 (1999)
78. (Content) Regulation of environment health in 1992.
79. Fiscal Year 2007-2008
80. BKK : primate city (area & population)
81. Data of Khlong in water environment control plant
82. Chart of Septic tank #5, Chart of drainage pipe elevation plan #1
83. Chart of the position of manhole, pipe and septic tank in household

84. Network Map of the existing Combined Drains in Din Daeng and Nongbon
85. AS Network Map of the existing Interceptor Pipes in Din Daeng
86. The Land development Act B.E.2543 (A.D.2000) (Eng. & Thai Version)
87. (Map) WWTP 7
88. Hydraulic Design
    88.1&2.for interceptor route&point chamber at Banthad Thong Rd., (Vol.2/1)
    And for throttle pipe at Rama 4 (Vol.2/2)
    88.3. for throttle pipe (Vol.3) Khlong Suan Luang
    88.4. for interceptor route & point chamber (Vol.4) Khlong Suan Oi
    88.6. for interceptor route (Vol.6) Samsen Rd.,
    88.7. for interceptor route (Vol.7) Si Ayutthaya Rd., - Ratchasima Rd.,
    88.8. Hydraulic Design (Vol.8) Pitsanuloh Rd.,
    88.9. for interceptor route & point chamber (Vol.9) Klong Bang Lamphu
    88.10. for interceptor route & point chamber (Vol.10) Krung Kasem Rd.,
    88.11. for interceptor route & point chamber (Vol.11) Krung Kasem Rd.,-Luk Luang Rd.,
    88.12. for throttle pipe (Vol.12) Krung Kasem Rd.,-Luk Luang Rd.,
    88.13. for throttle pipe (Vol.13) Rama 4 Rd., - Nakonpathom Rd.,
    88.14. for throttle pipe (Vol.14) Klong Phadung Krung Kasem
    88.15. for interceptor route (Vol.15) Klong Phadung Krung Kasem
    88.16. for interceptor point chamber (Vol.16) Klong Mahanak-Rama 6 Rd.,
    88.17. for throttle pipe (Vol.17) Klong Mahanak
    88.18. for interceptor point chamber (Vol.18) Klong Mahanak- Klong Bang Lumphu-Soi Bothitpimuk
89. (Map) Plan of Minburi WWTP (June 18,2010)
90. Database & Tariff Collection Section of WQMD
91. (Map) DDS Sewerage Treatment Areas
92. (Drawing) Water Supply Districts and Sewerage Treatment Areas
93. Wastewater Treatment Tank (by AQUA Nishihara co., ltd.)
94. STP Brochures (WWTP Chon nongsi, WWTP Si phraya, WWTP Dindaeng, WWTP Thung Khru #2, UNEP, BMA)
95. DDS E-magazine
96. Budget Fiscal year of DDS (2006 – 2009) (Eng. & Thai Version)
97. Report of survey : Willingness to Pay, tariff in wastewater treatment area (from DDS)
98. The study on wastewater treatment charge in Thailand and foreign countries, 2010 DDS, BMA. (Eng. & Thai Version)
99. Project drainage tunnel construction in BKK area. (DDS,BMA)
100. Bangkok Four year Public Administration Plan, 2005 – 2008.
101. Information of the housing areas in Prawet District.
102. Canal network (West & East Bangkok)
103. Meeting report (Management about wastewater, garbage and tariff of wastewater

treatment)

104. MWA Water Consumption (Dr.Pathan' Thesis)
105. Chart of Prawet district (Cleaning drainage and manhole)
106. (Book) Maps of all administrative districts in Bangkok – separate district
     (Diskette) district & Bangkok map
107. (Map #2) Maps of all administrative districts in Bangkok
108. Khlong Data in BKK. (Water Transportation Plan)
109. Profile of Bangkok City
110. Water Quality Management
111. Strategy to increase the efficiency of quality water management
112. Watergate and Pump station Chart
113. Network Map of the existing Combined Drains in Phra Khanong District
114. (Diskette) IPC Improvement Drawing of Rattanakosin and PCD (from DDS)
115. Final Design Report of Chatuchak District (from DDS)
116. Bangkok Wastewater Project – YANNAWA (3 items - Interceptor Sewers Calculations :
     KCN catchment, Rama 3 catchment, Rama 4 catchment Final design submission)
117. The survey and design the drainage system project in Bangkapi district
     – Main road (# 1/10)
118. The survey and design the drainage system project in Bangkapi district
     – Bangkapi district (#5/10)
119. The survey and design the drainage system project in Bangkapi district
     – Wang Thong Lang District (#8/10)
120. Regulation of the office of the Prime Minister in case of public consultation (2005)
     (From DDS)
121. Pipe Jacking Cost (From DDS)
122. Network Map of the existing combined drains in "Prawet" District
123. Bangna District – City Planning Map
124. Soil Boring Report – Project: DDS Building and Work Shop , Nongbon swamp, Prawet
     (JUNE 2010)
125. Drawing of Buildings in Rama 9 Park
126. Drawings of the existing WWTPs
127. Catalogs of Screw Press Dewatering
128. CPD Brochure - Land use
129. The meeting document of the Master Plan for drainage system project in Lad prao area,
     Bang khen area and the part of Chatuchak. (Document & Questionaire)
130. The Revenue and Payment report of BMA budget in 1997 - 2008
131. (MAP) Scope of the polder system for solving the flood problem.
132. (Copy) Documents of Price Assessment of Bang Sue Project.
133. (Copy) Bangkok MRT of the dark yellow line, F/S Drawings
134. Bangkok MRT Master Plan

Appendix-2
Outline of Seven Existing WWTPs

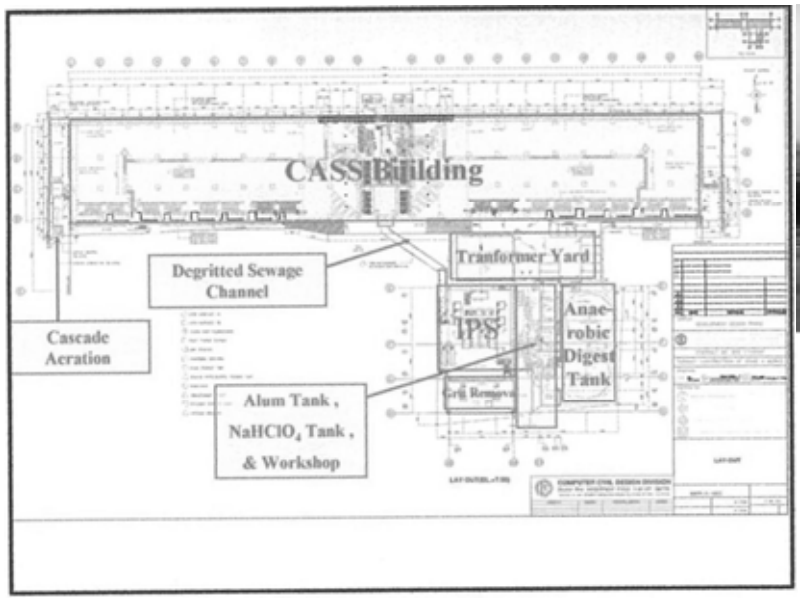
1) **Chatuchak WWTP**
2) **Chong Nonsi WWTP**
3) **Din Daeng WWTP**
4) **Nong Khaem WWTP**
5) **Rattanakosin WWTP**
6) **Si Praya WWTP**
7) **Thung Khru WWTP**

1) Chatuchak WWTP

Outline of the Project

1. Start of operation	2006 O&M Contract (May, 2006 to November, 2010, 54 months)
2. Treatment area:	33.4 km^2
3. Served population:	432,500 persons
4. Treatment process:	Cyclic Activated Sludge System (CASS)
5. Site area:	1.12 ha
6. Construction cost:	3,482,000,000 THB
7. Length of sewer pipes:	37.5 km(φ140 mm～2,500 mm) Manhole 199, Interceptor 181, Pumping station 13
8. Design capacity:	150,000 m^3/day
9. Current inflow:	124,000-129,000 m^3/day
10. Design Criteria for Influent Wastewater	
10.1 BOD	150 mg/l
10.2 COD	-
10.3 Total Nitrogen	30 mg/l
10.4 Total Phosphorus	8 mg/l
10.5 Suspended Solids	150 mg/l
11. Criteria for Effluent Water Standard	
11.1 Suspended Solids	$\leq$ 30 mg/l
11.2 BOD	$\leq$ 20 mg/l
11.3 Total Nitrogen	$\leq$ 10 mg/l
11.4 Ammonium Nitrogen	$\leq$ 5 mg/l
11.5 Total Phosphorus	$\leq$ 2 mg/l
11.6 DO	$\geq$ 5 mg/l

Treatment Area and Plan of WWTP



Mode of operation of SBR

Time; hr	0 - 1	1 - 2	2 - 3	3 - 4
Reactor 1	Fill – Aerate	Fill – Aerate	Fill – Settling	Decant
Reactor 2	Fill – Settling	Decant	Fill – Aerate	Fill – Aerate
Reactor 3	Decant	Fill – Aerate	Fill – Aerate	Fill – Settling
Reactor 4	Fill – Aerate	Fill – Settling	Decant	Fill – Aerate

Screen and grit chamber

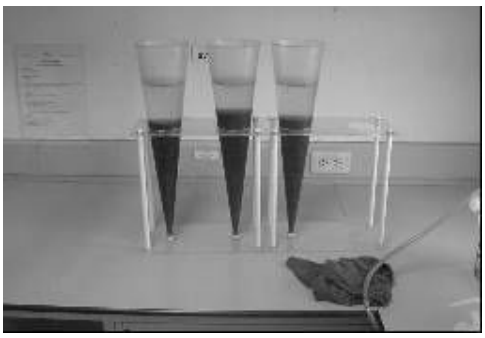
High pressure cleaning vehicle

Approach and connecting bridge

Treated effluent to Bang Sue Klong

CRT in control room

Laboratory



Experiment of activated sludge

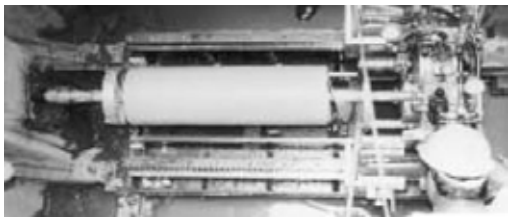
Washing equipment for chemical exposure

2) Chong Nonsi WWTP

Outline of the Project

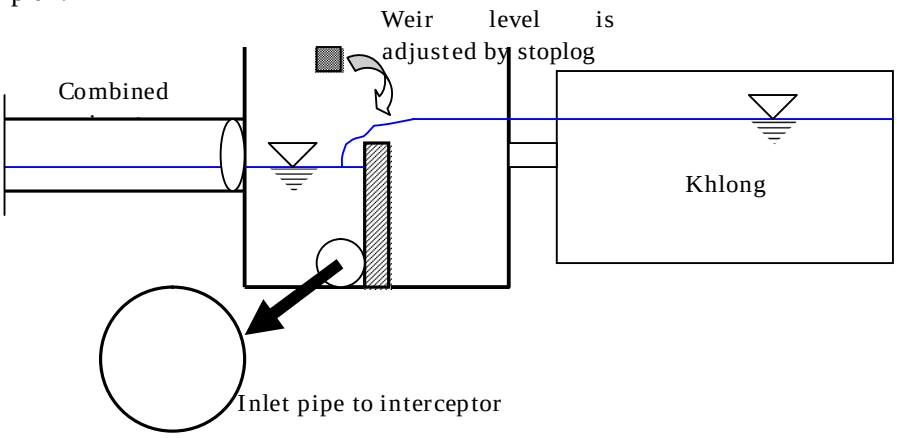
1. Start of operation 2. Treatment area:	2000 28.5 km^2
3. Served population:	580,000 persons
4. Treatment process:	Cyclic Activated Sludge System
5. Site area:	3.2 ha
6. Construction cost:	4,552,000,000 THB
7. Length of sewer pipes:	55 km
8. Design capacity:	200,000 m^3/day
9. Current inflow:	108,638-125,000 m^3/day
10. Design Criteria for Influent Wastewater	
10.1 BOD	150 mg/l
10.2 COD	-
10.3 Total Nitrogen	30 mg/l
10.4 Total Phosphorus	8 mg/l
10.5 Suspended Solids	150 mg/l
11. Criteria for Effluent Water Standard	
11.1 Suspended Solids	$\leq$ 30 mg/l
11.2 BOD	$\leq$ 20 mg/l
11.3 Total Nitrogen	$\leq$ 10 mg/l
11.4 Ammonium Nitrogen	$\leq$ 5 mg/l
11.5 Total Phosphorus	$\leq$ 2 mg/l
11.6 DO	$\geq$ 5 mg/l

Trunk sewers and pumping stations



Infiltration to interceptor chamber

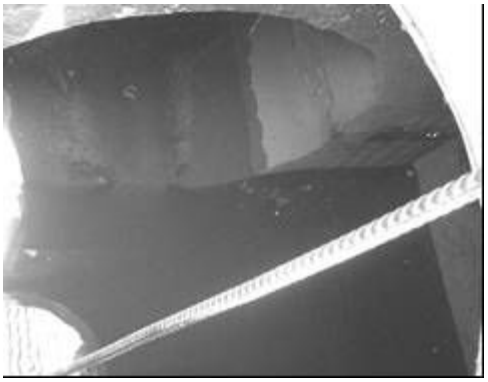
When water level in klong rises, klong water flow into interceptor chamber (infiltration). Level of inlet pipe and water level of klong affect intercepting of wastewater and flood control plan.

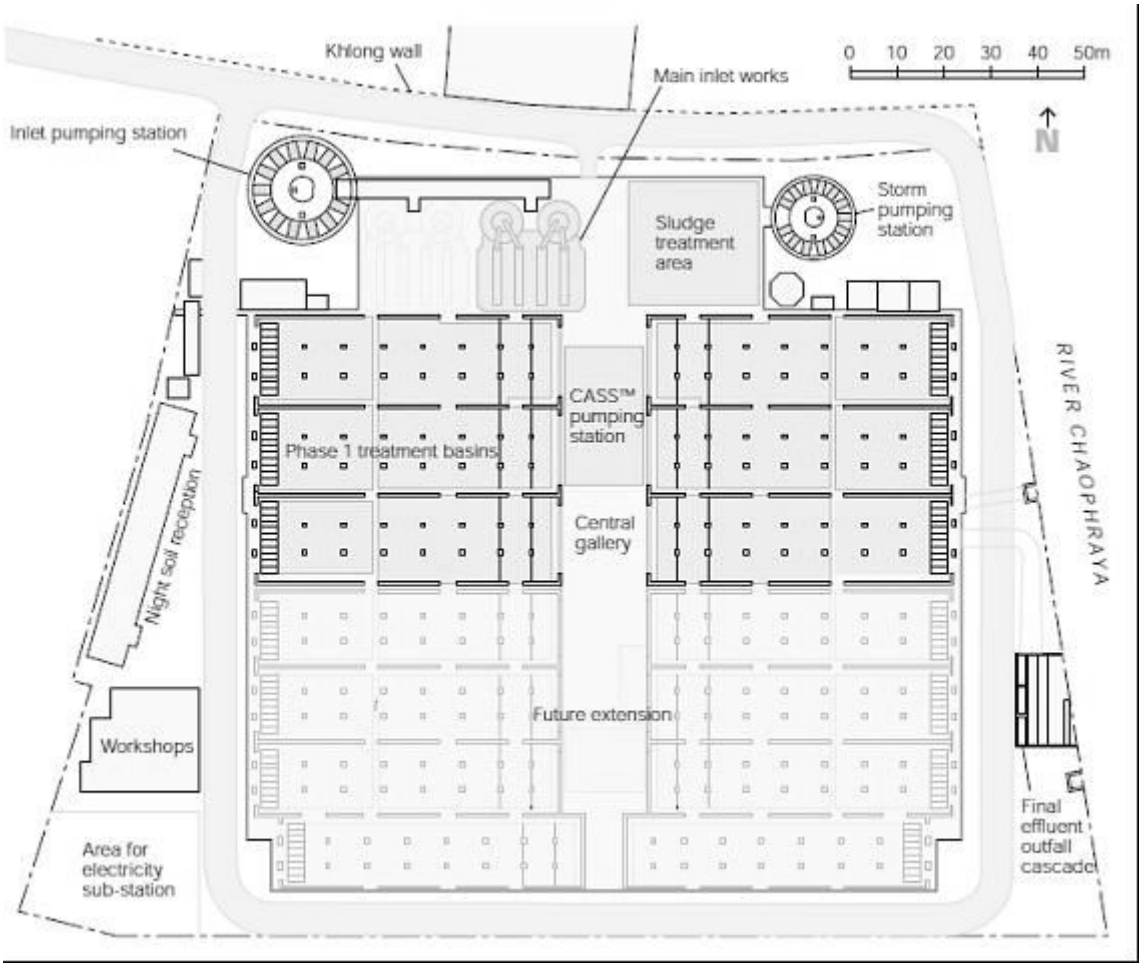


Submerged outlet pipe, pumping station

Untreated wastewater discharge

Treatment facilitiess

 **Chongnonsi WWTP**	 **Wastewater pump house**
 **Dynamic separator (swirl grit chamber)**	 **Reactor (supernatant collecting device)**
 **Laboratory**	 **Manhole（infiltration of klong water）**
 **BRT vehicle depot (expansion of WWTP)**	 **Storm water pumping station**



Plan and Section of WWTP