Table 3.1.1.1 Existing and Ongoing Major BMA Wastewater Schemes

Name	Si Phraya	Ratanakosin	Din Daeng BMA Stage 1	Yannawa BMA Stage 2	Nong Khaem BMA Stage 3	Ratburana BMA Stage 3	Chatuchak BMA Stage 4
Service Area (km^2)	2.7	4.1	37.8	28.5	42.9	42.3	33.4
Design Population							
Phase 1	120,000	160,000	697,000	560,000	178,000	177,000	430,000
Year	2009	2011	1990	1992	1992	1992	2020
Phase 2			1,080,000	900,000	450,000	375,000	
Year			2015	2020	2020	2020	
Design Capacity							
Dry Weather Flow							
Phase 1 (m^3/d)	30,000	40,000	341,000	200,000	157,000	65,000	150,000
Phase 2 (m^3/d)			463,000	360,000		130,000	
Main Treatment Process	Activated Sludge Contact Stabilization	2 stage Activated Sludge	Conventional Activated Sludge	Activated Sludge Sequential Batch Reactor	Activated Sludge Vertical Loop Reactor	Activated Sludge Vertical Loop Reactor	Activated Sludge type not decided
WWTP Site Area (ha)	0.3	0.64	2.72	3.2	8.32	1.41	1.12
Current Status	Operational	Contract suspended	Contract suspended	Under construction	Under construction	Under construction	Contract to be awarded
Expected Completion		1999	Not known	1999	2001	2001	2003

Table 3.1.1.3 BMA Community Wastewater Treatment Plants and Aerated Lagoons

	Wastewater Treatment Plants	Treatment Capacity (m^3/d)	Population Served	Year Completed	Ownerships	Treatment Process**	Sludge Disposal**
Community WWTPs	1. Huay Kwuang*	2,400	16,800	1975	BMA	AS	CD
	2. Bang Na	1,650	8,280	1981	BMA		
	3. Khlong Chan*	6,500	32,190	1979	BMA	EA	SS
	4. Ram Indra*	800	4,060	1978	BMA	EA	SS
	5. Tung Song Hong 1*	3,000	15,015	1975	BMA	AS	None
	6. Tung Song Hong 2*	1,100	5,555	1984	BMA	EA	SS
	7. Hua Mark	600	2,940	1978	BMA		
	8. Phibun Tatana	400	2,060	1979	BMA		
	9. Khlong Toey	1,450	7,200	1983	BMA		
	10. Tasai	1,400	7,095	1978	BMA		
	11. Rom Klao	3,800	19,150	1985	BMA		
	12. Bon Kai	400	1,900	1983	BMA		
	13. Bang Bua	1,200	6,070	1980	BMA		
	14. Din Daeng	1,000	5,100	1978	NHA		
	Total	**25,700**	**133,415**				
Aerated Lagoons for Khlong Water Improvement	15. Makkasan Pond*	140,000		1987	BMA	AL	None
	16. Rama IX Pond *	60,000		1989	BMA	AL	None
	17. Buddamonthon Sai Pond	3,500			BMA	AL	None

* WWTP inspected by Study Team

** AS = Conventional activated sludge
EA = Extended aeration Activated sludge
AL = Aerated Lagoons
CD = Cake trucked off site
SS = Disposed on sand beds on site

Table 3.1.2.1 Summary of Private WWTPs Inspected by Study Team

Location	Treatment Capacity (m^3/d)	Population	Started Operation	Treatment Process	Outlet for Effluent	Sludge Disposal
Hospital - Klang	200	400 beds	1979 Improved in 1987	AS	Khlong	LF
Hopital - Vajira	2,000	500 beds	1983	AS	Khlong	CS
Commercial Building - C.P. Tower	480	2,000	1990	CS	Drain	LD
Condominium - River Garden		100	1990	AF	Drain	LD
Hotel - Na Rai	700	471 rooms	1995	CS	Drain	none
Brewery - Singha Beers Boon Rawd Brewery Co.	6,000	-	Built 1980 Upgraded 1994/95	UASB/AS	Drain	CP

AS = Conventional Activated Sludge

CS = Contact Stabilisation Activated Sludge

AF = Anaerobic Filters

UASB = Unward Flow Anaerobic Sludge Blanket

LF = used as Liquid Fertiliser

CS = Compested and used on Site

LD = Liquid tankered off site for Disposal

CP = Cake used on Plantation

Table 3.2.2.3 Current Night Soil Collection Service

No.	Districts	Land Area (km^2)	Collected Night Soil (m^3/d)	Living Population (x1000)	Collection Ratio (%)
1	PHRA NAKHRON	5.5	24.0	119.2	20.1
2	DUSIT	10.7	21.9	215.9	10.1
3	NONG JOK	236.3	2.4	83.6	2.9
4	BANG RAK	5.5	18.8	110.5	17.0
5	BANG KHEN	37.3	23.3	207.7	11.2
6	BANG KAPI	29.7	41.4	207.4	20.0
7	PATHUMWAN	8.4	16.7	166.1	10.1
8	POM PRAP SATTRU PHAI	1.9	16.2	118.3	13.7
9	PHRA KHANONG	13.6	25.7	139.3	18.5
10	MIN BURI	58.2	14.2	97.0	14.6
11	LAT KRABANG	123.9	17.5	112.9	15.5
12	YAN NAWA	16.7	24.7	131.9	18.7
13	SAMPHANTHAWONG	1.5	4.7	67.6	6.9
14	PHAYA THAI	9.6	21.4	153.6	13.9
15	THON BURI	8.6	31.9	288.9	11.0
16	BANGKOK YAI	6.2	20.5	149.1	13.8
17	HUAY KWUANG	15.0	9.6	150.1	6.4
18	KHLONG SAN	6.1	37.3	178.3	20.9
19	TALING CHAN	32.9	21.5	105.1	20.4
20	BANGKOK NOI	11.9	26.0	212.8	12.2
21	BANG KHUN THIAN	123.3	21.5	105.7	20.3
22	PHASI CHAROEN	18.2	29.3	191.0	15.4
23	NONG KHAEM	40.5	16.9	110.8	15.3
24	RAT BURANA	15.7	17.1	136.3	12.5
25	BANG PHLAT	11.4	16.5	170.8	9.7
26	DIN DAENG	8.4	46.5	271.8	17.1
27	BUNG KUM	25.0	31.5	177.9	17.7
28	SATHRON	9.3	27.4	148.1	18.5
29	BANG SUE	11.6	33.5	256.7	13.1
30	CHATUCHAK	32.9	20.7	238.1	8.7
31	BANG KHO LAEM	10.9	23.1	159.3	14.5
32	PRAWET	45.9	16.5	139.5	11.8
33	KHLONG TOEY	12.3	31.5	203.5	15.5
34	SUAN LUANG	23.7	18.7	155.5	12.0
35	CHOM THONG	26.3	27.5	183.7	15.0
36	DON MUANG	31.6	23.9	191.4	12.5
37	RATCHATHEWI	7.1	24.3	184.4	13.2
38	LAT PHRAO	30.5	22.4	190.1	11.8
39	BANG NA	20.3	11.8	140.0	8.4
40	VADHANA	13.3	29.3	123.6	23.7
41	SAI MAI	36.7	12.9	203.1	6.4
42	LAK SI	25.1	12.8	156.6	8.1
43	WANG THONG LANG	19.2	23.1	142.4	16.2
44	KHANNA YAO	28.7	10.1	94.3	10.7
45	SAPHAN SUNG	30.1	9.8	96.4	10.2
46	SAM WA	116.1	5.1	77.0	6.7
47	BANG KAE	43.5	21.3	222.7	9.6
48	BANG BON	31.6	6.4	74.5	8.6
49	THAWI WATTANA	46.8	2.7	53.1	5.1
50	THUNG KRUE	27.8	4.7	111.6	4.2
Total (Average)		1,569	1,019	7,725	13.0

Source: From Night Soil Division of Department of Public Cleansing (DPC).
Collected data is from October 1997 to September 1998.

Note: Population is derived from the population projection in this Master Plan. The collected night soil was computed of night soil generation rate.

Table 3.4.1.1 Summary of Wastewater Quality Analyses from BMA WWTP Records and Previous Drain Surveys

Survey	Location	Type of Sewerage	TSS			BOD			COD		
			min (mg/l)	avr (mg/l)	max (mg/l)	min (mg/l)	avr (mg/l)	max (mg/l)	min (mg/l)	avr (mg/l)	max (mg/l)
BMA Records	Si Phraya WWTP*	Combined				37	61	89			
	Huay Kwuang WWTP*	Separate	89	182	295	160	246	400	200	402	657
	Other Community WWTPs inspected**	Separate	50	54	57	170	225	280		450	
Yannawa Project Contractor	Yannawa drains (4 locations)	Combined	21	166	411	26	69	214	56	210	365
JICA Expert Study	Lumphini drains (2 locations)	Combined	20	55	130	34	135	300			

* monthly averages of weekly analyses over 43 months from October 1995 to April 1999

** typical values available

Table 4.1.2.1 Summary of Flow and Wastewater and Treated Effluent Quality at Si Phraya WWTP

Source	Weather	Average Flow (m^3/d)	TSS			VSS			BOD			COD		
			min (mg/l)	avr (mg/l)	max (mg/l)	min (mg/l)	avr (mg/l)	max (mg/l)	min (mg/l)	avr (mg/l)	max (mg/l)	min (mg/l)	avr (mg/l)	max (mg/l)
Inlet Wastewater	Normal Weather	11,500	10	34	89	18	22	29	8	41	82	30	92	154
	Storm Event		30	59	65	23	38	60	26	41	66	87	126	189
Treated Effluent	Normal Weather		1	5	10				2	6	8	10	24	64

No. of Samples :

Wastewater TSS, BOD and COD : 26 spot + 3 composite in Normal Weather, 24 spot during Storm Events

VSS : 3 composite in Normal Weather, 24 spot during Storm Events

Effluent TSS, BOD and COD : 8 spot + 3 composite

VSS : 3 composite

Table 4.1.2.2 Average Sewage and Treated Effluent Heavey Metals at Si Phraya WWTP

	Cd (mg/l)	Cr (mg/l)	Pb (mg/l)	Mn (mg/l)	Ni (mg/l)	Hg (mg/l)
Incoming Sewage	0.001	<0.05	0.02	0.15	0.02	0.001
Treated Effluent	<0.001	<0.05	0.01	0.01	0.02	<0.001

No. of Samples : 2

Table 4.1.2.3 Summary of Flow and Wastewater and Treated Effluent Quality at Huay Kwuang WWTP

Source	Weather	Average Flow (m^3/d)	TSS			BOD			COD		
			min (mg/l)	avr (mg/l)	max (mg/l)	min (mg/l)	avr (mg/l)	max (mg/l)	min (mg/l)	avr (mg/l)	max (mg/l)
Inlet Wastewater	Normal Weather	1,330	12	**96**	164	102	**170**	240	190	**305**	412
	Storm Event	4,720	70	**711**	1,325	120	**370**	615	285	**1,111**	1,799
Treated Effluent	Normal Weather		1	**4**	8	5	**15**	32	29	**39**	60

No. of Samples :

Wastewater 26 spot in Normal Weather, 4 spot during Storm Event

Effluent 8 spot in Normal Weather

Table 4.1.2.4 Average Sewage and Treated Effluent Heavey Metals at Huay Kwuang WWTP

	Cd (mg/l)	Cr (mg/l)	Pb (mg/l)	Mn (mg/l)	Ni (mg/l)	Hg (mg/l)
Incoming Sewage	<0.001	<0.05	0.01	0.21	0.02	0.001
Treated Effluent	<0.001	<0.05	<0.01	0.07	0.08	<0.001

No. of Samples : 2

Table 4.2.2.1 Summary of Wastewater Quality Analyses from the Drains in Normal Weather

Survey	Wastewater Scheme Area	Location	No. & type of samples	TSS			VSS			BOD			COD		
				min (mg/l)	avr (mg/l)	max (mg/l)	min (mg/l)	avr (mg/l)	max (mg/l)	min (mg/l)	avr (mg/l)	max (mg/l)	min (mg/l)	avr (mg/l)	max (mg/l)
First Study Team and Counterpart Team Surveys	Si Phraya	Song Soi Phra	24 spot	7	37	73				48	83	120	72	169	378
	Yannawa	Charoen Krung Soi 77	24 spot	4	33	143				34	100	150	94	188	306
	Khlong Toey	Soi Wachirathum Soi 31	8 spot	11	25	35				30	42	53	77	93	129
Second Study Team Survey	Si Phraya	Th Maitri Chit	2 comp.	55	89	122	44	65	85	47	52	56			
	Yannawa	Th Sathu Pradit	2 comp.	32	33	33	25	26	27	36	51	66			
	Din Daeng	Th Banthat Thong	2 comp.	45	61	76	39	44	49	27	37	47			
	Ratanakosin	Th Ti Thong	2 comp.	19	21	23	18	20	21	18	20	21			
	Nong Khaem	Bang Kae Market	2 comp.	43	45	47	38	39	39	53	65	77			
	Ratburana	Th Suksawat	2 comp.	43	48	53	35	37	39	39	48	57			
All Locations			68	4	44	143	18	39	85	18	55	150	72	150	378

Table 4.2.2.2 Determination of Unit Flow and Loads from Survey in Drainage Pipes

Location	Season	Date	Time	Estimated Population	Measured Flow (m^3/d)	Measued BOD (mg/l)	Flow per Capita (l/c/d)	BOD per Capita (g/c/d)
Soi Song Phra in Si Phraya Area (Commercial Area)	Wet	26.10.98	17:00	1,463	1,380	87	943	82
			23:00	1,463	1,100	53	752	40
		27.10.98	05:00	1,463	450	93	308	29
			11:00	1,463	1,040	75	711	53
		Average		1,463	990	77	677	52
	Dry	19.11.98	12:00	1,463	510	66	349	23
			18:00	1,463	1,470	81	1,005	81
		20.11.98	00:00	1,463	840	81	574	47
			06:00	1,463	920	69	629	43
		Average		1,463	940	74	643	48
	Average both seasons			1,463	965	76	660	50
Charoen Krung Soi 77 in Yannawa Area (Mixed Area)	Wet	26.10.98	13:15	1,022	36	144	35	5
			19:00	1,022	70	90	68	6
		27.10.98	01:00	1,022	22	65	22	1
			07:00	1,022	43	53	42	2
		Average		1,022	43	88	42	4
	Dry	19.11.98	13:00	1,022	58	98	57	6
			19:00	1,022	77	99	75	7
		20.11.98	01:00	1,022	41	84	40	3
			07:00	1,022	89	86	87	7
		Average		1,022	65	92	64	6
	Average both seasons			1,022	54	90	53	5
Soi Wachiathun Sahit 31, Sukumvit Soi 101/1 in Proposed Khlong Toey East Area (Residential Area)	Wet	26.10.98	14:00	284	98	39	345	13
			20:00	284	113	32	398	13
		27.10.98	02:00	284	89	30	313	9
			08:00	284	106	35	373	13
	Average			284	101	34	356	12

Table 4.2.2.3 Summary of Wastewater Quality Analyses from the Drains during Storm Events

Survey	Wastewater Scheme Area	Location	No. of spot samples	TSS			VSS			BOD			COD		
				min (mg/l)	avr (mg/l)	max (mg/l)	min (mg/l)	avr (mg/l)	max (mg/l)	min (mg/l)	avr (mg/l)	max (mg/l)	min (mg/l)	avr (mg/l)	max (mg/l)
First Study Team and Counterpart Team Surveys	Si Phraya	Song Soi Phra	8	19	174	835				25	46	120	112	144	255
	Yannawa	Charoen Krung Soi 77	8	44	64	142				82	82	129	180	260	449
Second Study Team Survey	Si Phraya	Th Maitri Chit	24	23	69	336	22	46	189	24	58	111	82	151	400
	Yannawa	Th Sathu Pradit	36*	22	78	340	15	38	140	17	48	141	44	134	291
	Din Daeng	Th Banthat Thong	24	16	48	192	12	33	77	8	64	150	32	156	288
	Ratanakosin	Th Ti Thong	36*	11	36	125	8	26	70	14	33	66	16	93	189
	Nong Khaem	Bang Kae Market	24	38	64	134	22	41	84	24	80	204	126	216	416
	Ratburana	Th Suksawat	24	28	58	147	15	37	76	20	67	126	79	188	315
All Locations			184	11	74	835	8	37	189	8	60	204	16	168	449

* in one of the three storm events sampling was delayed until 6 h after the commencement of the storm

Table 4.2.2.5 Heavy Metal Analyses of Wastewater in Drains

Wastewater Scheme Area	Location	Cd (mg/l)	Cr (mg/l)	Pb (mg/l)	Mn (mg/l)	Ni (mg/l)	Hg (mg/l)
Si Phraya	Soi Song Phra	<0.001	<0.05	<0.01	0.074	<0.01	0.001
Yannawa	Charoen Krung Soi 77	<0.001	<0.05	0.01	0.12	0.01	0.003
Khlong Toey East	Soi Wachirathum Sahit 33	<0.001	<0.05	<0.01	0.078	<0.01	<0.001

Table 4.3.1.1 Methods of Measurement and Analysis for Sludge

Measurement and analysis items	Analysis method	Reference number of Standard Method
Sampling	Grab Sampling	
Moisture contents	Drying 103 °C	2540 G
Total solid contents	Gravimetric method	2540 G
Volatile solid contents	Gravimetric method	2540 G
Nitrogen contents	Nitrogen	4500 N
Carbon contents	Gravimetric method	10400 D
Sulfur contents	ICP-AFS method	3120 B
Phosphorus contents	Digest & ascorbic acid	1500-P B.E
Potassium (K)	Atomic Absorption Spectrometric (AA-direct)	3030E.,Flame Emission
Chlorine contents	DPD colorimetric method	4500-Cl G
Alkalinity	Titration method	2320 B
pH	Electrometric method	4500 H^+ B
Cadmium (Cd)	Atomic Absorption Spectrometric (AA-direct)	3030E, 3111 B
Chromium (Cr)	Atomic Absorption Spectrometric (AA-direct)	3030E, 3111 B
Copper (Cu)	Atomic Absorption Spectrometric (AA-direct)	3030E, 3111 B
Lead (Pb)	Atomic Absorption Spectrometric (AA-direct)	3030E, 3111 B
Manganese (Mn)	Atomic Absorption Spectrometric (AA-direct)	3030E,3111 B
Nickel (Ni)	Atomic Absorption Spectrometric (AA-direct)	3030E,3111 B
Zinc (Zn)	Atomic Absorption Spectrometric (AA-direct)	3030E, 3111 B
Mercury (Hg)	AA – Hydride	GBC operation manual [b]
Calorific value	Bomb calorimeter , By Calculation (ASTM)	ASTM [c]
Specific gravity of fixed solids	Gravimetric method	APHA 2540 G, 2710 F
Specific gravity of volatile solids	Gravimetric method	APHA 2540 G, 2710 F
Grain size distribution	By sieve	ASTM, E11;70 [c]

Note: Standard Methods for the Examination of Water and Wastewater (APHA , AWWA and WEF, 19TH Edition 1995) were applied, besides the following "b" and "c".

[b]: GBC Hg3000 Automatic Hydride Generator Operation Manual, Robert Danby and Stewart Shaw, 1st Edition , June 1,1990.

[c]: Annual Book of American Society of Testing Materials Standard, Volume 14.03 , 1995.

Table 4.3.2.2 General Properties and Nutrients of Sludge

Location Name		Si Phraya	Si Phraya	Huay Kwuang	Huay Kwuang	Nong Khaem	Nong Khaem	On Nut	On Nut
Categories of Sludge		Central WWTP	Central WWTP	Community WWTP	Community WWTP	NSTP	NSTP	NSTP	NSTP
Sampling Date		19-Oct-98	12-Nov-98	16-Oct-98	9-Nov-98	16-Oct-98	9-Nov-98	16-Oct-98	9-Nov-98
Weather		Rainy	Dry	Rainy	Dry	Rainy	Dry	Rainy	Dry
Moisture	(%)[1]	83.6	85.8	85.3	82.5	82.3	81.1	75.2	78.5
Total Solid (TS)	(%)[1]	16.4	14.2	14.6	17.5	17.7	18.9	24.9	21.5
Volatile Solid (VS)	(%)[2]	44.8	55.5	56.6	55.6	72.6	72.2	82.8	76.8
Calorific Value	(kcal/kg)[4]	313	376	402	533	596	663	876	788
Sulfur (S)	(mg/kg)[3]	8	49	10	46	2	57	23	55
Chlorine (Cl)	(mg/kg)[3]	290	406	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected
Alkalinity	(mg/kg)[3]	5,608	6,975	20,521	21,586	8,851	19,933	26,873	18,248
pH (1 : 3)	(-)	6.9	7.2	7.0	7.2	7.3	7.8	8.2	8.7
Calorific Value	(kcal/kg)	313	376	402	533	596	663	876	788
Specific Gravity of Fixed Solids	(-)	1.087	1.095	1.097	1.119	1.155	1.167	1.276	1.216
Specific Gravity of Volatile Solids	(-)	1.096	1.111	1.079	1.100	1.053	1.057	1.067	1.094
Grain Size Distribution									
- Larger than 2 mm	(%)[1]	0.14	0.98	0.79	0.31	0.98	0.65	17.60	7.62
- 1 - 2 mm	(%)[1]	0.47	0.69	0.36	0.32	0.79	0.87	2.56	5.25
- 0.5 - 1mm	(%)[1]	1.58	1.74	0.74	2.50	2.44	3.91	5.96	18.08
- Less than 0.5 mm	(%)[1]	97.8	96.6	98.1	96.9	95.8	94.6	73.9	69.1
Carbon (C)	(%)[2]	33.8	24.7	43.5	9.1	59.9	47.1	59.3	43.5
Nitrogen (N)	(mg/kg)[3]	28,921	38,696	40,205	36,750	46,021	45,493	28,427	35,795
Phosphorus (P)	(mg/kg)[3]	3,803	4,732	6,287	7,967	2,637	4,187	2,065	4,531
Potassium (K)	(mg/kg)[1]	172	426	1,800	1,570	195	665	51.2	1,562

Note:

Units: (1); Weight by Wet-weight, (2); Weight by Dry weight, (3); kg-Dry weight, (4); kg-Wet weight.

Source: JICA Study Team

Table 4.3.2.3 Heavy Metal Contents of Sludge

Location		Si Phraya	Si Phraya	Huay Kwuang	Huay Kwuang	Nong Khaem	Nong Khaem	On Nut	On Nut	Si Phraya	Si Phraya	Si Phraya	Huay Kwuang	Huay Kwuang	Huay Kwuang	Nong Khaem	Nong Khaem	Nong Khaem	On Nut	On Nut	On Nut
Categories of Sludge		Central WWTP	Central WWTP	Community WWTP	Community WWTP	NSTP	NSTP	NSTP	NSTP	Central WWTP	Central WWTP	Central WWTP	Community WWTP	Community WWTP	Community WWTP	NSTP	NSTP	NSTP	NSTP	NSTP	NSTP
Sampling Date		19-Oct-98	12-Nov-98	16-Oct-98	9-Nov-98	16-Oct-98	9-Nov-98	16-Oct-98	9-Nov-98	21-Jun-99	23-Jun-99	25-Jun-99	23-Jun-99	24-Jun-99	25-Jun-99	1-Jul-99	2-Jul-99	5-Jul-99	1-Jul-99	2-Jul-99	5-Jul-99
Weather		Rainy	Fine	Rainy	Fine	Rainy	Fine	Rainy	Fine	Fine	Fine	Fine	Fine	Fine	Fine	Fine	Fine	Fine	Fine	Fine	Fine
Cadmium (Cd)	(mg/kg)[1]	4.5	1.9	2.5	2.6	2.8	3.9	1.8	2.6	0.5	1.0	0.8	0.5	1.2	0.5	1.0	0.5	0.5	1.2	0.5	0.5
Chromium (Cr)	(mg/kg)[1]	102	645	69	53	4	30	47	13	636	576	751	43	96	80	44	36	46	22	27	29
Copper (Cu)	(mg/kg)[1]	61	312	69	86	231	74	159	57	1,178	1,728	1,441	400	598	449	334	256	224	285	244	161
Lead (Pb)	(mg/kg)[1]	53	105	63	64	51	39	21	32	146	210	178	213	350	223	49	43	36	49	36	27
Manganese (Mn)	(mg/kg)[1]	37	844	417	383	147	324	124	272	1,388	2,069	1,592	398	681	452	329	259	213	376	322	232
Nickel (Ni)	(mg/kg)[1]	30	177	34	30	28	29	17	19	309	520	449	18	33	15	12	12	7.0	15	0.5	0.5
Zinc (Zn)	(mg/kg)[1]	146	586	165	553	90	521	66	575	654	949	739	739	1,296	496	439	405	372	690	461	384
Mercury (Hg)	(mg/kg)[1]	2.7	8.1	3.2	1.1	0.2	13	0.1	1.4	9.1	15	0.5	12	7.2	8.0	35	23	32.0	3.6	16	10

Note:

Units: (1): kg-Dry weight,

Source: JICA Study Team

Table 4.4.1.1 Summary of the Response to the Queries from Sludge Questionaire Survey (1/2)

Query	Number of Respondents					Total	% of Total
	Nonthaburi	Samut Sakhon	Nakhon Pathom	Pathum Thani	Chachoengsao		
Types of Crop and Fertilizer Use							
1. Major crop grown and Fertilizer used							
Rice or Paddy	8	3	20	16	34	81	32
Fruit trees							
-mango	11	6	11	13	24	65	25
-coconut	6	7	5	3	9	30	12
- orange	1	0	1	4	0	6	2
- other	11	4	9	3	5	32	13
Vegetable	3	4	15	6	4	32	13
Flowering plants	8	0	1	0	0	9	4
Total	40	24	62	45	76	255	100
Type of chemical fertilizer							
-16-20-0 (N-P-K)	12	4	20	15	32	83	29
-15-15-15 (N-P-K)	12	8	17	15	26	78	27
-46-0-0 (N-P-K)	9	4	16	9	26	64	22
-21-0-0 (N-P-K)	5	2	7	2	6	22	8
-16-16-16 (N-P-K)	11	8	10	6	3	38	13
Total	49	26	70	47	93	285	100
Organic fertilizer							
Type of manure							
-animal dung	11	10	20	13	28	82	70
Compost							
-piece of plantation	8	1	10	4	12	35	30
Total	19	11	30	17	40	117	100
Type of soil condition							
-Clay	12	9	16	12	25	74	75
-Fliable	1	0	7	0	1	9	9
-Sandy	0	0	0	0	2	2	2
-Mixed Fliable and Sandy	2	0	5	0	7	14	14
Total	15	9	28	12	35	99	100
2. How is the chemical fertilizer transferred to the fields?							
A. by supplier or provider	5	7	5	5	13	35	33
B. by the farmer	8	9	16	11	27	71	67
Total	13	16	21	16	40	106	100
3. What is the condition of the received chemical fertilizer?							
A. Liquid	0	0	3	0	2	5	5
B. semi-solid	1	0	2	2	3	8	8
C. Solid	11	10	19	14	35	89	87
Total	12	10	24	16	40	102	100
4. How is the fertilizer applied to the fields by most of the farmers under your supervision?							
A. Manual application	12	9	20	16	35	92	88
B. by tractor or other equipment	0	0	1	0	2	3	3
C. Mixer with the irrigation water	1	3	4	0	1	9	9
Total	13	12	25	16	38	104	100
5. How often does the farmer apply this fertilizer?							
A. Annually	1	0	1	1	5	8	8
B. Bi-Annually	4	1	6	5	9	25	26
C. Quarterly	3	0	1	4	5	13	14
D. when available	4	7	12	5	14	42	44
E. No set pattern	1	0	3	1	2	7	7
Total	13	8	23	16	35	95	100
6. Have the farmers in your area ever used organic fertilizer?							
A. Yes	12	10	20	15	30	87	94
B. No (If No, go to Question 10)	0	0	1	1	4	6	6
Total	12	10	21	16	34	93	100
7. From where do the farmers obtain the organic fertilizer?							
A. from their own farm	3	3	6	3	10	25	8
B. purchase from market	4	1	7	6	7	25	8
C. purchase from nearby farm	0	0	8	2	6	16	5
D. other sources, please specify_____	6	8	5	7	13	39	13
8. How is the organic fertilizer transported to the farmers fields?							
A. by the supplier or provider	5	6	6	6	7	30	10
B. by the farmer	8	4	20	9	28	69	23
C. collected as a group using group members vehicle	1	0	1	0	1	3	1
D. other, please specify_____	2	0	0	0	1	3	1
9. How does the farmer apply the organic fertilizer to the fields?							
A. Manual application	12	10	21	15	28	86	29
B. by tractor or other equipment	0	0	0	0	4	4	1
Total	41	32	74	45	105	300	100

Note : Kaset Tamboon = Local officer from Department of Agriculture Extension
BAAC. = Bank of Agriculture and Agricultural Co Operation

Table 4.4.1.1 Summary of the Response to the Queries from Sludge Questionaire Survey (2/2)

Query	Number of Respondents					Total	% of Total
	Nontha Buri	Samut Sakhon	Nakhon Pathom	Pathum Thani	Cha Cheng Sao		
Sources of Information							
10. What are the farmers main sources of information (about fertilizers, new types of crop, new method of farming practice etc.)?							
A. Kaset Tambons	12	10	20	15	35	92	41
B. Media (TV, Radio, Newspaper etc.)	11	9	16	13	30	79	35
C. BAAC or other farming organizations	4	3	8	6	13	34	15
D. Other, please specify	4	2	2	3	7	18	8
Total	31	24	46	37	85	223	100
Experience and Acceptance of Sewage Sludge							
11. What is your opinion about the acceptance of sewage sludge use by farmers? : Do the farmers know about sewage sludge?							
A. Yes	9	5	3	9	15	41	45
B. No (If No, go to Question 15)	3	3	18	7	19	50	55
Total	12	8	21	16	34	91	100
: Would farmers use sludge on their fields if available free of charge?							
A. Yes	12	7	18	13	25	75	83
B. No	0	1	3	2	9	15	17
Total	12	8	21	15	34	90	100
: Would farmers use sludge on their fields even if they have to pay for it?							
A. Yes	4	2	2	4	4	16	18
B. No	8	5	18	10	27	68	81
Total	12	7	20	14	31	84	100
12. From your working experience, what information should be offered to the farmers to encourage them to use sewage sludge as an organic fertilizer?							
A. will be increse crop productions	2	1	0	4	3	10	11
B. the financial saver than chemical fertilization	5	1	2	3	4	15	16
C. non toxic effect to the soil	4	1	4	3	1	13	14
D. testing and training with real case study	6	7	9	5	19	46	1
E. other answer that different from above	4	1	1	3	2	11	12
Total	21	11	16	18	29	95	100
13. From your working experience, what incentives should be offered to the farmers to encourage them to use sewage sludge?							
A. Cheaper than chemical fertilizer	7	2	4	5	1	19	32
D. testing and training with real case study	6	1	13	4	8	32	54
C. other answer that different from above	0	0	2	3	3	8	14
Total	13	3	19	12	12	59	100
14. From your working experience, when are the farmers likely to have a demand for sewage sludge during the year?							
A. January	0	2	10	6	4	22	6
B. Febuary	0	3	11	6	2	22	6
C. March	9	3	12	7	8	39	10
D. April	4	6	13	7	18	48	12
E. May	3	6	13	13	20	55	14
F. June	4	5	15	9	8	41	10
G. July	1	4	16	11	5	37	9
H. August	3	3	14	6	7	33	32
I. September	3	2	10	6	5	26	7
J. October	2	1	10	5	8	26	7
K. November	2	1	10	7	4	24	6
L. December	1	1	10	7	2	21	5
Total	35	37	144	90	91	394	100
15. If the farmer does not use sewage sludge, please specify their reason:							
A. Problem with application or equipment	4	6	12	6	22	50	22
B. Problem with transportation	7	3	8	5	18	41	18
C. lack of time or labour	5	7	8	3	16	39	17
D. Problem with health risk or smells	4	2	11	10	11	38	17
E. No money	5	0	6	2	17	30	13
F. Other, please specify	3	4	6	4	8	25	11
Total	28	22	51	30	92	223	100

Table 4.4.1.2 Selected Responses from Farmers' Survey

Distribution of Respondents by Types of Preferred Sewage Sludge and by Provinces

Provinces	Types of Preferred Sludge							
	Solid		Mixed Compost Sludge		Both		Total	
	Farmers	%	Farmers	%	Farmers	%	Farmers	%
Bangkok	12	46.15	12	46.15	2	7.70	26	100.00
Nonthaburi	0	0.00	11	100.00	0	0.00	11	100.00
Chachoengsao	1	3.85	25	96.15	0	0.00	26	100.00
Total	13	20.63	48	76.19	2	3.17	63	100.00

Distribution of Respondents Who Would Buy Mixed Compost Sludge by Types of Crops

Types of crops	Number of respondents who would buy mixed compost sludge							
	Yes		No		Undecided		Total	
	Farmers	%	Farmers	%	Farmers	%	Farmers	%
Fruit trees	36	41.86	30	34.88	20	23.26	86	100.00
Vegetables and flowers	30	51.72	17	29.31	11	18.97	58	100.00
Field crops	3	42.86	3	42.86	1	14.29	7	100.00
Total	69	45.70	50	33.11	32	21.19	151	100.00

Note: Multiple answers

Distribution of Respondents Who Applied Human Waste on Their Farms by Provinces

Provinces	Number of respondents who would buy mixed compost sludge					
	Yes		No		Total	
	Farmers	%	Farmers	%	Farmers	%
Bangkok	12	28.57	30	71.43	42	100.00
Nonthaburi	10	25.00	30	75.00	40	100.00
Chachoengsao	10	25.00	30	75.00	40	100.00
Total	32	26.23	90	73.77	122	100.00

Table 4.4.2.1 Mixing Process of Composting for Non-Digested Sludge

	Inorganic substances	Organic substances	Water	Total	Water contents
Original contents					(%)
Dewatered sludge	0.07	0.13	0.80	1.00	80.00
Bulking materials	0.08	0.77	0.15	1.00	15.00
Mixed ratio					
Dewatered sludge	**1.00**				
Bulking materials	**0.50**				
Contents after composting					
Dewatered sludge	0.07	0.13	0.80	1.00	80.00
Bulking materials	0.04	0.39	0.08	0.50	15.00
Mixed sludge	0.11	0.52	0.88	1.50	58.33
Contants change ratio in composting process					
Dewatered sludge	1.00	0.50	0.50		
Bulking materials	1.00	1.00	0.50		
Final ratio in compost					
Dewatered sludge	0.07	0.07	0.40	0.54	74.77
Bulking materials	0.04	0.39	0.04	0.46	8.11
Compost	0.11	0.45	0.44	**1.00**	43.86

0.2 kg DS ⟶ 1 kg dewatered sludge ⟶ 1.00 kg compost

Ratio of compost to DS in kg **5.0**

Table 4.4.2.2 Potential Demand Estimation (1)

(A) AIT Report 98

Location	Fruit Trees (ha)	Vegetables and Flowers (ha)	Total Useful Area (ha)
Bangkok	7,947	3,334	11,281
Kanchanaburi	15,208	7,148	22,356
Nakhon Pathom	13,895	6,142	20,037
Nonthaburi	4,939	1,016	5,955
Pathumthani	28,678	939	29,617
Ratchaburi	15,159	7,752	22,911
Samut Prakan	8,755	0	8,755
Samut Sakhon	14,314	1,660	15,974
Samut Songkhran	14,844	192	15,036
Total	123,739	28,183	151,922

Dry sludge application rate	(t DS/ha/y)	5	
Ratio of farmers who want to buy	(%)	20	
Potential sludge demand	(t DS/d)	416	(=151,922 x 5 / 365 x 20 /100)

(B) JICA Study Team from the First Survey to Agriculture Promotion Experts

Location	Fruit Trees (ha)	Vegetables and Flowers (ha)	Total Useful Area (ha)
Bangkok	7,947	3,334	11,281
Kanchanaburi	15,208	7,148	22,356
Nakhon Pathom	13,895	6,142	20,037
Nonthaburi	4,939	1,016	5,955
Pathumthani	28,678	939	29,617
Ratchaburi	15,159	7,752	22,911
Samut Prakan	8,755	0	8,755
Samut Sakhon	14,314	1,660	15,974
Samut Songkhran	14,844	192	15,036
Chachoeng Sao	23,272	1,126	24,398
Total	147,011	29,309	176,320

Dry sludge application rate	(t DS/ha/y)	5	
Ratio of farmers who want to buy	(%)	18	
Potential sludge demand	(t DS/d)	435	(=176,320 x 5 / 365 x 18 /100)

(C) JICA Study Team from Interview to Compost Manufacturer

Location	Fruit Trees (ha)
Bangkok	7,947
Kanchanaburi	15,208
Nakhon Pathom	13,895
Nonthaburi	4,939
Pathumthani	28,678
Ratchaburi	15,159
Samut Prakan	8,755
Samut Sakhon	14,314
Samut Songkhran	14,844
Chachoeng Sao	23,272
Suphanburi	12,282
Ayuthaya	5,907
Angthong	6,702
Saraburi	11,408
Nakhon Nayok	9,923
Chonburi	58,916
Total	252,149

Compost application rate	(t/rai/y)	1.5	
Compost application rate	(t/ha/y)	9.4	
Compost application rate	(t DS/ha/y)	1.88	
Ratio of farmers who want to buy	(%)	47.0	
Potential sludge demand	(t DS/d)	610	(=252,149 x 9.4 / 365 / 5.0 x 0.47)

Table 4.4.2.3 Potential Demand Estimation (2)

(A) Public parks in BMA

Total area in Queen Sirikit Park	(ha)	22.4
Ratio of flower beds and trees	(%)	15
Area of flower beds and trees	(ha)	3.36
Wastewater sludge cake used in QSP	(t/d)	3
Unit use of sludge cake	(t/d/ha)	0.89
Total area of 12 parks in BMA	(ha)	286.60
Total area of flower beds and trees	(ha)	42.99
Potential demand of sludge cake	(t/d)	38.38
Potential demand of dry sludge	**(t DS/d)**	**7.68**

(B) Road green zones in BMA

Total area of road green zone in BMA	(ha)	213
Sludge application rate	(t DS/y/ha)	5
Potential demand of sludge in BMA	**(t DS/d)**	**2.92**

Table 4.4.2.4 Telephone Interview to Golf Clubs

Name	Address	Contact Name Telephone Number	Area Occupied (ha)	Type of Fertilizer used	Frequency of Application
1. Royal Lake Side	Km. 51 Bangpakong	Khun. Supha, Manager (038) 573-275	64	Monthly chemical some organic (Ami-Ami, Agimoto)	Once / month
2.Thanont Golf (Kritsada)	Minburi	Khun. Jessada 916-9100-4, 9169901-2	64	Chemical	When necessory
3. Panya Park	Nong-Chok	Khun. Komes, Manager 989-4200-23	112	Chemical	Once / month
4. Pinehurst	Rungsit	Khun. Samruay 516-8679	80	Chemical	Once / year
5. Nichigo	Karnchanaburi	Khun. Prasong, Manager (034) 513-334	128	Chemical (Micro Green)	Three / month
6. The Country Club Khowyai	Nakornrajshasima	Khun. Mana 01-213-8435	80	Chemical	Once / month
7. President	Nong-Chok	Khun. Samorn 988-7555-63		Chemical	Time / month
8. Lakewood	Km.15 Bangna-Trad Rd.	Khun. Sittichai, Ass. Manager 312-6276-7,312-6275	128	Chemical	Weekly
9. Thana City	Samutprakarn	Khun. Sakda 336-1971-9	64	Chemical (16-16-16, 12-0-0)	Once / month
10. Subrapruek	Bangplea Samutprakarn	Khun. Karatphan, Manager 317-0801-4	80	Chemical (slow release)	Four / year
11. Bangpoo Country Club	Samutprakarn	Khun. Soontorn 324-0320-9	48	Chemical - Ammonium Sulphate	Four / year
12. Natural Park Ram-Indra	Ram-Indra	Khun. Pongsak 914-930-6	64	No contact	
13. Panya - Indra	Ram-Indra	Khun. Opart 519-5840 ext.382,943-0010-24	112	No contact	
14. Ratchaburi Country Club	Ratchaburi	Khun. Chan or Nopporn 281-8591, (032) 261-223-6	320	No contact	

Table 4.4.2.5 Supply and Demand Estimation

	Estimated amount (t DS/d)	Sludge application rate (t DS/ha/y)	No. of target provinces	Ratio of willingness to pay (%)	Target crops			Remarks
					Fruit trees	Vege. and flowers	Field crops	
Expected supply								
From all WWTPs in 2020	259.0							
From all NSTPs in 2020	44.0							
Total	**303.0**							
Potential demand								
Agricultural use								
From the past report								
AIT 1998 report	416	5.00	9	20	O	O		
From the JICA study team								
1st survey to Kaset Thambon	435	5.00	10	18	O	O		
Interview to compost manufacturer	610	1.88	16	47	O			
Final estimation of sludge compost demand	487							Average
Public parks in BMA	8							
Road green zones in nearby 10 provinces	3							
Golf courses	0							
Total potential demand	**498**							

Table 4.4.2.6 Summary of Questionnaire Survey at Flower Market

	Name of fertilizer	Sales price (Bahts/kg)	Remarks
Chemical	16-16-16	20	
	13-00-46	20	
	12-24-12	20	
	15-15-15	20	
	46-0-0	20	
	Viking(pellet)	22	
	Siam fort	35	
Organic	Manure	0.75 to 0.9	cow, soil
	Manure	1	
	Ngamdee compost	1	cow, chicken, soil, leave
	Cow manure	1.7 to 4.25	
	Sida(garbage)	0.9 to 1.25	
	Sida (manure)	1.33	cow, chicken, soil, sand
	Cow compost	2 to 2.7	
	Korean compost	15	
	Chicken pellet	15	
	Garden(pellet)	40	
	BMA(pellet)	50	
	BMA fertilizer	1	not available now

		YES	NO
Q1	Do you know about sewage sludge, which can be used as compost and soil conditioner?	6	4
Q2	Do you think your customer will buy it? (Presently used at Queen Sirikit Part)	10	0
Q3	Do you think they will pay it at the similar price of your organic fertilizer?	10	0

Comment

Cow manure is easier to sell than sludge, if same price.
Korean compost has never been sold for one year, because expensive.
Price of sludge compost should be cheaper.
BMA garbage fertilizer was very popular because cheap and good.
People do not care about the dirty of sludge.
They do not know the agricultural use of night soil.

Table 4.4.2.7 Telephone Survey to Compost Manufacturers

Company	Unit	Provest	Supan Compost	Golden Land	SIDA	Bilonic Humas
Production capacity	(t/y)	6,000	35,000	100,000	n.a.	130,000
Raw materials		Sugar cane	Duck manure Chaff	Sugar cane	Sugar cane Caw manure	n.a.

Total compost production	271,000
Total estimated compost market size (Equivalent to t DS/d)	**149**

Table 4.4.2.8 List of Orginic Fertilizer Producers registered in Min. of Industry

	Type of Fertilizer	Company	Region	Province	Production Cap.(t/y)	Workers
1	Organic	Siam Fertilizer	C	Nontha Buri	20,000	24
2	Manure Organic Compost	Sida Fertilizer	C	Pathum Thani	4,800	20
3	Compost	A.C. Telecom	C	Pathum Thani	720	17
4	Organic Compost	Wong Sa Wang Kan Kaset	C	Lop Buri	n.a.	62
5	Compost	Ta Wan Ook Chemical	E	Chon Buri	10,000	12
6	Organic (Pellet)	Organic Fertilizer	C	Cha Choeng Sao	1,200	8
7	Organic	Ka Si Korn Siam	C	Cha Choeng Sao	1,200	20
8	Organic (Pellet)	Din Dee & Protein	C	Cha Choeng Sao	1,000	25
9	Organic	Pad Riew Organic Industry	C	Cha Choeng Sao	3,600	13
10	Organic Compost	Jong Jit Kasettakam	E	Prachean Buri	2,500	15
11	Compost	Tha Tee Kaset Pan	NE	Sri Sa Ket	9,000	17
12	Organic (Compost)	Chieng Mai Humost	N	Chieng Mai	1,500	20
13	Organic	Thai Fong Nong Compost	N	Chieng Rai	1,200	15
14	Organic	Ameri Tech Rise	C	Nakon Sawan	4,000	38
15	Compost	Mr. Somchit Thong Sakul	C	Uthai Thani	56	5
16	Compost	Sod Sheun Karn Kaset	W	Kanchana Buri	n.a.	6
17	Compost	Mr. Somchit Thong Sakul	W	Kanchana Buri	2,400	7
18	Compost	Golden Land Compost	W	Kanchana Buri	100,000	13
19	Compost	Thana Reuk Pa Ngeon	C	Nakorn Pathom	250	6
20	Manure	Mr. Wan Sinkong	C	Nakorn Pathom	360	5
21	Manure (bat)	Thai Charoen Industry	C	Nakorn Pathom	180	10
22	Compost	T.C. Agricultural Industry	C	Sa Mut Sa korn	n.a.	14
23	Compost	Ut Sa Ha Karm Karn Kaset	S	Na Korn Sri Tham Ma Rat	720	8
24	Compost	Ma Ha Chai Industry	S	Na Korn Sri Tham Ma Rat	84	4
25	Organic	Pui In See Patthana Din Factory	S	Chum Porn	7,200	8
26	Compost	Mit Kaset	C	Su Phan Buri	480	15
27	Compost	In tha Kit Song Pee Nong	C	Su Phan Buri	600	14
28	Compost	Jong Krieng Factory	C	Su Phan Buri	108,000	36
29	Organic	Kaset Pan Mai	C	Nakorn Sawan	5,000	13
				Total :	**286,050**	**470**

C: Central
N: North
S: South
E: East
W: West
NE: Northeast

		(%)
Sub-total of Central	151,446	52.94
Sub-total of North	2,700	0.94
Sub-total of South	8,004	2.8
Sub-total of East	12,500	4.37
Sub-total of West	102,400	35.8
Sub-total of Northeast	9,000	3.15
Overall Total	286,050	100
Total of Central, East, and West	**266,346**	**93.11**
Total estimated compost market size (Equivalent to t DS/d)	**146**	

Table 4.4.2.9 Current Market Estimation from the 2nd Survey (1/3)

(A) JICA Study Team from the Second Survey to Farmers

Estimation of Market Size for Compost

From Table A.2.6 in Supporting Report A. Amount of compost used (kg/rai/y)	Mid. value (kg/rai/y)	Share of respondents (%)		
Lowest to 200	100	54.55	54.55	
200 to 400	300	18.18	54.54	
400 to 600	500	12.73	63.65	
600 to 800	700	9.09	63.63	
800 to highest	900	5.45	49.05	
		Weighted average	285.42	(kg/rai/y)
		Weighted average	1783.875	(kg/ha/y)

From Table A.2.8 in Supporting Report A Cost of compost (Baht/Kg)	Mid. value (kg/rai/y)	Share of respondents (%)		
Lowest to 1	0.5	66.04	0.3302	
1 to 3	1.5	11.32	0.1698	
3 to 5	4	9.43	0.3772	
5 to 10	7.5	5.66	0.4245	
10 to 15	12.5	1.89	0.23625	
15 to highest	17.5	5.66	0.9905	
		Weighted average	2.19825	(Baht/Kg)

Location	Fruit Trees (ha)	Vegetables and Flowers (ha)	Field crops (ha)
Bangkok	7,947	3,334	330
Kanchanaburi	15,208	7,148	219,918
Nakhon Pathom	13,895	6,142	24,587
Nonthaburi	4,939	1,016	0
Pathumthani	28,678	939	0
Ratchaburi	15,159	7,752	88,093
Samut Prakan	8,755	0	0
Samut Sakhon	14,314	1,660	0
Samut Songkhran	14,844	192	0
Chachoeng Sao	23,272	1,126	96,523
Total	**147,011**	**29,309**	**429,451**
Grand total	**605,771**		

Target area	(ha)	605,771	
Compost application rate	(kg/ha/y)	1,784	
Average price of fertilizer	(Baht/Kg)	2.20	
Estimated market size of compost	**(t/y)**	**1,080,620**	
Estimated market size of compost	**(Mil. Baht/Y)**	**2,375**	
Compost application rate	(t/ha/y)	1.78	
Compost application rate	(t DS/ha/y)	0.358	
Estimated sludge demand for compost	**(t DS/d)**	**594**	**(605,771 x 1.78 /365 / 5.0)**

(B) JICA Study Team from the Second Survey to Farmers

Estimation of Market Size for Chemical Fertilizer

From Table A.2.6 in Supporting Report A Amount of chemical used (kg/rai/y)	Mid. value (kg/rai/y)	Share of respondents (%)		
Lowest to 200	100	80.61	80.61	
200 to 400	300	10.2	30.6	
400 to 600	500	4.08	20.4	
600 to 800	700	2.04	14.28	
800 to highest	900	3.06	27.54	
		Weighted average	173.43	(kg/rai/y)
		Weighted average	1083.9375	(kg/ha/y)

Table 4.4.2.9 Current Market Estimation from the 2nd Survey (2/3)

From Table A.2.8 in Supporting Report A Cost of chemical fertilizer (Baht/Kg)	Mid. value (kg/rai/y)	Share of respondents (%)		
Lowest to 1	0.5	0	0	
1 to 3	1.5	0	0	
3 to 5	4	2	0.08	
5 to 10	7.5	52	3.9	
10 to 15	12.5	42	5.25	
15 to highest	17.5	4	0.7	
		Weighted average	9.93	(Baht/Kg)

Location	Fruit Trees (ha)	Vegetables and Flowers (ha)	Field crops (ha)
Bangkok	7,947	3,334	330
Kanchanaburi	15,208	7,148	219,918
Nakhon Pathom	13,895	6,142	24,587
Nonthaburi	4,939	1,016	0
Pathumthani	28,678	939	0
Ratchaburi	15,159	7,752	88,093
Samut Prakan	8,755	0	0
Samut Sakhon	14,314	1,660	0
Samut Songkhran	14,844	192	0
Chachoeng Sao	23,272	1,126	96,523
Total	**147,011**	**29,309**	**429,451**
Grand total	**605,771**		

Target area	(ha)	605,771
Fertilizer application rate	(kg/ha/y)	1,084
Average price of fertilizer	(Baht/Kg)	9.93
Estimated market size of chemical	**(t/y)**	**656,618**
Estimated market size of chemical	**(Mil. Baht/y)**	**6,520**

(C) JICA Study Team from the Second Survey to Farmers

Estimation of Market Size for Animal Manure

From Table A.2.6 in Supporting Report A Amount of animal manure used (kg/rai/y)	Mid. value (kg/rai/y)	Share of respondents (%)		
Lowest to 200	100	69.81	69.81	
200 to 400	300	15.09	45.27	
400 to 600	500	5.66	28.3	
600 to 800	700	3.77	26.39	
800 to highest	900	5.66	50.94	
		Weighted average	220.71	(kg/rai/y)
		Weighted average	1379.4375	(kg/ha/y)

From Table A.2.8 in Supporting Report A Cost of animal manure (Baht/Kg)	Mid. value (kg/rai/y)	Share of respondents (%)		
Lowest to 1	0.5	26.19	0.13095	
1 to 3	1.5	45.24	0.6786	
3 to 5	4	21.43	0.8572	
5 to 10	7.5	7.14	0.5355	
10 to 15	12.5	0	0	
15 to highest	17.5	0	0	
		Weighted average	2.0713	(Baht/Kg)

Table 4.4.2.9 Current Market Estimation from the 2nd Survey (3/3)

Location	Fruit Trees (ha)	Vegetables and Flowers (ha)	Field crops (ha)
Bangkok	7,947	3,334	330
Kanchanaburi	15,208	7,148	219,918
Nakhon Pathom	13,895	6,142	24,587
Nonthaburi	4,939	1,016	0
Pathumthani	28,678	939	0
Ratchaburi	15,159	7,752	88,093
Samut Prakan	8,755	0	0
Samut Sakhon	14,314	1,660	0
Samut Songkhran	14,844	192	0
Chachoeng Sao	23,272	1,126	96,523
Total	**147,011**	**29,309**	**429,451**
Grand total	**605,771**		

Target area	(ha)	605,771
Compost application rate	(kg/ha/y)	1,379
Average price of fertilizer	(Baht/Kg)	2.07
Estimated market size of compost	**(t/y)**	**835,624**
Estimated market size of compost	**(Mil. Baht/Y)**	**1,731**

(D) JICA Study Team from the Second Survey to Farmers
Potential Demand of Nightsoil Sludge

(From Table A.3.18 in Supporting Report A.) Types of crops	No. of respondents who have applied human waste (%)
Fruit trees	53.66
Vegetables and flowers	43.9
Field crops	2.44

Location	Fruit Trees (ha)	Vegetables and Flowers (ha)	Field crops (ha)
Bangkok	7,947	3,334	330
Kanchanaburi	15,208	7,148	219,918
Nakhon Pathom	13,895	6,142	24,587
Nonthaburi	4,939	1,016	0
Pathumthani	28,678	939	0
Ratchaburi	15,159	7,752	88,093
Samut Prakan	8,755	0	0
Samut Sakhon	14,314	1,660	0
Samut Songkhran	14,844	192	0
Chachoeng Sao	23,272	1,126	96,523
Total	147,011	29,309	429,451

No. of respondents who have applied human waste on their farms	53.66	43.9	2.44	
Nightsoil application rate (kg/rai/y)	100	100	100	(Table A.2.6)
Nightsoil application rate (kg/ha/y)	625	625	625	
Moisture contents (%)	80	80	80	
Nightsoil application rate (t DS/ha/y)	0.125	0.125	0.125	
Potential sludge demand (t DS/d)	**50**	**10**	**147**	
Total sludge demand (t DS/d)	**207**			

Target area (ha)	605,771
Nightsoil application rate (kg/ha/y)	625
Total potential demand (t/y)	**378,607**

Table 4.4.2.10 Supply and Market Estimation

	Estimated size (t DS/d)	Estimated size (t/y)	Estimated size (Mil. B/y)	Average price (B/t)	Remarks
Expected supply					
From all WWTPs in 2020	259.0				
From all NSTPs in 2020	44.0				
Total	**303.0**				
Estimated current market size in nearby 10 provinces					
Market size estimation 1 (From interview and statistic surveys)					
Registered compost manufacturers in MOI	146.3				
Telephone interviews to compost manufacture	148.9				
Current NS use at schools/districts	28.0				
Total	**323.2**				No double counting
Market size estimation 2 (From the 2nd survey)					
Compost market size	**593.6**	1,080,620	2,375	2,198	
Animal manure		835,624	1,731	2,071	
NS sludge	**207.5**	378,607	0	0	Free of charge
Chemical		656,618	6,520	9,930	

Table 4.5.2.1 Water Use at Existing Wastewater and Night Soil Treatment Plant

	Name of Treatment Plant	Target for Treatment	Treatment Capacity (m^3/d)	Influent (m^3/d)	Water Consumption (m^3/d) P.W.	G.W.	K.W.	Re.W.	Objective of Water Use		Method of Re.W.Production	Construction
1	On Nut NSTP	Night Soil	600	200	n/a	No Meter	18	-	G.W.	L,Sh,Wf	-	1973
									K.W.	C(6),Cs(10),Ch(2)	-	
2	Nong Khaem NSTP	Night Soil	600	400	35	-	-	700	P.W.	L(3),Ch(20),T+Sb+G(12)	-	1991
									Re.W.	Wa(670), Ba(30)	Rapid Sand Filter	
3	Si Phraya WWTP	Wastewater	30,000	20,000	5	-	-	10-20	Re.W.	Wf+T+C+F(10-20)	Rapid Sand Filter	1993
								80-180	Re.W.	R,G (by district office, 80-180)	-	
4	Huay Kwuang WWTP	Wastewater	2,400	1,076	8	-	-	12	P.W.	T+K+B+L+Sh(8)	-	1975
									Re.W.	Wa(6),G(4),F(2)	-	

Note: P.W.=Public Water Supply
G.W.=Ground Water
K.W.=Khlong Water
Re.W.=Reclaimed Wastewater

Objective of water use
- T: Toilet flushing
- K: Kitchen use
- B: Bathroom
- C: Car wash
- G: Garden watering
- F: Cleaning floor
- Fi: Fire extinguish
- R: Road cleaning

- L: Laboratory use
- Ch: Chemical dilusion
- C: Car & Equipment water use
- Sh: Shower
- Cs: Cleaning bar screen
- Wf: Washing filter cloth
- Ba: Back wash for Filter
- Wa: Washing Plant and Equipment (Belt Press, Drum Screen, Screw Press etc.)

Table 4.5.2.2 Present Condition for Road Plant Watering/Road Cleaning by District Office

Catchment Area	Name of District	Area of District ha	Water Use Quantity					
			Road Plant Watering m^3/d		Road Cleaning m^3/d		W.Q. of Road Plant Watering $m^3/d/100ha$	W.Q. of Road Cleaning $m^3/d/100ha$
Si Phraya	Bang Rak	554	144	Re	18	Re	26	3
	Samphanthawong	146	12	Re	24	Re	8	16
Ratanakosin	Dusit	1,067	144	K	72	K	13	7
	Pom Prap Sattru Phai	193	72	P	12	K	37	6
BKK Central	Ratchathewi	713	66	K	37	K,Re	9	5
Yannawa	Sathon	933	90	Ri	36	Ri	10	4
	Bang Kho Laem	1,092	108	Ri	36	Ri	10	3
Khlong Toey East	Phra Khanong	1,360	84	Re	6	Re	6	0
Thonburi North	Bang Phlat	1,136	36	K	48	Ri	3	4
Thonburi Central	Bangkok Yai	618	198	Ri	24	Ri	32	4
	Bangkok Noi	1,194	250	K	250	K	21	21
Thonburi South	Rat Burana	1,570	48	Re	24	Ri	3	2
Bung Kum	Khanna Yao	2,872	-		48	K	-	2
			ave. 104		ave. 49		ave. 15	ave. 6
Recent Urbanized Area	Min Buri	5,824	420	K	420	K	7	7
	Bang Khun Thian	12,326	96	K	108	G	1	1
	Phasi Charoen	1,820	150	K	60	K	8	3
	Suan Luang	2,368	720	K	30	K	30	1
	Sam Wa	11,609	120	K	6	K	1	0
	Thawi Wattana	4,683	42	K	42	K	1	1
			ave. 258		ave. 111		ave. 8	ave. 2

Note :
W.Q. = Watering Quantiy per 100 ha

P : Public Water
Ri : River Water
K : Khlong Water
Re : Reclaimed Wastewater

Table4.5.2.3 Water Use of Public Transportation Depots

	Name of Organization	Type of Transport	No. of Employee	No.of Cars	No. of Depot	Water Consumption (m^3/d)				Objectives of Re.W. Use	Remarks
						P.W.	G.W.	K.W.	Re.W.		
1	BMTA	Bus	21,693	4,098	33	1,330	-	175	-	-	Water consumption is about 70 m^3/d for the main depts
2	SRT Makkasan Railway Plant	Train	n.a.	68	1	726	-	-	-	-	Water is used for building cleaning.
3	SRT Hua Lamphong Railway Station	Train	n.a.	165	1	928	-	-	-	-	ditto.
4	Noi/Thonburi Railway Station	Train	n.a.	18	1	650	-	-	-	-	ditto.
5	BTS Chatuchak Depot	Electrical Train	500	35	1	60	-	-	-	-	T(40). F(5). Te (car washing 15). starting by the end of 1999
6	DPC(G) Nong Khaem Compost Plant Sub-Division	Truck	154	426	1	30	150	-	25	R(20).Fi(5)	P.W.:B(17).G(10).F(3) G.W.:C(130).B(8).G(7).F(5)
	Total										

Note: P.W.=Public Water Supply
G.W.=Ground Water
K.W.=Khlong Water
Re.W.=Reclaimed Wastewater
BMTA=Bangkok Mass Transit Authority
SRT=State Railway of Thailand
BTS=Bangkok Mass Transit System Public Company Ltd.
DPC(G)=Department of Public Cleansing(Garbage)
DPC(R.C.)=Department of Public Cleansing(Road Cleaning)

Objectives of water use

T: Toilet flushing
K: Kitchen use
B: Bathroom
C: Car wash
G: Garden(Sprinkling to plants)
F: Cleaning floor
Fi: Fire extinguish
R: Road cleaning
Co: Cooling water
Bo: Boiler feeding
Tc: Train car washing

Table 4.5.2.4 Water Use of Public Office

No.	Name of Building	Location	The floor Space(m^2)	No. of Staff	Water Consumption (m^3/d)					Purpose of water use	
					P.W.	G.W.	Ri.W.	K.W.	Re.W.		
1	BMA building	Huay Kwuang	24,284	3,200	156	-	-	10-20	-	K.W.	10 m^3/d for normal condition 20 m^3/d for special festival
2	Bang Phlat District Office building	Bang Phlat	3 floor	200	35	-	-	-	-		T,B
3	Saphan Sung District Office building	Saphan Sung	1,500	293	10	-	-	-	-		F,T,B,C,G
4	Phasi Charoen District Office building	Phasi Charoen	3,500	230	16	-	-	-	-		T,K,B,C,G,F,R
5	Bang Khun Thian District Office building	Bang Khun Thian	2,638	267	40	-	-	12	-	K.W.	G
6	Min Buri District Office building	Min Buri	2,913	577	41	-	-	-	-		
7	Ratchathewi District Office building	Ratchathewi	12,500	282	27	-	-	-	-		T,K,G,F
8	Sam Wa District Office building	Sam Wa	1,476	165	-	14	-	-	-		T,F
9	Sathorn District Office building	Sathorn	10,700	708	33	-	-	-	-		T,B,F
10	Min Buri District Office building	Min Buri	2,913	577	41	-	-	-	-		

Note: P.W.=Public Water Supply
G.W.=Ground Water
Ri.W.=Chao Phraya River Water
K.W.=Khlong Water
Re.W.=Reclamaited Wastewater

Table 4.5.3.1 Water Use of Large Building

	Name of Building	Location	Main Purpose	The Floor Space(m^2)	No. of Room	Water Consumption (m^3/d)				Objectives of Re.W. Use	Remarks
						P.W	G.W.	Ri.W.	Re.W.		
1	Grand President	Khlong Toey	Condominium	10,998	440	302	-	-	-	-	There are 3 towers. Each tower has a Septic Tank in the basement.
2	Royal President	Khlong Toey	Condominium	5,045	186	130	-	-	-	-	No building has a Septic Tank.
3	President Park	Khlong Toey	Condominium	6,276	232	125	-	-	-	-	There are 2 buildings. Each tower has a Septic Tank in the basement.
4	BTS H.Q. Buildi	Chatuchak	Office building	10,800	1,000 persons	90	-	-	-	-	Building has a Septic Tank with Upflow anaerobic treatment process.
5	Rembrant Tower	Khlong Toey	Condominium	41,774	195	113	-	-	-	-	
6	Esso Tower	Khlong Toey	Office building	36,000	1,200 persons	135	-	-	18	Road Plant Watering	Rama IV Project Spinkle the green zone (about 500 m)

Note: P.W.=Public Water Supply
G.W.=Ground Water
Ri.W.=Chao Phraya River Water
Re.W.=Reclaimed Wastewater

Objectives of Re.W. Use
T: Toilet flushing
K: Kitchen use
B: Bathroom
C: Car wash
G: Garden(Sprinkling)
F: Cleaning floor
Fi: Fire distinguish
R: Road cleaning
Co: Cooling water
Bo: Boiler feeding

Table 4.5.3.2 Water Use of Hotel

No.	Name of Hotel	Location	No.of Room	No. of Customer	No. of Employee	Water Consumption (m^3/d) P.W.	Ri.W.	Re.W.	Objectives of Re. W.	Remarks
1	Oriental Bangkok	Bang Rak	396	250	1,000	dry season 900	wet season 900	300	S	no use Ri.W. in dry season
2	Shangri-La	Bang Rak	868	1,000	1,000	dry season 1,355	wet season 1,400		-	no use Ri.W. in dry season
3	Royal Orchid Sheraton	Bang Rak	773	815	741	yearly ave. 720	yearly ave. 263	100	G	no use Ri.W. in dry season
4	Holiday Inn	Bang Rak	650	500	600	600		20	G	

Note: P.W. = Public Water Supply
G.W. = Ground Water
Re.W. = Reclaimed Wastewater
Ri.W. = Chao Phraya River Water
Objectives of Re.W. use
G: Garden (Sprinkling to plants)
S: Washing water for smoke extraction apparatus (cyclone)

Table 4.5.3.3 Water Use of Hospital

No.	Name of Hospital	Location	No. of Bed	No. of Patient	No. of Employee	Water Consumption (m^3/d) P.W.	G.W.	Ri.W.	Re.W.	Objectives of Water Use		Remarks
1	Ramathibodi	Ratcha Thewi	1,000	4,500 pat. / day	5,662	1,600			200	Re. W.	C.,F.,R.,G. (100 m^3/d) T(100 m^3/d)	Re.W. for toilet is treated by softer
2	Sirisaj	BangkokNoi	n.a.	n.a.	n.a.	5,000	n.a.		50	Re.W. T.,B.,K.,F		
3	Phayathai 1	RatchaThewi	350	n.a.	1,300	500						
4	Bangkok	Bang Rak	400	180 bed/day	1,070	300			150	P.W. T.,B.,K.,F. Re. W. G.,F.,R.		
5	Huachiew	Pom Prap	n.a.	n.a.	n.a.	n.a.			n.a.			Treated wastewater reuse for sprinkling to plants

Note: P.W.=Public Water Supply
G.W.=Ground Water
Ri.W.=Chao Phraya River Water
Re.W.=Reclaimed Wastewater
Objectives of Re.W. use
T: Toilet flushing
K: Kitchen use
B: Bathroom
C: Car wash
G: Garden(Sprinkling)
F: Cleaning floor
Fi: Fire extinguish
R: Road cleaning
Co: Cooling water
Bo: Boiler feeding

Table 4.5.3.4 Water Use of Others(Stadium, Big Garden etc.)

No.	Name of Facilities	Location	Purpose of water use	Total area / Area of green	Water Consumption (m^3/d) P.W	G.W.	Ri.W.	K.W.	Re.W.	Purposes of water use		Remarks
1	Queen Shirikit Park	Chatuchak	Park	32 ha / (22 ha)	5	750	-	-	-	P.W. G.W	T,B G	5 wells
2	Suan Laung Rama IX Park	Prawet	Park	80 ha / (64 ha)	26	no meter	-	-	-	P.W. G.W	T.K.B G	
3	Buddhamontol Park	Nakhon Pathom Province	Park	400 ha / (304 ha)	-	300	-	-	-			
4	Dragon Hill Golf Course	Ratburi Province	Golf Course	n.a. / n.a.	-	100	-	-	-	G.W	T,K,B	Water is obtained from the pond provided in the area.
5	Royal Golf & Country Club	Samut Prakarn	Golf Course	192 ha / (64 ha)	-	n.a.	-	n.a.	-	G.W	T,K,B	Water is obtained from the pond provided in the area.
4	Gymnagium 2, Youth Center (Thai - Japan)	Huay Kwuang	Playing Field	14 ha / (4 ha)	140	255	-	-	-	P.W. G.W	T,B,F G	

Note: P.W.=Public Water Supply
G.W.=Ground Water
Ri.W.=Chao Phraya River Water
K.W.=Khlong Water
Re.W.=Reclaimed Wastewater

T: Toilet flushing
K: Kitchen use
B: Bathroom
G: Garden(Sprinkling)

Table 4.5.3.5 Water Use Condition of Bangkok Public Parks

No.	Name of the park	Location	Area	Water Source									
				Public Water Supply		Khlong Water		River Water		Underground Water		Total	
				Dry	Rainy	Dry	Rainy	Dry	Rainy	Dry	Rainy	Dry	Rainy
			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)	(m^3/d)	(m^3/d)
1	Benchasiri Park	Khlong Toey	4.6	2	0	0	0	0	0	216	0	218	0
2	Bung Kum Water Park	Bung Kum	56.0	0	0	2,520	630	0	0	0	0	2,520	630
3	Chatuchak Park	Chatuchak	30.4	400	100	20	0	0	0	75	30	495	130
4	Lumpini Park	Pathum Wan	57.6	0	0	1,900	475	0	0	165	40	2,065	515
5	Nong Chok Park	Nong Chok	5.7	15	6	0	0	0	0	30	10	45	16
6	Phra Nakhon Park	Lat Krabang	8.0	12	6	96	0	0	0	18	0	126	6
7	Queen Sirikit Park	Chatuchak	22.4	0	0	0	0	0	0	1,069	535	1,069	535
8	Rommaninat	Phra Nakhon	4.8	0	0	400	200	0	0	0	0	400	200
9	Saranrom Park	Phra Nakhon	3.7	0	0	120	50	30	10	0	0	150	60
10	Suan Luang Rama IX	Pravet	80.0	30	30	0	0	0	0	14,000	4,000	14,030	4,030
11	Thonburirom Park	Ratburana	10.1	5	0	980	500	0	0	0	0	985	500
12	Santipa Park	n.a.	3.2	0	0	0	0	226	76	32	0	258	76
Total			286.5	464	142	6,036	1,855	256	86	15,605	4,615	22,361	6,698

Source : data by Public Parks Division, Dept. of Social Welfare, BMA

	Dry	Rainy
	(m^3/ha/d)	(m^3/ha/d)
The amount of water used per hectare of green field	78	23
The amount of water used per hectare of green field (without Suan Luang Rama IX Park)	40	13

Table 4.5.3.6 Effluent Standards by the Act of Building Control (1)

Standards Value

The Standard of Effluent Quality		Type of Building			
		A	B	C	D
1. pH		5-9	5-9	5-9	5-9
2. BOD	mg/l	20	30	60	90
3. SS	mg/l	30	40	50	60
4. Settable Solids	mg/l	500	500	500	500
5. TDS	mg/l	0.5	0.5	0.5	0.5
6. TKN	mg/l	-	-	40	40
7. ORG-N	mg/l	10	10	15	15
8. NH3-N	mg/l	-	-	25	25
9. Oil &	mg/l	20	20	20	20
10.Sulfide	mg/l	1.0	1.0	3.0	4.0

Source: Ministerial regulation (edition 44) 1995 issued under the Building Control Act (1979)

Table 4.5.3.7 Effluent Standards by the Act of Building Control (2)

Type and Size of Building according to Ministerial Regulation (Edition 44)

Types of Building	Unit	The standard of Effluent and Building Size			
		A	B	C	D
1. Apartment	room	500 or more	100 but not more than 500	Less than 100	-
2. Hotel	room	200 or more	60 but not more than 200	Less than 60	-
3. Dormitory	room	-	250 or more	50 but not more than 250	Less than 50
4. Service Place	m^2	-	5,000 or more	1,000 but not more than	Less than 1,000
5. Clinic	bed	30 or more	10 but not more than 30	-	Less than 10
6. Education Place	m^2	25,000 or more	5,000 but not more than	-	Less than 5,000
7. Government and Private Organization	m^2	55,000 or more	10,000 but not more than	5,000 but not more than	Less than 5,000
8. Department Store	m^2	25,000 or more	5,000 but not more than	1,000 but not more than	Less than 1,000
9. Market	m^2	2,500 or more	1,500 but not more than	500 but not more than	Less than 500
10. Restaurant	m^2	2,500 or more	500 but not more than	100 but not more than 500	Less than 100
11. Building in Allocated Land	m^2	500 or more	100 but not more than 500	10 but not more than 100	-
12. Building	m^2	-	10,000 or more	2,000 but not more than	Less than 2,000

Table 4.5.5.1 Irrigation Standard of Water Quality

The Royal Irrigation Department

1	pH 6.5 -8.5	
2	EC x 10^6 not more than 2,000 micromos/cm	
3	TDS not more than 1,300 mg/l	
4	The temperature of water not more than 40°C	
5	DO not less than 5.0 mg/l	
6	BOD not more than 20 mg/l	
7	SS not more than 30 mg/l	
8	Permanganate (PV) not more than 60 mg/l	
9	Sulphide comparable to H_2S not more than 1 mg/l	
10	Cyanide comparable to HCN not more than 0.2 mg/l	
11	Oil/fat not more than 5 mg/l	
12	Formaldehyde not more than 5 mg/l	
13	Phenol / Cresol not more than 1 mg/l	
14	Cl^- not more than 1 mg/l	
15	None pesticides and radioactive substance	
16	None colour / odor	
17	None tar oil	
18	Heavy metal	
	18.1	Zn not more than 5 mg/l
	18.2	Cr not more than 0.3 mg/l
	18.3	As not more than 0.25 mg/l
	18.4	Cu not more than 1 mg/l
	18.5	Hg not more than 0.005 mg/l
	18.6	Cd not more than 0.03 mg/l
	18.7	Ba not more tnan 1 mg/l
	18.8	Se not more than 0.02 mg/l
	18.9	Pb not more than 0.1 mg/l
	18.10	Ni not more than 0.2 mg/l
	18.11	Mn not more than 5 mg/l

Table 4.5.5.2 FAO - Guidelines for Interpretations of Water Quality for Irrigation[1]

Potential Irrigation Problem	Units	Degree of Restriction on Use		
		None	Slight to Moderate	Severe
Salinity (affected crop water availability)				
EC_w	dS/m	< 0.7	0.7 - 3.0	> 3.0
(or)				
TDS	mg/l	<450	450 - 2000	> 2000
Infiltration (affects infiltration rate of water into the soil. Evaluate using EC_w and SAR together)[3]				
SAR = 0 - 3 and EC_w =		> 0.7	0.7 - 0.2	< 0.2
= 3 - 6 =		> 1.2	1.2 - 0.3	< 0.3
= 6 - 12 =		> 1.9	1.9 - 0.5	< 0.5
= 12 - 20 =		> 2.9	2.9 - 1.3	< 1.3
= 20 - 40 =		> 5.0	5.0 - 2.9	< 2.9
Specific Ion Toxicity (affects sensitive crops)				
Sodium (Na)[4]				
surface irrigation	SAR	< 3	3 - 9	> 9
sprinkler irrigation	mg/l	<3	> 3	
Chloride (Cl)[4]				
surface irrigation	mg/l	< 4	4 - 10	> 10
sprinkler irrigation	mg/l	< 3	> 3	
Boron (B)[5]	mg/l	< 0.7	0.7 - 3.0	> 3.0
Trace Elements (see Table 21)				
Miscellaneous Effects (affects susceptible crops)				
Nitrogen (NO_3 - N)[6]	mg/l	< 5	5 - 30	> 30
Bicarbonate (HCO_3) (overhead sprinkling only)	mg/l	< 1.5	1.5 - 8.5	> 8.5
pH		Normal Range 6.5 - 8.4		

Note :

[1] Adapted from University of California Committee of Consultants 1974.

[2] EC_w means electrical conductivity, a measure of the water salinity, reported in deciSiemens per metre at 25°C (dS/m) or in units millimhos per centimeter (mmho/cm). Both are equivalent. TDS means total dissolved solids, reported in milligrams per litre (mg/l).

[3] SAR means sodium adsorption ratio. SAR is sometimes reported by the symbol RNa. See Figure 1 for the SAR calculation procedure. At a given SAR, infiltration rate increases as water salinity increases. Evaluate the potential infiltration problem by SAR as modified by ECw. Adapted from Rhodes 1977, and Oster and Schroer 1979.

[4] For surface irrigation, most tree crops and woody plants are sensitive to sodium and chloride; use the values shown. Most annual crops are not sensitive; use the salinity tolerance tables (Tables 4 and 5). For chloride tolerance of selected fruit crops, see Table 14. With overhead sprinkler irrigation and low humidity (< 30 percent), sodium and chloride may be absorbed through the leaves of sensitive crops. For crop sensitivity to absorption, see Tables 18, 19 and 20.

[5] For boron tolerances, see Tables 16 and 17

[6] NO_3 - N means nitrate nitrogen reported in terms of elemental nitrogen (NH_4 - N and Organic -N should be included when wastewater is being tested)

Source : FAO IRRIGATION AND DRAINAGE PAPER 29 Rev.1, Water quality for agriculture, 1985

Table 4.5.5.3 FAO - Laboratory Determinations Needed to Evaluate Common Irrigation Water Quality Problems

Water parameter	Symbol	Unit[1]	Usual Range in Irrigation Water	
SALINITY				
Salt Content				
Electrical Conductivity	EC_w	dS/m	0 - 3	dS/m
(or)				
Total Dissolved Solids	TDS	mg/l	0 - 2000	mg/l
Cations and Anions				
Calcium	Ca^{++}	me/l	0 - 20	me/l
Magnesium	Mg^{++}	me/l	0 - 5	me/l
Sodium	Na^{+}	me/l	0 - 40	me/l
Carbonate	CO_3^{--}	me/l	0 - .1	me/l
Bicarbonate	HCO_3^{-}	me/l	0 - 10	me/l
Chloride	Cl^{-}	me/l	0 - 30	me/l
Sulfate	SO_4^{--}	me/l	0 - 20	me/l
NUTRIENTS[2]				
Nitrate - Nitrogen	NO_3-N	mg/l	0 - 10	mg/l
Ammonium - Nitrogen	NH_4-N	mg/l	0 - 5	mg/l
Phosphate - Phosphorus	PO_4-P	mg/l	0 - 2	mg/l
Potassium	K^{+}	mg/l	0 - 2	mg/l
MISCELLANEOUS				
Boron	B	mg/l	0 - 2	mg/l
Acid/Basicity	pH	1 - 14	6.0 - 8.5	
Sodium Adsorption Ratio[3]	SAR	(me/l)[1,2]	0 - 15	

Note :

[1] dS/m = deciSiemen/metre in S.I. units (equivalent to 1 mmho/cm = 1 millimmho/centimetre)
mg/l = milligram per litre = parts per million (ppm).
me/l = milliequivalent per litre (mg/l = equivalent weight = me/l); in SI units, 1 me/l = 1 millimol/litre adjusted for electron charge.

[2] NO_3-N means the laboratory will analyse for NO_3 but will report the NO_3 in terms of chemically equivalent nitrogen. Similarly, for NH_4-N, the laboratory will analyse for NH_4 but report in terms of chemically equivalent elemental nitrogen. The total nitrogen available to the plant will be the sum of the equivalent elemental nitrogen. The same reporting method is used for phosphorus.

[3] SAR is calculated from the Na, Ca and Mg reported in me/l (see Figure 1.)

Source : FAO IRRIGATION AND DRAINAGE PAPER 29 Rev.1, Water quality for agriculture, 1985

Table 4.5.5.4 Comparison between Irrigation Standards and Investigation Value

No.	Item	Unit	Irrigation Standards Value	Investigation Value by this study[1)]
1	pH		6.5 -8.5	
2	EC	micromos/cm	not more than 2,000	
3	TDS	mg/l	not more than 1,300	
4	Temperature	°C	not more than 40°C	
5	DO	mg/l	not less than 5.0	
6	BOD	mg/l	not more than 20	ave.3(wet),ave.8(dry)
7	SS	mg/l	not more than 30	ave.6(wet),ave.2(dry)
8	Permanganate (PV)	mg/l	not more than 60	
9	Sulphide	mg/l	not more than 1	
10	Cyanide	mg/l	not more than 0.2	
11	Oil/fat	mg/l	not more than 5	
12	Formaldehyde	mg/l	not more than 5	
13	Phenol/Cresol	mg/l	not more than 1	
14	Cl	mg/l	not more than 1	
15	Pesticides and radioactive substance		None	
16	colour / odor		None	
17	Tar oil		None	
18	Heavy metal			
	Zn	mg/l	not more than 5	
	Cr	mg/l	not more than 0.3	<0.05, <0.05
	As	mg/l	not more than 0.25	
	Cu	mg/l	not more than 1	
	Hg	mg/l	not more than 0.005	<0.001, <0.001
	Cd	mg/l	not more than 0.03	<0.001, <0.001
	Ba	mg/l	not more than 1	
	Se	mg/l	not more than 0.02	
	Pb	mg/l	not more than 0.1	0.02, <0.01
	Ni	mg/l	not more than 0.2	0.03, 0.017
	Mn	mg/l	not more than 5	0.02, 0.006

Note : [1)] Si Phraya WWTP Effluent data.

Table 4.5.6.1 Water Use of Industrial Estate, Industrial Area in Bangkok

No.	Name		Location	Public or Private	No. of Company		Area ha	Unit Area ha/company	Water Source	Present Water Consumption m^3/d	Remarks
					Present	Full					
1	Bangchan	Industrial Estate	Khanna Yao	IEAT	74	75	108	1.44 [2]	G.W.	7,000 [1]	7,000 m^3/d / 108 ha = 65 $m^3/d/ha$
2	Lat Krabang	Industrial Estate	Lat Krabang	IEAT	147	200	383	1.92 [2]	G.W.	17,000 [1]	
3	Bung-Klo	Industrial Area	Nong Jok	Private	13	n.a.	23	n.a.	n.a.	n.a.	
4	Au-Ta-Nee	Industrial Estate	Prawet	Private	24	30	27	0.32	P.W.	n.a.	
5	Ring Shat-Sha-Wan [3]	Industrial Area	Bang Khun Thian	Private	134	2,000	52	0.03 [2]	n.a.	n.a.	mini factory
6	Bang-Bon	Industrial Area	Bang Bon	Private	n.a.	n.a.	11	0.02	P.W.	n.a.	mini factory, hasn't started
	Total				392		604				

Note: IEAT = Industrial Estate Authority Thailand
G.W. = Ground water
n.a. = not available
P.W. = Public Water Supply
[1] Data of year 1994
[2] Area(ha) / Full No. of Company
[3] Ring Shat-Sha-Wan = Ring Shat-Sha-Wan Factory and Ring Sang Pra Teep

Table 4.5.6.2 Water Use of Factory

No.	Name of Company	Type of Industry	Location	Production	Amount of Production	No. of Employee	Water Consumption (m^3/d)				Objectives of Water Use	
							P.W.	G.W.	Ri.W.	Re.W.		
1	Suba Farm	Food	Bung Kum	Killed & Preserved Meat	50 (t/d)	900	2,000			100	Re.W.	Wd (for crate)
2	Khun Rung Thiwa	Textile	Bang Kapi	Dying Clothes, Garments make-ups	12 (t/d of fabric)	3,000		3,600			G.W.	P=3,400 Bo=100 B+F=80
3	A certain company	Textile	A certain place	Dying Clothes, Spinning Thread	2 million yard/month	1,650		2,000			G.W.	P+Co+B+Wd=1,900 T+K+B+C+G+F+R=100

Note: P.W. = Public Water Supply
G.W. = Ground Water
Ri.W. = Chao Phraya River Water
Re.W. = Reclaimed Wastewater

Objectives of Re.W. Use:
C: Car wash
B: Bathroom
T: Toilet flushing
K: Kitchen use
G: Garden(Sprinkling)
F: Cleaning floor
Fi: Fire distinguish
R: Road Cleaning
P: Process water
Co: Cooling water
Bo: Boiler feeding
Wd: Washing water

Table 4.5.7.1 Requested Water Quality and Preferable Reuse Water Charge

Name of Institution etc.	Potential Demand	Requested Water Quality	Preferable Reuse Water Charge
Queen Sirikit Park	Plant Watering	decided by objective of water use	don't pay groundwater tariff because of public facilities
Royal Golf & Country Club	Plant Watering	decided by objective of water use	no willingness to pay money for water
Holiday Inn Hotel	Building Miscellaneous Water	decided by objective of water use	less than water supply charge 14 Baht/m^3
RID (Royal Irrigation Department)	Irrigation	no odor and color, hygienic and RID Irrigation standards	free
A certain company (dyeing)	Industrial Water	equal groundwater, no impurity	less than groundwater tariff 3.5 Baht/m^3
IWTI (Industrial Water Technology Institute)	Industrial Water	various and very strict, for example, EC for cooling water is about 0.25	7.5 Baht/m^3 (Industrial Exclusive Water Supply Plan in Samut Prakarn Province)

Table 4.5.8.1 Demand for Reclaimed Wastewater

Potential Demand for Reclaimed Wastewater	Water source	Demand	Related problem	Demand for Reclaimed
Road Plant Watering/ Road Cleaning	Khlong Water	a lot	Polluted	a lot
	River Water	a lot	Salt	
	Ground Water	sometimes	Subsidence	
	Public Water Supply	a few	high cost	
Building Miscellaneous Water	Khlong Water	-	-	sometimes
	River Water	a few	Salt	
	Ground Water	-	-	
	Public Water Supply	a lot	high cost	
Plant Watering (Parks, Golfcource etc.)	Khlong Water	a lot	Polluted	sometimes
	Ground Water	a lot	Subsidence	
Purification of Khlong	-	-	-	a lot
Agricultural Water Use	Khlong Water	a lot	Shortage	a potential
Industrial Water Use	Ground Water	sometimes	Subsidence	a potential
	Public Water Supply	a few	high cost	

Table 4.5.8.2 Reclaimed Wastewater Reuse by Each Item (1998)

Potential Demand for Reclaimed Wastewater	Forecast Demand for Reclaimed Wastewater (Public WWTP)		Type of Reuse	Drought Mitigation		Environmental Improvement			Land Subsidence
						Green Area Expansion		Environmental Purification	
				Public	Private	Public	Private		
	(m^3/d)	%		(m^3/d)	(m^3/d)	(m^3/d)	(m^3/d)	(m^3/d)	(m^3/d)
Road Plant Watering/Cleaning Road	**180**	**0.9**	Reuse		-	180[4]	18[5]	-	-
Buildings Miscellaneous Water	(20)	(0.1)	Recycle	20[2]	250[3]		-	-	-
Plant Watering (Parks, Golfcource etc.)	-	-	Reuse		-	-	50[6]	-	-
Purification of Khlong	**19,820**	**99.1**	Discharge		-		-	19,820	-
Agricultural Water	-	-	Reuse		-		-	-	-
Industrial Water	-	-	Reuse		-		-	-	-
Total	**20,000**[1]	**100.0**		20[2]	250[3]	180	68	19,820	-

Note :

[1] Total value does not include the R.Q. of U.B. because it is recycled in Si Phraya WWTP.

[2] used for washing filter cloth etc. in the Si Phraya WWTP.

[3] used for toilet flushing etc. in Ramathibodi, Siriraj Hospital.

[4] from Si Phraya WWTP

[5] from Esso building for Rama IV Road plant watering.

[6] from on-site buildings for plant watering.

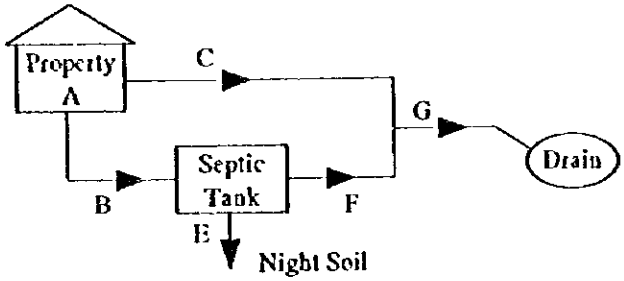
Table 6.1.1.1 Domestic Unit Flow and Load Determinations and Forecasts (1/2)

Source	DWF per Person (l/c/d)	Peak Flow for Intercepor (xDWF)	BOD per Person (g/c/d)	Comment
Si Phraya (existing)	250	1	16	Flow from WWTP design capacity. BOD from measured BOD concentration. Includes non-domestic flow.
Ratanakosin (on going)	250	n.a.	n.a.	Flow from WWTP capacity. Includes non-domestic flow.
Din Daeng (BMA 1) (on going)	410	5	82	Flow based on 100% water consumption records. Peak from Contract Spec. BOD based on Spec. Concentration of 200 mg/l.
Yannawa (BMA 2) (on going)	357 (Ph 1) 400 (Ph 2)	5	54 (Ph 1) 80 (Ph 2)	DWF from Spec. total flow and popn. Peak from Spec. BOD from Spec. concentrations of 150 and 200 mg/l. Includes non-domestic flow.
Nong Khaem (BMA 3) (on going)	376	5	56 (Ph 1) 75 (Ph 2	Flow from Spec. Peak from Spec. BOD from Spec. concentration. Includes non-domestic flow.
Ratburana (BMA 3) (on going)	376	5	56 (Ph 1) 75 (Ph 2	Flow from Spec. Peak from Spec. BOD from Spec. concentration. Includes non-domestic flow.
Chatuchak (BMA 4) (before contract)	376	5	56 (Ph 1) 75 (Ph 2)	DWF from Spec. total flow and popn. Peak from Spec. BOD from Spec. concentrations of 150 and 200 mg/l. Includes non-domestic flow.
Plan for Khlong Toey and Thonburi (1998)	376	5	56 (Ph 1) 75 (Ph 2)	Flow from SAPROF study for OECF based on: 256 l/c/d domestic + 120 l/c/d non-domestic as above. Peak from BMA. BOD based on BMA concentration criteria of 150 and 200 mg/l.
PCD BMR Wastewater Management Master Plan (1993)	200 (1990) 220 (2000) 240 (2010) 260 (2020)	3	30	Flow based on 80% of forecast water consumption from MWA. BOD not explained

Table 6.1.1.1 Domestic Unit Flow and Load Determinations and Forecasts (2/2)

Source	DWF per Person (l/c/d)	Peak Flow for Intercepor (xDWF)	BOD per Person (g/c/d)	Comment
PCD BMR Wastewater Management Plan (1996)	209-512 (1997) 222-516 (2001) 239-542 (2006) 257-570 (2011) 277-599 (2016)	5 for small upstream areas reducing to 2 for large down-stream areas.	35 (1996) 50 (2016)	Water consumption forecasts from MWA and Provincial Waterworks Authority (PWA). No explanation for BOD in available reports. Assumes that wastewater is equal to water consumption.
MWA Master Plan for Water Supply (1990)	190/230 (1987) 200/242 (1997) 210/254 (2007) 220/260 (2017)			Water demand not wastewater forecasts for Central Business Districts/outside Central Business Districts. These are exclusive of government, commercial and industrial demands
Current MWA planning (1998)	256 (to 2017)			Domestic water demand only. This is as later planned BMA Schemes where 120 l/c/d is added for non-domestic flow.
Wastewater User Charge Study (1998)	as PCD BMR Master Plan above			
NESDB Water Quality Management Study (1988)			48	53 mg/l at source, 48 mg/l at the drain due to losses in septic tank
Sludge Master Plan Survey (1988) in Huay Kwuang WWTP Catchment	183		45	Based on metered water consumption and measured BOD concentration in 1996. This is considered the most relevant indication of unit flow and load although no septic tanks are provided in this catchment.

Table 6.1.1.2 Domestic BOD Production and Discharge to Drain



A = B + C
E = B x D and is reduced by anaerobic decomposition in the Septic Tank
F = B - E
G = C + F

Domestic BOD Production and Discharge to Drain

	Unit	Range	Value adopted for Master Plan
BOD produced			
Total (A)	g/c/d	43 - 55	49
Toilet Waste (B)	g/c/d	22	22
Other Wastes (C)	g/c/d	12 - 33	27
Septic Tank			
BOD reduction (D)	%	20 - 50	40
BOD removed (E)	g/c/d	5 - 11	9
BOD in effluent (F)	g/c/d	17 - 22	13
BOD discharged & Drain (G)	g/c/d	32 - 50	40

Table 6.1.2.1 Selection of Areas for Future Wastewater Schemes

Implementation	Name of the AREA	Area (km²)	Forecast Population in 2020 (x1000)	Target Year	Forecast Density (pers/ha)	Selection Criteria					Score (a) %	Priority for Sewerage and WWTPs	
						Density	City Planning	Transport	Industry	Khlong Quality		Rank (b)	Category
Existing	Si Phraya	2.7	120	2009	444	Point max = 6 1=<100/ha 2=100-125 3=125-150 4=150-175 5=175-200 6=>200	Point max = 3 1=all low 2=some med 3=some high	Point max = 2	Point max = 1	Point for ave. BOD in mg/l 0=<10 1=10-20 2=20-30 3=>30 N.D=No Data			1 = 1st Priority 2 = 2nd Priority 3 = 3rd Priority
Under	Ratanakosin	4.1	160	2011	171								
	Din Daeng (Stage 1)	37.8	1,080	2015	291								
	Yannawa (Stage 2)	28.5	900	2020	316								
	Nong Khaem (Stage 3)	44.0	450	2020	104								
	Rathburana (Stage 4)	42.0	375	2020	87								
	Chatuchak (Stage 5)	33.4	430	2015	129								
Planned	Thonburi South	22.3	565	2020	253	6	3	2	0	3	93	1	1
	Thonburi Central	17.5	399	2020	228	6	3	0	0	1	80	3	1
	Thonburi North	11.4	215	2020	188	5	3	1	0	3	80	3	1
	Khlong Toey West	25.7	396	2020	154	4	3	2	0	2	73	4	1
	Khlong Toey East	31.9	452	2020	142	3	2	2	1	2	67	5	1
	Nong Bon	55.0	372	2020	68	1	1	2	1	1	40	10	3
Proposed	Bang Sue	19.7	415	2020	211	6	3	2	0	2	87	2	2
	Huay Kwuang	15.3	317	2020	207	6	2	2	0	2	80	3	2
	Wang Thong Lang	35.7	479	2020	134	3	2	2	0	2	60	6	2
	Bung Kum	42.8	512	2020	120	3	2	1	0	N.D	50	7	2
	Lat Krabang	16.5	172	2020	95	2	2	2	1	N.D	50	7	3
	Lak Si	25.1	300	2020	120	2	1	2	0	2	47	8	3
	Eastern Corridor	44.9	337	2020	75	1	2	1	1	2	47	8	3
	City South West	47.6	409	2020	86	1	2	2	1	1	47	8	3
	Don Muang	29.7	364	2020	123	2	1	2	0	N.D	42	9	3
	Sai Mai	51.2	531	2020	104	2	1	2	0	N.D	42	9	3
	Bang Khen	22.3	238	2020	107	2	2	1	0	1	40	9	3
	Lat Phrao	26.3	274	2020	104	2	1	0	0	N.D	25	11	3
	Nong Jok	26.1	125	2020	48	1	2	0	0	N.D	25	11	3
TOTAL	Existing/Under Construction	109	3,143		280								
	Planned Cat1	164	2,421		148								
	Proposed Cat2	114	1,723		151								
	Proposed Cat3	347	3,122		90								
	Total	762	10,360		135								

Note:
(a) % from total score of 15 where Khlong data available, and 12 where not.
(b) Reverse order of score

Table 6.1.2.2 Proposed Programme for Future Wastewater Schemes

Wastewater Scheme Yannawa Phase 1	Assumed Completion
Ratanakosin	1999
Yannawa Phase 1	
Din Daeng Phase 1	2000
Nong Khaem	2001
Ratburana	
Chatuchak	2003
Thonburi South Phase 1	2005
Thonburi Central Phase 1	2006
Thonburi North Phase 1	2007
Khlong Toey West Phase 1	2008
Khlong Toey East Phase 1	2009
Din Daeng Phase 2	2010
Bang Sue	2012
Huay Kwuang	2014
Yannawa Phase 2	2015
Ratburana Phase 2	
Thonburi South Phase 2	
Wang Thong Lang	2016
Thonburi Central Phase 2	
Thonburi North Phase 2	2017
Bung Kum	2018
Khlong Toey West Phase 2	
Khlong Toey East Phase 2	2019

Table 6.1.3.1 Forecasts of Wastewater Flows and Loads for Proposed New Service Areas (1/2)

Future Master Plan Service Area	Area	Forecast Population			Forecast Domestic Flow			Forecast Domestic BOD			Forecast Commercial and Institutional Flow			Forecast Commercial and Institutional BOD		
		2000	2010	2020	2000	2010	2020	2000	2010	2020	2000	2010	2020	2000	2010	2020
	(km^2)	(x1000)	(x1000)	(x1000)	($x10^3$ m^3/d)	($x10^3$ m^3/d)	($x10^3$ m^3/d)	(t/d)	(t/d)	(t/d)	($x10^3$ m^3/d)	($x10^3$ m^3/d)	($x10^3$ m^3/d)	(t/d)	(t/d)	(t/d)
Thonburi South	22.3	534	549	565	136.7	140.5	144.6	21.4	22.0	22.6	7.0	7.2	7.4	1.0	1.0	1.1
Thonburi Central	17.5	355	376	400	90.9	96.3	102.4	14.2	15.0	16.0	15.2	16.1	17.1	3.0	3.2	3.4
Thonburi North	11.4	175	193	216	44.8	49.4	55.3	7.0	7.7	8.6	9.0	9.9	11.1	3.2	3.5	3.9
Khlong Toey West	25.7	333	369	406	85.2	94.5	103.9	13.3	14.8	16.2	13.3	14.7	16.2	4.0	4.4	4.9
Khlong Toey East	31.9	278	354	453	71.2	90.6	116.0	11.1	14.2	18.1	3.4	4.3	5.5	0.5	0.6	0.8
Total planned	**108.8**	**1675**	**1841**	**2040**	**428.8**	**471.3**	**522.2**	**67.0**	**73.7**	**81.6**	**47.9**	**52.2**	**57.3**	**11.7**	**12.7**	**14.1**
Bang Sue	19.7	327	359	391	83.7	91.9	100.1	13.1	14.4	15.6	7.6	8.3	9.1	2.1	2.3	2.5
Huay Kwuang	15.3	164	228	317	42.0	58.4	81.2	6.6	9.1	12.7	12.2	17.0	23.6	4.6	6.4	8.9
Wang Thong Lang	35.7	274	361	478	70.1	92.4	122.4	11.0	14.4	19.1	4.2	5.5	7.3	0.6	0.8	1.0
Bung Kum	42.8	256	362	512	65.5	92.7	131.1	10.2	14.5	20.5	2.5	3.5	5.0	0.2	0.3	0.4
Total proposed	**113.5**	**1021**	**1310**	**1698**	**261.3**	**335.4**	**434.8**	**40.9**	**52.4**	**67.9**	**26.5**	**34.3**	**45.0**	**7.5**	**9.8**	**12.8**
TOTAL	**222.3**	**2696**	**3151**	**3738**	**690.1**	**806.7**	**957.0**	**107.9**	**126.1**	**149.5**	**74.4**	**86.5**	**102.3**	**19.2**	**22.5**	**26.9**

Table 6.1.3.1 Forecasts of Wastewater Flows and Loads for Proposed New Service Areas (2/2)

Future Master Plan Service Area	Area	Forecast Industrial Flow			Forecast Industrial BOD			Forecast Total DWF			Forecast Total BOD			Forecast BOD at WWTP			Forecast Total Sludge		
		2000	2010	2020	2000	2010	2020	2000	2010	2020	2000	2010	2020	2000	2010	2020	2000	2010	2020
	(km^2)	($x10^3$ m^3/d)	($x10^3$ m^3/d)	($x10^3$ m^3/d)	(t/d)	(t/d)	(t/d)	($x10^3$ m^3/d)	($x10^3$ m^3/d)	($x10^3$ m^3/d)	(t/d)	(t/d)	(t/d)	(t/d)	(t/d)	(t/d)	(t DS/d)	(t DS/d)	(t DS/d)
Thonburi South	22.3	35.2	46.2	60.7	6.2	8.1	10.7	178.9	193.9	212.7	28.6	31.1	34.4	20.0	21.8	24.1	20.0	21.8	24.1
Thonburi Central	17.5	21.1	27.7	36.4	2.6	3.4	4.5	127.2	140.1	155.9	19.8	21.6	23.9	13.9	15.1	16.7	13.9	15.1	16.7
Thonburi North	11.4	6.7	8.8	11.5	0.8	1.1	1.4	60.5	68.1	77.9	11.0	12.3	13.9	7.7	8.6	9.8	7.7	8.6	9.8
Khlong Toey West	25.7	26.4	34.7	45.5	2.6	3.4	4.5	124.9	143.9	165.6	19.9	22.6	25.6	13.9	15.8	17.9	13.9	15.8	17.9
Khlong Toey East	31.9	19.4	25.5	33.4	2.0	2.6	3.4	94.0	120.4	154.9	13.6	17.4	22.3	9.5	12.2	15.6	9.5	12.2	15.6
Total planned	**108.8**	**108.8**	**142.9**	**187.5**	**14.2**	**18.6**	**24.5**	**585.5**	**666.4**	**767.0**	**92.9**	**105.0**	**120.2**	**65.0**	**73.5**	**84.1**	**65.0**	**73.5**	**84.1**
Bang Sue	19.7	9.8	12.9	16.9	2.0	2.6	3.4	101.1	113.1	126.1	17.2	19.3	21.5	12.0	13.5	15.1	12.0	13.5	15.1
Huay Kwuang	15.3	11.3	14.8	19.5	1.2	1.6	2.1	65.5	90.2	124.3	12.4	17.1	23.7	8.7	12.0	16.6	8.7	12.0	16.6
Wang Thong Lang	35.7	6.6	8.7	11.4	0.8	1.1	1.4	80.9	106.6	141.1	12.4	16.3	21.5	8.7	11.4	15.1	8.7	11.4	15.1
Bung Kum	42.8	6.8	8.9	11.7	0.7	0.9	1.2	74.8	105.1	147.8	11.1	15.7	22.1	7.8	11.0	15.5	7.8	11.0	15.5
Total proposed	**113.5**	**34.5**	**45.3**	**59.5**	**4.7**	**6.2**	**8.1**	**322.3**	**415**	**539.3**	**53.1**	**68.4**	**88.8**	**37.2**	**47.9**	**62.3**	**37.2**	**47.9**	**62.3**
TOTAL	**222.3**	**143.3**	**188.2**	**247.0**	**18.9**	**24.8**	**32.6**	**907.8**	**1081.4**	**1306.3**	**146.0**	**173.4**	**209.0**	**102.2**	**121.4**	**146.4**	**102.2**	**121.4**	**146.4**

Note:
Domestic flow at 256 l/c/d
Domestic BOD at 40g/c/d at drain entry throughout
Commercial and Institutional flow from 1993 PCD BMR Master Plan basic data, projected flows proportional to population + allowance for educational establishments
Commercial and Institutional BOD derived in the same way as flow but no BOD allowance for educational establishments
Industrial flow from1993 PCD BMR Master Plan basic data, projected flows proportional to forecast growth in manufacturing GDP of 2.76% pa
Industrial BOD in the same way as flow
BOD reduction in Drainage system assumed at 30 %
Sludge production at 1.0 kg/kg BOD

Table 6.1.3.2 Determination of Commercial and Institutional Flows and Loads in 2000

Name of Catchment Area	District Name	District Area (km^2)	Percentage of District Area (%)	Catchment Area (km^2)	In Previous Master Plan		In Educa/Social Establishments		Total	
					Flow ($x10^3 m^3/d$)	BOD (t/d)	Population (x1000)	Flow ($x10^3 m^3/d$)	Flow ($x10^3 m^3/d$)	BOD (t/d)
Khlong Toey West	Khlong Toey	12.27	100	12.27	5.3	2.0				
	Vadhana	13.28	100	13.28	5.3	2.0				
Total				25.55	10.6	4.0	66.6	2.7	13.3	4.0
Khlong Toey East	Phra Khanong	13.60	75	10.20	0.5	0.2				
	Suan Luang	23.68	40	9.47	0.0	0.0				
	Bang Na	20.28	70	14.20	0.7	0.3				
Total				33.87	1.2	0.5	55.6	2.2	3.4	0.5
Thonburi North	Bang Phlat	11.36	100	11.36	7.6	3.2				
Total				11.36	7.6	3.2	35.0	1.4	9.0	3.2
Thonburi Central	Bangkok Noi	11.94	95	11.34	2.6	0.3				
	Bangkok Yai	6.18	100	6.18	9.8	2.7				
Total				17.52	12.4	3.0	71.0	2.8	15.2	3.0
Thonburi South	Thonburi	8.63	100	8.63	0.9	0.2				
	Khlong San	6.05	100	6.05	1.5	0.6				
	Chom Thong	26.25	35	9.19	0.3	0.2				
Total				23.87	2.7	1.0	106.8	4.3	7.0	1.0
Bang Sue	Dusit	10.67	20	2.13	0.8	0.1				
	Bang Sue	11.55	90	10.40	3.2	1.5				
	Chatuchak	32.91	20	6.58	1.0	0.2				
Total				19.11	5.0	2.1	65.4	2.6	7.6	2.1
Huay Kwang	Huay Kwang	15.30	100	15.30	10.9	4.6				
Total				15.30	10.9	4.6	32.8	1.3	12.2	4.6
Wang Thong Lang	Bang Kapi	29.70	40	11.85	0.7	0.2				
	Suan Luang	23.68	10	2.37	0.0	0.0				
	Wang T. L.	19.21	100	19.21	1.2	0.4				
Total				33.46	1.9	0.6				
Adjusted Total				35.70	2.0	0.6	54.8	2.2	4.2	0.6
Bang Kum	Bang Kum	25.00	90	22.50	0.3	0.1				
	Khanna Yao	28.72	60	17.23	0.2	0.1				
	Lat Phrao	30.48	25	7.62	0.1	0.0				
Total				47.35	0.6	0.2				
Adjusted Total				42.80	0.5	0.2	51.2	2.0	2.5	0.2

Note:
Areas from Wastewater User Charge Study or measured.
% areas from Wastewater User Charge Study or from inspection adjusted to measured total
2000 flows and BOD derived from PCD BMR Wastewater Management Master Plan
Population of Educational Establishments taken as 20% of total with flow of 40 l/c/d with no allowance for additional load

Table 6.1.3.3 Determination of Industrial Flows and Loads in 2000

Name of Catchment Area	District Name	District Area (km^2)	Percentage of District Area (%)	Catchment Area (km^2)	1996		1990		2000	
					Flow ($x10^3 m^3/d$)	BOD (t/d)	Flow ($x10^3 m^3/d$)	BOD (t/d)	Flow ($x10^3 m^3/d$)	BOD (t/d)
Khlong Toey West	Khlong Toey	12.27	100	12.27	12.3	1.2				
	Vadhana	13.28	100	13.28	12.3	1.2				
Total				25.55	24.6	2.4	20.1	2.0	26.4	2.6
Khlong Toey East	Phra Khanoong	13.60	75	10.20	6.9	0.7				
	Suan Luang	23.68	40	9.47	2.2	0.2				
	Bang Na	20.28	70	14.20	9.0	0.9				
Total				33.87	18.1	1.8	14.8	1.5	19.4	2.0
Thonburi North	Bang Phlat	11.36	100	11.36	6.2	0.7				
Total				11.36	6.2	0.7	5.1	0.6	6.7	0.8
Thonburi Central	Bangkok Noi	11.94	95	11.34	7.1	0.9				
	Bangkok Yai	6.18	100	6.18	12.6	1.6				
Total				6.18	12.6	1.6	16.1	2	21.1	2.6
Thonburi South	Thonburi	8.63	100	8.63	14.2	2.4				
	Khlong San	6.05	100	6.05	12.2	1.6				
	Chom Thong	26.25	35	9.19	6.4	1.7				
Total				23.87	32.8	5.7	26.8	4.7	35.2	6.2
Bang Sue	Dusit	10.67	20	2.13	1.3	0.2				
	Bang Sue	11.55	90	10.40	7.1	1.5				
	Chatuchak	32.91	20	6.58	0.8	0.1				
Total				19.11	9.2	1.8	7.5	1.5	9.8	2.0
Huay Kwuang	Huay Kwuang	15.30	100	15.30	10.5	1.1				
Total				15.30	10.5	1.1	8.6	0.9	11.3	1.2
Wang Thong Lang	Bang Kapi	29.70	40	11.88	1.9	0.2				
	Suan Luang	23.68	10	2.37	0.6	0.1				
	Wang T. L	19.21	100	19.21	3.2	0.4				
Total				33.46	5.7	0.7	4.7	0.6		
Adjusted Total				35.70	6.1	0.7	5.0	0.6	6.6	0.8
Bung Kum	Bung Kum	25.00	90	22.50	2.5	0.3				
	Khanna Yao	28.72	60	17.23	2.2	0.2				
	Lat Phrao	30.48	25	7.62	2.3	0.2				
Total				47.35	7.0	0.7	5.7	0.6		
Adjusted Total				42.80	6.3	0.6	5.2	0.5	6.8	0.7

Note:
Areas from Wastewater User Charge Study or measured.
% areas from Wastewater User Charge Study or from inspection adjusted to measurd total
1996 flows and BOD derived from Wastewater User Charge Study tables
1990 figures back calculated at 3.33% pa growth in GDP taken from PCD BMR Master Plan
2000 figures projected at 2.76% pa growth

Table 6.1.3.4 Provisional Schedule of Central WWTP Process Units for Proposed Wastewater Schemes (1/2)

Wastewater Scheme	DWF	BOD Load	Sludge Solids	Preliminary Treatment						
				Flow	Raked Bar Screens		Fine Drum Screens		Vortex Grit Separators	
					No	Size W x D	No	Size Dia. x W	No	Size Dia.
	($x10^3$ m^3/d)	(t/d)	(t DS/d)	($x10^3$ m^3/d)		(m x m)		(m x m)		(m)
Khlong Toey West	166	18	17	830	5	2.0 x 2.0	5	5.0 x 2.5	4	9.0
Khlong Toey East	155	16	19	775	4	2.0 x 2.0	4	5.0 x 2.5	4	9.0
Thonburi North	78	10	10	390	3	2.0 x 2.0	3	5.0 x 2.5	2	9.0
Thonburi Central	156	17	16	780	4	2.0 x 2.0	4	5.0 x 2.5	4	9.0
Thonburi South	213	24	22	1,065	5	2.0 x 2.0	5	5.0 x 2.5	4	10.0
Bang Sue	126	15	15	630	4	2.0 x 2.0	4	5.0 x 2.5	4	8.0
Huay Kwuang	124	17	17	620	4	2.0 x 2.0	4	5.0 x 2.5	4	8.0
Wang Thong Lang	141	15	15	705	4	2.0 x 2.0	4	5.0 x 2.5	4	8.0
Bung Kum	148	16	16	740	4	2.0 x 2.0	4	5.0 x 2.5	4	8.0

Wastewater Scheme	Biological Treatment		
	Modified SBR ASP process		
	Flow	No of Basins	Size L x W x D
	($x10^3$ m^3/d)		(m)
Khlong Toey West	249	24	48x18x4.5
Khlong Toey East	233	24	43x18x4.5
Thonburi North	117	24	26x18x4.5
Thonburi Central	234	24	46x18x4.5
Thonburi South	320	24	64x18x4.5
Bang Sue	189	24	40x18x4.5
Huay Kwuang	186	24	44x18x4.5
Wang Thong Lang	212	24	40x18x4.5
Bung Kum	222	24	43x18x4.5

Table 6.1.3.4 Provisional Schedule of Central WWTP Process Units for Proposed Wastewater Schemes (2/2)

Flows, Loads and Capacities
Flows and loads from Table 6.2.8
Preliminary treatment capacity at 5 x DWF
Biological treatment capacity at 1.5 x DWF

Process Sizing:
Coarse bar screens limited to 0.9 m/s through bars with stand-by unit
Fine drum screens with 5 mm apertures with stand-by unit
unit capacity from manufacturer: 5 m dia x 2.5 m width for max 2.9 m^3/s
= 250,000 m^3/d
Vortex grit separators with grit classifiers with stand-by classifier
unit capacity from manufacturer: 10 m dia for max 3 m^3/s = 260 m^3/d,
9 m dia for 210 m^3/s, 8 m dia for 170 m^3/s
Mod. SBR ASP basins calculated assuming
F/M ratio of 0.09 kg/kg.d, MLSS of 2,500 mg/l and 2.0 h settling/decant time

W = Width
D = Depth
L = Length
H = Height

Calculation of SBR Basin Capacities

Wastewater Scheme	DWF ($x10^3$ m^3/d)	BOD Load (t/d)	F/M ratio Assumed (kg/kg.d)	ML Solids (t)	MLSS Assumed (mg/l)	Reactor Capacity ($x10^3$ m^3)	Hydraulic Retention for Reaction (h)	Settling/ Decant Time Assumed (h)	Total Retention (h)	Total Basin Capacity ($x10^3$ m^3)
Khlong Toey West	166	18	0.09	200	2,500	80	11.6	2.0	13.6	94
Khlong Toey East	155	16	0.09	178	2,500	71	11.0	2.0	13.0	84
Thonburi North	78	10	0.09	111	2,500	44	13.7	2.0	15.7	51
Thonburi Central	156	17	0.09	189	2,500	76	11.6	2.0	13.6	89
Thonburi South	213	24	0.09	267	2,500	107	12.0	2.0	14.0	124
Bang Sue	126	15	0.09	167	2,500	67	12.7	2.0	14.7	77
Huay Kwuang	124	17	0.09	189	2,500	76	14.6	2.0	16.6	86
Wang Thong Lang	141	15	0.09	167	2,500	67	11.3	2.0	13.3	78
Bung Kum	148	16	0.09	178	2,500	71	11.5	2.0	13.5	83

Table 6.2.1.1 Past Record of Night Soil Collection

Month/Year	Total Number of Houses Served	Nightsoil Quantity of Transferred for Treatment (m^3)	Nightsoil Collected per House (m^3/house/year)	Nightsoil Collected per Capita (m^3/cap/year)
Oct.1991	9,428	7,444	0.79	0.20
Nov.1991	9,594	10,683	1.11	0.28
Dec.1991	9,625	10,794	1.12	0.28
Jan.1992	11,910	12,415	1.04	0.26
Feb.1992	9,787	12,731	1.30	0.33
Mar.1992	10,410	11,348	1.09	0.27
Apr.1992	7,985	9,561	1.20	0.30
May.1992	8,045	10,381	1.29	0.32
Jun.1992	9,863	12,173	1.23	0.31
Jul.1992	9,537	11,815	1.24	0.31
Aug.1992	9,256	10,691	1.16	0.29
Sep.1992	10,097	10,180	1.01	0.25
Total	115,537	130,216	1.13	0.28 (0.767 l/c/d)
Oct.1992	10,452	12,550	1.20	0.30
Nov.1992	10,198	12,141	1.19	0.30
Dec.1992	10,674	13,210	1.24	0.31
Jan.1993	10,993	13,750	1.25	0.31
Feb.1993	11,314	13,960	1.23	0.31
Mar.1993	11,288	13,783	1.22	0.31
Apr.1993	8,963	10,959	1.22	0.31
May.1993	10,005	12,340	1.23	0.31
Jun.1993	9,800	12,172	1.24	0.31
Jul.1993	10,652	13,078	1.23	0.31
Aug.1993	9,806	12,916	1.32	0.33
Sep.1993	10,460	12,203	1.17	0.29
Total	124,605	153,062	1.23	0.31 (0.849 l/c/d)

Source: Final Report of Master Plan on Treatment and Disposal of Domestic Sewage Sludge including Night Soil and Oil and Grease Residues for Baukok Metropolitan, by AIT (1995)
Note: These are the records during the period between Oct. 1990 - Sept. 1993.

Table 6.2.2.1 Expansion Plan of Night Soil Collection in 2020

No.	District	Living Population (-)	Collection Ratio (%)	Served Population (-)	Collected Night Soil (m^3/d)	Service Area
1	PHRA NAKHORN	125,800	20.0	25,160	25.2	Ratburana
2	DUSIT	220,100	20.0	44,020	44.0	Ratburana
3	NONG JOK	156,000	10.0	15,600	15.6	On-Nut
4	BANG RAK	131,800	20.0	26,360	26.4	Yannawa
5	BANG KHEN	403,800	20.0	80,760	80.8	Yannawa
6	BANG KAPI	371,600	20.0	74,320	74.3	On-Nut
7	PATHUMWAN	200,400	20.0	40,080	40.1	Yannawa
8	POM PRAP SATTRU PHAI	135,500	30.0	40,650	40.7	Ratburana
9	PHRA KHANONG	238,700	20.0	47,740	47.7	Yannawa
10	MIN BURI	246,300	30.0	73,890	73.9	On-Nut
11	LAT KRABANG	343,000	30.0	102,900	102.9	On-Nut
12	YAN NAWA	152,500	30.0	45,750	45.8	Yannawa
13	SAMPHANTHAWONG	71,600	30.0	21,480	21.5	Ratburana
14	PHAYA THAI	181,400	20.0	36,280	36.3	Yannawa
15	THON BURI	296,800	30.0	89,040	89.0	Non Khaem
16	BANGKOK YAI	184,000	20.0	36,800	36.8	Non Khaem
17	HUAY KWUANG	311,500	20.0	62,300	62.3	Yannawa
18	KHLONG SAN	189,300	30.0	56,790	56.8	Ratburana
19	TALING CHAN	146,700	20.0	29,340	29.3	Non Khaem
20	BANGKOK NOI	226,500	20.0	45,300	45.3	Non Khaem
21	BANG KHUN THIAN	208,400	20.0	41,680	41.7	Non Khaem
22	PHASI CHAROEN	295,600	20.0	59,120	59.1	Non Khaem
23	NONG KHAEM	218,900	20.0	43,780	43.8	Non Khaem
24	RAT BURANA	270,400	20.0	54,080	54.1	Ratburana
25	BANG PHLAT	214,800	20.0	42,960	43.0	Non Khaem
26	DIN DAENG	359,900	30.0	107,970	108.0	Yannawa
27	BUNG KUM	395,000	20.0	79,000	79.0	On-Nut
28	SATHORN	168,100	20.0	33,620	33.6	Yannawa
29	BANG SUE	324,400	20.0	64,880	64.9	Ratburana
30	CHATUCHAK	280,600	10.0	28,060	28.1	Yannawa
31	BANG KHO LAEM	185,000	20.0	37,000	37.0	Ratburana
32	PRAWET	163,900	20.0	32,780	32.8	On-Nut
33	KHLONG TOEY	233,500	20.0	46,700	46.7	Yannawa
34	SUAN LUANG	302,900	20.0	60,580	60.6	On-Nut
35	CHOM THONG	224,800	20.0	44,960	45.0	Non Khaem
36	DON MUANG	321,400	20.0	64,280	64.3	Yannawa
37	RATCHATHEWI	238,000	30.0	71,400	71.4	Yannawa
38	LAT PHRAO	315,600	20.0	63,120	63.1	Yannawa
39	BANG NA	216,200	20.0	43,240	43.2	Yannawa
40	VADHANA	172,300	30.0	51,690	51.7	Yannawa
41	SAI MAI	373,600	20.0	74,720	74.7	On-Nut
42	LAK SI	300,000	20.0	60,000	60.0	Yannawa
43	WANG THONG LANG	268,800	20.0	53,760	53.8	Yannawa
44	KHANNA YAO	217,700	20.0	43,540	43.5	On-Nut
45	SAPHAN SUNG	222,600	20.0	44,520	44.5	Ratburana
46	SAM WA	203,800	10.0	20,380	20.4	On-Nut
47	BANG KAE	332,000	10.0	33,200	33.2	Non Khaem
48	BANG BON	147,500	10.0	14,750	14.8	Non Khaem
49	THAWI WATTANA	112,600	10.0	11,260	11.3	Non Khaem
50	THUNG KRUE	234,400	10.0	23,440	23.4	Non Khaem
	BMA Total	11,856,000	20.6	2,445,030	2,445	

Note : JICA Study Team

Table 6.3.3.1 Reclaimed Wastewater Reuse Amount for Road Plant Watering and Road Cleaning

No.	Name of WWTP	Treatment Capacity	Reclaimed Wastewater Reuse Quantity					
			Existing			by 2020		
			Area	W.Q. of R.W. $m^3/d/100ha$	W.Q. of R.C. $m^3/d/100ha$	Area	W.Q. of R.W. $m^3/d/100ha$	W.Q. of R.C. $m^3/d/100ha$
				R.W.	R.C.		R.W.	R.C.
		m^3/d	ha	m^3/d	m^3/d	ha	m^3/d	m^3/d
1	Si Phraya	30,000	1,537	30	10	1,537	30	10
				461	154		461	154
2	Ratanakosin	40,000	1,814	30	10	1,814	30	10
				544	181		544	181
3	Din Daeng	341,500	2,508	30	10	2,508	30	10
				752	251		752	251
4	Yannawa	200,000	3,691	30	10	3,691	30	10
				1,107	369		1,107	369
5	Nong Khaem	157,000	8,401	30	10	8,401	30	10
				2,520	840		2,520	840
6	Ratburana	65,000	2,784	30	10	2,784	30	10
				835	278		835	278
7	Chatuchak	150,000	3,291	30	10	3,291	30	10
				987	329		987	329
8	Thonburi South	181,000	—	—	—	5,663	30	10
							1,699	566
9	Thonburi Central	158,000	—	—	—	1,812	30	10
							544	181
10	Thonburi North	78,000	—	—	—	1,136	30	10
							341	114
11	Khlong Toey West	165,000	—	—	—	2,555	30	10
							767	256
12	Khlong Toey East	185,000	—	—	—	3,388	30	10
							1,016	339
13	Bang Sue	126,000	—	—	—	1,155	30	10
							347	116
14	Huay Kwuang	124,000	—	—	—	1,503	30	10
							451	150
15	Wang Thong Lang	141,000	—	—	—	4,891	30	10
							1,467	489
16	Bung Kum	148,000	—	—	—	5,372	30	10
							1,612	537
Total		2,289,500	24,026	7,206	2,402	51,501	15,450	5,150
Annual amount(unit: thousand m^3/year)				1,973	125		4,229	269

Note: W.Q. = Watering Quantiy per hectare
R.W. = Road Plant Watering (everyday)
R.S. = Road Cleaning (once a week)

Table 6.3.3.2 Reclaimed Wastewater Reuse by Each Item (2020)

Plan	Potential Demand for Reclaimed Wastewater	Forecast Demand for Reclaimed Wastewater (Public WWTP)		Type of Reuse	Drought Mitigation		Environmental Improvement			Land Subsidence
							Green Area Expansion		Environmental Purification	
					Public	Private	Public	Private		
		(m^3/d)	%		(m^3/d)	(m^3/d)	(m^3/d)	(m^3/d)	(m^3/d)	(m^3/d)
Short Term Plan	Road Plant Watering	15,450	0.7	Reuse	-	-	15,450	720	-	-
	Road Cleaning	5150[1)]	-	Reuse	-	-	5,150	-	-	-
	Buildings Miscellaneous Water	(22,000)[2)]	(1.0)	Recycle	22,000[3)]	18,000[4)]	-	-	-	-
	Plant Watering (Parks, Golfcource etc.)	3,900	0.2	Reuse	-	-	3,900	2,000	-	3,900
	Purification of Khlong	2,270,150	99.1	Discharge	-	-	-	-	2,271,200	-
Long Term Plan	Agricultural Water	-	-	Reuse	n.a.	-	-	-	-	-
	Industrial Water	-	-	Reuse	n.a.	-	-	-	-	n.a.
	Total	2,289,500	100.0		-	-	-	-	-	-

Note :

1) one time per week.

2) Total value does not include the Reuse Quantity of Buildings, because it is recycled between WWTP and the buildings which use reclaimed wastewater.

3) from Public WWTP for toilet flushing etc.

4) from on-site WWTP for toilet flushing etc.

Table 6.3.4.1 Water Quality Standards for Reclaimed Wastewater Reuse

Parameter	Unit	Standard values		BMA Treated Effluent Quality Requirement
		Class 1	Class 2	
1 Number of coliform groups	colonies/100ml	1,000 or less	1000 or less	-
2 Biochemical Oxygen Demand (BOD)	mg/l	10 or less	5 or less	20 or less
3 Suspended Solid (SS)	mg/l	6 or less	3 or less	30 or less
4 hydrogen ion activity (pH)	-	5.8-8.6	5.8-8.6	-
5 Odor	-	n.u.	n.u.	-
6 Color	Pt-Co	40 or less	10 or less	-
7 N (total)	mg/l	-	-	10 or less
8 N (NH_3)	mg/l	-	-	5 or less
9 P	mg/l	-	-	2 or less
10 DO	mg/l	-	-	5 or more
Remarks		(a), (c)	(b)	

Note : n.u. = not unpleasant

Pt-Co = Platinum Cobalt Scale

(a) Water for plant watering, landscape

(b) Miscellaneous use (toilet flushing, floor cleaning, car washing)

(c) Exception in Class1 standards values

Landscapes: parks, golf course	Coliform MPN/100ml median (daily sampling)	23
Landscapes: playground, schoolyards	Coliform MPN/100ml median (daily sampling)	2.2

Table 6.3.4.2 Japanese Water Quality Standards for Reclaimed Wastewater Reuse

Name of Ministry		MOC		MOITI	MOHW
Usage		Landscape	Bathing	Miscellaneous use	Toilet flushing
Parameter	Unit				
1 Number of coliform groups	colonies/100ml	1,000 or less	50 or less	1,000 or less	1,000 or less
2 Biochemical Oxygen Demand (BOD)	mg/l	10 or less	3 or less	-	-
3 hydrogen ion activity (pH)	-	5.8-8.6	5.8-8.6	6.5-8.6	5.8-8.6
4 Turbidity	Silica Scale	10 or less	5 or less	-	-
5 Odor	-	n.u.	n.u.	n.u.	n.u.
6 Appearance	-	-	-	n.u.	n.u.
7 Chemical Oxygen Demand (COD)	mg/l	-	-	20 or less	-
8 Color	Pt-Co	40 or less	10 or less	1 or less	-
9 Total Solid (TS)	mg/l	-	-	800 or less	-
10 Free residual chlorine	mg/l	-	-	-	contain
Remark		(a)	(b)	(c)	

Note : MOC = Ministry of Construction
MOITI = Ministry of International Trade and Industry
MOHW = Ministry of Health and Welfare
n.u. = not unpleasant
Pt-Co = Platinum Cobalt Scale
(a) do not use water for bathing
(b) use water for bathing
(c) water for miscellaneous use : toilet flushing, plant watering, cooling water, cleaning and washing, car washing, landscape

Source : Japanese Guideline of Plan and Design on Sewage Works (1994), published by Japan Sewage Works Association

Table 6.3.4.3 Irrigation Standards for Reclaimed Wastewater Reuse

No.	Item	Unit	Irrigation Standards Value[1]	BMA Treated Effluent Quality Requirement	Japanese Irrigation Standards
1	pH		6.5 -8.5		6.0 -7.5
2	EC	micromos/cm	not more than 2,000		not more than 0.3 mS
3	TDS	mg/l	not more than 1,300		
4	Temperature	°C	not more than 40°C		
5	DO	mg/l	not less than 5.0		
6	BOD	mg/l	not more than 20	not more than 20	$COD_{(Mn)}$ not more than 6
7	TDS	mg/l	not more than 1,300		
8	SS	mg/l	not more than 30	not more than 30	not more than 100
9	Permanganate (PV)	mg/l	not more than 60		
10	Sulphide	mg/l	not more than 1		
11	Cyanide	mg/l	not more than 0.2		
12	Oil/fat	mg/l	not more than 5		
13	Formaldehyde	mg/l	not more than 5		
14	Phenol/Cresol	mg/l	not more than 1		
15	Cl^-	mg/l	not more than 1		
16	Pesticides and radioactive substance		None		
17	colour / odor		None		
18	Tar oil		None		
19	Heavy metal				
	Zn	mg/l	not more than 5		not more than 5
	Cr	mg/l	not more than 0.3		
	As	mg/l	not more than 0.25		not more than 0.05
	Cu	mg/l	not more than 1		not more than 0.02
	Hg	mg/l	not more than 0.005		
	Cd	mg/l	not more than 0.03		
	Ba	mg/l	not more than 1		
	Se	mg/l	not more than 0.02		
	Pb	mg/l	not more than 0.1		
	Ni	mg/l	not more than 0.2		
	Mn	mg/l	not more than 5		
	N(total)	mg/l		not more than 10	not more than 1.0
	$N(NH_3)$	mg/l		not more than 5	
	P	mg/l		not more than 2	
	DO	mg/l		more than 5	more than 5
20	Coliform[2),3)]	MPN/100ml			
	Irrigation, fish pond		2.2		
	Produce eaten raw, surface irrigated		2.2		
	Produce eaten raw, spray irrigated		2.2		
	Processed produce, surface irrigated		No requirement		
	Processed produce, spray irrigated		23		

Note : [1] Irrigation Standards value (RID) except Coliform values.

[2] Additional item, Coliform, MPN/100ml, median(daily sampling)

[3] Source: State of California wastewater reclamation criteria for irrigation and recreational imj

Table 6.3.5.1 Reclaimed Wastewater Reuse Plan for Road Plant Watering and Road Cleaning

No.	Name of WWTP	Treatment Capacity	Existing			by 2020		
			R.W.	U.N.	Total Cost	R.W.	U.N.	Total Cost
		m^3/d	m^3/d	units	thousand baht	m^3/d	units	thousand baht
1	Si Phraya	30,000	461	2	6,406	461	2	6,406
2	Ratanakosin	40,000	544	2	6,406	544	2	6,406
3	Din Daeng	341,500	752	3	9,609	752	3	9,609
4	Yannawa	200,000	1,107	4	12,812	1,107	4	12,812
5	Nong Khaem	157,000	2,520	8	25,624	2,520	8	25,624
6	Ratburana	65,000	835	3	9,609	835	3	9,609
7	Chatuchak	150,000	987	3	9,609	987	3	9,609
12	Thonburi South	181,000				1,699	6	19,218
11	Thonburi Central	158,000				544	2	6,406
10	Thonburi North	78,000				341	1	3,203
8	Khlong Toey West	165,000				767	3	9,609
9	Khlong Toey East	185,000				1,016	3	9,609
13	Bang Sue	126,000				347	1	3,203
14	Huay Kwuang	124,000				451	2	6,406
15	Wang Thong Lang	141,000				1,467	5	16,015
16	Bung Kum	148,000				1,612	5	16,015
Total		2,289,500	7,206	25	80,075	15,450	53	169,759

Note : Relaimed Wastewater Reuse Facilities are as follows :
Additional Treatment Facilities (Pump+Sand Filter)
Relaimed Wastewater Supply Facilities (Storage Tank + Pump + Service Tank)
One Package Capacity of Reclaimed Wastewater Reuse Facilities is 300 m^3/d.
U.N.=Unit Number
R.W.=Reclaimed Wastewater

Table 6.3.5.2 Khlong Purification by Reclaimed Wastewater (Khlong Toey East Catchment Area)

Khlong Number		Khlong Length km	Khlong Width(ave.) m	Volume of Khlong m^3	Applied Reclaimed Wastewater m^3/d
1	1	5.3			
	2	1.3			
	3	0.6			
	4	0.9			Khong Water Quality Improvement
	Subtotal	8.1	12.5	101,250	Project, System 4
2	1	2.6			
	2	1.1			
	3	1.2			
	4	1.1			
	5	1.1			Khong Water Quality Improvement
	Subtotal	7.1	7.5	53,250	Project, System 4
3	1	1.0			
	2	0.7			
	3	0.7			
	Subtotal	2.4	3	7,200	-
4	1	2.9			
	2	0.5			
	3	0.7			
	Subtotal	4.1	3	12,300	12,300
5	1	0.5			
	2	0.5			
	Subtotal	1.0	3	3,000	-
6	1	3.3			
	2	0.9			
	3	0.6			
	Subtotal	4.2	3	12,600	12,600
Total		26.9		189,600	24,900

Table 6.3.5.3 Cost Estimate for Khlong Purification Facilities (Khlong Toey East Catchment Area)

Quantity of Khlong Purification Reclaimed Wastewater Route 4 : 12,300 m^3/d
Route 6 : 12,600 m^3/d

Transportation Method by pipeline Thousand Baht

Route No.	Facilities	Specification	Q'ty	Initial Cost	Annual O&M Cost
Route 4	Pump well	65 m^3 x 1(4x4x4.5 m), concrete made	1	300	-
	Pump	5 m^3/min x 22 kW	2	1,600	1,350
	Transportation Pipeline	dia400 mm Ductile Pipe, 0.6 km in	1	6,200	-
		dia400 mm Ductile Pipe, 2.3 km under	1	47,800	-
	Subtotal			55,900	1,350
Route 6	Pump well	65 m^3 x 1(4x4x4.5 m), concrete made	1	300	-
	Pump	5 m^3/min x 30 kW	2	1,800	1,770
	Transportation Pipeline	dia400 mm Dictile Pipe, 2.0 km in	1	20,800	-
		dia400 mm Ductile Pipe, 1.8 km under	1	37,400	-
	Subtotal			60,300	1,770
Total				116,200	3,120

Unit Cost

Route	Initial	O & M	Total
Route 4	0.6	0.3	0.9
Route 6	0.7	0.4	1.1

Table 6.3.5.4 Khlong Purification by Reclaimed Wastewater (Khlong Toey East Catchment Area)

Khlong Number		Khlong Length km	Wastewater to khlong	Dilution ratio and BOD(mg/l) after dilution				
				5	10	13	15	20
				32.7	22.4	19.7	18.5	16.5
1	1	5.3						
	2	1.3						
	3	0.6						
	4	0.9						
	Subtotal	8.1	2,791	Khong Water Quality Improvement Project, System 4				
2	1	2.6						
	2	1.1						
	3	1.2						
	4	1.1						
	5	1.1						
	Subtotal	7.1	2,447	Khong Water Quality Improvement Project, System 4				
3	1	1.0						
	2	0.7						
	3	0.7						
	Subtotal	2.4	827	-	-	-	-	-
4	1	2.9						
	2	0.5						
	3	0.7						
	Subtotal	4.1	1,413	7,065	14,130	18,369	21,195	28,260
5	1	0.5						
	2	0.5						
	Subtotal	1.0	345	-	-	-	-	-
6	1	3.3						
	2	0.9						
	3	0.6						
	Subtotal	4.2	1,447	7,235	14,470	18,811	21,705	28,940
Total		26.9	9,270	14,300	28,600	37,180	42,900	57,200

Note : Wastewater to khlong 9,270 m^3/d (=Forecast DWF 185,400 m^3/d x 0.05)

Table 6.3.5.5 Cost Estimate for Khlong Purification Facilities (Khlong Toey East Catchment Area)

Quantity of Khlong Purification Reclaimed Wastewater Route 4 : 18,369 m^3/d
Route 6 : 18,811 m^3/d

Transportation Method by pipeline Thousand Baht

Route No.	Facilities	Specification	Q'ty	Initial Cost	Annual O & M Cost
Route 4	Pump well	100 m^3 (5x5x4.5 m), concrete made	1	370	-
	Pump with Header	5 m^3/min x 22 kW	3	2,400	2,020
	Transportation Pipeline	dia500 mm Ductile Pipe, 0.6 km in	1	7,800	-
		dia500 mm Ductile Pipe, 2.3 km under roads	1	59,800	-
	Subtotal			70,370	2,020
Route 6	Pump well	100 m^3 (5x5x4.5 m), concrete made	1	370	-
	Pump	5 m^3/min x 30 kW	3	2,700	2,650
	Transportation Pipeline	dia500 mm Ductile Pipe, 2.0 km in	1	26,000	-
		dia500 mm Ductile Pipe, 1.8 km under roads	1	46,800	-
	Subtotal			75,870	2,650
Total				146,240	4,670

Unit Cost

Route	Initial	O & M	Total
Route 4	0.5	0.3	0.8
Route 6	0.6	0.4	1.0

Table 6.3.6.1 Cost for Reclaimed Wastewater Reuse Facilities

Purpose: Road Plant Watering/ Road Cleaning

Capacity per one package: 300 m^3/d

Plan	Items	Specification	Initial Cost thousand baht	O & M Cost thousand baht/year
A Plan	Additional treatment facilities			
	pump	1 m^3/min	84	
	sand filter	300 m^3/d (60 m^3/hr)	2,700	
	Reclaimed wastewater supply facilities			
	storage tank	60 m^3	35	
	pump	1 m^3/min	84	
	service tank	24 m^3	300	98
	Tank car for watering			
	tank car	6 t x 8 cars ,L=2.5 km(ave.)	Lease	2,520
	total		3,203	2,618
B-1 Plan	Additional treatment facilities			
	pump	1 m^3/min	84	
	sand filter	300 m^3/d (60 m^3/hr)	2,700	
	Reclaimed wastewater supply facilities			
	storage tank	30 m^3	25	
	pump	0.5 m^3/min	59	
	service tank	12 m^3	210	94
	Reclaimed wastewater supply relay facilities (2 Facilities)			
	storage tank	30 m^3 x 2	50	
	pump	0.5 m^3/min x 2	118	
	service tank	12 m^3 x 2	420	18
	Tank car for transportation			
	tank car	12 t x 2 cars, L=3 km	Lease	2,650
	Tank car for watering			
	tank car	6 t x 8 cars ,L=1.5 km(ave.)	Lease	2,450
	total		3,666	5,212
B-2 Plan	Additional treatment facilities			
	pump	1 m^3/min	84	
	sand filter	300 m^3/d (60 m^3/hr)	2,700	
	Reclaimed wastewater supply facilities			
	storage tank	30 m^3	25	
	pump	0.5 m^3/min	59	
	service tank	12 m^3	210	94
	Reclaimed wastewater supply relay facilities (2 facilities)			
	storage tank	30 m^3 x 2	50	
	pump	0.5 m^3/min x 2	118	
	service tank	12 m^3 x 2	420	18
	Transportation pipeline (L=3 km x 2 lines)			
	pump	0.5 m^3/min x 2	108	288
	pipeline	dia.100 mm x 2 km x 2	9,400	240
	Tank car for watering			
	tank car	6 t x 8 cars ,L=1.5 km (ave.)	Lease	2,450
	total		13,174	3,090

not include tanker lease cost

	Baht/m^3
O&M	0.9
Initial Cost	1.5
Total	2.4

not include tanker lease cost

	Baht/m^3
O&M	1.0
Initial Cost	1.7
Total	2.7

not include tanker lease cost

	Baht/m^3
O&M	5.8
Initial Cost	6.0
Total	11.8

Source : JICA Study Team

Unit Cost

Case	Initial	O & M	Total
A	1.5	23.9	25.4
B-1	1.7	47.6	49.3
B-2	2.0	28.2	30.2

Table 6.3.6.4 Equipment List and Cost for Reclaimed Wastewater Reuse Facilities for Building Miscellaneous Water (Plan A) (1/3)

Purpose: Building Miscellaneous Water
Plan: A
Quantity of Reclaimed Wastewater: 900 m^3/d
Number of Package Facilities: one package(900 m^3/d)
Transportation Method: by pipeline

Case	Items	Specification	Initial Cost thousand baht	O & M Cost thousand baht/year
1 km	Package Facilities (1 packages=900 m^3/d)			
	Pump	1 m^3/min x 3, 2.2 kW x 3	252	
	Sand Filter	300 m^3/d (60 m^3/hr) x 3	8,100	
	Activated Carbon Filter	300 m^3/d (60 m^3/hr) x 3	9,000	261
	Storage Tank	60 m^3 x 1	35	
	Subtotal		17,387	
	Pump	2 m^3/min x 1.5kW	84	
	Transportation Pipeline	dia.250 mm, L= 1 km	2,500	190
	Total		19,971	451
2 km	Package Facilities (1 packages=900 m^3/d)		17,387	
	Pump	2 m^3/min x 3.7 kW	84	288
	Transportation Pipeline	dia.250 mm, L= 2 km	5,000	190
	Total		22,471	478
3 km	Package Facilities (1 packages=900 m^3/d)		17,387	
	Pump	2 m^3/min x 3.7 kW	84	288
	Transportation Pipeline	dia.250 mm, L= 3 km	7,500	190
	Total		24,971	478
4 km	Package Facilities (1 packages=900 m^3/d)		17,387	
	Pump	2 m^3/min x 5.5 kW	92	311
	Transportation Pipeline	dia.250 mm, L= 4 km	10,000	190
	Total		27,479	501
5 km	Package Facilities (1 packages=900 m^3/d)		17,387	
	Pump	2 m^3/min x 7.5 kW	101	334
	Transportation Pipeline	dia.250 mm, L= 5 km	12,500	190
	Total		29,988	524

Source : JICA Study Team

Unit Cost

Case	Initial	O & M	Total
1 km	3.0	1.4	4.4
2 km	3.4	1.5	4.9
3 km	3.8	1.5	5.3
4 km	4.2	1.5	5.7
5 km	4.6	1.6	6.2

Table 6.3.6.4 Equipment List and Cost for Reclaimed Wastewater Reuse Facilities for Building Miscellaneous Water (Plan A) (2/3)

Purpose Building Miscellaneous Water
Plan A
Quantity of Reclaimed Wastewater 1,800 m^3/d
Number of Package Facilities two package(900 m^3/d x 2)
Transportation Method by pipeline

Case	Items	Specification	Initial Cost thousand baht	O & M Cost thousand baht/year
1 km	Package Facilities (2 packages = 900 m^3/d x 2)			
	Pump	1 m^3/min x 3 x 2	504	
	Sand Filter	300 m^3/d (60 m^3/hr) x 3 x 2	16200	
	Activated Carbon Filter	300 m^3/d (60 m^3/hr) x 3 x 2	18,000	457
	Storage Tank	60 m^3 x 1 x 2	70	
	Subtotal		34,774	
	Pump	2 m^3/min x 2.2 kW x 2	168	
	Transportation Pipeline	dia.300 mm, L= 1 km	3,200	190
	Total		38,142	647
2 km	Package Facilities (2 packages = 900 m^3/d x 2)		34,774	
	Pump	2 m^3/min x 5.5 kW x 2	184	710
	Transportation Pipeline	dia.300 mm, L= 2 km	6,400	190
	Total		41,358	900
3 km	Package Facilities (2 packages = 900 m^3/d x 2)		34,774	
	Pump	2 m^3/min x 7.5 kW x 2	202	859
	Transportation Pipeline	dia.300 mm, L= 3 km	9,600	190
	Total		44,576	1,049
4 km	Package Facilities (2 packages = 900 m^3/d x 2)		34,774	
	Pump	2 m^3/min x 11 kW x 2	246	1,122
	Transportation Pipeline	dia.300 mm, L= 4 km	12,800	190
	Total		47,820	1,312
5 km	Package Facilities (2 packages = 900 m^3/d x 2)		34,774	
	Pump	2 m^3/min x 11 kW x 2	246	1,122
	Transportation Pipeline	dia.300 mm, L= 5 km	16,000	190
	Total		51,020	1,312

Source : JICA Study Team

Unit Cost

Case	Initial	O & M	Total
1 km	2.9	1.0	3.9
2 km	3.1	1.4	4.5
3 km	3.4	1.6	5.0
4 km	3.6	2.0	5.6
5 km	3.9	2.0	5.9

Table 6.3.6.4 Equipment List and Cost for Reclaimed Wastewater Reuse Facilities for Building Miscellaneous Water (Plan A) (3/3)

Purpose: Building Miscellaneous Water
Plan: A
Quantity of Reclaimed Wastewater: 2,700 m^3/d
Number of Package Facilities: three package($900 m^3/d \times 3$)
Transportation Method: by pipeline

Case	Items	Specification	Initial Cost thousand baht	O & M Cost thousand baht/yr
1 km	Package Facilities (3 packages=$900 m^3/d \times 3$)			
	Pump	$1 m^3/min \times 3 \times 3$	756	
	Sand Filter	$300 m^3/d$ ($60 m^3/hr$) $\times 3 \times 3$	24300	
	Activated Carbon Filter	$300 m^3/d$ ($60 m^3/hr$) $\times 3 \times 3$	27,000	599
	Storage Tank	$60 m^3 \times 1 \times 3$	105	
	Subtotal		52,161	
	Pump	$2 m^3/min \times 2.2 kW \times 3$	252	
	Transportation Pipeline	dia.350 mm, L= 1 km	3,800	190
	Total		56,213	789
2 km	Package Facilities (3 packages=$900 m^3/d \times 3$)		52,161	
	Pump	$2 m^3/min \times 5.5 kW \times 3$	276	970
	Transportation Pipeline	dia.350 mm, L= 2 km	7,600	190
	Total		60,037	1,160
3 km	Package Facilities (3 packages=$900 m^3/d \times 3$)		52,161	
	Pump	$2 m^3/min \times 7.5 kW \times 3$	303	1,196
	Transportation Pipeline	dia.350 mm, L= 3 km	11,400	190
	Total		63,864	1,356
4 km	Package Facilities (3 packages=$900 m^3/d \times 3$)		52,161	
	Pump	$2 m^3/min \times 11 kW \times 3$	369	1,588
	Transportation Pipeline	dia.350 mm, L= 4 km	15,200	190
	Total		67,730	1,778
5 km	Package Facilities (3 packages=$900 m^3/d \times 3$)		52,161	
	Pump	$2 m^3/min \times 11 kW \times 3$	369	1,588
	Transportation Pipeline	dia.350 mm, L= 5 km	19,000	190
	Total		71,530	1,778

Source : JICA Study Team

Unit Cost

Case	Initial	O & M	Total
1 km	2.9	0.8	3.7
2 km	3.0	1.2	4.2
3 km	3.2	1.4	4.6
4 km	3.4	1.8	5.2
5 km	3.6	1.8	5.4

Table 6.3.6.5 Equipment List and Cost for Reclaimed Wastewater Reuse Facilities for Building Miscellaneous Water (Plan B) (1/3)

Purpose: Building Miscellaneous Water
Plan: B
Quantity of Reclaimed Wastewater: 900 m^3/d
Number of Package Facilities: one package(900 m^3/d)
Transportation Method: Tank Car (12 m^3)

Case	Items	Specification	Initial Cost (thousand baht)	O & M Cost (thousand baht/year)
1 km	Package Facilities (1 package = 900 m^3/d)			
	Pump	1 m^3/min x 3	252	
	Sand Filter	300 m^3/d (60 m^3/hr) x 3	8,100	
	Activated Carbon Filter	300 m^3/d (60 m^3/hr) x 3	9,000	
	Storage Tank	60 m^3 x 1	35	295
	Service Tank	24 m^3 x 1	300	
	Subtotal		17,687	
	Pump	1 m^3/min x 2.2 kW	84	
	Tank Car	12 m^3 x 4 cars, L=1 km	Lease	6,370
	Total		17,771	6,665
2 km	Package Facilities (1 package = 900 m^3/d)		17,687	
	Pump	1 m^3/min x 2.2 kW	84	295
	Tank Car	12 m^3 x 4 cars, L=2 km	Lease	7,160
	Total		17,771	7,455
3 km	Package Facilities (1 package = 900 m^3/d)		17,687	
	Pump	1 m3/min x 2.2 kW	84	295
	Tank Car	12 m^3 x 4 cars, L=3 km	Lease	7,950
	Total		17,771	8,245
4 km	Package Facilities (1 package = 900 m^3/d)		17,687	
	Pump	1 m3/min x 2.2 kW	84	295
	Tank Car	12 m^3 x 4 cars, L=4 km	Lease	8,740
	Total		17,771	9,035
5 km	Package Facilities (1 package = 900 m^3/d)		17,687	
	Pump	1 m3/min x 2.2 kW	84	295
	Tank Car	12 m^3 x 4 cars, L=5 km	Lease	9,530
	Total		17,771	9,825

Source : JICA Study Team

Unit Cost

Case	Initial	O & M	Total
1 km	2.7	20.3	23.0
2 km	2.7	22.7	25.4
3 km	2.7	25.1	27.8
4 km	2.7	27.5	30.2
5 km	2.7	29.9	32.6

Table 6.3.6.5 Equipment List and Cost for Reclaimed Wastewater Reuse Facilities for Building Miscellaneous Water (Plan B) (2/3)

Purpose: Building Miscellaneous Water
Plan: B
Quantity of Reclaimed Wastewater: 1,800 m^3/d
Number of Package Facilities: two package(900 m^3/d x 2)
Transportation Method: Tank Car (12 m^3)

Case	Items	Specification	Initial Cost (thousand baht)	O & M Cost (thousand baht/yr)
1 km	Package Facilities (2 package = 900 m^3/d x 2)			
	Pump	1 m^3/min x 3 x 2	504	
	Sand Filter	300 m^3/d (60 m^3/hr) x 3 x 2	16,200	
	Activated Carbon Filter	300 m^3/d(60 m^3/hr) x 3 x 2	18,000	
	Storage Tank	60 m^3 x 2	70	408
	Service Tank	24 m^3 x 2	600	
	Subtotal		35,374	
	Pump	1 m^3/min x 2.2 kW x 2	168	
	Tank Car	12 m^3 x 4 cars x 2, L=1 km	Lease	12,740
	Total		35,542	13,148
2 km	Package Facilities (2 package = 900 m^3/day x 2)		35,374	
	Pump	1 m^3/min x 2.2 kW x 2	168	408
	Tank Car	12 m^3 x 4 cars x 2, L=2 km	Lease	14,320
	Total		35,542	14,728
3 km	Package Facilities (2 package = 900 m^3/d x 2)		35,374	
	Pump	1 m^3/min x 2.2 kW x 2	168	408
	Tank Car	12 m^3 x 4 cars x 2, L=3 km	Lease	15,900
	Total		35,542	16,308
4 km	Package Facilities (2 package = 900 m^3/d x 2)		35,374	
	Pump	1 m^3/min x 2.2 kW x 2	168	408
	Tank Car	12 m^3 x 4 cars x 2, L=4 km	Lease	17,480
	Total		35,542	17,888
5 km	Package Facilities (2 package = 900 m^3/d x 2)		35,374	
	Pump	1 m^3/min x 2.2 kW x 2	168	408
	Tank Car	12 m^3 x 4 cars x 2, L=5 km	Lease	19,060
	Total		35,542	19,465

Source : JICA Study Team

Unit Cost

Case	Initial	O & M	Total
1 km	2.7	20.0	22.7
2 km	2.7	22.4	25.1
3 km	2.7	24.8	27.5
4 km	2.7	27.2	29.9
5 km	2.7	29.6	32.3

Table 6.3.6.5 Equipment List and Cost for Reclaimed Wastewater Reuse Facilities for Building Miscellaneous Water (Plan B) (3/3)

Purpose: Building Miscellaneous Water
Plan: B
Quantity of Reclaimed Wastewater: 2,700 m^3/d
Number of Package Facilities: three package(900 m^3/d x 3)
Transportation Method: Tank Car (12 m^3)

Case	Items	Specification	Initial Cost (thousand baht)	O & M Cost (thousand baht/year)
1 km	Package Facilities (3 package = 900 m^3/d x 3)			
	Pump	1 m^3/min x 3 x 3	756	
	Sand Filter	300 m^3/d(60 m^3/hr) x 3 x 3	24,300	
	Activated Carbon Filter	300 m^3/d(60 m^3/hr) x 3 x 3	27,000	
	Storage Tank	60 m^3 x 3	105	518
	Service Tank	24 m^3 x 3	900	
	Subtotal		53,061	
	Pump	1 m^3/min x 2.2 kW x 3	252	
	Tank Car	12 m^3 x 4 cars x 3, L=1 km	Lease	19,110
	Total		53,313	19,628
2 km	Package Facilities (3 package = 900 m^3/d x 3)		53,061	
	Pump	1 m^3/min x 2.2 kW x 3	252	518
	Tank Car	12 m^3 x 4 cars x 3, L=2 km	Lease	21,480
	Total		53,313	21,998
3 km	Package Facilities (3 package = 900 m^3/d x 3)		53,061	
	Pump	1 m^3/min x 2.2 kW x 3	252	518
	Tank Car	12 m^3 x 4 cars x 3, L=3 km	Lease	23,850
	Total		53,313	24,368
4 km	Package Facilities (3 package = 900 m^3/d x 3)		53,061	
	Pump	1 m^3/min x 2.2 kW x 3	252	518
	Tank Car	12 m^3 x 4 cars x 3, L=4 km	Lease	26,220
	Total		53,313	26,738
5 km	Package Facilities (3 package = 900 m^3/d x 3)		53,061	
	Pump	1 m^3/min x 2.2 kW x 3	252	518
	Tank Car	12 m^3 x 4 cars x 3, L=5 km	Lease	28,590
	Total		53,313	29,108

Source : JICA Study Team

Unit Cost

Case	Initial	O & M	Total
1 km	2.7	19.9	22.6
2 km	2.7	22.3	25.0
3 km	2.7	24.7	27.4
4 km	2.7	27.1	29.8
5 km	2.7	29.5	32.2

Table 6.3.6.6 Equipment List and Cost for Reclaimed Wastewater Reuse Facilities for Plant Watering

Purpose: Plant watering (Parks, Golf source etc.)
Capacity: 300 m^3/d
Transportation Method: by Tanker

Items	Specification	Initial Cost (Thousand baht)	O&M Cost (Thousand baht)
Additional Treatment Facilities			
Pump	1 m^3/min	84	
Sand Filter	300 m^3/d (60 m^3/hr)	2,700	
Reclaimed Wastewater Supply Facilities			
Storage Tank	60 m^3	3,000	
Pump	1 m^3/min	84	
Service Tank	24 m^3	300	98
Tank Car for Transportation			
Tank Car	12 m^3 x 2 cars, L=3 km	Lease	2,650
Total		6,168	2,748

Unit Cost

Case	Initial	O&M	Total
A	2.8	25.1	27.9

Table 7.1.3.3 Sludge Generation from NSTPs in 2020

No.	District	Total Population (-)	Collection Ratio (%)	Served Population (-)	Night Soil Sludge Generation (t DS/d)
1	PHRA NAKHORN	125,800	20.0	25,160	0.45
2	DUSIT	220,100	20.0	44,020	0.79
3	NONG JOK	156,000	10.0	15,600	0.28
4	BANG RAK	131,800	20.0	26,360	0.47
5	BANG KHEN	403,800	20.0	80,760	1.45
6	BANG KAPI	371,600	20.0	74,320	1.34
7	PATHUMWAN	200,400	20.0	40,080	0.72
8	POM PRAP SATTRU PHAI	135,500	30.0	40,650	0.73
9	PHRA KHANONG	238,700	20.0	47,740	0.86
10	MIN BURI	246,300	30.0	73,890	1.33
11	LAT KRABANG	343,000	30.0	102,900	1.85
12	YAN NAWA	152,500	30.0	45,750	0.82
13	SAMPHANTHAWONG	71,600	30.0	21,480	0.39
14	PHAYA THAI	181,400	20.0	36,280	0.65
15	THON BURI	296,800	30.0	89,040	1.60
16	BANGKOK YAI	184,000	20.0	36,800	0.66
17	HUAY KWUANG	311,500	20.0	62,300	1.12
18	KHLONG SAN	189,300	30.0	56,790	1.02
19	TALING CHAN	146,700	20.0	29,340	0.53
20	BANGKOK NOI	226,500	20.0	45,300	0.82
21	BANG KHUN THIAN	208,400	20.0	41,680	0.75
22	PHASI CHAROEN	295,600	20.0	59,120	1.06
23	NONG KHAEM	218,900	20.0	43,780	0.79
24	RAT BURANA	270,400	20.0	54,080	0.97
25	BANG PHLAT	214,800	20.0	42,960	0.77
26	DIN DAENG	359,900	30.0	107,970	1.94
27	BUNG KUM	395,000	20.0	79,000	1.42
28	SATHORN	168,100	20.0	33,620	0.61
29	BANG SUE	324,400	20.0	64,880	1.17
30	CHATUCHAK	280,600	10.0	28,060	0.51
31	BANG KHO LAEM	185,000	20.0	37,000	0.67
32	PRAWET	163,900	20.0	32,780	0.59
33	KHLONG TOEY	233,500	20.0	46,700	0.84
34	SUAN LUANG	302,900	20.0	60,580	1.09
35	CHOM THONG	224,800	20.0	44,960	0.81
36	DON MUANG	321,400	20.0	64,280	1.16
37	RATCHATHEWI	238,000	30.0	71,400	1.29
38	LAT PHRAO	315,600	20.0	63,120	1.14
39	BANG NA	216,200	20.0	43,240	0.78
40	VADHANA	172,300	30.0	51,690	0.93
41	SAI MAI	373,600	20.0	74,720	1.34
42	LAK SI	300,000	20.0	60,000	1.08
43	WANG THONG LANG	268,800	20.0	53,760	0.97
44	KHANNA YAO	217,700	20.0	43,540	0.78
45	SAPHAN SUNG	222,600	20.0	44,520	0.80
46	SAM WA	203,800	10.0	20,380	0.37
47	BANG KAE	332,000	10.0	33,200	0.60
48	BANG BON	147,500	10.0	14,750	0.27
49	THAWI WATTANA	112,600	10.0	11,260	0.20
50	THUNG KRUE	234,400	10.0	23,440	0.42
	BMA Total	11,856,000	20.6	2,445,030	44.0

Note:

1) The sludge generation rate is defined as 18 g DS/cap/d

Table 7.1.3.4 Total Sludge Generation by Years in BMA

Plant Location	Sludge Generation by Years (t DS/d)																				
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Community WWTPs	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6
Central WWTPs																					
Existing and Ongoing																					
Si Phraya	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Ratanakosin	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6
Din Daeng Phase 1		23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9
Din Daeng Phase 2												11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9
Yannawa Phase 1	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8
Yannawa Phase 2																	5.2	5.2	5.2	5.2	5.3
Nong Khaem			10.1	10.3	10.5	10.7	10.9	11.1	11.3	11.5	11.7	12.0	12.2	12.5	12.7	13.0	13.3	13.5	13.8	14.1	14.4
Ratburana Phase 1			5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7
Ratburana Phase 2																	5.8	5.9	6.1	6.2	6.3
Chatuchak					10.7	10.9	11.2	11.4	11.6	11.8	12.0	12.3	12.5	12.8	13.0	13.3	13.3	13.3	13.3	13.3	13.3
Planned and Proposed																					
Thonburi South Phase 1							16.2	16.4	16.7	16.9	17.1	17.4	17.7	18.0	18.3	18.6	18.9	19.1	19.4	19.7	20.0
Thonburi South Phase 2																	3.9	3.9	4.0	4.0	4.1
Thonburi Central Phase 1								10.1	10.3	10.5	10.8	11.1	11.4	11.7	12.0	12.3	12.6	13.0	13.3	13.6	13.9
Thonburi Central Phase 2																		2.6	2.7	2.7	2.8
Thonburi North Phase 1									6.6	6.7	6.8	6.9	6.9	7.0	7.1	7.2	7.3	7.4	7.5	7.6	7.7
Thonburi North Phase 2																			2.0	2.1	2.1
Khlong Toey West Phase 1										12.5	12.6	12.7	12.8	13.0	13.1	13.2	13.4	13.5	13.6	13.8	13.9
Khlong Toey West Phase 2																				4.0	4.0
Khlong Toey East Phase 1											9.0	9.0	9.1	9.1	9.2	9.2	9.3	9.3	9.4	9.4	9.5
Khlong Toey East Phase 2																					6.1
Bang Sue														14.0	14.1	14.3	14.5	14.6	14.8	14.9	15.1
Huay Kwuang																14.3	14.8	15.2	15.7	16.1	16.6
Wang Thong Lang																		14.0	14.4	14.7	15.1
Bung Kum																				15.1	15.5
Central WWTPs Sludge Total	22.3	46.3	62.2	62.5	73.5	74.0	90.7	101.5	109	123	133	146	148	163	164	180	197	216	220	241	251
NSTPs																					
Existing																					
Nong Khaem	7.4	7.5	6.9	7.0	7.1	7.7	7.9	8.1	8.2	8.4	9.1	9.2	9.4	9.6	9.8	10.6	8.2	8.3	8.5	8.7	9.3
On-Nut	7.4	7.5	6.9	7.0	7.1	7.7	7.9	8.1	8.2	8.4	9.1	9.2	9.4	9.6	9.8	10.6	8.2	8.3	8.5	8.7	10.4
Ongoing																					
Yannawa	6.9	7.0	6.4	6.5	6.7	7.2	7.4	7.5	7.7	7.8	8.4	8.6	8.8	9.0	9.2	9.9	13.6	13.9	14.2	14.5	17.3
Ratburana	0.0	0.0	2.3	2.3	2.4	2.6	2.6	2.7	2.7	2.8	3.0	3.1	3.1	3.2	3.3	3.5	5.4	5.6	5.7	5.8	7.0
NSTPs Sludge Total	21.6	22.0	22.5	22.9	23.3	25.3	25.8	26.3	26.8	27.3	29.6	30.2	30.8	31.4	32.1	34.6	35.4	36.1	36.9	37.7	44.0
Total in BMA	51.6	76.0	92.3	93.0	104.4	107	124	135	144	158	170	184	186	202	204	223	240	259	265	287	302

Source : JICA Study Team