Table 7.1.4.1 Risk Evaluation of Heavy Metal Intrusion

Service Areas	Industry Categories: Dyeing		Machinery		Electro-plating		Cosmetic/ Tooth Paste		Battery		Printing		Total Weighting Point	Total Toxic Factory Number	Total Factory Number	Average Weight Point to One Factory	Toxic Factory Ratio to All Factories	Industrial Wastewater Ratio to Total Sewage	Toxicity Point at Present	Toxicity Index at Present	Potential Growth Index of Industrial Sector	Total Toxicity Index	Risk Ranking
Relative Rating by Industries	3		3		5		1		1		3												
	(A)	(B)	(A)	(B)	(A)	(B)	(A)	(B)	(A)	(B)	(A)	(B)	(C)= Σ (B)	(D)= Σ (A)	(E)	(F)= (C)/(D)	(G)= (D)/(E) x100	(H) (%)	(I)= (F)x(G) x(H)/100	(J)= 10/16 x(I)	(K)	(L)= (J)x(K)	
Si Phraya	0	0	99	297	4	20	1	1	7	7	4	12	337	115	1,040	2.9	11.1	48	15.6	9.7	2	19.4	8
Ratanakosin	0	0	68	204	44	220	1	1	11	11	7	21	457	131	1,173	3.5	11.2	30	11.7	7.3	3	21.9	6
Din Daeng	2	6	524	1572	12	60	7	7	44	44	43	129	1818	632	5,827	2.9	10.8	16	5.0	3.1	3	9.4	15
Yannawa	2	6	307	921	30	150	16	16	21	21	151	453	1567	527	5,305	3.0	9.9	31	9.2	5.7	3	17.2	9
Nong Khaem	1	3	204	612	30	150	7	7	14	14	81	243	1029	337	3,347	3.1	10.1	25	7.7	4.8	9	43.2	2
Ratburana	5	15	75	225	15	75	4	4	5	5	36	108	432	140	1,884	3.1	7.4	20	4.6	2.9	10	28.7	3
Chatuchak	1	3	148	444	4	20	3	3	17	17	2	6	493	175	902	2.8	19.4	6	3.3	2.0	3	6.1	16
Thonburi South	9	27	298	894	33	165	11	11	18	18	154	462	1577	523	5,726	3.0	9.1	29	8.0	5.0	4	20.0	7
Thonburi Central	4	12	165	495	7	35	2	2	11	11	20	60	615	209	1,927	2.9	10.8	23	7.3	4.6	3	13.8	10
Thonburi North	0	0	95	285	2	10	1	1	8	8	14	42	346	120	857	2.9	14.0	15	6.1	3.8	3	11.4	13
Khlong Toey West	1	3	154	462	1	5	10	10	11	11	22	66	557	199	2,032	2.8	9.8	27	7.4	4.6	6	27.8	4
Khlong Toey East	1	3	236	708	9	45	10	10	12	12	51	153	931	319	2,207	2.9	14.5	22	9.3	5.8	10	58.0	1
Bang Sue	0	0	85	255	3	15	3	3	13	13	4	12	298	108	1,207	2.8	8.9	13	3.2	2.0	5	10.0	14
Huay Kwuang	1	3	105	315	0	0	7	7	4	4	9	27	356	126	681	2.8	18.5	16	8.4	5.2	5	26.1	5
Wang Thong Lang	4	12	187	561	11	55	3	3	12	12	22	66	709	239	1,512	3.0	15.8	8	3.8	2.3	5	11.7	12
Bung Kum	0	0	127	381	1	5	1	1	14	14	4	12	413	147	778	2.8	18.9	8	4.2	2.7	5	13.3	11

Notes:

1) (A): Numbers of factories

2) (B): Weighting points, = (A) x (Relative Rating by Industries)

3) (H): Industrial wastewater amount to total wastewater amount derived from PCD Master Plan for the existing and ongoing projects and from Table 6.1.3.1 for proposed schemes.

4) (K): Estimated based on Land Use Plan for the target year of 2017.

Source: JICA Study Team

Table 7.2.4.3 Standards of Heavy Metal Contents for Agricultural Use Sludge in Developed Countries (1/2)

(1) Sewage Sludge Regulation in E.C

Items / Heavy Metals	Max.content of sludge (mg/kg)	Max. allowable content in agricultural soil pH 6-7 (mg/kg)	Max. loading (10 years, kg/ha/yr.)
Cd	20 - 40	1 - 3	0.15
Cr	not specified	100 - 150	not specified
Cu	1,000 - 1,750	50 - 140	12
Hg	16 - 25	1 - 1.5	0.1
Pb	750 - 1,200	50 - 300	15
Ni	300 - 400	30 - 75	3
Zn	2,500 - 4,000	150 - 300	30

(2) Maximum Content and Loading of Heavy Metals in U.K. (1989)

Items / Heavy Metals	Max. allowable content (mg/kg dry soil)				Max. loading (10 years kg/ha/yr.)
	pH 5.0-5.5	pH 5.5-6.0	pH 6.0-7.0	pH > 7.0	
Zn	200	250	300	450	15
Cu	80	100	135	200	7.5
Ni	50	60	75	110	3
	pH > 5.0				
Cd	3				0.5
Pb	300				0.15
Hg	1				0.1
Cr	400 (tentative)				15 (tentative)
Mo	4				0.2
Se	3				0.15
As	50				0.7
F	500				20

(3) Maximum Heavy Metal Contents for Agricultural Use of Sludge

(Units: mg/kg)

Country	Year of Establishment	Cd	Cu	Cr	Ni	Pb	Zn	Hg
France	1988	20	1,000	1,000	200	800	3,000	10
Spain	1990	20	1,000	1,000	300	750	2,500	16
Denmark	1990	1.2	1,000	100	45	120	4,000	1.2
	1995	0.8	1,000	100	30	120	4,000	0.8
Finland	1995	1.5	600	300	100	100	1,500	1.0
Norway	1995	4	1,000	125	80	100	1,500	5
Sweden	1995	2	600	100	50	100	800	2.5

Table 7.2.4.3 Standards of Heavy Metal Contents for Agricultural Use Sludge in Developed Countries (2/2)

(4) Maximum Allowable Content of Agriculture Soil

(Units: mg/kg)

Country	Year of Establishment	Cd	Cu	Cr	Ni	Pb	Zn	Hg
France	1988	2	100	150	50	100	300	1
Italy	(no data)	3	100	150	50	100	300	-
Spain	1990	1	50	100	30	50	150	1
Netherlands	(no data)							
A-Value		0.8	36	100	35	85	140	0.3
C-Value		12	190	380	210	530	720	10
Denmark	1990	0.5	40	30	15	40	100	0.5
Finland	1995	0.5	100	200	60	60	150	0.2
Norway	1995	1	50	100	30	50	150	1
Sweden	1995	0.5	40	30	15	40	100	0.5

(5) Limitation in Sewage Sludge Use in Ontario State, Canada

Items / Heavy metals	Non polluted soil average (mg/l)	Max. limit in soil (mg/l)	Max. loading (kg/ha)	Min. required N/metal content	Application times to attain the limit	(N/metal content) to attain the limit by 50 application times
As	7	14	14	100	10	480
Cd	0.8	1.6	1.6	500	6	4,200
Co	5	20	30	50	11	220
Cr	15	120	210	6	9	32
Cu	25	100	150	10	11	45
Hg	0.1	0.5	0.8	1,500	9	8,500
Mo	2	4	4	180	5	1,700
Ni	16	32	32	40	9	210
Pb	15	60	90	15	10	75
Se	0.4	1.6	2.4	500	9	2,800
Zn	55	220	330	4	10	20

Source: Manual of the Use for Agricultural Land and Green Land of Sewage Sludge, issued by "Association of Sewage Sludge Use" in Japan (1996).

Table 7.2.6.1 Sludge Mass Transition in Sludge Treatment Steps

Sludge Treatment Steps	Unit	Sludge Treatment Options					
		Option L1	Option L2	Option L3	Option L4	Option A1	Option A2
		Landfill	Landfill	Landfill	Landfill	Agricultural Use	Agricultural Use
		Ash after Digestion	Dewatered Sludge after Digestion	Ash without Digestion	Dewatered Sludge without Digestion	Compost after Digestion	Compost without Digestion
Inlet of Thickening (from Wastewater Treatment Plant)							
Dry Sludge	(t DS/d)	20.0	20.0	20.0	20.0	20.0	20.0
Organic Sludge	(t DS/d)	9.6	9.6	9.6	9.6	9.6	9.6
Inorganic Sludge	(t DS/d)	10.1	10.1	10.1	10.1	10.1	10.1
Wet Sludge	(t/d)	2,000	2,000	2,000	2,000	2,000	2,000
Outlet of Thickening							
Dry Sludge	(t DS/d)	20.0	20.0	20.0	20.0	20.0	20.0
Organic Sludge	(t DS/d)	9.6	9.6	9.6	9.6	9.6	9.6
Inorganic Sludge	(t DS/d)	10.1	10.1	10.1	10.1	10.1	10.1
Wet Sludge	(t/d)	400	400	400	400	400	400
Outlet of Digestion							
Dry Sludge	(t DS/d)	14.9	14.9			14.9	
Organic Sludge	(t DS/d)	4.8	4.8			4.8	
Inorganic Sludge	(t DS/d)	10.1	10.1			10.1	
Wet Sludge	(t/d)	298	298			298	
Outlet of Dewatering							
Dry Sludge	(t DS/d)	14.9	14.9	19.7	19.7	14.9	19.7
Organic Sludge	(t DS/d)	4.8	4.8	9.6	9.6	4.8	9.6
Inorganic Sludge	(t DS/d)	10.1	10.1	10.1	10.1	10.1	10.1
Wet Sludge	(t/d)	74.6	74.6	98.6	98.6	74.6	98.6
Outlet of Incineration							
Dry Sludge	(t DS/d)	10.3		10.6			
Organic Sludge	(t DS/d)	0.2		0.5			
Inorganic Sludge	(t DS/d)	10.1		10.1			
Wet Sludge	(t/d)	10.9		11.1			
Outlet of Composting							
Dry Sludge	(t DS/d)					12.5	14.9
Organic Sludge in Raw Sludge	(t DS/d)					2.4	4.8
Inorganic Sludge in Raw Sludge	(t DS/d)					10.1	10.1
Product Volume including Bulking Material	(t/d)					74.6	98.6

Note:

The comparison is undertaken based on the following conditions:

VS ratio of raw sludge: 48 %,
VS removal ratio in digester: 50 %,
Dewatered sludge moisture: 80 %,
VS removal in composting: 50 %,
Raw sludge dry solids: 20 t/d,
Raw sludge concentration: 1.0 %,
Ash moisture content: 5 %,
Remaining organic in ash: 5 %.

Table 7.2.6.2 Detail Cost of Sludge Treatment Options

Sludge Treatment Steps	Unit	Option L1	Option L2	Option L3	Option L4	Option A1	Option A2
		Landfill	Landfill	Landfill	Landfill	Agricultural Use	Agricultural Use
		Ash after Digestion	Dewatered Sludge after Digestion	Ash without Digestion	Dewatered Sludge without Digestion	Compost after Digestion	Compost without Digestion
1. Thickening	(US$/d)	382	382	382	382	382	382
2. Digestion	(US$/d)	307	307			307	
- Treatment Cost	(US$/d)	587	587			587	
- Recovered Cost	(US$/d)	280	280			280	
3. Dewatering	(US$/d)	606	606	744	744	606	744
4. Incineration	(US$/d)	7,005		8,633			
5. Landfill	(US$/d)	125	1,454	128	1,923		
5. Compost	(US$/d)					▲ 32	▲ 1,463
- Treatment Cost	(US$/d)					3,696	3,468
- Recovered Cost	(US$/d)					3,728	4,931
6. Sludge Transportation	(US$/d)	76	371	78	491	580	767
Treatment Cost (without Recovery)	(US$/d)	8,780	3,400	9,965	3,540	5,850	5,361
Net Cost (with Recovery)	(US$/d)	8,500 [1)]	3,120 [1)]	9,965	3,540	1,843 [2)]	430 [2)]

Note: The assumed capacity of sludge treatment for the purpose of cost comparison is 20 t DS/d at the inlet of thickening..

1): The net costs are computed by the deduction of the recovered cost by power generation.

2): The net costs are computed by the deduction of the recovered costs by compost selling.

Table 7.2.6.4 Cost Calculation Basis for Alternative Selection

Scope of Costs:

1) Included facilities:	Civil and architecture works, Mechanical and Electrical works
2) Conditions of daily expense calculation:	
- Life of facilities:	50 years for civil and architecture works, 15 years for mechanical and electrical works,
- Remaining Values:	Nothing
3) Included operation expenses:	Consumption of chemicals and electricity, maintenance and labor

Functional Equations:

1) Sludge thickening: Daily expense =	$(3.9Q^{0.30} + 35.1Q^{0.82} + 9.4Q) \times 22.8 \times \alpha \times K$ (US$/d)	Experiential equation analyzed statistically
2) Digester: Daily expense =	$(25.7Q^{0.59} + 51.8Q^{0.54} + 5.16Q + C) \times 22.8 \times \alpha \times K$ (US$/d)	Experiential equation analyzed statistically
3) Dewatering: Daily expense =	$(38.7Q^{0.74} + 36.4Q^{0.28} + 3.31CQ^{0.72} + 76Q) \times 22.8 \times \alpha \times K$ (US$/d)	Experiential equation analyzed statistically
4) Incineration: Daily expense =	$(0.85Q^{0.48} + 7.9Q^{0.79} + 2.75Q^{0.74} + 6.42Q^{0.63} + 0.154CQ^{0.85}) \times 22.8 \times \alpha \times K$ (US$/d)	Experiential equation analyzed statistically
5) Composting: Daily expense =	$(33Q^{0.68} + 2.9Q^{0.93} + (0.184Q + 1.08) \times C) \times 22.8 \times \alpha \times K$ (US$/d)	Experiential equation analyzed statistically
6) Pipeline transportation by pumping: Daily expense =	$(15.3Q^{0.33} + 1.81Q^{1.29} + 2.46Q^{0.37} + 2C) \times 22.8 \times \alpha \times K$ (US$/d)	Experiential equation analyzed statistically
7) Truck transportation (for sludge cake): Unit cost =	$0.14 \times L + 0.78$ (US$/t-Sludge Cake)	Derived from this Study
8) Barge transportation (for sludge cake) Unit cost =	$0.0785 \times L + 1.7$ (US$/t-Sludge Cake)	Derived from this Study
9) Landfill disposal Unit cost =	Dewatered sludge 19.3 US$/t-Wet Ash 11.5 US$/t-Wet	Derived from this Study

Symbols:

Q :	Inlet sludge flow	($1000m^3/d$)
α :	Coefficient for local price adjustment	
K :	Coefficient for special design conditions and works	
C :	Labor expense	(million JY/man.year)
L :	Transportation distance	(km)

Table 7.3.3.2 Detail Cost of Sludge Transportation Alternatives

Central WWTPs	Sludge generation	Distance	Expenses of transportation (US$/d)			Expenses of sludge treatment (US$/d)			Total expenses (=Transportation+ Sludge treatment) (US$/d)		
	(t DS/d)	(km)	Truck (80 % Moisture cake)	Barge (80 % Moisture cake)	Pumping (1 % slurry)	Sludge thickening for Central WWTPs	Sludge thickening for Nong Khaem STC	Sludge dewatering	Truck (T1)	Barge (T3)	Pipeline (T2)
			(1)	(2)	(3)	(4)	(4)'	(5)	=(1)+(4)+(5)	=(2)+(4)+(5)	= (3)+(4)'
Khlong Toey East	15.6	35	443	347	2,311	554		1,703	2,700	2,604	2,311
Ratburana	12.0	21	223	201	1,505	446		1,381	2,051	2,028	1,505
Khlong Toey West	17.9	30	446	363	2,050	621		1,905	2,972	2,889	2,050
Huay Kwuang	16.6	32	437	350	2,152	583		1,791	2,811	2,724	2,152
Ratanakosin	5.6	16	85	83	723	240		775	1,100	1,098	723
Thonburi South	24.1	16	364	356	866	796		2,436	3,596	3,589	866
Si Phraya	1.0	15	14	14	1,035	64		257	335	335	1,035
Nong Kaem STC							2,835				2,835
Total	92.8	165	2,011	1,714	10,641	3,305		10,249	15,566	15,268	13,476
(Ratio)									(100)	(98)	(87)

Note: The above costs for the Nong Khaem STC were calculated by using the cost basis in Table 7.2.6.4.

Table 8.1.2.1 List of Unit Costs

	US$ Basis		Baht Basis	
Wastewater Treatment Plant				
Exchange rate	(B/US$)	36		
Construction cost	(US$/m³/d)	1,000	(B/m³/d)	36,000
Annual O&M cost	(US$/m³/d)	15	(B/m³/d)	540
WW treatment charge	(US$/m³)	0.139	(B/m³)	5.00
Wastewater Sludge				
Compost-DS ratio (Non-digested, 1:0.5)	(t compost/t DS)	5.0		
Plant construction (20 year depreciation)				
Incineration (ash type)	(US$/t/day)	21	(B/t/day)	767
Digestion	(US$/t DS)	41	(B/t DS)	1,464
Compost	(US$/t DS)	29	(B/t DS)	1,035
Production/treatment/O&M cost				
Incineration (ash type)	(US$/t/day)	21	(B/t/day)	758.7
Digestion	(US$/t DS)	34.8	(B/t DS)	1,254
Compost	(US$/t DS)	83.3	(B/t DS)	3,000
Unit revenue from digestion	(US$/t DS)	55.0	(B/t DS)	1,980
Distance from WWTP to STC	(km)	25.0		
Distance from STC to Landfill	(km)	15.0		
Distance from Compost Factory to Market	(km)	10.0		
Distance from WWTP to Compost Factory	(km)	100.0		
Landfill (controlled type)	(US$/t)	7.30	(B/t)	263
Weight reduction by incineration: cake/ash		12.5		
Bulking materials density		0.2		
Bulking materials cost	(US$/t)	2	(B/t)	75
Compost sales price	(US$/t)	42	(B/t)	1,500
Wastewater Reclaimed Water				
Watering public parks and gardens				
and plants along road (everyday)	(m³/100ha)	30		
Road sprinkling (once a week)	(m³/100ha)	10		
Cost of additional facility installation	(US$/unit)	88,972	(B/unit)	3,203,000
O&M for additional facility	(US$/m³)	0.025	(B/m³)	0.89
Reclaimed water sales price	(US$/m³)	0.139	(B/m3)	5.00
Reclaimed water production cost	(US$/m³)	0.067	(B/m³)	2.40
Transportation cost (6 ton truck)				
Hauling distance 2 km	(US$/m³)	1.075	(B/m³)	38.70
Hauling distance 4 km	(US$/m³)	1.372	(B/m³)	49.39
Hauling distance 6 km	(US$/m³)	1.669	(B/m³)	60.07
Hauling distance 8 km	(US$/m³)	1.965	(B/m³)	70.75
Hauling distance 10 km	(US$/m³)	2.262	(B/m³)	81.44
Night Soil Treatment Plant				
Plant construction	(US$/m³/d)	9,722	(B/m³/d)	350,000
O&M	(US$/m³/d)	2,600	(B/m³/d)	93,600
Charge cost/bill	(US$/bill/month)	0.078	(B/bill/month)	2.8
No. of people/house	(People/house)	5		
Charge rate	(US$/m³)	1.389	(B/m³)	50
Transportation of collection (20km)	(US$/m³)	3.000	(B/m³)	108

Table 8.1.2.2 Cost Recovery by Generating Power in Digestion Process

Specification		
Capacity	(t DS/d)	160
Generation capacity	(kWh)	8,000
Cost		
Construction cost	(US$)	18,500,000
O&M cost	(US$/y)	500,000
Total cost for 20 years	(US$)	28,500,000
Revenue		
Generation efficiency	(%)	88
Daily generated power	(kWh/d)	140,800
Annual operation days	(d/y)	320
Annual generated power	(kWh/y)	45,056,000
Total power for 20 years	(kWh)	901,120,000
Unit sales price	(B/kWh)	2.25
Unit sales price	(US$/kWh)	0.063
Total revenue for 20 years	(US$)	56,320,000
Unit revenue		
Total revenue for 20 years	(US$)	56,320,000
Unit revenue per capacity	(US$/t DS/d)	352,000
Unit revenue per capacity	(B/t DS/d)	12,672,000
Unit revenue per t DS	**(US$/t DS)**	**55.00**
Unit revenue per t DS	**(B/t DS)**	**1,980**

Note: The estimation of unit cost recovery here is calculated based on assumption of treatment capacity of 160 t DS/d.

Table 8.1.2.3 Cost Estimation for Digestion Plant and Composting Plant

Digestion cost at STC		
Dry solid capacity	(t DS/d)	160
Construction cost		
Digestion	(US$)	7,500,000
Generation	(US$)	18,500,000
Odor removal	(US$)	7,000,000
Dewater	(US$)	9,500,000
Leachet	(US$)	5,000,000
Sub-total	(US$)	47,500,000
Sub-unit cost	(US$/t DS)	41
O&M		
Digestion	(US$/y)	140,000
Generation	(US$/y)	500,000
Odor removal	(US$/y)	800,000
Dewater	(US$/y)	550,000
Leachet	(US$/y)	45,000
Sub-total	(US$/y)	2,035,000
Sub-unit cost	(US$/t DS)	35
Unit cost	(US$/t DS)	76
Composting cost at centralized plant		
Dry solid capacity	(t DS/d)	112
Construction		
Composting process	(US$)	16,500,000
Odor removal	(US$)	7,000,000
Sub-total	(US$)	23,500,000
Sub-unit cost	(US$/t DS)	29
O&M		
Composting process	(US$/y)	2,607,000
Odor removal	(US$/y)	800,000
Sub-total	(US$/y)	3,407,000
Sub-unit cost	(US$/t DS)	83
Unit cost	(US$/t DS)	112

Note: The estimation of unit cost recovery for STC is calculated based on assumption of treatment capacity of 160 t DS/d.
The estimation of composting unit cost is calculated based on assumption of treatment capacity of 112 t DS/d.

Table 8.1.2.4 Mixing Process of Composting (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 8.1.3.1 Local Cost Based Comparison Among Sludge Treatment Options

Option No.		Agricultural use A2	Landfill disposal L2	Landfill disposal L1	Landfill disposal L4
Option Name		compost without Digestion	Dewatered sludge after Digestion	Ash after Digestion	Dewatered sludge without digestion
Cost					
Dewater at on-site					
Dry solid capacity	(t DS/d)	10	10	10	10
Construction	(US$)	2,038,000	2,038,000	2,038,000	2,038,000
O&M	(US$/y)	253,000	253,000	253,000	253,000
Unit cost	**(US$/t DS)**	**97**	**97**	**97**	**97**
Transport					
Unit cost	**(US$/t DS)**	**5.09**	**1.67**	**1.67**	**0.00**
Incineration					
Unit cost of construct.	(US$/t DS)			106.54	
Unit cost for O&M	(US$/t DS)			105.38	
Unit cost	**(US$/t DS)**			**211.92**	
Digestion					
Dry solid capacity	(t DS/d)		160	160	
Construction unit cost	(US$/t DS)		41	41	
O&M unit cost	(US$/t DS)		35	35	
Unit cost	**(US$/t DS)**	**0**	**76**	**76**	**0**
Composting					
Dry solid capacity	(t DS/d)	112			
Construction unit cost	(US$/t DS)	29			
O&M unit cost	(US$/t DS)	83			
Production					
Bulking materials	(t/d)	280			
Bulking materials cost	(US$/d)	583			
Transportation	(US$/t)	0.79			
Production unit cost	(US$/t DS)	7.18			
Unit cost	**(US$/t DS)**	**119**			
Unit cost(excl. construction)	*(US$/t DS)*	*91*			
Compost production	(t/t DS)	5			
Transport					
Unit cost	**(US$/t DS)**	**0.99**	**1.22**	**0.16**	**2.36**
Landfill					
Unit cost	**(US$/t DS)**		**36.50**	**2.92**	**36.50**
Total cost	**(US$/t DS)**	**223**	**212**	**389**	**136**
Revenue					
Sales income of compost	**(US$/t DS)**	**208**	**0**	**0**	**0**
Cost recover by generation	**(US$/t DS)**		**55.00**	**55.00**	**0.00**
Total revenue	**(US$/t DS)**	**208**	**55**	**55**	**0**
Treatment cost including Dewater(=Cost-Revenue)					
Overall dry sludge treatment cost	**(US$/t DS)**	**15**	**157**	**334**	**136**
	(B/t DS)	**531**	**5,657**	**12,039**	**4,899**
Balance after WWTP					
(Excluding dewater)	**(US$/t DS)**	**-82**	**60**	**237**	**39**
	(B/t DS)	**-2,969**	**2,156**	**8,539**	**1,399**
Balance after composting (=Revenue-Cost)					
(Amount of profit)	**(US$/t DS)**	**87.56**			
	(B/t DS)	**3,152**			

Table 8.2.1.1 Operation Data Analysis for Si Phraya Wastewater Treatment Plant (1)

Cost structure	1995 October (Baht)	1995 November (Baht)	1995 December (Baht)	1996 January (Baht)	1996 February (Baht)	1996 March (Baht)	1996 April (Baht)	1996 May (Baht)	1996 June (Baht)	1996 July (Baht)	1996 August (Baht)	1996 September (Baht)	1996 October (Baht)	1996 November (Baht)	1996 December (Baht)	1997 January (Baht)	1997 February (Baht)	1997 March (Baht)
1 Electricity	197,560	196,277	205,605	215,158	202,659	223,562	216,933	229,511	213,662	219,654	199,499	277,432	363,293	364,412	365,594	373,688	199,690	212,958
2 Chemical	68,600	72,290	87,530	67,820	66,150	71,015	70,625	71,800	72,360	73,815	72,415	75,215	111,445	112,566	113,965	112,565	57,265	52,965
3 Water supply	550	495.15	940.95	996.3	830.25	774.9	885.6	553.5	664.2	664.2	664.2	774.09	774.9	719.55	608.85	608.85	608.85	498.15
4 Maintenance & operation	68,400	218,200	218,200	218,200	218,200	218,200	218,200	218,200	218,200	218,200	218,200	218,200	240,800	240,800	240,800	26,922	26,922	26,922
Mech. Repair	0	103,300	103,300	103,300	103,300	103,300	103,300	103,300	103,300	103,300	103,300	103,300	108,300	108,300	108,300	12,068	12,068	12,068
Lub oil and spare parts	62,000	33,300	33,300	33,300	33,300	33,300	33,300	33,300	33,300	33,300	33,300	33,300	50,000	50,000	50,000	11,654	11,654	11,654
Repairing electric	0	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000			
Repairing electric system	6,400	31,600	31,600	31,600	31,600	31,600	31,600	31,600	31,600	31,600	31,600	31,600	32,500	32,500	32,500	3,200	3,200	3,200
5 Interceptor construction																186,250	186,250	186,250
6 Dumping sludge																		
7 Wage	247,740	238,620	259,740	253,410	241,630	242,620	238,800	238,070	239,560	242,110	237,865	254,940	279,890	274,740	281,660	278,890	273,340	281,960
Permanent staff																		
Part time staff																		
Over time																		
8 Miscellaneous	17,000	17,000	17,000	17,000	17,000	17,000	17,000	17,000	17,000	17,000	17,000	17,000	25,000	25,000	25,000	25,000	25,000	25,000
Monthly total	599,850	742,882	789,016	772,584	746,469	773,172	762,444	775,135	761,446	771,443	745,643	843,561	1,021,203	1,018,237	1,027,628	1,003,924	769,076	786,554
Exclude Item 5	599,850	742,882	789,016	772,584	746,469	773,172	762,444	775,135	761,446	771,443	745,643	843,561	1,021,203	1,018,237	1,027,628	817,674	582,826	600,304
Exclude Item 5 & 7	352,110	504,262	529,276	519,174	504,839	530,552	523,644	537,065	521,886	529,333	507,778	588,621	741,313	743,497	745,968	538,784	309,486	318,344
Treated water																		
1 Flow inf. (m^3/d)	8500	8490	8760	8,650	8,640	8,720	8,850	8500	8500	8400	8150	8780	18100	19200	19000	19100	9600	9600
2 BOD inf. (mg/l)	66	58	46	67	53	58	47	61	65	70	64	75	60	66	69	75	78	62
3 BOD removal (%)	92.4	93.12	91.3	94	92.4	93.1	89.4	93.4	92.3	92.9	90.6	93.3	91	93	94.2	94.7	93.6	93.5
No. of staff																		
1 Permanent staff	10	10	10	10	10	10	10	10	10	10	12	10	12	12	12	12	12	12
2 Part time staff	18	18	18	18	17	17	17	17	17	17	20	17	16	16	16	16	16	16
3 Driver																3	3	3
Unit cost to treat waste water (Baht/m^3/d)																		
1 Include all cost	2.28	2.82	2.91	2.88	2.79	2.86	2.78	2.94	2.89	2.96	2.95	3.10	1.82	1.71	1.74	1.70	2.58	2.64
2 Exclude Item 5	2.28	2.82	2.91	2.88	2.79	2.86	2.78	2.94	2.89	2.96	2.95	3.10	1.82	1.71	1.74	1.38	1.96	2.02
3 Exclude Item 5 & 7	1.34	1.92	1.95	1.94	1.88	1.96	1.91	2.04	1.98	2.03	2.01	2.16	1.32	1.25	1.27	0.91	1.04	1.07
Unit cost for labor (Baht/month/man)	8,848	8,522	9,276	9,050	8,940	8,986	8,844	8,817	8,873	8,967	7,433	9,442	9,996	9,812	10,059	8,996	8,817	9,095
Sludge (t/month)																		
Sludge content in wastewater(g/m^3)																		

Note: Data of Oct. and Dec. in 1997 are missing.

Interceptor construction started in Jan. 1997, which is not related to wastewater treatment operation.

Source: Monthly Operation Record of Si Phraya WWTP

Table 8.2.1.1 Operation Data Analysis for Si Phraya Wastewater Treatment Plant (2)

	1997 April	1997 May	1997 June	1997 July	1997 August	1997 September	1997 November	1998 January	1998 February	1998 March	1998 April	1998 May	1998 June	1998 July	1998 August	Average unit cost 95/10-96/9	Average unit cost 96/10-97/9	Average unit cost 97/11-98/8	Overall
Cost structure	(Baht)	(Baht)	(Baht)	(Baht)	(Baht)	(Baht)	(Baht)	(Baht)	(Baht)	(Baht)	(Baht)	(Baht)	(Baht)	(Baht)	(Baht)	(B/m³)	(B/m³)	(B/m³)	(B/m³)
1 Electricity	174,141	167,117	336,049	351,162	353,945	338,527	352,903	343,470	311,604	313,625	322,832	355,159	320,091	318,543	315,662	0.84	0.62	0.55	0.64
2 Chemical	51,105	59,433	108,193	136,253	139,353	134,952	135,338	136,337	136,338	126,690	120,810	122,770	193,500	211,050	210,000	0.28	0.21	0.26	0.24
3 Water supply	664.2	664.2	642	553.5	498.2	599.4	621.6	633	588	605	649	715	561	495	462	0.00	0.00	0.00	0.00
4 Maintenance & operation	26,922	26,922	26,922	26,917	26,922	26,922	66,730	66,730	66,730	66,730	66,730	66,730	66,730	66,730	66,730	0.80	0.17	0.11	0.28
Mech. Repair	12,068	12,068	12,068	12,063	12,068	12,068	7,650	7,650	7,650	7,650	7,650	7,650	7,650	7,650	7,650	0.37	0.07	0.01	0.11
Lub oil and spare parts	11,654	11,654	11,654	11,654	11,654	11,654	41,460	41,460	41,460	41,460	41,460	41,460	41,460	41,460	41,460	0.14	0.04	0.07	0.07
Repairing electric				0	0	0	0	0	0	0	0	0	0	0	0	0.18	0.03	0.00	0.05
Repairing electric system	3,200	3,200	3,200	3,200	3,200	3,200	17,620	17,620	17,620	17,620	17,620	17,620	17,620	17,620	17,620	0.11	0.02	0.03	0.04
5 Interceptor construction	186,250	186,250	186,250	186,250	186,250	186,250	552,580	522,580	522,580	522,580	522,580	522,580	522,580	522,580	522,580	0.00	0.29	0.88	0.45
6 Dumping sludge								0	0	0	0	0	0	0	0	0.00	0.00	0.00	0.00
7 Wage	284,410	285,220	279,180	282,620	278,600	273,980	285,240	293,640	313,420	302,980	215,200	217,560	219,610	224,980	228,970	0.95	0.58	0.43	0.60
Permanent staff								128,360	128,360	128,360	44,040	44,040	44,040	44,040	44,040				
Part time staff								83,200	100,200	104,300	100,200	100,200	100,200	100,200	100,200				
Over time								82,080	84,860	70,320	70,960	73,320	75,370	80,740	84,730				
8 Miscellaneous	25,000	25,000	25,000	25,000	25,000	25,000	35,000	45,000	45,000	45,000	45,000	45,000	50,000	50,000	50,000	0.07	0.05	0.08	0.06
Monthly total	748,492	750,606	962,236	1,008,755	1,010,568	986,230	1,428,412	1,408,390	1,396,260	1,378,210	1,293,801	1,330,514	1,373,072	1,394,378	1,394,404				
Exclude Item 5	562,242	564,356	775,986	822,505	824,318	799,980	875,832	885,810	873,680	855,630	771,221	807,934	850,492	871,798	871,824				
Exclude Item 5 & 7	277,832	279,136	496,806	539,885	545,718	526,000	590,592	592,170	560,260	552,650	556,021	590,374	630,882	646,818	642,854				
Treated water																			
1 Flow inf. (m³/d)	9900	9950	20900	18250	19320	20200	20280	20,280	20,280	18,800	18,000	20,400	20,300	20,600	20,100				
2 BOD inf. (mg/l)	43	49	57.4	55	50	55	62.3	62.3	62.3	89.0	57.6	56.2	64.9	70.2	59.0				
3 BOD removal (%)	90.7	92.2	90.1	92.7	94	94.5	88.3	88.3	88.3	90.0	89.6	91.6	90.9	92.9	87.8				
No. of staff																			
1 Permanent staff	12	12	12	12	12	12	12	12	12	12	5	5	5	5	5				
2 Part time staff	16	16	16	16	16	16	19	20	24	22	21	21	21	21	21				
3 Driver	3	3	3	3	3	3		0	3	3	3	3	3	3	3				
Unit cost to treat waste water (Baht/m³/d)																			
1 Include all cost	2.44	2.43	1.49	1.78	1.69	1.57	2.27	2.24	2.46	2.36	2.40	2.10	2.25	2.18	2.24	2.94	1.91	2.31	2.29
2 Exclude Item 5	1.83	1.83	1.20	1.45	1.38	1.28	1.39	1.41	1.54	1.47	1.43	1.28	1.40	1.37	1.40	2.94	1.63	1.43	1.84
3 Exclude Item 5 & 7	0.91	0.90	0.77	0.95	0.91	0.84	0.94	0.94	0.99	0.95	1.03	0.93	1.04	1.01	1.03	1.99	1.05	1.00	1.23
Unit cost for labor (Baht/month/man)	9,175	9,201	9,006	9,117	8,987	8,838	9,201	9,176	8,036	8,189	7,421	7,502	7,573	7,758	7,896				
											Average labor unit cost (Baht/month/man)				8,767				
Sludge (t/month)											36	27	54	45	35				
Sludge content in wastewater(g/m³)											66.67	44.12	88.67	72.82	58.04				
											Average sludge content (g/m³)				66.06				

Table 8.2.1.2 Operation Data of the Nong Khaem Night Soil Treatment Plant

		2535 1992	2536 1993	2537 1994	2538 1995	2539 1996	2540 1997	Total (m^3)	Average (m^3/d)
	Operator	Asano	Asano	Asano	Asano	Worachak	Worachak		
Night soil	(m^3)	89,041	100,745	89,446	98,659	106,957	103,840	588,688	269
Leachate	(m^3)	9,136	50,467	53,361	42,892	43,603	30,648	230,107	105
Total	(m^3)	98,177	151,212	142,807	141,551	150,560	134,488	818,795	374
								(Baht/m^3)	(%)
Salary	(Baht)	19,251,736	28,015,656	27,641,768	26,107,024	27,739,840	28,477,854	192	56.06
Electricity	(Baht)	1,879,236	2,658,013	2,377,467	2,105,664	2,117,200	1,699,226	16	4.58
Water	(Baht)	149,320	214,917	298,490	282,421	255,452	194,747	2	0.50
Chemicals	(Baht)	6,207,200	12,706,930	3,378,148	6,189,919	2,401,522	2,799,639	41	12.01
Labor	(Baht)	9,432,370	6,819,000	9,305,981	7,763,128	9,037,640	7,735,079	61	17.86
Maintenance	(Baht)	3,322,190	4,443,640	4,446,928	4,280,229	4,620,798	4,098,036	31	8.99
Total	(Baht)	40,242,052	54,858,156	47,448,782	46,728,386	46,172,451	45,004,581	343	100.00
Night soil	(m^3/d)	244	276	245	270	293	284		
Leachate	(m^3/d)	25	138	146	118	119	84		
Total	(m^3/d)	269	414	391	388	412	368		
Treatment unit cost	(Baht/m^3)	410	363	332	330	307	335	343	

Source: Operation data of Nong Khaem NSTP

Note

Plant is in non-stop operation, 24 hours and 365 days.
Salary is Worachak adm/tech staff and Labor is Worachak workers, not including BMA staff.
Leachate is leaked water from nearby garbage dumping site, pumped up to the plant.
Previous analysis show low level of heavy metal contain in sludge, even mixed up with leachate.
Chemical expenditure fluctuated greatly since as large amounted were imported.
Labor and maintenance for 1993 to 1996 are estimated from data for 1991 to 1992.
There is leachate treatment plant in On Nut, managed by DDS.
Garbage Disposal Div. of DPC manages compost incinerator at On Nut and Landfill site at Lat Krabang.

Contract treatment amount with Worachak

Period	Target (m^3/d)	Actual (m^3/d)	Remark
95.12.16-96.12.15	480	412	
96.12.16-97.12.15	500	368	
97.12.16-98.12.15	530	542	(Data in Dec.)
98.12.16-99.12.15	600		
99.12.16-00.12.15	600		

Worachak Balance

Item	1996	1997
Revenue	32,370,400	28,914,920
Expenditure	41,398,277	40,310,969
Profit & Loss	-9,027,877	-11,396,049

Note:
Revenue = total treated volume (m3) x 215 (Bahts/m3
Expenditure = Salary + Labor + Maintenance

Table 8.2.2.1 Financial Analysis for WWTP

(Mil. B)

	Date of Operation Start	Population in 2020 (1000)	Capacity (m^3/d)	Plant construct. (Mil.B)	Past investment (%)	Additional investment	Annual cost Construct cost	O&M cost	Charging cost	Total cost	Annual total revenue	Annual balance
Si Phraya	1996	120	30,000	460	100	0	15	16	0.8	32	55	22
Ratanakosin	1999	70	40,000	880	80	176	29	22	0.5	51	73	22
Din Daeng Phase 1	2000	1,080	341,000	6,400	86	896	213	184	7.3	405	622	218
Din Daeng Phase 2	2010		122,000	4,392	0	4,392	146	66	0.0	212	223	10
Yannawa Phase 1	1999	900	200,000	4,700	79	987	157	108	6.0	271	365	94
Yannawa Phase 2	2015		160,000	5,760	0	5,760	192	86	0.0	278	292	14
Nong Khaem	2001	450	157,000	2,900	20	2,320	97	85	3.0	184	287	102
Kathurana Phase 1	2001	375	65,000	1,900	20	1,520	63	35	2.5	101	119	18
Kathurana Phase 2	2015		65,000	2,340	0	2,340	78	35	0.0	113	119	6
Chatuchak	2003	430	150,000	4,000	0	4,000	133	81	2.9	217	274	57
Thonburi South Phase 1	2005	565	133,700	4,813	0	4,813	160	72	3.8	236	244	8
Thonburi South Phase 2	2015		47,100	1,696	0	1,696	57	25	0.0	82	86	4
Thonburi Central Phase 1	2006	400	95,700	3,445	0	3,445	115	52	2.7	169	175	5
Thonburi Central Phase 2	2016		62,200	2,239	0	2,239	75	34	0.0	108	114	5
Thonburi North Phase 1	2007	216	60,500	2,178	0	2,178	73	33	1.5	107	110	4
Thonburi North Phase 2	2017		17,400	626	0	626	21	9	0.0	30	32	1
Khlong Toey West Phase 1	2008	406	132,500	4,770	0	4,770	159	72	2.7	233	242	9
Khlong Toey West Phase 2	2018		32,500	1,170	0	1,170	39	18	0.0	57	59	3
Khlong Toey East Phase 1	2009	453	163,100	5,872	0	5,872	196	88	3.0	287	298	11
Khlong Toey East Phase 2	2019		22,300	803	0	803	27	12	0.0	39	41	2
Bang Sue	2012	391	126,100	4,540	0	4,540	151	68	2.6	222	230	8
Huay Kwang	2014	317	124,300	4,475	0	4,475	149	67	2.1	218	227	8
Wang Thong Lang	2016	478	141,100	5,080	0	5,080	169	76	3.2	249	258	9
Bung Kum	2018	512	147,800	5,321	0	5,321	177	80	3.4	261	270	9

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
Si Phraya	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	471
Ratanakosin	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	454
Din Daeng Phase 1	218	218	218	218	218	218	218	218	218	218	218	218	218	218	218	218	218	218	218	218	218	4,569
Din Daeng Phase 2											10	10	10	10	10	10	10	10	10	10	10	114
Yannawa Phase 1	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	1,980
Yannawa Phase 2																14	14	14	14	14	14	82
Nong Khaem		102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	102	2,041
Kathurana Phase 1		18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	353
Kathurana Phase 2																6	6	6	6	6	6	33
Chatuchak				57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	1,017
Thonburi South Phase 1						8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	121
Thonburi South Phase 2																4	4	4	4	4	4	24
Thonburi Central Phase 1							5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	82
Thonburi Central Phase 2																	5	5	5	5	5	26
Thonburi North Phase 1								4	4	4	4	4	4	4	4	4	4	4	4	4	4	52
Thonburi North Phase 2																		1	1	1	1	6
Khlong Toey West Phase 1									9	9	9	9	9	9	9	9	9	9	9	9	9	111
Khlong Toey West Phase 2																			3	3	3	8
Khlong Toey East Phase 1										11	11	11	11	11	11	11	11	11	11	11	11	130
Khlong Toey East Phase 2																				2	2	4
Bang Sue													8	8	8	8	8	8	8	8	8	73
Huay Kwang															8	8	8	8	8	8	8	59
Wang Thong Lang																	9	9	9	9	9	44
Bung Kum																			9	9	9	27
Total balance	356	476	476	532	532	540	545	549	557	568	579	579	587	587	595	618	632	634	646	648	648	11,881

Table 8.2.2.2 Financial Analysis for WW Sludge Treatment

Sludge distribution

		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Accumulated Total	Share (%)
High-Risk CWTP Sludge	t DS/d	5.5	5.6	21.5	21.8	22.1	22.3	38.9	39.4	40.0	53.0	62.6	63.4	64.1	64.9	65.6	80.6	91.6	92.9	94.3	99.7	107.2	1,156.8	38.8%
Low-Risk CWTP Sludge	t DS/d	16.8	40.7	40.7	40.7	51.4	51.6	51.9	62.1	69.2	69.7	70.3	82.8	83.5	98.1	98.9	99.8	105.6	122.7	125.8	141.8	143.4	1,667.4	55.9%
Community WWTPs Sludge	t DS/d	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	159.6	5.3%
Total in BMA	t DS/d	29.9	53.9	69.8	70.1	81.1	81.6	98.3	109.1	116.8	130.3	140.5	153.8	155.2	170.6	172.1	187.9	204.7	223.1	227.7	249.1	258.2	2,983.9	100.0%
Sludge to Non Khaem STC	t DS/d	5.5	5.6	21.5	21.8	22.1	22.3	38.9	39.4	40.0	53.0	62.6	63.4	64.1	64.9	65.6	80.6	91.6	92.9	94.3	99.7	107.2	1,156.8	38.8%
Sludge to Composting	t DS/d	24.4	48.3	48.3	48.3	59.0	59.2	59.5	69.7	76.8	77.3	77.9	90.4	91.1	105.7	106.5	107.4	113.2	130.3	133.4	149.4	151.0	1,827.0	61.2%

Revenue from WWTP sludge

		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Accumulated Total
Sludge to Non Khaem STC	(Mil. B)	-4.4	-4.4	-16.9	-17.2	-17.4	-17.6	-30.6	-31.0	-31.4	-41.7	-49.3	-49.9	-50.5	-51.1	-51.6	-63.4	-72.1	-73.1	-74.2	-78.5	-84.4	-910.6
Sludge to Composting	(Mil. B)	26.4	52.3	52.3	52.3	64.0	64.2	64.4	75.6	83.2	83.8	84.4	98.0	98.7	114.6	115.4	116.3	122.6	141.2	144.6	161.9	163.6	1,979.9
Balance	(Mil. B)	22.1	47.9	35.4	35.2	46.6	46.6	33.8	44.5	51.8	42.1	35.1	48.1	48.2	63.5	63.8	52.9	50.6	68.1	70.3	83.4	79.3	1,069.3

Table 8.2.2.3 Cost Comparison of Reclaimed Water Reuse with Public Supply Water

(In case of 6 tons truck)

Additional transportation distance	(km)	1	2	3	4	5	6	7	8	9	10
Additional time	(hr)	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00
Additional driver's labor cost	(B)	4.50	9.00	13.50	18.00	22.50	27.00	31.50	36.00	40.50	45.00
Additional fuel cost	(B)	5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00	45.00	50.00
Additional consumables	(B)	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00
Total additional cost	(B)	11.50	23.00	34.50	46.00	57.50	69.00	80.50	92.00	103.50	115.00
Additional unit cost of transportation	(B/m^3)	1.92	3.83	5.75	7.67	9.58	11.50	13.42	15.33	17.25	19.17
Final unit cost of reuse water	(B/m^3)	4.32	6.23	8.15	10.07	11.98	13.90	15.82	17.73	19.65	21.57
Public water price	(B/m^3)	14.31	14.31	14.31	14.31	14.31	14.31	14.31	14.31	14.31	14.31
Benefit to use reclaimed water	(B/m^3)	9.99	8.08	6.16	4.24	2.33	0.41	-1.51	-3.42	-5.34	-7.26

Unit cost

Driver's labor cost	(B/hr)	45
Fuel cost	(B/l)	10
Fuel consumption of 6 ton truck	(km/l)	2
Average speed	(km/hr)	10
Consumables	(B/km)	2

Table 8.2.2.4 Financial Analysis for Reclaimed Wastewater Reuse (1)

		Catchment area	Capacity	Max demand for tree watering	Max demand for road sampling	Max annual demand	No. of additional facility	Additional investment cost	Annual O&M cost
		(km^2)	(m^3/d)	(m^3/d)	(m^3/d)	(m^3/y)	(Unit)	(Mil. B)	(Mil. B/y)
1	Si Phraya	2.7	30,000	461	154	134,229	2	6.406	0.12
2	Ratanakosin	4.1	40,000	544	181	158,358	2	6.406	0.14
3	BKK Central Phase 1	37.8	341,500	752	251	218,948	3	9.609	0.20
	BKK Central Phase 2		122,000			0		0	0.00
4	Yannawa Phase 1	28.5	200,000	1107	369	322,282	4	12.812	0.29
	Yannawa Phase 2		160,000			0		0	0.00
5	Nong Khaem	42.9	157,000	2520	840	733,650	8	25.624	0.66
6	Ratburana Phase 1	42.3	65,000	835	278	243,077	3	9.609	0.22
	Ratburana Phase 2		65,000			0		0	0.00
7	Chatuchak	33.4	150,000	987	329	287,346	3	9.609	0.26
8	Klong Toey West	25.7	166,000	767	256	223,315	3	9.609	0.20
9	Klong Toey East	31.9	155,000	1016	339	295,806	3	9.609	0.26
10	Tomburi North	11.4	78,000	341	114	99,293	1	3.203	0.09
11	Tomburi Central	17.5	156,000	544	181	158,358	2	6.406	0.14
12	Tomburi South	22.3	213,000	1699	566	494,614	6	19.218	0.44
13	Bang Sue	19.7	126,000	347	116	101,040	1	3.203	0.09
14	Bung Kum	42.8	148,000	1612	537	469,286	5	16.015	0.42
15	Huay Kwang	15.3	124,000	451	150	131,283	2	6.406	0.12
16	Wang Thong Lang	35.7	141,000	1467	489	427,089	5	16.015	0.38
	Total	414.0	2,637,500	15,450	5,150				
	Annual supply and demand		962,687,500	4,229,438	268,536	4,497,973	53	169.76	4.03
	Ratio (%)		100.00	0.44	0.03				
	Ratio of total demand (%)			0.47					

Note: Annual demand for tree watering is calculated by
(Total demand) x 365 x 0.75, since the demand in rainy season is half.
Annual demand for road sampling is calculated by
(Total demand) x 365 x 1/7, because it is done only once a week.

Table 8.2.2.5 Financial Analysis for Reclaimed Wastewater Reuse (2)

	Reclaimed Water Production Cost					Amount of reclaimed water reuse	Revenue From Reclaimed Water Sale					Total
	1999 to 2000 (Mil. B)	2001 to 2005 (Mil. B)	2006 to 2010 (Mil. B)	2011 to 2015 (Mil. B)	2016 to 2020 (Mil. B)	(Mil. m^3)	1999 to 2000 (Mil. B)	2001 to 2005 (Mil. B)	2006 to 2010 (Mil. B)	2011 to 2015 (Mil. B)	2016 to 2020 (Mil. B)	(Mil. B)
1 Si Phraya	0.64	1.61	1.61	1.61	1.61	2.95	1.34	3.36	3.36	3.36	3.36	14.77
2 Ratanakosin	0.76	1.90	1.90	1.90	1.90	3.48	1.58	3.96	3.96	3.96	3.96	17.42
3 BKK Central Phase 1	1.05	2.63	2.63	2.63	2.63	4.82	2.19	5.47	5.47	5.47	5.47	24.08
BKK Central Phase 2												0.00
4 Yannawa Phase 1	1.55	3.87	3.87	3.87	3.87	7.09	3.22	8.06	8.06	8.06	8.06	35.45
Yannawa Phase 2												0.00
5 Nong Khaem		8.80	8.80	8.80	8.80	14.67		18.34	18.34	18.34	18.34	73.37
6 Ratburana Phase 1		2.92	2.92	2.92	2.92	4.86		6.08	6.08	6.08	6.08	24.31
Ratburana Phase 2												0.00
7 Chatuchak		3.45	3.45	3.45	3.45	5.75		7.18	7.18	7.18	7.18	28.73
8 Klong Toey West		2.68	2.68	2.68	2.68	4.47		5.58	5.58	5.58	5.58	22.33
9 Klong Toey East			3.55	3.55	3.55	4.44			7.40	7.40	7.40	22.19
10 Tomburi North			1.19	1.19	1.19	1.49			2.48	2.48	2.48	7.45
11 Tomburi Central				1.90	1.90	1.58				3.96	3.96	7.92
12 Tomburi South				5.94	5.94	4.95				12.37	12.37	24.73
13 Bang Sue				1.21	1.21	1.01				2.53	2.53	5.05
14 Bung Kum				5.63	5.63	4.69				11.73	11.73	23.46
15 Huay Kwang					1.58	0.66					3.28	3.28
16 Wang Thong Lang					5.13	2.14					10.68	10.68
Total	4.00	27.85	32.60	47.28	53.98	69.04	8.34	58.03	67.91	98.49	112.45	345.22
Total cost to produce reclaimed water (Mil. B)					165.70						345.22	
Unit cost to produce reclaimed water (B/m^3)					2.40					Total balance	179.51	

Table 8.2.2.6 Financial Analysis for Incidental Water Use

(B/m^3)

Quantity of Reclaimed Wastewater				
		900	1800	2700
Distance		(m^3/d)	(m^3/d)	(m^3/d)
1	(km)	4.4	3.9	3.7
2	(km)	4.9	4.5	4.2
3	(km)	5.3	5.0	4.6
4	(km)	5.7	5.6	5.2
5	(km)	6.2	5.9	5.4

	Ratio		Reclaimed water demand		Supply cost	Sales revenue	Balance	Accumulated profit up to 2000
	(%)		(m^3/d)	(m^3/y)	(Mil/B/y)	(Mil/B/y)	(Mil/B/y)	(Mil/B/y)
Population in Catchment area		7,163,000						
No. of user in 2001	1.00	71,630	5,501	2,007,932	10.04	16.06	6.02	30.12
No. of user in 2006	2.00	143,260	11,002	4,015,864	20.08	32.13	12.05	60.24
No. of user in 2011	3.00	214,890	16,504	6,023,796	30.12	48.19	18.07	90.36
No. of user in 2016	4.00	286,520	22,005	8,031,729	40.16	64.25	24.10	120.48
							Total	301.19

Sales charge	8	(B/m^3)
Water use of public water	256	(l/c/d)
Amount replaced by reclaimed w.	76.8	(l/c/d)
Financial benefit of individual people for 20 years, compared to public supply water	3,538	(B/capita/20 years)

Table 8.2.2.7 Financial Analysis for Reclaimed Water Reuse

		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total	Share (%)
Reclaimed water for road sprinkling and tree watering																								
Cost	(Mil. B)	5.6	5.6	5.6	5.6	5.6	5.6	6.5	6.5	6.5	6.5	6.5	9.5	9.5	9.5	9.5	9.5	10.8	10.8	10.8	10.8	10.8	167.3	
Revenue	(Mil. B)	11.6	11.6	11.6	11.6	11.6	11.6	13.6	13.6	13.6	13.6	13.6	19.7	19.7	19.7	19.7	19.7	22.5	22.5	22.5	22.5	22.5	348.5	
Balance	**(Mil. B)**	6.0	6.0	6.0	6.0	6.0	6.0	7.1	7.1	7.1	7.1	7.1	10.2	10.2	10.2	10.2	10.2	11.7	11.7	11.7	11.7	11.7	181.2	37.1%
Reclaimed water for incidental use																								
Cost	(Mil. B)	10.0	10.0	10.0	10.0	10.0	10.0	20.1	20.1	20.1	20.1	20.1	30.1	30.1	30.1	30.1	30.1	40.2	40.2	40.2	40.2	40.2	512.0	
Revenue	(Mil. B)	16.1	16.1	16.1	16.1	16.1	16.1	32.1	32.1	32.1	32.1	32.1	48.2	48.2	48.2	48.2	48.2	64.3	64.3	64.3	64.3	64.3	819.2	
Balance	**(Mil. B)**	6.0	6.0	6.0	6.0	6.0	6.0	12.0	12.0	12.0	12.0	12.0	18.1	18.1	18.1	18.1	18.1	24.1	24.1	24.1	24.1	24.1	307.2	62.9%
Total	(Mil. B)	12.1	12.1	12.1	12.1	12.1	12.1	19.1	19.1	19.1	19.1	19.1	28.3	28.3	28.3	28.3	28.3	35.8	35.8	35.8	35.8	35.8	488.4	100.0%

Table 8.2.2.8 Financial Analysis for Nightsoil Treatment

		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
Sludge production																							
High-Risk NSTP Sludge	(t DS/d)	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	5.8
Low-Risk NSTP Sludge	(t DS/d)	21.6	22.0	20.2	20.5	20.9	22.7	23.2	23.6	24.1	24.5	26.6	27.1	27.7	28.2	28.8	31.1	29.9	30.6	31.2	31.9	37.0	31.9
Subtotal	**(t DS/d)**	**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**	**622.5**
Nightsoil collection	(m^3/d)	540.5	550.9	561.3	571.7	582.1	632.0	644.8	657.5	670.3	683.0	739.3	754.9	770.4	786.0	801.5	865.2	884.2	903.2	922.3	941.3	1,100.3	15,562.7
Population to be treated		540,473	550,881	561,290	571,698	582,107	632,016	644,774	657,533	670,291	683,050	739,296	754,856	770,416	785,976	801,536	865,161	884,196	903,231	922,266	941,301	1,100,347	
Family numbers		108,095	110,176	112,258	114,340	116,421	126,403	128,955	131,507	134,058	136,610	147,859	150,971	154,083	157,195	160,307	173,032	176,839	180,646	184,453	188,260	220,069	
Cost																							
Bill charging cost	(Mil. B/y)	3.63	3.70	3.77	3.84	3.91	4.25	4.33	4.42	4.50	4.59	4.97	5.07	5.18	5.28	5.39	5.81	5.94	6.07	6.20	6.33	7.39	104.6
Collection cost by truck	(Mil. B/y)	21.31	21.31	21.31	21.31	21.31	21.31	21.31	21.31	21.31	21.31	21.31	21.31	21.31	21.31	21.31	21.31	21.31	21.31	21.31	21.31	21.31	447.4
Plant O&M	(Mil. B/y)	50.59	51.56	52.54	53.51	54.49	59.16	60.35	61.55	62.74	63.93	69.20	70.65	72.11	73.57	75.02	80.98	82.76	84.54	86.32	88.11	102.99	1,456.7
Landfill for high risk sludge	(Mil. B/y)	0.00	0.00	1.80	1.84	1.87	2.03	2.07	2.11	2.15	2.19	2.38	2.43	2.48	2.53	2.58	2.78	4.28	4.38	4.47	4.56	5.51	54.4
Subtotal	**(Mil. B/y)**	**75.53**	**76.57**	**79.42**	**80.49**	**81.57**	**86.74**	**88.06**	**89.38**	**90.70**	**92.02**	**97.85**	**99.46**	**101.07**	**102.68**	**104.29**	**110.88**	**114.29**	**116.29**	**118.29**	**120.30**	**137.20**	**2,063.1**
Revenue																							
Compost for low risk sludge	(Mil. B/y)	23.43	23.88	21.85	22.25	22.66	24.60	25.10	25.59	26.09	26.59	28.78	29.38	29.99	30.59	31.20	33.67	32.43	33.13	33.83	34.52	40.12	599.7
Service charge	(Mil. B/y)	9.86	9.86	9.86	9.86	9.86	9.86	9.86	9.86	9.86	9.86	9.86	9.86	9.86	9.86	9.86	9.86	9.86	9.86	9.86	9.86	9.86	207.1
Subtotal	**(Mil. B/y)**	**33.29**	**33.74**	**31.71**	**32.12**	**32.52**	**34.46**	**34.96**	**35.46**	**35.95**	**36.45**	**38.64**	**39.24**	**39.85**	**40.46**	**41.06**	**43.54**	**42.29**	**42.99**	**43.69**	**44.39**	**49.98**	**806.8**
Balance																							
Revenue-Cost	(Mil. B/y)	-42.23	-42.83	-47.71	-48.38	-49.05	-52.28	-53.10	-53.93	-54.75	-55.57	-59.21	-60.21	-61.22	-62.22	-63.23	-67.34	-72.00	-73.30	-74.60	-75.91	-87.22	-1,256.29
																					Total	-1,256.29	

Table 8.2.2.9 Overall Financial Analysis Balance

(Mil. B)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total	Share (%)
WWTP																							
Balance	355.9	475.6	475.6	532.1	532.1	539.7	545.2	548.8	557.4	568.2	578.6	578.6	586.7	586.7	595.1	618.2	632.3	633.8	645.7	647.6	647.6	11,881.3	93.83%
WW sludge																							
Balance	23.0	52.0	46.9	47.3	56.0	56.6	48.1	59.5	67.4	61.2	57.0	74.2	75.2	91.3	92.4	85.5	86.9	104.8	107.4	121.7	119.2	1,533.5	12.11%
Reclaimed water reuse																							
Balance	12.1	12.1	12.1	12.1	12.1	12.1	19.1	19.1	19.1	19.1	19.1	28.3	28.3	28.3	28.3	28.3	35.8	35.8	35.8	35.8	35.8	488.4	3.86%
NS																							
Balance	-42.2	-42.8	-47.2	-47.9	-48.5	-51.7	-52.5	-53.3	-54.1	-55.0	-58.5	-59.5	-60.5	-61.5	-62.5	-66.6	-70.8	-72.1	-73.3	-74.6	-85.7	-1,241.0	-9.80%
Overall cash flow																							
Balance	**348.7**	**496.8**	**487.4**	**543.7**	**551.7**	**556.6**	**559.8**	**574.1**	**589.8**	**593.6**	**596.1**	**621.5**	**629.6**	**644.7**	**653.3**	**665.5**	**684.2**	**702.2**	**715.5**	**730.5**	**716.9**	**12,662.2**	**100.00%**

Table 8.2.2.10 Breakeven Cost Analysis

	Set Value (B/m^3)	Accumulated Surplus up to 2020 (Mil. B)
WWTP System		
WW treatment charge rate		
Original rate +40%	7.00	37,229.48
Original rate +20%	6.00	24,555.37
Original rate	5.00	11,881.25
Original rate -20%	4.00	-792.86
Original rate -40%	3.00	-13,466.98
Estimated Breakeven rate	**4.06**	**0.00**
NSTP System		
NS charge rate	(B/m^3)	(Mil. B)
Original rate +1000%	500.00	607.94
Original rate +600%	300.00	-220.61
Original rate	50.00	-1,256.29
Estimated Breakeven rate	**353.00**	**0.00**
Compost sales price	(B/t)	(Mil. B)
Original rate +100%	3,000.00	216.91
Original rate +50%	2,250.00	-519.69
Original rate	1,500.00	-1,256.29
Estimated Breakeven rate	**2,780.00**	**0.00**
Overall System		
WW treatment charge rate	(B/m^3)	(Mil. B)
Original rate	5.00	12,182.68
Original rate -20%	4.00	-491.43
Original rate -40%	3.00	-13,165.54
Estimated Breakeven rate	**4.04**	**0.00**

Table 8.2.3.1 Estimation of WW and NS Sludge Production by Years under Scenario 1

(t DS/d)

Generated Sludge(Dry Sludge)		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Share (%) in 2020
Nong Kaem STC																							
Total	**t-DS/d**	**5.5**	**5.6**	**23.8**	**24.1**	**24.4**	**24.9**	**41.5**	**42.1**	**42.7**	**55.8**	**65.6**	**66.5**	**67.2**	**68.1**	**68.8**	**84.1**	**97.0**	**98.4**	**100.0**	**105.5**	**114.2**	**37.8%**
East Plant																							
Bung Kum	t DS/d																				15.1	15.5	5.1%
Wang Thong Lang	t DS/d																		14.0	14.4	14.7	15.1	5.0%
On-Nut (Nihgt soil)	t DS/d	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	3.4%
Community WWTP	t DS/d	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	0.8%
Subtotal		9.9	10.0	9.4	9.5	9.7	10.3	10.4	10.6	10.7	10.9	11.6	11.8	12.0	12.2	12.3	13.1	10.7	24.9	25.4	41.0	43.5	14.4%
North Plant																							
Bang Sue	t DS/d														14.0	14.1	14.3	14.5	14.6	14.8	14.9	15.1	5.0%
Chatchak	t DS/d					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	4.4%
Din Daeng	t DS/d		23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	35.8	35.8	35.8	35.8	35.8	35.8	35.8	35.8	35.8	35.8	11.8%
Community WWTP	t DS/d	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	0.8%
Subtotal		2.5	26.4	26.4	26.4	37.2	37.4	37.6	37.8	38.0	38.2	38.5	50.6	50.9	65.1	65.5	65.9	66.1	66.2	66.4	66.5	66.7	22.1%
West Plant																							
Thonburi North	t DS/d									6.6	6.7	6.8	6.9	6.9	7.0	7.1	7.2	7.3	7.4	9.6	9.7	9.8	3.2%
Thonburi Central	t DS/d								10.1	10.3	10.5	10.8	11.1	11.4	11.7	12.0	12.3	12.6	15.6	15.9	16.3	16.7	5.5%
Nong Khaem (Night soil)	t DS/d	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	3.1%
Yannawa (Sewage)	t DS/d	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	22.0	22.0	22.0	22.0	22.1	7.3%
Yannawa (Night soil)	t DS/d	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	5.7%
Community WWTP	t DS/d	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	0.8%
Subtotal		33.6	33.9	32.6	32.9	33.1	34.3	34.6	45.0	52.1	52.7	54.4	55.1	55.9	56.7	57.5	59.4	66.3	69.7	72.7	73.7	77.8	25.7%
Total	t DS/d	46.0	70.3	68.5	68.8	79.9	81.9	82.6	93.3	100.9	101.9	104.4	117.5	118.7	134.0	135.3	138.4	143.1	160.8	164.6	181.3	188.0	62.2%
Grand total (Total generated sludge)	**t DS/d**	51.6	76.0	92.3	93.0	104.4	106.9	124.1	135.4	143.6	157.7	170.0	184.0	186.0	202.1	204.1	222.5	240.1	259.3	264.6	286.7	302.2	100.0%

Table 8.2.3.2 Pre-Feasibility Study of Sludge Treatment for Scenario 1

(Mil. US$)

			2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total	Residual value
Sludge to be treated																									
Low risk (A2)	(t DS/d)		46.02	70.34	68.46	68.83	79.95	81.93	82.61	93.34	100.87	101.86	104.41	117.53	118.75	133.97	135.29	138.44	143.08	160.85	164.61	181.26	188.02	2,380.42	
High risk (L2)	(t DS/d)		5.54	5.63	23.81	24.13	24.45	24.92	41.49	42.09	42.69	55.79	65.62	66.49	67.24	68.09	68.85	84.09	97.00	98.42	99.95	105.48	114.19	1,225.98	
Total			51.56	75.97	92.27	92.96	104.39	106.86	124.10	135.43	143.56	157.65	170.03	184.02	185.99	202.06	204.13	222.53	240.08	259.27	264.57	286.74	302.21	3,606.40	
Cost																									
Initial investment cost	Capacity																								
North compost factory																									
Phase 1	(t DS/d)	40	8.39																					8.39	0.00
Phase 2	(t DS/d)	40							8.39															8.39	2.52
East compost factory																									
Phase 1	(t DS/d)	16	3.36																					3.36	0.00
Phase 2	(t DS/d)	32																	6.71					6.71	5.37
West compost factory																									
Phase 1	(t DS/d)	40	8.39																					8.39	0.00
Phase 2	(t DS/d)	40							8.39															8.39	2.10
NSTP rehabilitation																									
Nong Kaem	(m^3/d)	150	0.49																					0.49	
On-nut	(m^3/d)	400	1.30																					1.30	
Subtotal			21.93	0.00	0.00	0.00	0.00	0.00	16.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.71	0.00	0.00	0.00	0.00	45.43	9.99
O&M cost																									
Low risk (A2)																									
Transportation 1	(Mil. US$)		0.09	0.13	0.13	0.13	0.15	0.15	0.15	0.17	0.19	0.19	0.19	0.22	0.22	0.25	0.25	0.26	0.27	0.30	0.31	0.34	0.35	4.42	
Composting	(Mil. US$)		1.52	2.32	2.26	2.27	2.64	2.71	2.73	3.08	3.33	3.37	3.45	3.88	3.92	4.43	4.47	4.57	4.73	5.31	5.44	5.99	6.21	78.65	
Transportation 2	(Mil. US$)		0.02	0.03	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.06	0.06	0.07	0.07	0.86	
High risk (L2)																									
Transportation 1	(Mil. US$)		0.00	0.00	0.01	0.01	0.01	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.05	0.06	0.06	0.06	0.06	0.07	0.75	
Digestion	(Mil. US$)		0.07	0.07	0.30	0.31	0.31	0.32	0.53	0.54	0.54	0.71	0.83	0.85	0.86	0.87	0.88	1.07	1.23	1.25	1.27	1.34	1.45	15.59	
Transportation 2	(Mil. US$)		0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.05	0.05	0.54	
Landfill	(Mil. US$)		0.07	0.08	0.32	0.32	0.33	0.33	0.55	0.56	0.57	0.74	0.87	0.89	0.90	0.91	0.92	1.12	1.29	1.31	1.33	1.41	1.52	16.33	
Subtotal	(Mil. US$)		1.77	2.63	3.06	3.08	3.48	3.56	4.04	4.43	4.71	5.10	5.46	5.95	6.01	6.57	6.64	7.16	7.67	8.34	8.51	9.25	9.72	117.15	
Total	(Mil. US$)		23.70	2.63	3.06	3.08	3.48	3.56	20.82	4.43	4.71	5.10	5.46	5.95	6.01	6.57	6.64	7.16	14.39	8.34	8.51	9.25	9.72	162.58	
Revenue																									
Low risk (A2)																									
Compost sales	(Mil. US$)		3.49	5.34	5.19	5.22	6.06	6.21	6.27	7.08	7.65	7.73	7.92	8.91	9.01	10.16	10.26	10.50	10.85	12.20	12.49	13.75	14.26	180.56	
High risk (L2)																									
Power generaton	(Mil. US$)		0.11	0.11	0.48	0.48	0.49	0.50	0.83	0.84	0.86	1.12	1.32	1.33	1.35	1.37	1.38	1.69	1.95	1.98	2.01	2.12	2.29	24.61	
Residual value of plants	(Mil. US$)																						9.99		
Total	(Mil. US$)		3.60	5.45	5.67	5.71	6.55	6.72	7.10	7.93	8.51	8.85	9.24	10.25	10.36	11.53	11.64	12.19	12.80	14.18	14.49	15.87	26.54	215.16	
Balance	(Mil. US$)		-20.10	2.82	2.61	2.62	3.07	3.15	-13.72	3.49	3.79	3.74	3.78	4.30	4.35	4.96	5.01	5.03	-1.59	5.84	5.98	6.62	16.82	52.58	
Present value																							Total present value		
Discount rate	5%		-20.10	2.68	2.37	2.27	2.53	2.47	-10.24	2.48	2.57	2.41	2.32	2.52	2.42	2.63	2.53	2.42	-0.73	2.55	2.48	2.62	6.34	17.54	
Discount rate	10%		-20.10	2.56	2.16	1.97	2.10	1.96	-7.75	1.79	1.77	1.59	1.46	1.51	1.39	1.44	1.32	1.20	-0.35	1.16	1.08	1.08	2.50	1.83	
FIRR	(%)		10.92%																						

Table 8.2.3.3 Pre-Feasibility Study of Sludge Treatment for Scenario 2

(Mil. US$)

			2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total	Residual value
Sludge to be treated																									
Low risk (A2)	(t DS/d)		46.02	70.34	68.46	68.83	79.95	81.93	82.61	93.34	100.87	101.86	104.41	117.53	118.75	133.97	135.29	138.44	143.08	160.85	164.61	181.26	188.02	2,380.42	
High risk	(t DS/d)		5.54	5.63	23.81	24.13	24.45	24.92	41.49	42.09	42.69	55.79	65.62	66.49	67.24	68.09	68.85	84.09	97.00	98.42	99.95	105.48	114.19	1,225.98	
Landfill after digestion (L2)			5.54	5.63	23.81	24.13	24.45	24.92	41.49	42.09	42.69	55.79	49.21	49.87	50.43	51.07	51.63	63.07	72.75	73.82	74.96	79.11	85.65	992.12	
Incineration (L1)			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.40	16.62	16.81	17.02	17.21	21.02	24.25	24.61	24.99	26.37	28.55	233.86	
Total			51.56	75.97	92.27	92.96	104.39	106.86	124.10	135.43	143.56	157.65	170.03	184.02	185.99	202.06	204.13	222.53	240.08	259.27	264.57	286.74	302.21	3,606.40	
Cost																									
Initial investment cost	Capacity																								
North compost factory																									
Phase 1	(t DS/d)	40	8.39																					8.39	0.00
Phase 2	(t DS/d)	40							8.39															8.39	2.52
East compost factory																									
Phase 1	(t DS/d)	16	3.36																					3.36	0.00
Phase 2	(t DS/d)	32																	6.71					6.71	5.37
West compost factory																									
Phase 1	(t DS/d)	40	8.39																					8.39	0.00
Phase 2	(t DS/d)	40							8.39															8.39	2.10
NSTP rehabilitation																									
Nong Khaem	(m³/d)	150	0.49																					0.49	
On-nut	(m³/d)	400	1.30																					1.30	
Incineration	(t DS/d)	22										17.11												17.11	8.56
Subtotal			21.93	0.00	0.00	0.00	0.00	0.00	16.79	0.00	0.00	17.11	0.00	0.00	0.00	0.00	0.00	0.00	6.71	0.00	0.00	0.00	0.00	62.54	18.54
O&M cost																									
Low risk (A2)																									
Transportation 1	(Mil. US$)		0.09	0.13	0.13	0.13	0.15	0.15	0.15	0.17	0.19	0.19	0.19	0.22	0.22	0.25	0.25	0.26	0.27	0.30	0.31	0.34	0.35	4.42	
Composting	(Mil. US$)		1.52	2.32	2.26	2.27	2.64	2.71	2.73	3.08	3.33	3.37	3.45	3.88	3.92	4.43	4.47	4.57	4.73	5.31	5.44	5.99	6.21	78.65	
Transportation 2	(Mil. US$)		0.02	0.03	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.06	0.06	0.07	0.07	0.86	
Subtotal	(Mil. US$)		1.62	2.48	2.41	2.43	2.82	2.89	2.91	3.29	3.56	3.59	3.68	4.14	4.19	4.72	4.77	4.88	5.05	5.67	5.80	6.39	6.63	83.93	
High risk/Landfill (L2)																									
Transportation 1	(Mil. US$)		0.00	0.00	0.01	0.01	0.01	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.05	0.05	0.05	0.05	0.61	
Digestion	(Mil. US$)		0.07	0.07	0.30	0.31	0.31	0.32	0.53	0.54	0.54	0.71	0.63	0.63	0.64	0.65	0.66	0.80	0.93	0.94	0.95	1.01	1.09	12.62	
Transportation 2	(Mil. US$)		0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.44	
Landfill	(Mil. US$)		0.07	0.08	0.32	0.32	0.33	0.33	0.55	0.56	0.57	0.74	0.66	0.66	0.67	0.68	0.69	0.84	0.97	0.98	1.00	1.05	1.14	13.22	
Subtotal	(Mil. US$)		0.15	0.15	0.65	0.65	0.66	0.68	1.12	1.14	1.16	1.51	1.33	1.35	1.37	1.38	1.40	1.71	1.97	2.00	2.03	2.14	2.32	26.88	
High risk/Incineration (L1)																									
Transportation 1	(Mil. US$)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.14	
Digestion	(Mil. US$)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.21	0.21	0.22	0.22	0.27	0.31	0.31	0.32	0.34	0.36	2.97	
Incineration	(Mil. US$)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.63	0.64	0.65	0.65	0.66	0.81	0.93	0.95	0.96	1.01	1.10	8.99	
Transportation 2	(Mil. US$)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	
Landfill	(Mil. US$)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.25	
Subtotal	(Mil. US$)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.87	0.88	0.89	0.90	0.91	1.11	1.28	1.30	1.32	1.40	1.51	12.37	
Subtotal	(Mil. US$)		1.77	2.63	3.06	3.08	3.48	3.56	4.04	4.43	4.71	5.10	5.88	6.37	6.44	7.01	7.08	7.70	8.30	8.97	9.16	9.93	10.46	123.19	
Total	(Mil. US$)		23.70	2.63	3.06	3.08	3.48	3.56	20.82	4.43	4.71	22.21	5.88	6.37	6.44	7.01	7.08	7.70	15.01	8.97	9.16	9.93	10.46	185.72	
Revenue																									
Low risk (A2)																									
Compost sales	(Mil. US$)		3.49	5.34	5.19	5.22	6.06	6.21	6.27	7.08	7.65	7.73	7.92	8.91	9.01	10.16	10.26	10.50	10.85	12.20	12.49	13.75	14.26	180.56	
High risk (L2)																									
Power generation	(Mil. US$)		0.11	0.11	0.48	0.48	0.49	0.50	0.83	0.84	0.86	1.12	1.32	1.33	1.35	1.37	1.38	1.69	1.95	1.98	2.01	2.12	2.29	24.61	
Residual value of plants	(Mil. US$)																						18.54		
Total	(Mil. US$)		3.60	5.45	5.67	5.71	6.55	6.72	7.10	7.93	8.51	8.85	9.24	10.25	10.36	11.53	11.64	12.19	12.80	14.18	14.49	15.87	35.10	223.71	
Balance	(Mil. US$)		-20.10	2.82	2.61	2.62	3.07	3.15	-13.72	3.49	3.79	-13.37	3.36	3.87	3.91	4.52	4.56	4.49	-2.21	5.20	5.34	5.94	24.64	37.99	
Present value																								**Total present value**	
Discount rate	5%		-20.10	2.68	2.37	2.27	2.53	2.47	-10.24	2.48	2.57	-8.62	2.06	2.27	2.18	2.40	2.31	2.16	-1.01	2.27	2.22	2.35	9.29	6.88	
Discount rate	10%		-20.10	2.56	2.16	1.97	2.10	1.96	-7.75	1.79	1.77	-5.67	1.29	1.36	1.25	1.31	1.20	1.07	-0.48	1.03	0.96	0.97	3.66	-5.58	
FIRR	(%)		7.22%																						

Table 8.2.3.4 Pre-Feasibility Study of Sludge Treatment for Scenario 3

(Mil. US$)

			2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total	Residual value
Sludge to be treated																									
Low risk	(t DS/d)		46.02	70.34	68.46	68.83	79.95	81.93	82.61	93.34	100.87	101.86	104.41	117.53	118.75	133.97	135.29	138.44	143.08	160.85	164.61	181.26	188.02	2,380.42	
Agri use (A2)	(t DS/d)		23.01	35.17	34.23	34.42	39.97	40.97	41.31	46.67	50.44	50.93	52.20	58.76	59.37	66.98	67.64	69.22	71.54	80.42	82.31	90.63	94.01	1,190.21	
Landfill w/o digestion (L4)	(t DS/d)		23.01	35.17	34.23	34.42	39.97	40.97	41.31	46.67	50.44	50.93	52.20	58.76	59.37	66.98	67.64	69.22	71.54	80.42	82.31	90.63	94.01	1,190.21	
High risk (L2)	(t DS/d)		5.54	5.63	23.81	24.13	24.45	24.92	41.49	42.09	42.69	55.79	65.62	66.49	67.24	68.09	68.85	84.09	97.00	98.42	99.95	105.48	114.19	1,225.98	
Total			51.56	75.97	92.27	92.96	104.39	106.86	124.10	135.43	143.56	157.65	170.03	184.02	185.99	202.06	204.13	222.53	240.08	259.27	264.57	286.74	302.21	3,606.40	
Cost																									
Initial investment cost		Capacity																							
North compost factory																									
Phase 1	(t DS/d)	20	4.20																					4.20	0.00
Phase 2	(t DS/d)	20							4.20															4.20	1.26
East compost factory																									
Phase 1	(t DS/d)	8	1.68																					1.68	0.00
Phase 2	(t DS/d)	16																	3.36					3.36	2.69
West compost factory																									
Phase 1	(t DS/d)	20	4.20																					4.20	0.00
Phase 2	(t DS/d)	20							4.20															4.20	1.05
NSTP rehabilitation																									
Nong Kaem	(m^3/d)	150	0.49																					0.49	
On-nut	(m^3/d)	400	1.30																					1.30	
Subtotal			11.85	0.00	0.00	0.00	0.00	0.00	8.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.36	0.00	0.00	0.00	0.00	23.60	4.99
O&M cost																									
Low risk/Agri use (A2)																									
Transportation 1	(Mil. US$)		0.04	0.07	0.06	0.06	0.07	0.08	0.08	0.09	0.09	0.09	0.10	0.11	0.11	0.12	0.13	0.13	0.13	0.15	0.15	0.17	0.17	2.21	
Composting	(Mil. US$)		0.76	1.16	1.13	1.14	1.32	1.35	1.36	1.54	1.67	1.68	1.72	1.94	1.96	2.21	2.24	2.29	2.36	2.66	2.72	2.99	3.11	39.33	
Transportation 2	(Mil. US$)		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.43	
Subtotal	(Mil. US$)		0.81	1.24	1.21	1.21	1.41	1.44	1.46	1.65	1.78	1.80	1.84	2.07	2.09	2.36	2.39	2.44	2.52	2.84	2.90	3.20	3.31	41.97	
Low risk/Landfill w/o digestion (L4)																									
Transportation	(Mil. US$)		0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.07	0.08	0.08	1.02	
Landfill	(Mil. US$)		0.31	0.47	0.46	0.46	0.53	0.55	0.55	0.62	0.67	0.68	0.70	0.78	0.79	0.89	0.90	0.92	0.95	1.07	1.10	1.21	1.25	15.86	
Subtotal	(Mil. US$)		0.33	0.50	0.49	0.49	0.57	0.58	0.59	0.66	0.72	0.72	0.74	0.83	0.84	0.95	0.96	0.98	1.01	1.14	1.17	1.29	1.33	16.88	
High risk (L2)																									
Transportation 1	(Mil. US$)		0.00	0.00	0.01	0.01	0.01	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.05	0.06	0.06	0.06	0.06	0.07	0.75	
Digestion	(Mil. US$)		0.07	0.07	0.30	0.31	0.31	0.32	0.53	0.54	0.54	0.71	0.83	0.85	0.86	0.87	0.88	1.07	1.23	1.25	1.27	1.34	1.45	15.59	
Transportation 2	(Mil. US$)		0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.05	0.05	0.54	
Landfill	(Mil. US$)		0.07	0.08	0.32	0.32	0.33	0.33	0.55	0.56	0.57	0.74	0.87	0.89	0.90	0.91	0.92	1.12	1.29	1.31	1.33	1.41	1.52	16.33	
Subtotal	(Mil. US$)		0.15	0.15	0.65	0.65	0.66	0.68	1.12	1.14	1.16	1.51	1.78	1.80	1.82	1.85	1.87	2.28	2.63	2.67	2.71	2.86	3.09	33.22	
Subtotal	(Mil. US$)		1.29	1.89	2.34	2.36	2.64	2.70	3.17	3.45	3.65	4.03	4.36	4.71	4.76	5.16	5.21	5.70	6.17	6.64	6.78	7.34	7.74	92.06	
Total	(Mil. US$)		13.14	1.89	2.34	2.36	2.64	2.70	11.56	3.45	3.65	4.03	4.36	4.71	4.76	5.16	5.21	5.70	9.52	6.64	6.78	7.34	7.74	115.67	
Revenue																									
Low risk (A2)																									
Compost sales	(Mil. US$)		1.75	2.67	2.60	2.61	3.03	3.11	3.13	3.54	3.83	3.86	3.96	4.46	4.50	5.08	5.13	5.25	5.43	6.10	6.24	6.87	7.13	90.28	
High risk (L2)																									
Power generaton	(Mil. US$)		0.11	0.11	0.48	0.48	0.49	0.50	0.83	0.84	0.86	1.12	1.32	1.33	1.35	1.37	1.38	1.69	1.95	1.98	2.01	2.12	2.29	24.61	
Residual value of plants	(Mil. US$)																						4.99		
Total	(Mil. US$)		1.86	2.78	3.07	3.09	3.52	3.61	3.97	4.39	4.68	4.98	5.28	5.79	5.85	6.45	6.51	6.94	7.37	8.08	8.25	8.99	14.42	119.88	
Balance	(Mil. US$)		-11.29	0.89	0.74	0.74	0.88	0.91	-7.59	0.94	1.03	0.95	0.92	1.09	1.10	1.29	1.30	1.24	-2.15	1.43	1.47	1.65	6.67	4.22	
Present value																								Total present value	
Discount rate	5%		-11.29	0.85	0.67	0.64	0.73	0.71	-5.67	0.67	0.70	0.61	0.56	0.63	0.61	0.68	0.66	0.60	-0.98	0.63	0.61	0.65	2.52	-4.21	
Discount rate	10%		-11.29	0.81	0.61	0.56	0.60	0.56	-4.29	0.48	0.48	0.40	0.35	0.38	0.35	0.37	0.34	0.30	-0.47	0.28	0.26	0.27	0.99	-7.62	
FIRR	(%)		1.94%																						

Table 8.2.3.5 Sensitivity Analysis of Sludge Treatment for Scenario 1

(FIRR in %)

		Unit cost for compost plant construction (US$/t DS/d))				
		-20%	-10%	**Original**	+10%	+20%
Compost sales price (B/t)		167,857	188,839	**209,821**	230,804	251,786
+20%	1,800	22.72%	19.76%	**17.38%**	15.43%	13.78%
+10%	1,650	18.71%	16.21%	**14.17%**	12.48%	11.04%
Original	**1,500**	**14.75%**	**12.65%**	**10.92%**	**9.47%**	**8.23%**
-10%	1,350	10.75%	9.01%	**7.56%**	6.34%	5.29%
-20%	1,200	6.55%	5.14%	**3.96%**	2.96%	2.10%

Table 8.2.3.6 Summary of Pre-Feasibility Study for 3 Scenarios

		Scenario 1		Scenario 2		Scenario 3	
		Sludge in 2020		Sludge in 2020		Sludge in 2020	
		(t DS/d)	(%)	(t DS/d)	(%)	(t DS/d)	(%)
Assumption							
No-use							
Option L2 (Landfill after digestion)		114.2	37.8%	85.6	28.3%	114.2	37.8%
Option L1 (Landfill after incineration)		0.0	0.0%	28.5	9.4%	0.0	0.0%
Option L4 (Landfill w/o digestion)		0.0	0.0%	0.0	0.0%	94.0	31.1%
Use							
Option A2 (Compost)		188.0	62.2%	188.0	62.2%	94.0	31.1%
Total		302.2	100.0%	302.2	100.0%	302.2	100.0%
Accumulated cost up to 2020	(Mil. US$)	162.58		185.72		115.67	
Accumulated revenue up to 2020	(Mil. US$)	215.16		223.71		119.88	
Accumulated balance up to 2020	(Mil. US$)	52.58		37.99		4.22	
FIRR	(%)	10.92%		7.22%		1.94%	
Net present value at 5% discount rate	(Mil. US$)	17.54		6.88		-4.21	
Net present value at 10% discount rate	(Mil. US$)	1.83		-5.58		-7.62	

Table 11.1.1.1 Requirements Regarding the Environmental Impact Assessment (EIA) (1/2)

Items	Types of Projects or Activities	Size
1.	Dam or reservoir	Storage volume of 100 million cubic meter (MC) or more or storage, surface area of 15 square kilometers or more
2.	Irrigation	Irrigated area of 80,000 rais (12,800 ha) or more
3.	Commercial airport	All sizes
4.	Hotel or resort	80 rooms or more
5.	Mass transit system and expressway as defined by the Mass Transit System and Expressway Act, or projects similar to expressway or rail type mass transit system	All sizes
6.	Mining as defined by the Mineral Act	All sizes
7.	Industrial estate as defined by the industrial Estate Authority of Thailand Act, or project similar to industrial estate	All sizes
8.	Commercial port and harbor	With capacity for vessels of 500 t-gross or more
9.	Thermal power plant	Capacity of 10 MW or more
10.	Industries:	
	(1) Petrochemical Industry	Using raw materials which are produced from oil refinery and/or natural gas separation with production capacity of 100 t/d or more
	(2) Oil refinery	All sizes
	(3) Natural gas separation of processing	All sizes
	(4) Chloro-alkaline industry requiring NaCl as raw material for production of Na_2CO_3, NaOH, HCl, Cl_2, NaOCl and bleaching power	Production capacity of each or combined products or 100 t/d or more.
	(5) Iron and/or steel Industry	Production capacity of 100 t/d or more (production capacity calculated by using production capacity of furnace in t/hour multiplied by 24 hours) 100 t/day or using furnaces with combined capacity greater than 5 t/batch
	(6) Cement Industry	All sizes
	(7) Smelting Industry other than iron and steel	Production capacity of 50 t/d or more
	(8) Pulp Industry	Production capacity of 50 t/d or more
11.	All projects in watershed area classified as 1B by the Cabinet Resolution	All sizes

Table 11.1.1.1 Requirements Regarding the Environmental Impact Assessment (EIA) (2/2)

Items	Types of Projects or Activities	Size
12.	Coastal reclamation	All sizes
13.	Building in areas adjacent to rivers, coastal areas, lakes or beaches or in the vicinity of national parks or historical parks	Building 1. 23.00 m height or more. 2. Total area of all floors or area of any floor in the same building is 10,000 m^2 or more
14.	Residential building as defined by the Building Act	80 units or more
15.	Land appropriate (or housing development)	Number of land plots is 500 plots or more Total land area is more than 100 rais (16 ha)
16.	Hospital which is located: (1) in area adjacent to rivers, coastal areas, lakes, or beaches (2) In area other than (1)	(1) 30 beds or more (2) 60 beds or more
17.	Pesticide industry or industry producing active ingredient by chemical process	All sizes
18.	Chemical fertilizer industry using chemical process in production	All sizes
19.	Highway or road as defined by Highway Act passing through following area: (1) Wildlife sanctuaries and wildlife non-hunting area as defined by Wildlife Conservation and Protection Act (2) National parks as defined by National Park Act (3) Watershed class 2 as approved by the cabinet (4) Mangrove forests designated as National Forest Preserves (5) Coastal area within 50 meters of maximum sea level	All projects which are equivalent to or above the minimum standard of rural highway, including roadbed expansion.
20.	Central waste treatment plants as defined by the Factory Act	All sizes
21.	Sugar Industry (1) producing raw sugar, white sugar, refined sugar (2) producing glucose, dextrose, fructose or the like	(1) All sizes (2) production capacity of 20 t/d55 or more
22.	Petroleum Development (1) Geophysical drilling exploration and/or production (2) Oil and gas pipeline system	(1) All sizes (2) All sizes

Source: (1) The Ministry of Science, Technology and Environment Re: Specifying types and sizes of projects or activities of government agency, state enterprise or private person which are required to prepare reports on environmental impact assessment.

(2) The Ministry of Science, Technology and Environment Re: Specifying types and sizes of projects or activities of government agency, state enterprise or private person which are required to prepare reports on environmental impact assessment No.2, B.E. 2535 (1992).

(3) The Ministry of Science, Technology and Environment Re: Specifying types and sizes of projects or activities of government agency, state enterprise or private person which are required to prepare reports on environmental impact assessment No.3, B.E. 2539 (1996).

Table 11.3.1.1 Format for Screening (Option A)

No.	Environmental Item	Description	Evaluation
Social Environment			
1.	Resettlement	Resettlement due to land occupancy (transfer of the rights of residence and land ownership)	[Y] (N) [?]
2.	Economic Activities	Loss of production base and change of economic structure	[Y] (N) [?]
3.	Traffic and Public Facilities	Impacts on schools, hospitals, and present traffic conditions, such as traffic jams and accidents	(Y) [N] [?]
4.	Split of Communities	Separation of regional communities by hindrance of regional traffic	[Y] (N) [?]
5.	Cultural Property	Loss or decrease of the value of cultural assets, such as temples, shrines and archaeological assets	[Y] (N) [?]
6.	Water Rights and Rights of Common	Obstruction of fishing rights, water rights, and rights of common	[Y] (N) [?]
7.	Public Health Condition	Worsening of health and sanitary condition due to the generation of garbage and pathogenic insects	[Y] (N) [?]
8.	Waste	Generation of construction waste, surplus soils, sludge, and domestic waste	(Y) [N] [?]
9.	Hazards (Risk)	Increase in risk of cave-ins, ground failure and accidents	[Y] (N) [?]
Natural Environment			
10.	Topography and Geology	Change of valuable topography and geology due to excavation and earthfill	[Y] (N) [?]
11.	Soil Erosion	Topsoil erosion by rainfall after land reclamation and deforestation	[Y] (N) [?]
12.	Groundwater	Exhaustion of groundwater caused by over-draft, and water pollution by leachate	(Y) [N] [?]
13.	Hydrological Situation	Changes of river discharge and riverbed condition due to filling work and drainage inflow	[Y] (N) [?]
14.	Coastal Zone	Coastal erosion and change of coastal vegetation due to change of littoral drift and reclamation	[Y] (N) [?]
15.	Fauna and Flora	Obstruction of breeding and extinction of species due to the changes of habitat conditions	[Y] (N) [?]
16.	Meteorology	Change of micro-climate, such as temperature, wind, etc., due to large-scale reclamation and construction	[Y] (N) [?]
17.	Landscape	Change of topography and vegetation due to reclamation. Deterioration of aesthetic harmony by structures	[Y] (N) [?]
Pollution			
18.	Air Pollution	Pollution caused by exhaust gas or toxic gas from vehicles and factories	[Y] (N) [?]
19.	Water Pollution	River and groundwater pollution caused by inflow of drainage and sludge from water treatment facilities	[Y] [N] (?)
20.	Soil Contamination	Contamination caused by discharge or diffusion of waste water drainage or toxic materials	[Y] [N] (?)
21.	Noise and Vibration	Noise and vibration generated by vehicles and operation of water treatment plants	(Y) [N] [?]
22.	Land Subsidence	Land deformation and land subsidence caused by the lowering of water table	[Y] (N) [?]
23.	Offensive Odor	Generation offensive odor and exhausted gas	(Y) [N] [?]
Overall Evaluation: Either IEE or EIA is necessary for the Project Implementation?			(Y) [N]

Table 11.3.1.2 Format for Screening (Option B)

No.	Environmental Item	Description	Evaluation
Social Environment			
1.	Resettlement	Resettlement due to land occupancy (transfer of the rights of residence and land ownership)	[Y] (N) [?]
2.	Economic Activities	Loss of production base and change of economic structure	[Y] (N) [?]
3.	Traffic and Public Facilities	Impacts on schools, hospitals, and present traffic conditions, such as traffic jams and accidents	(Y) [N] [?]
4.	Split of Communities	Separation of regional communities by hindrance of regional traffic	[Y] (N) [?]
5.	Cultural Property	Loss or decrease of the value of cultural assets, such as temples, shrines and archaeological assets	[Y] (N) [?]
6.	Water Rights and Rights of Common	Obstruction of fishing rights, water rights, and rights of common	[Y] (N) [?]
7.	Public Health Condition	Worsening of health and sanitary condition due to the generation of garbage and pathogenic insects	[Y] [N] (?)
8.	Waste	Generation of construction waste, surplus soils, sludge, and domestic waste	(Y) [N] [?]
9.	Hazards (Risk)	Increase in risk of cave-ins, ground failure and accidents	[Y] (N) [?]
Natural Environment			
10.	Topography and Geology	Change of valuable topography and geology due to excavation and earthfill	[Y] (N) [?]
11.	Soil Erosion	Topsoil erosion by rainfall after land reclamation and deforestation	[Y] (N) [?]
12.	Groundwater	Exhaustion of groundwater caused by over-draft, and water pollution by leachate	[Y] [N] (?)
13.	Hydrological Situation	Changes of river discharge and riverbed condition due to filling work and drainage inflow	[Y] (N) [?]
14.	Coastal Zone	Coastal erosion and change of coastal vegetation due to change of littoral drift and reclamation	[Y] (N) [?]
15.	Fauna and Flora	Obstruction of breeding and extinction of species due to the changes of habitat conditions	[Y] [N] (?)
16.	Meteorology	Change of micro-climate, such as temperature, wind, etc., due to large-scale reclamation and construction	[Y] (N) [?]
17.	Landscape	Change of topography and vegetation due to reclamation. Deterioration of aesthetic harmony by structures	[Y] [N] (?)
Pollution			
18.	Air Pollution	Pollution caused by exhaust gas or toxic gas from vehicles and factories	[Y] (N) [?]
19.	Water Pollution	River and groundwater pollution caused by inflow of drainage and sludge from water treatment facilities	[Y] [N] (?)
20.	Soil Contamination	Contamination caused by discharge or diffusion of waste water drainage or toxic materials	[Y] (N) [?]
21.	Noise and Vibration	Noise and vibration generated by vehicles and operation of water treatment plants	(Y) [N] [?]
22.	Land Subsidence	Land deformation and land subsidence caused by the lowering of water table	[Y] (N) [?]
23.	Offensive Odor	Generation offensive odor and exhausted gas	[Y] [N] (?)
Overall Evaluation: Either IEE or EIA is necessary for the Project Implementation?			(Y) [N]

Table 11.4.1.1 Environmental Issues Raised by IEE

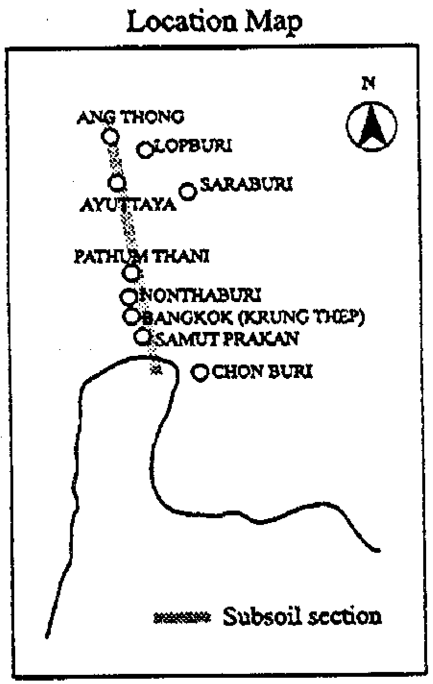
Option 1	Option 2
Social Environment	Social Environment
1) Traffic and Public Facilities	1) Traffic and Public Facilities
2) Waste	2) Public Health Condition
	3) Waste
Natural Environment	Natural Environment
1) Ground Water	1) Ground Water
	2) Fauna & Flora
	3) Landscape
Pollution	Pollution
1) Water Pollution	1) Water Pollution
2) Soil Contamination	2) Noise and Vibration
3) Noise and Vibration	3) Offensive Odor
4) Offensive Odor	

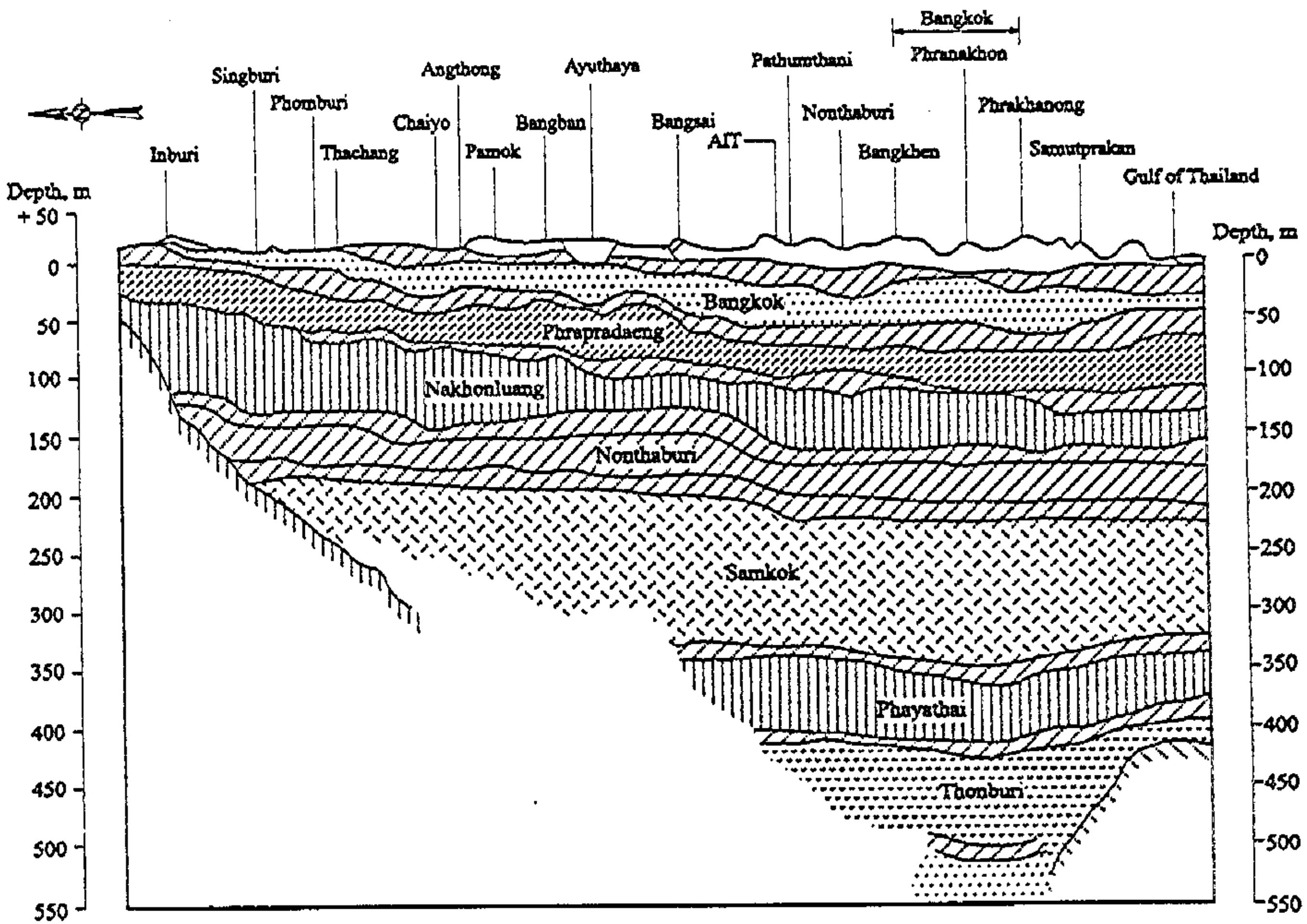
Table 11.4.1.2 Summary of IEE

Environmental Item	Option A	Option B	Problem	Countermeasure
1. Traffic and Public Facilities	S	S	Traffic will increase	Route and time of transport have to pre-planned.
2. Public Health Condition	N	X	In case of land application, a health risk is prevailing	Proper reuse plan in to be developed, final disposal should be monitored carefully.
3. Waste	S	S	Generation of waste	No problem it final disposal conducted properly and regulatory.
4. Ground Water	M	S	Leachate can pollute ground water resources	Sanitary landfill with leachate treatment is recommended. If not possible, ground water use should be restricted.
5. Fauna & Flora	N	X	Trace toxic can change flora & fauna	Controlled land application should be adopted.
6. Landscape	N	X	Use of comport may change crop pattern	Controlled land application should be adopted.
7. Water Pollution	X	S	Groundwater pollution can lead to wide-spread water pollution	Sanitary landfill is recommended.
8. Soil Contamination	X	N	May cause pollution by trace toxic substances	Sanitary landfill and controlled land application is required.
9. Noise and Vibration	S	S	Will generate during transportation	Route and time of transport have to be pre-planned.
10. Offensive Odor	S	S	May cause some odor during transport and disposal	Closed truck should be used for transport, agricultural area should be chosen carefully.

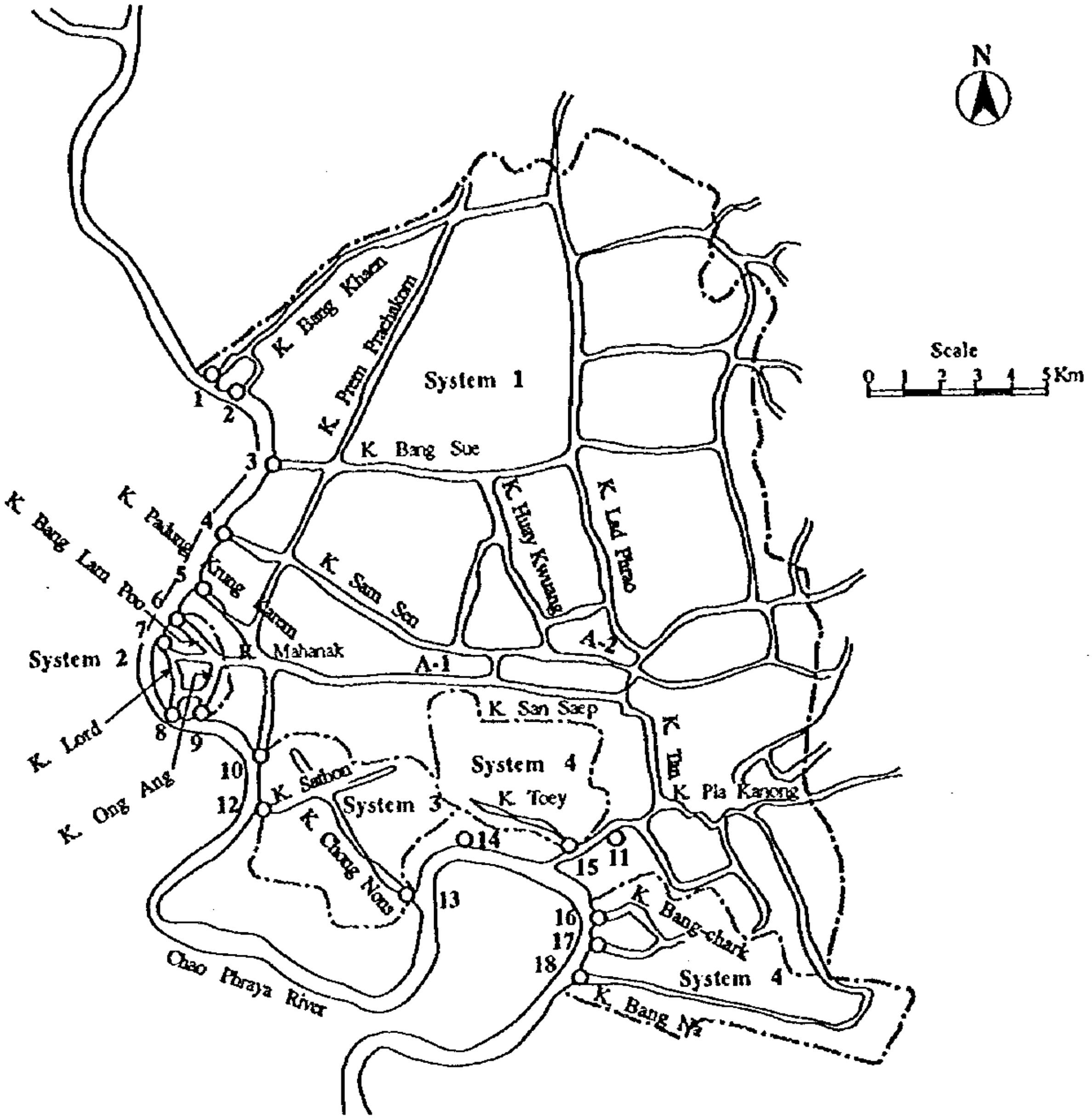
M: Major, S: Small, N: None, X: Not clear

Figures





THE STUDY FOR MASTER PLAN ON SEWAGE SLUDGE TREATMENT / DISPOSAL AND RECLAIMED WASTEWATER REUSE IN BANGKOK	Figure 2.1.4.1 SUB-SOIL STRATA OF THE CHAO PHRAYA PLAIN
JAPAN INTERNATIONAL COOPERATION AGENCY	



Station for Water Dilution Systems

No.	Name of Pump Station & Gate
System 1 & 2	
1	Bang Khen Ghao P.S.
2	Bang Khen Mai P.S.
3	Bang Sue P.S.
4	Sam Sen P.S.
5	Tavate P.S.
6	Ban Lum Phu G.
7	Phra Phinklao G.
8	Pak K. Talad G.
9	Ong Ang G.
10	Krung kasem P.S.
11	Phra Khanong P.S.

System 3	
12	Sathorn P.S.
13	Chong Non Sri Temporary P.S.
14	Rama IV P.S.
System 4	
15	K. Toey P.S.
16	Bang Chak P.S.
17	Bang Or P.S.
18	Bang Na P.S.

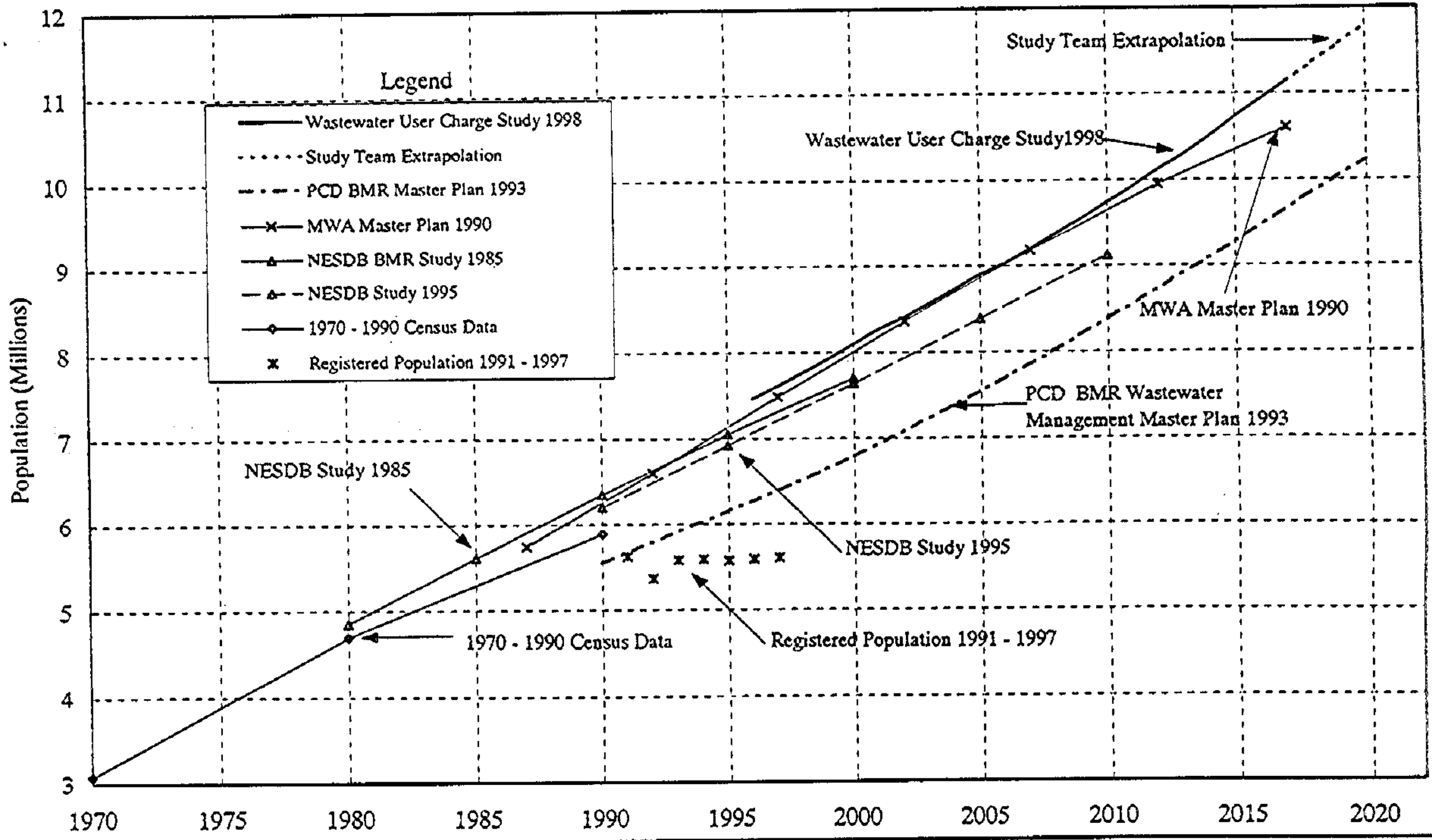
Aerated Lagoon Systems

No.	Name of Aerated Lagoon Systems
A-1	Makkasan Pond
A-2	Rama IX Pond
A-3	Buddamonthon Sai 2

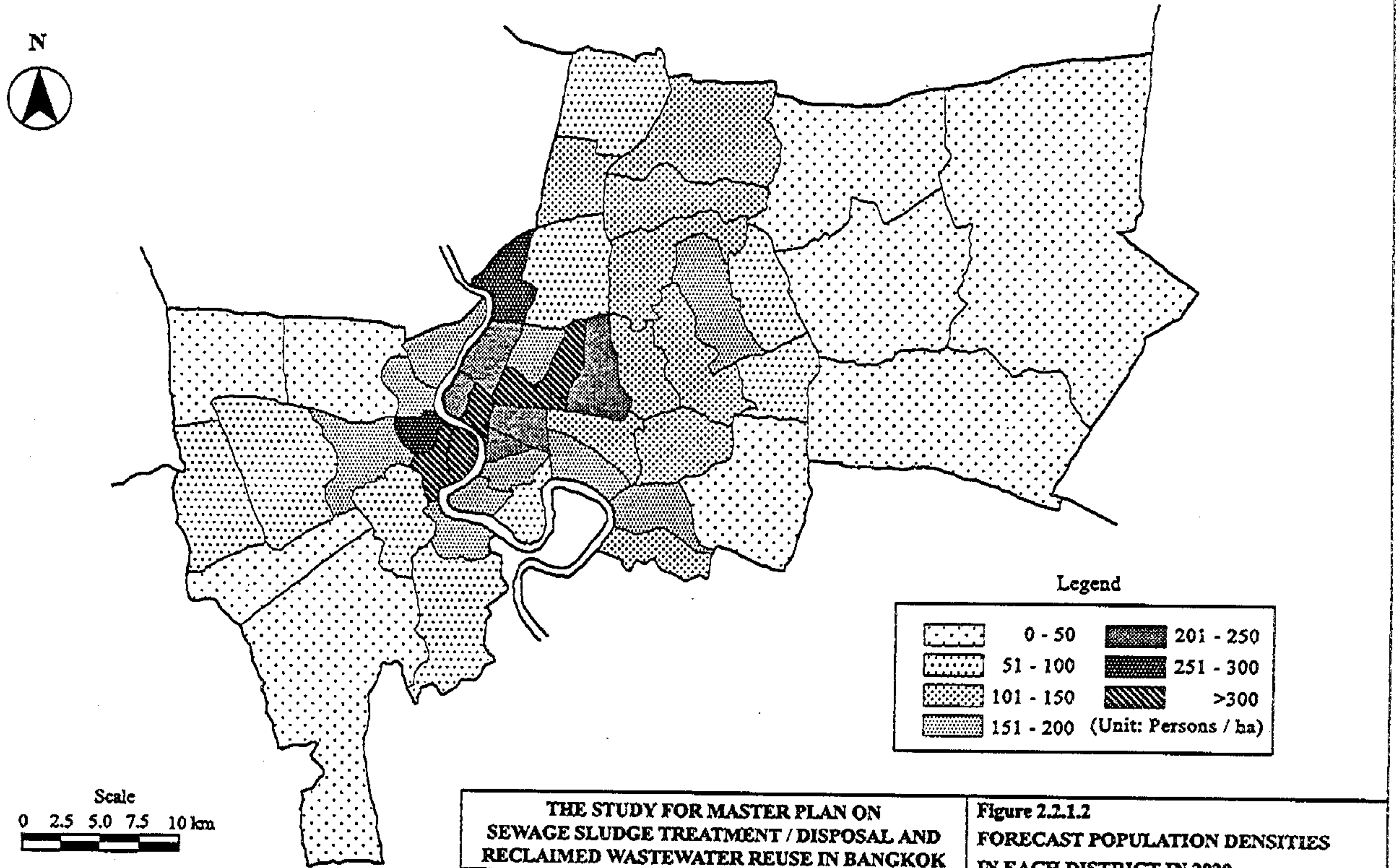
THE STUDY FOR MASTER PLAN ON
SEWAGE SLUDE TREATMENT / DISPOSAL AND
RECLAIMED WASTEWATER REUSE IN BANGKOK

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 2.1.5.1
LOCATION OF KHLONG WATER
IMPROVEMENT FACILITIES



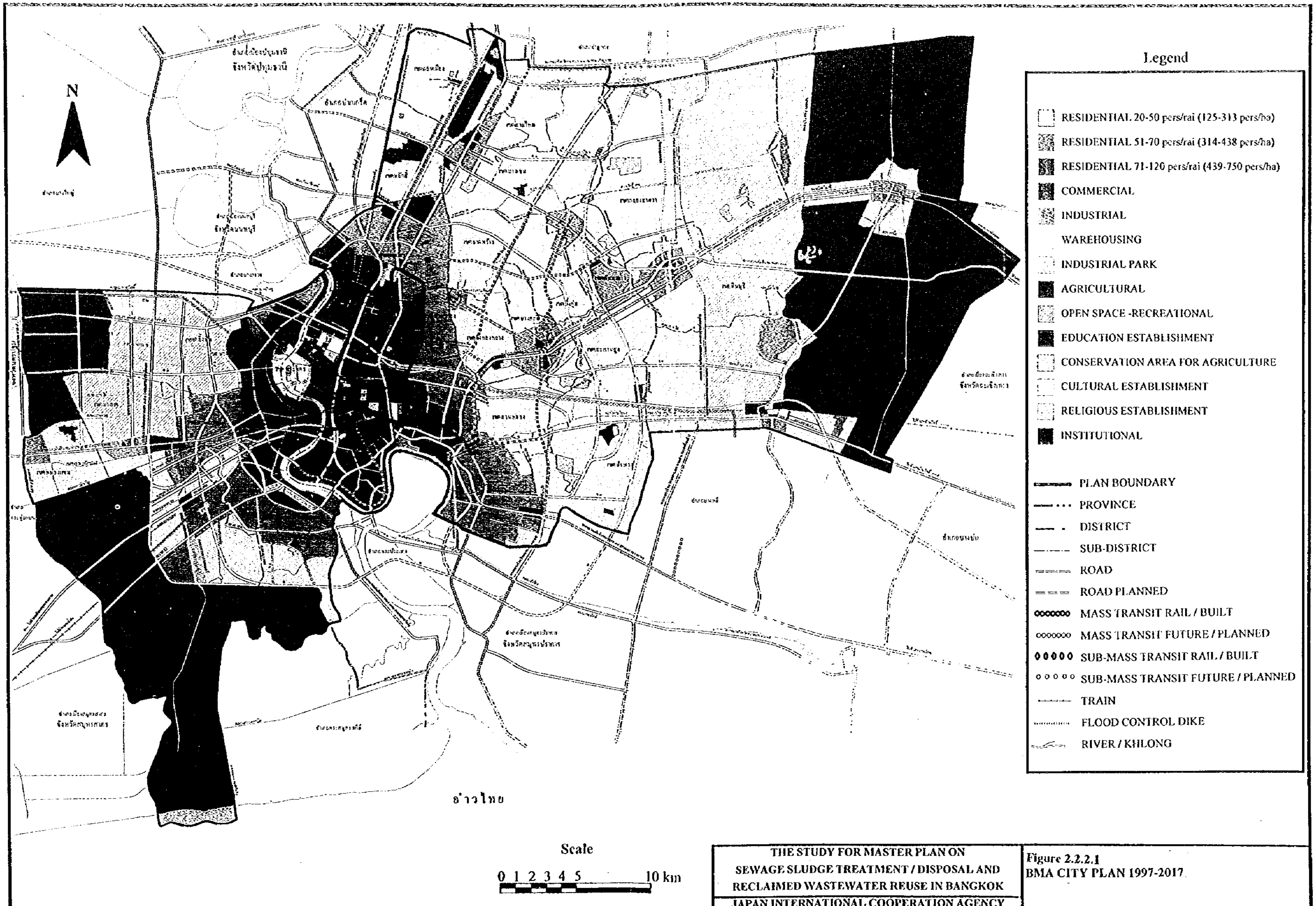
THE STUDY FOR MASTER PLAN ON SEWAGE SLUDGE TREATMENT / DISPOSAL AND RECLAIMED WASTEWATER REUSE IN BANGKOK	Figure 2.2.1.1 COMPARISON OF POPULATION PROJECTIONS IN BMA AREA
JAPAN INTERNATIONAL COOPERATION AGENCY	



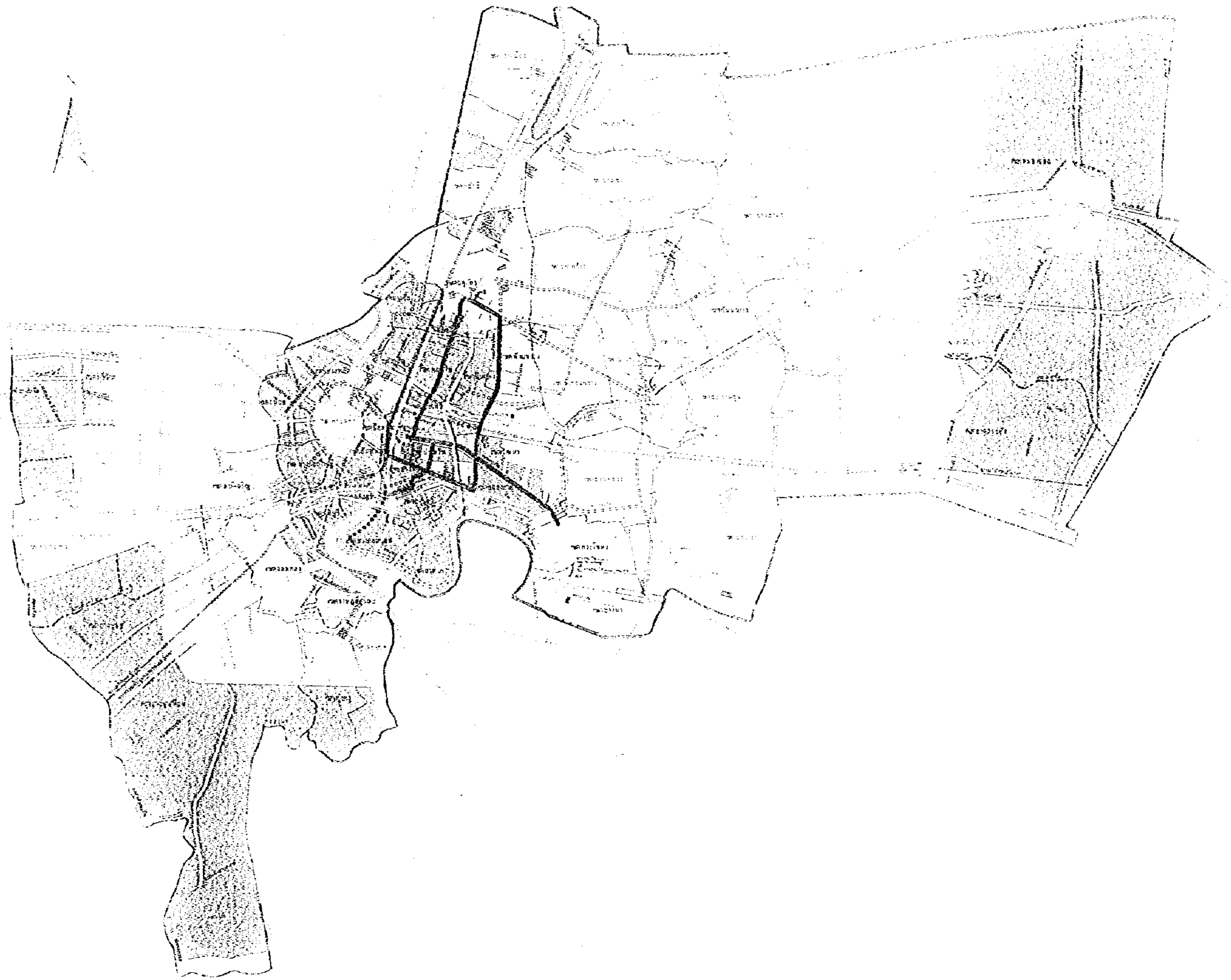
THE STUDY FOR MASTER PLAN ON SEWAGE SLUDGE TREATMENT / DISPOSAL AND RECLAIMED WASTEWATER REUSE IN BANGKOK

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 2.2.1.2
FORECAST POPULATION DENSITIES IN EACH DISTRICT IN 2020



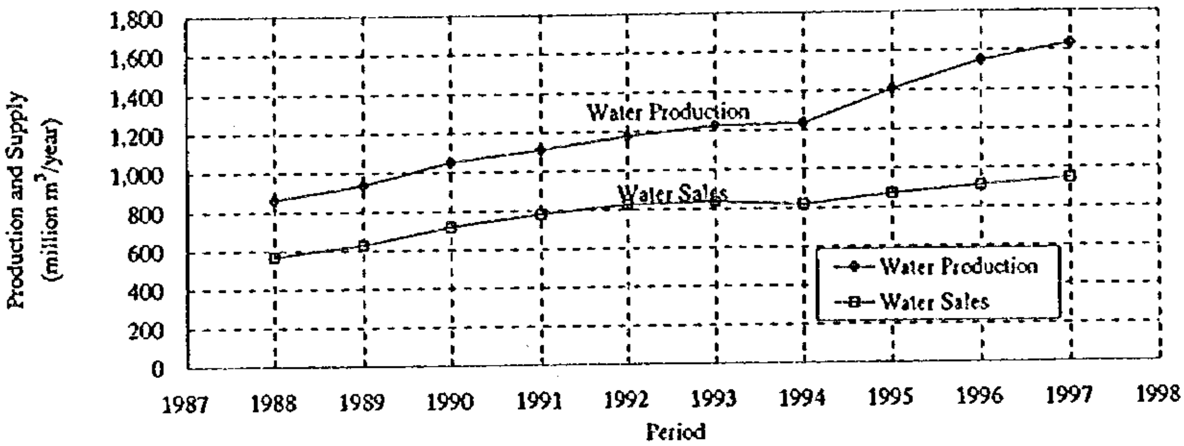
THE STUDY FOR MASTER PLAN ON SEWAGE SLUDGE TREATMENT / DISPOSAL AND RECLAIMED WASTEWATER REUSE IN BANGKOK	Figure 2.2.2.1 BMA CITY PLAN 1997-2017
JAPAN INTERNATIONAL COOPERATION AGENCY	

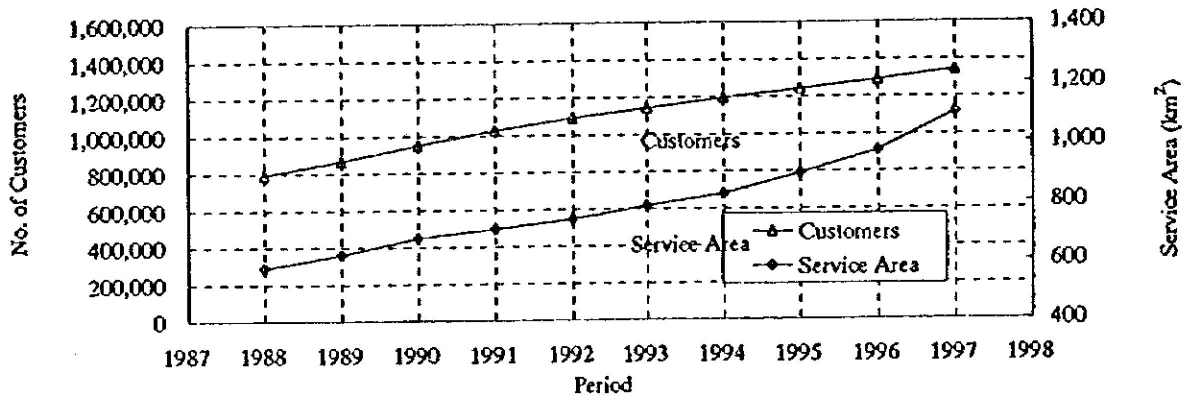


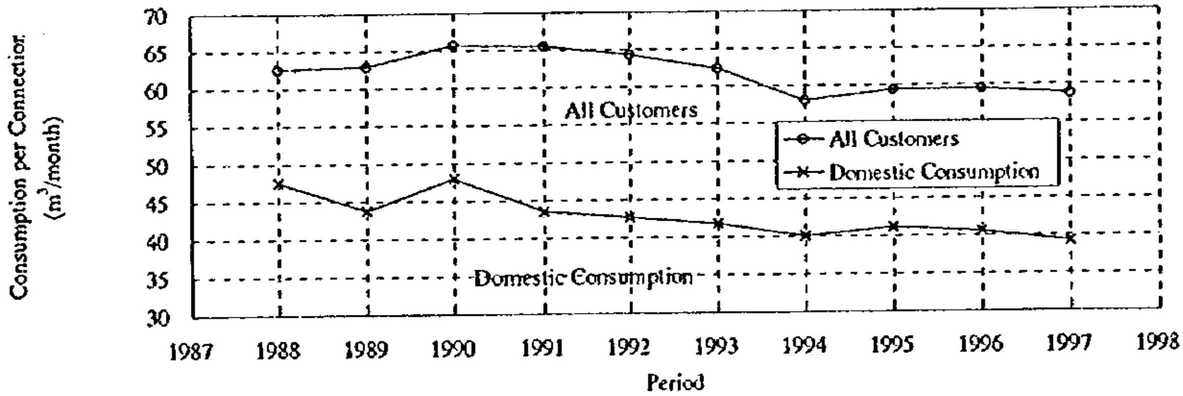
Scale

0 1 2 3 4 5 10 km

THE STUDY FOR MASTER PLAN ON SEWAGE SLUDGE TREATMENT, DISPOSAL AND RECLAIMED WASTEWATER REUSE IN BANGKOK	Figure 2.2.1 BMA CITY PLAN 1997-2017
JAPAN INTERNATIONAL COOPERATION AGENCY	

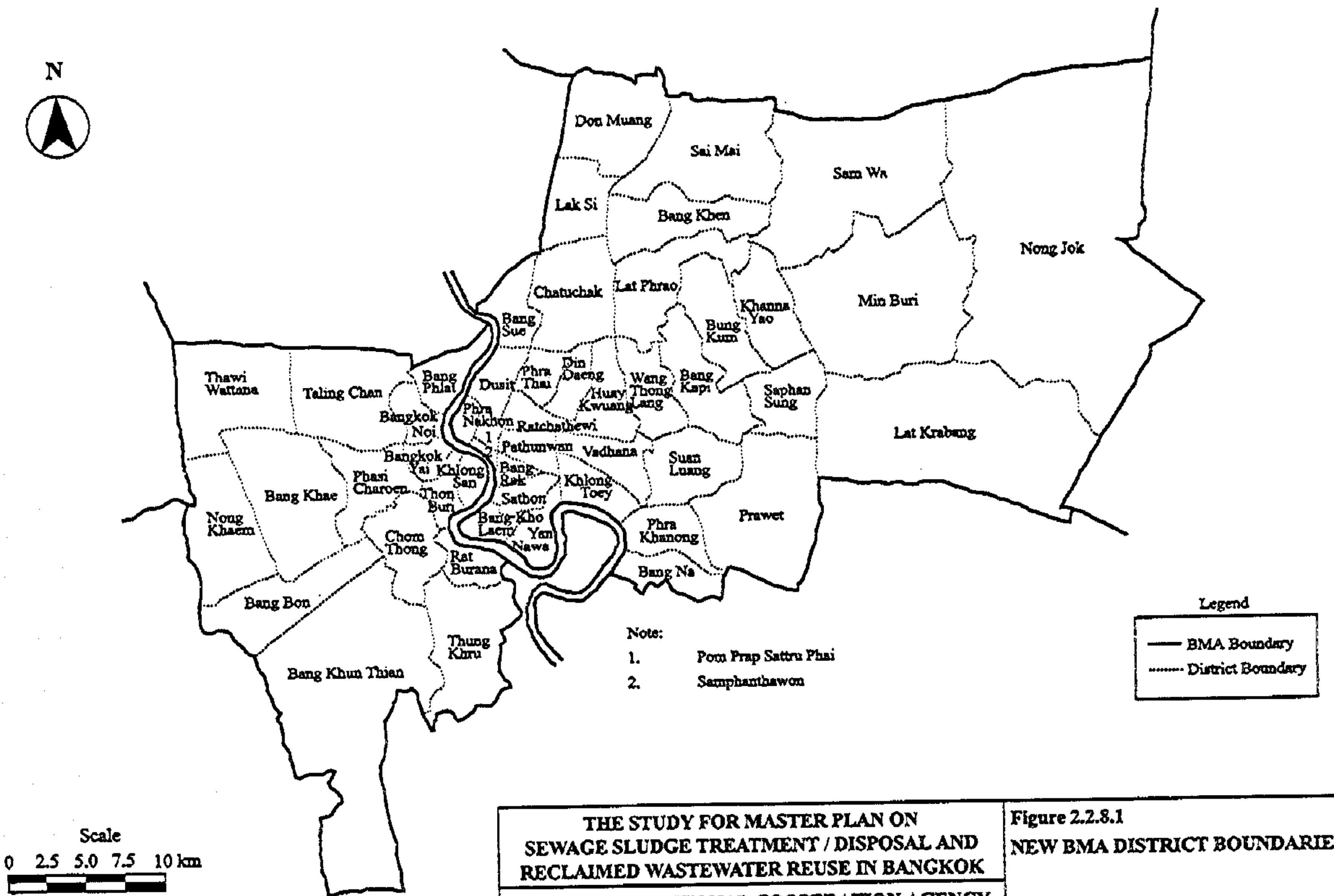




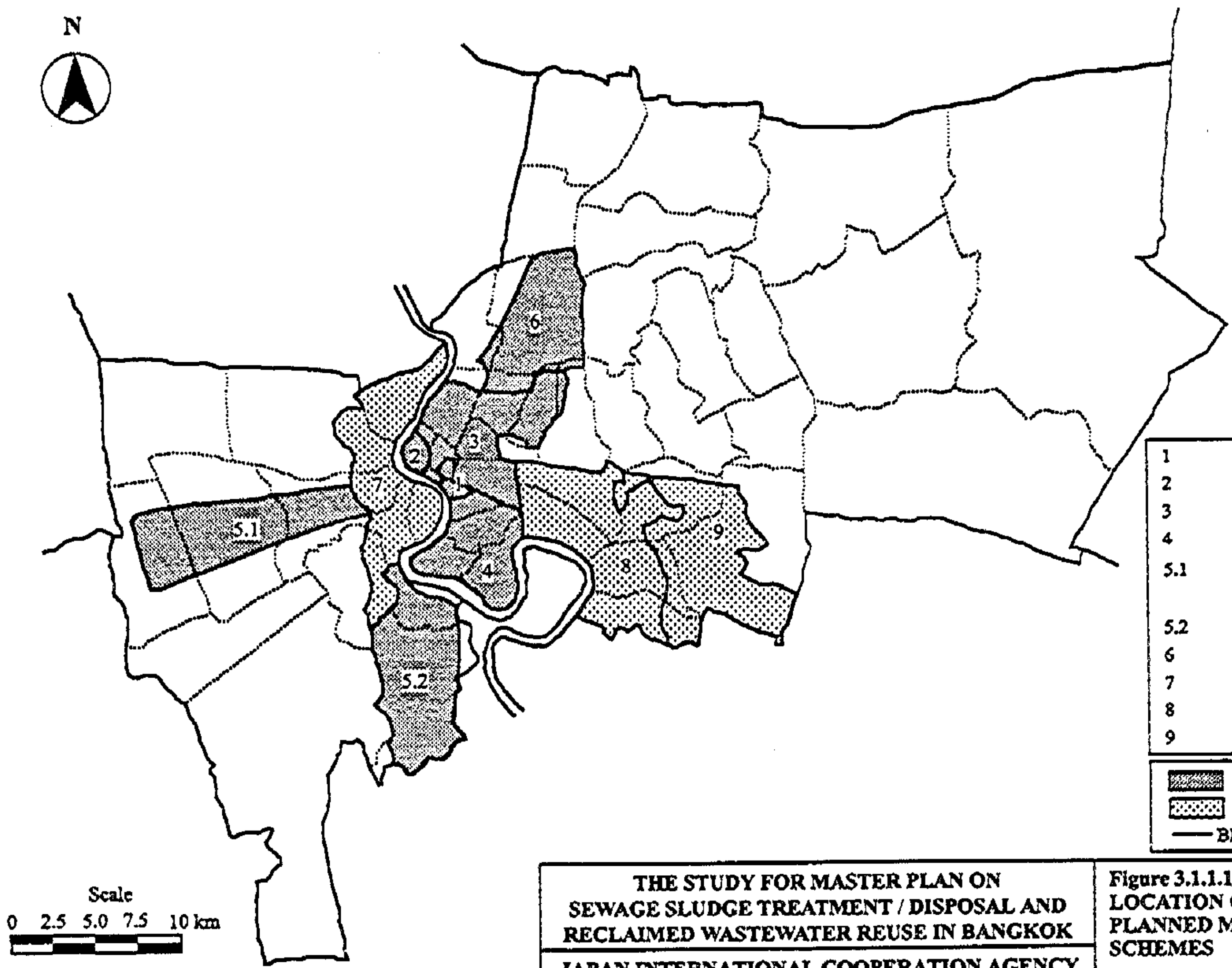


Source: MWA Annual Report 1997

THE STUDY FOR MASTER PLAN ON SEWAGE SLUDGE TREATMENT / DISPOSAL AND RECLAIMED WASTEWATER REUSE IN BANGKOK	Figure 2.2.3.1 GROWTH IN MWA WATER SERVICES
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY FOR MASTER PLAN ON SEWAGE SLUDGE TREATMENT / DISPOSAL AND RECLAIMED WASTEWATER REUSE IN BANGKOK	Figure 2.2.8.1 NEW BMA DISTRICT BOUNDARIES
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY FOR MASTER PLAN ON
SEWAGE SLUDGE TREATMENT / DISPOSAL AND
RECLAIMED WASTEWATER REUSE IN BANGKOK

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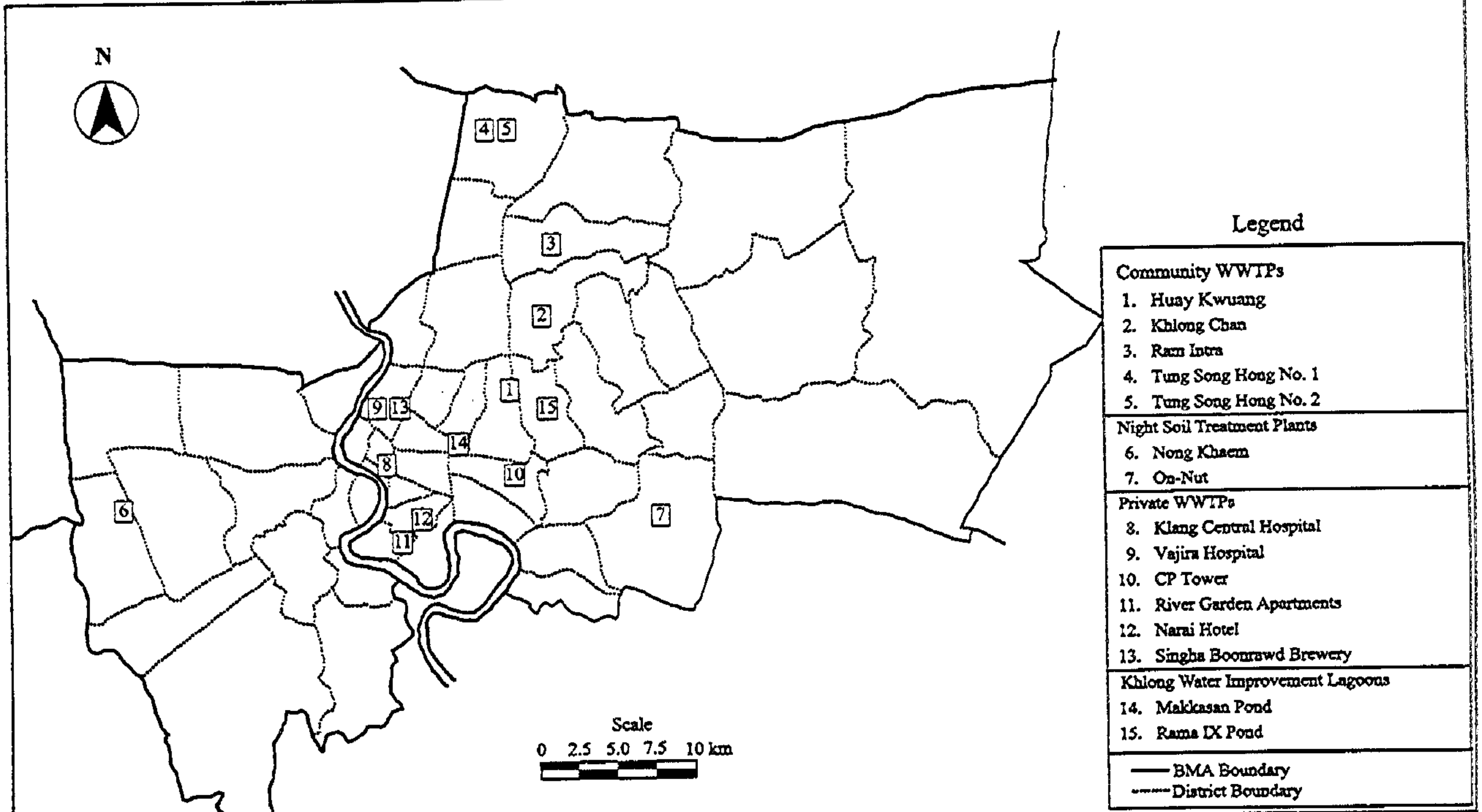
Figure 3.1.1.1
LOCATION OF EXISTING, ONGOING AND PLANNED MAJOR BMA WASTEWATER SCHEMES



THE STUDY FOR MASTER PLAN ON SEWAGE SLUDGE TREATMENT / DISPOSAL AND RECLAIMED WASTEWATER REUSE IN BANGKOK

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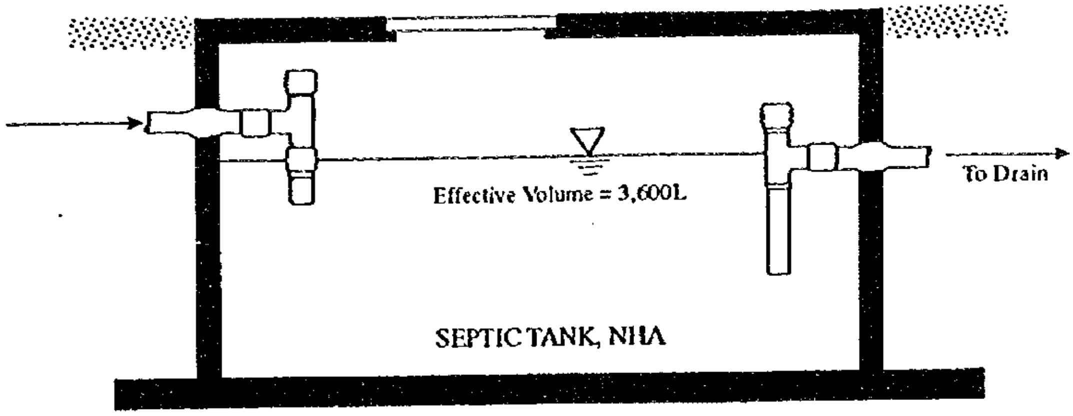
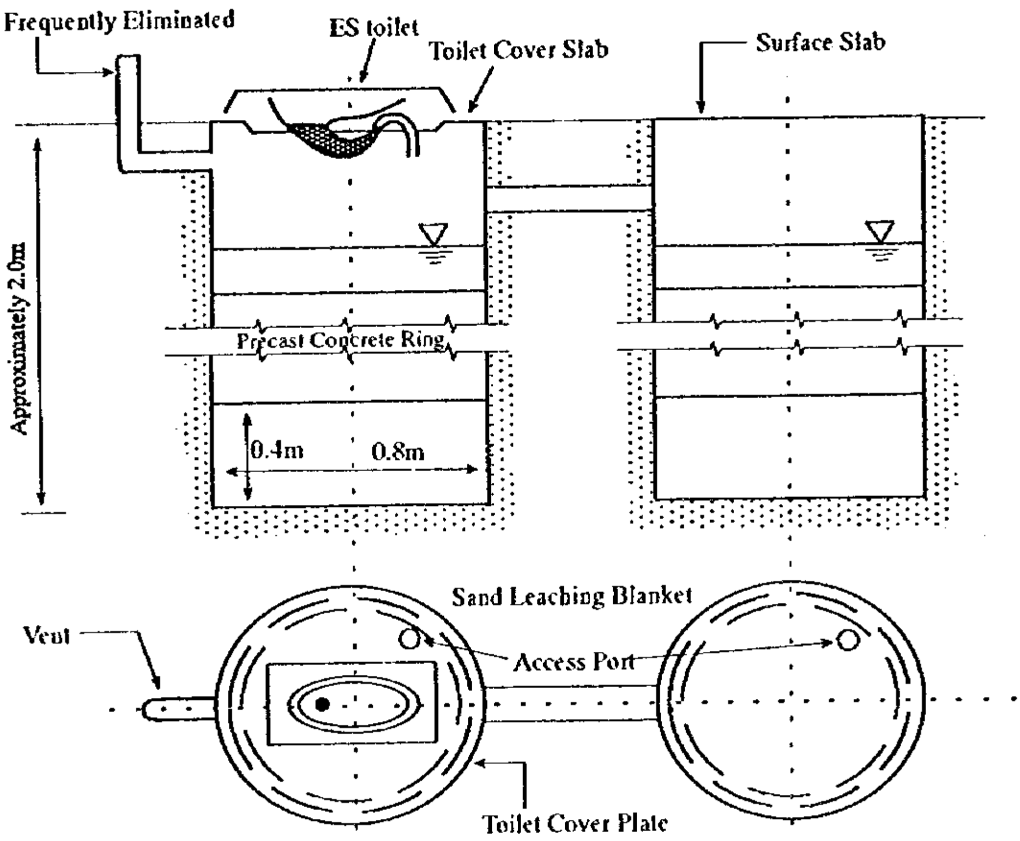
Figure 3.1.1.2
LOCATION OF SMALL WASTEWATER NIGHT SOIL AND KHLONG WATER TREATMENT FACILTIES INSPECTED BY THE STUDY TEAM



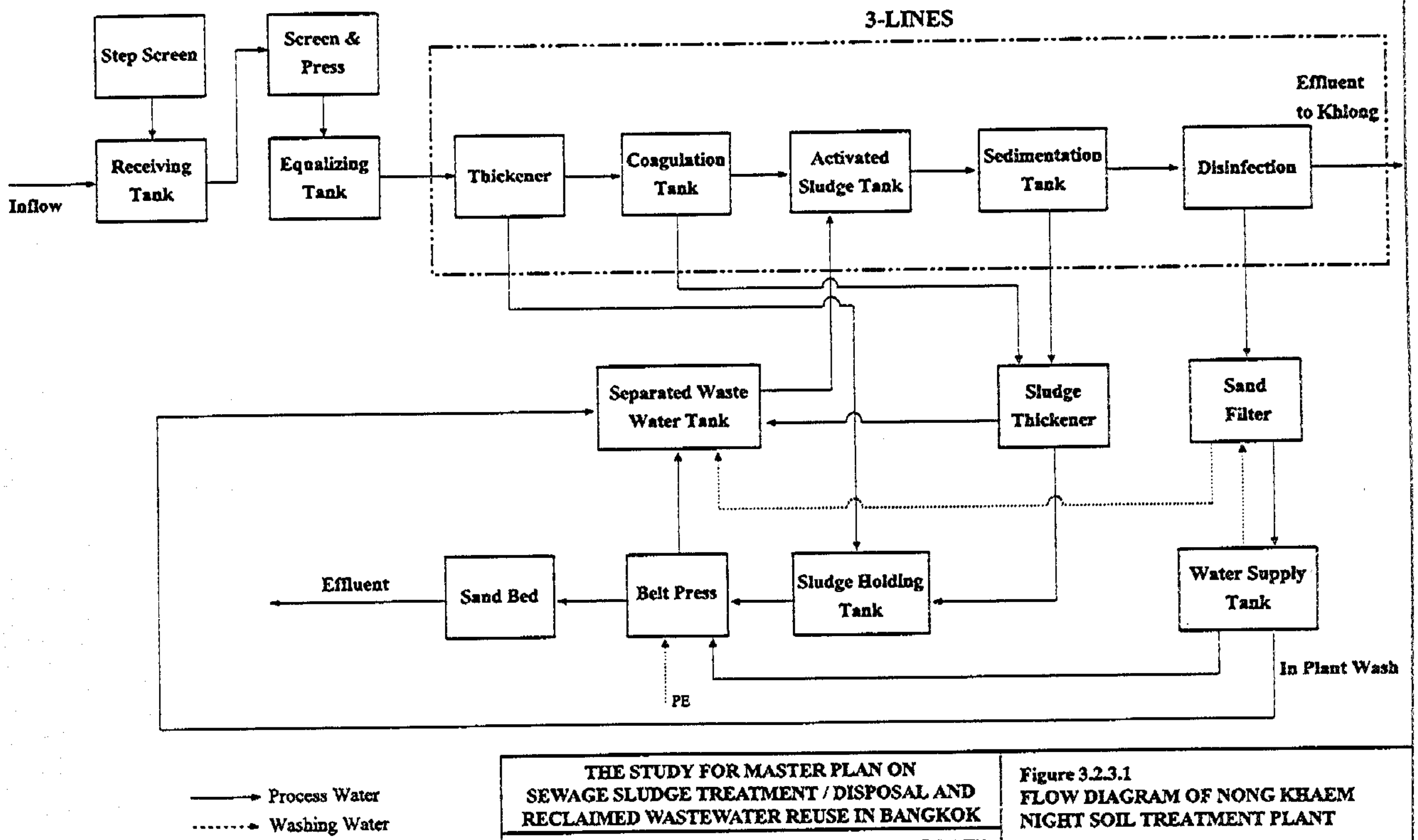
Sectional View of a Septic Tank
(Outlet is Connected to the Combined Sewer)



Sectional View of a Typical "Leaching Cesspol"

Source: 1998 AIT Feasibility Study on Agricultural Use and Land Application of Sewage and Night Soil Sludge for Bangkok Metropolitan

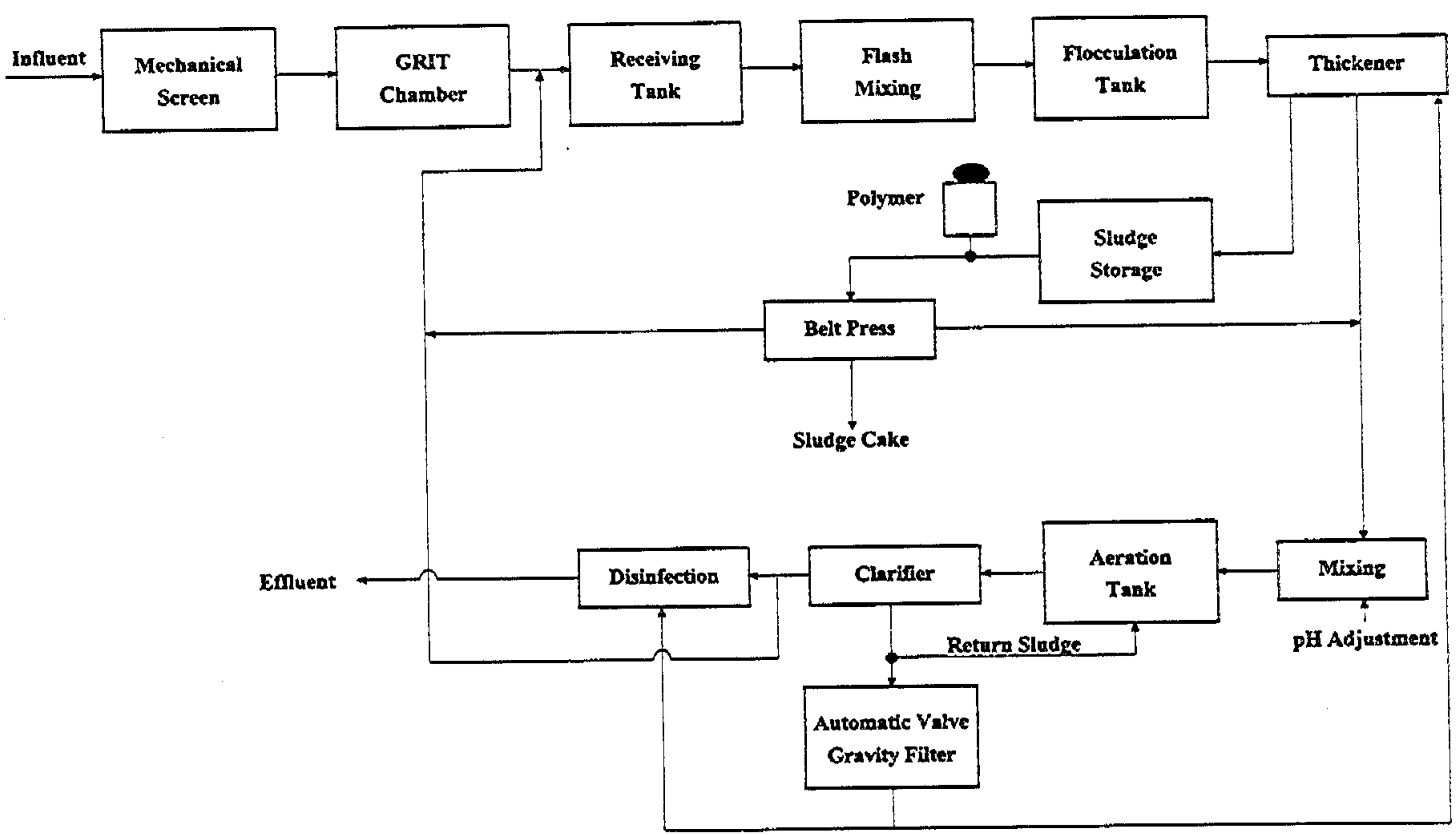
THE STUDY FOR MASTER PLAN ON SEWAGE SLUDE TREATMENT / DISPOSAL AND RECLAIMED WASTEWATER REUSE IN BANGKOK	Figure 3.1.2.1 TYPICAL SEPTIC TANK ARRANGEMENTS IN BANGKOK
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY FOR MASTER PLAN ON
SEWAGE SLUDGE TREATMENT / DISPOSAL AND
RECLAIMED WASTEWATER REUSE IN BANGKOK

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 3.2.3.1
FLOW DIAGRAM OF NONG KHAEM
NIGHT SOIL TREATMENT PLANT



THE STUDY FOR MASTER PLAN ON
SEWAGE SLUDGE TREATMENT / DISPOSAL AND
RECLAIMED WASTEWATER REUSE IN BANGKOK

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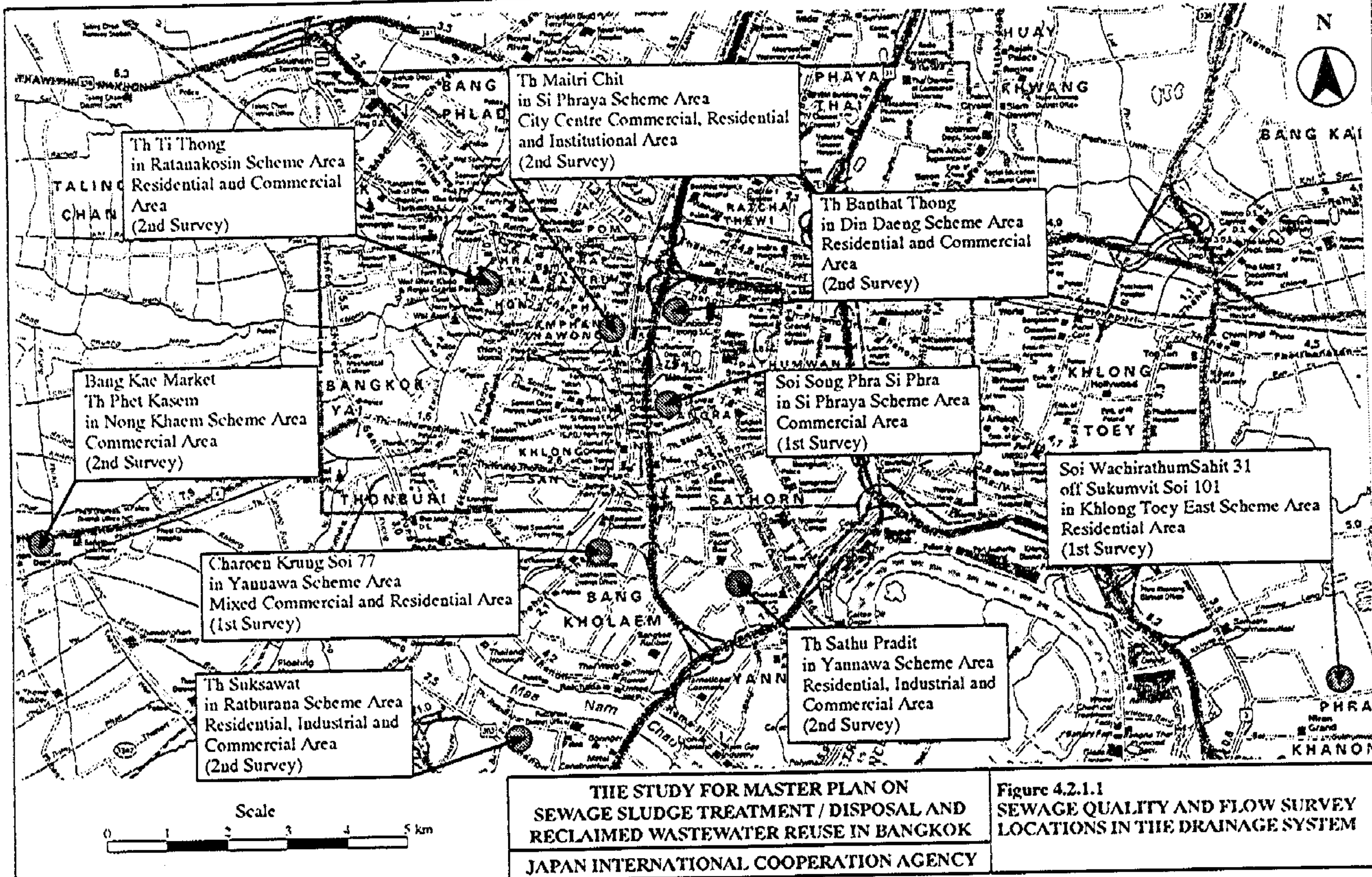
Figure 3.2.3.2
FLOW DIAGRAM OF ON-NUT
NIGHT SOIL TREATMENT PLANT



THE STUDY FOR MASTER PLAN ON
SEWAGE SLUDGE TREATMENT / DISPOSAL AND
RECLAIMED WASTEWATER REUSE IN BANGKOK

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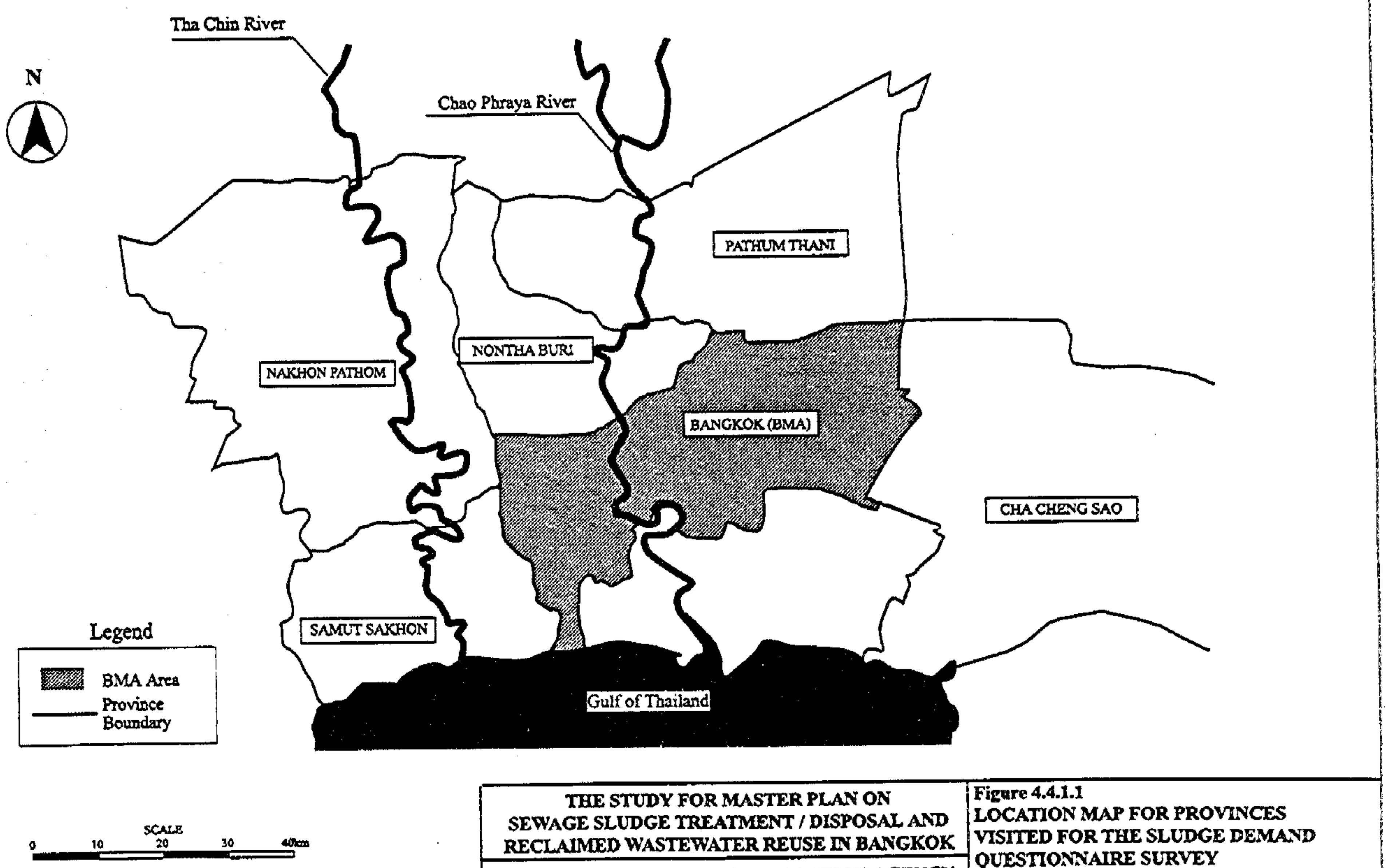
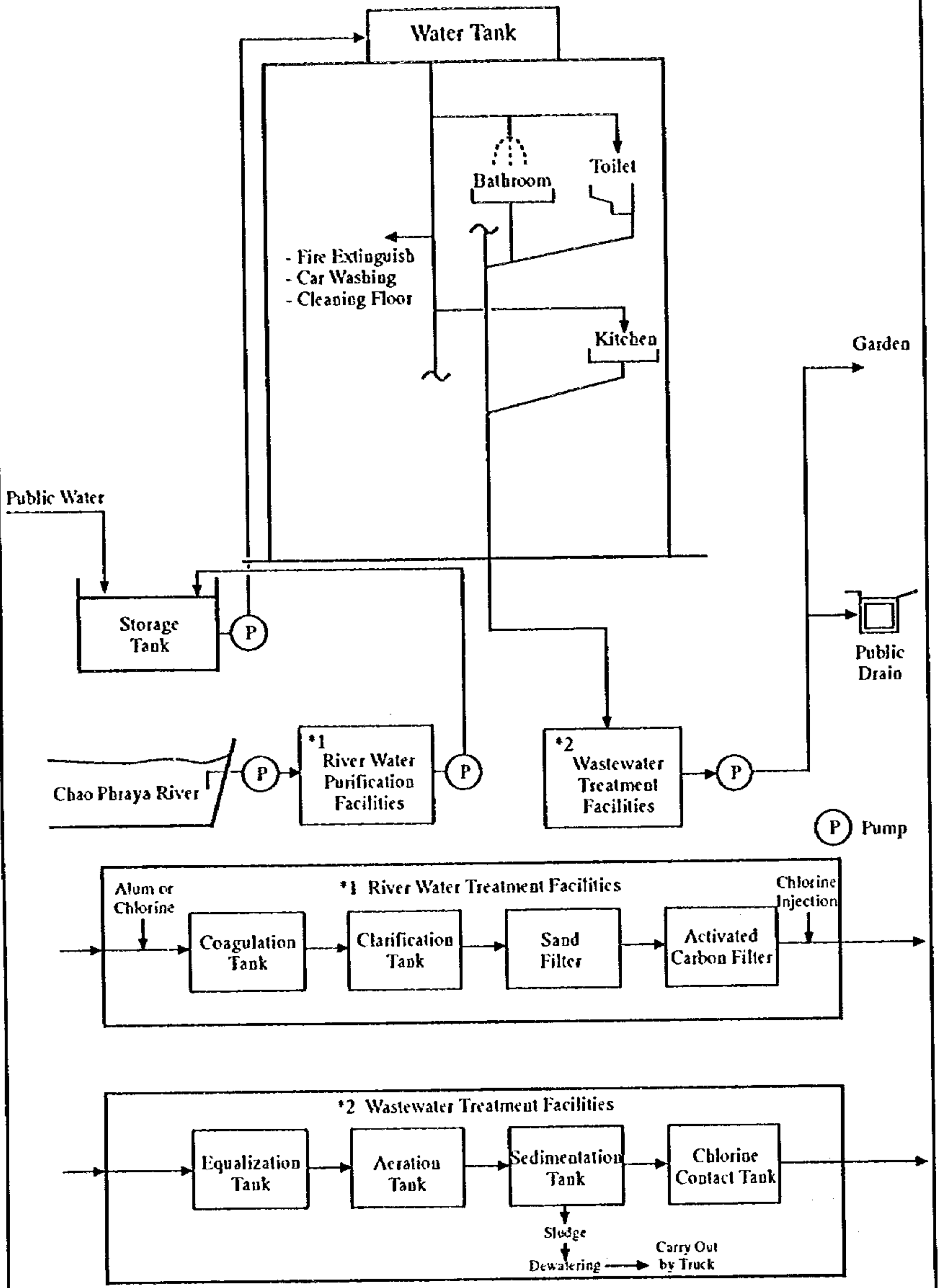
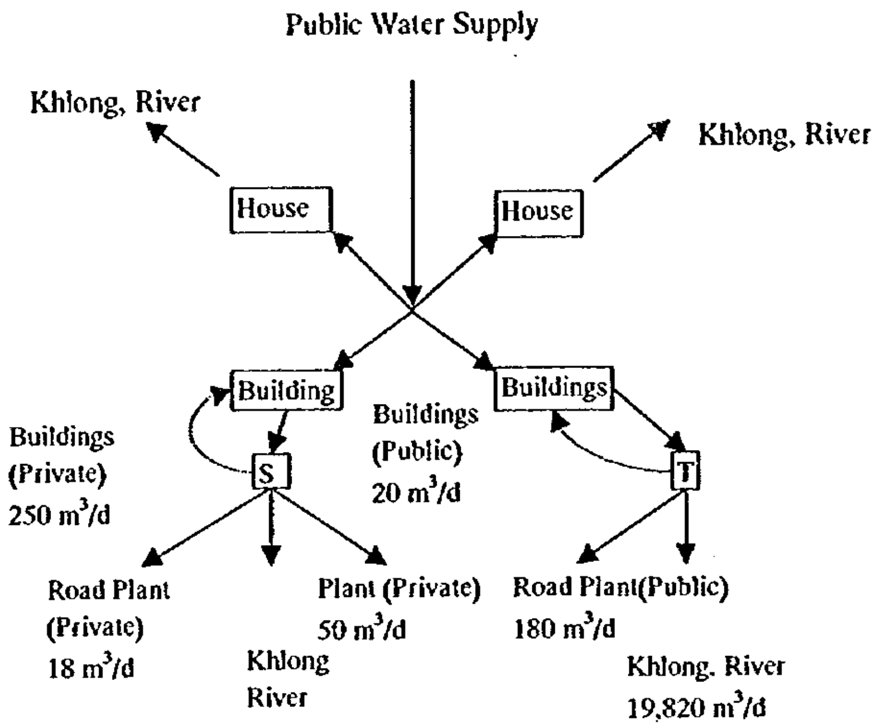
Figure 4.2.1.1
SEWAGE QUALITY AND FLOW SURVEY
LOCATIONS IN THE DRAINAGE SYSTEM



THE STUDY FOR MASTER PLAN ON SEWAGE SLUDGE TREATMENT / DISPOSAL AND RECLAIMED WASTEWATER REUSE IN BANGKOK	Figure 4.4.1.1 LOCATION MAP FOR PROVINCES VISITED FOR THE SLUDGE DEMAND QUESTIONNAIRE SURVEY
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY FOR MASTER PLAN ON SEWAGE SLUDGE TREATMENT / DISPOSAL AND RECLAIMED WASTEWATER REUSE IN BANGKOK	Figure 4.5.3.1 TYPICAL TREATMENT SYSTEM OF SHERATON HOTEL
JAPAN INTERNATIONAL COOPERATION AGENCY	



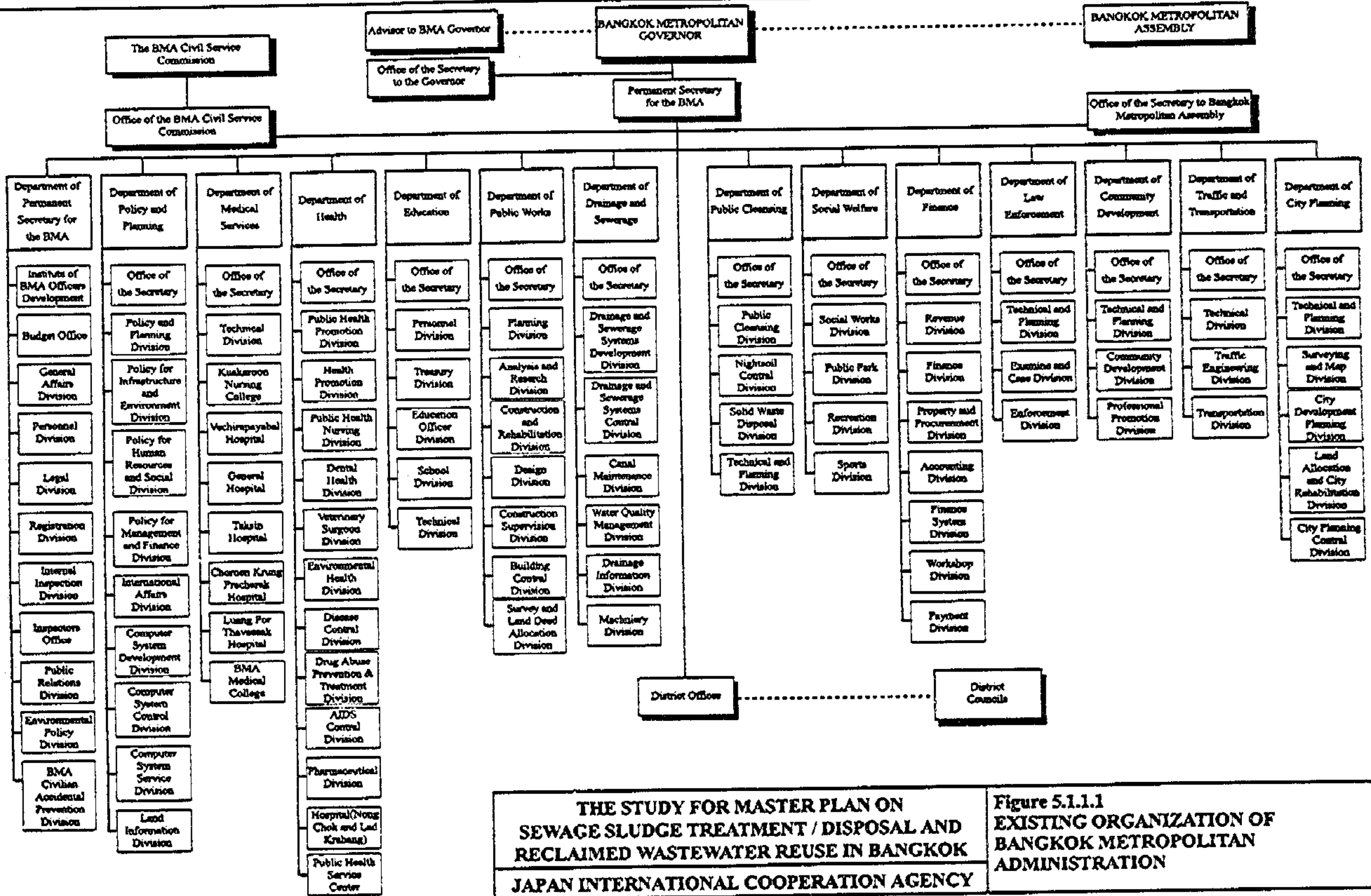
Legend

Road Plant	Road Plant Watering
Road	Road Cleaning
Buildings	Buildings Miscellaneous Water
Plant	Plant Watering (Parks, Golfcource)
Khlong	Purification of Khlong
Agricultural	Agricultural Water
Industrial	Industrial Water

T Public Wastewater Treatment Plant

S Wastewater Treatment Facilities in buildings

THE STUDY FOR MASTER PLAN ON SEWAGE SLUDGE TREATMENT / DISPOSAL AND RECLAIMED WASTEWATER REUSE IN BANGKOK	Figure 4.5.8.1 RECLAIMED WASTEWATER REUSE BY EACH ITEM(1998)
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY FOR MASTER PLAN ON SEWAGE SLUDGE TREATMENT / DISPOSAL AND RECLAIMED WASTEWATER REUSE IN BANGKOK

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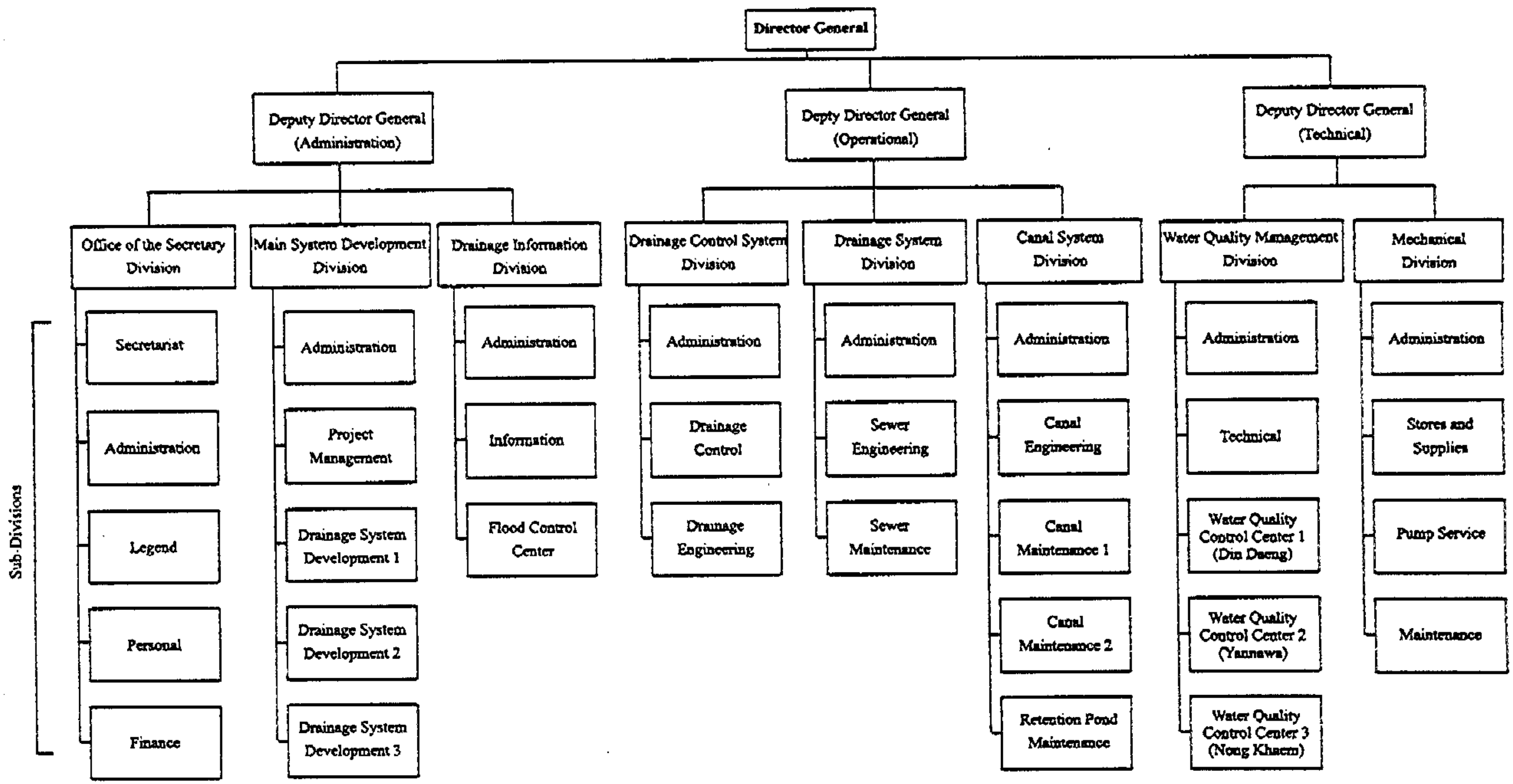
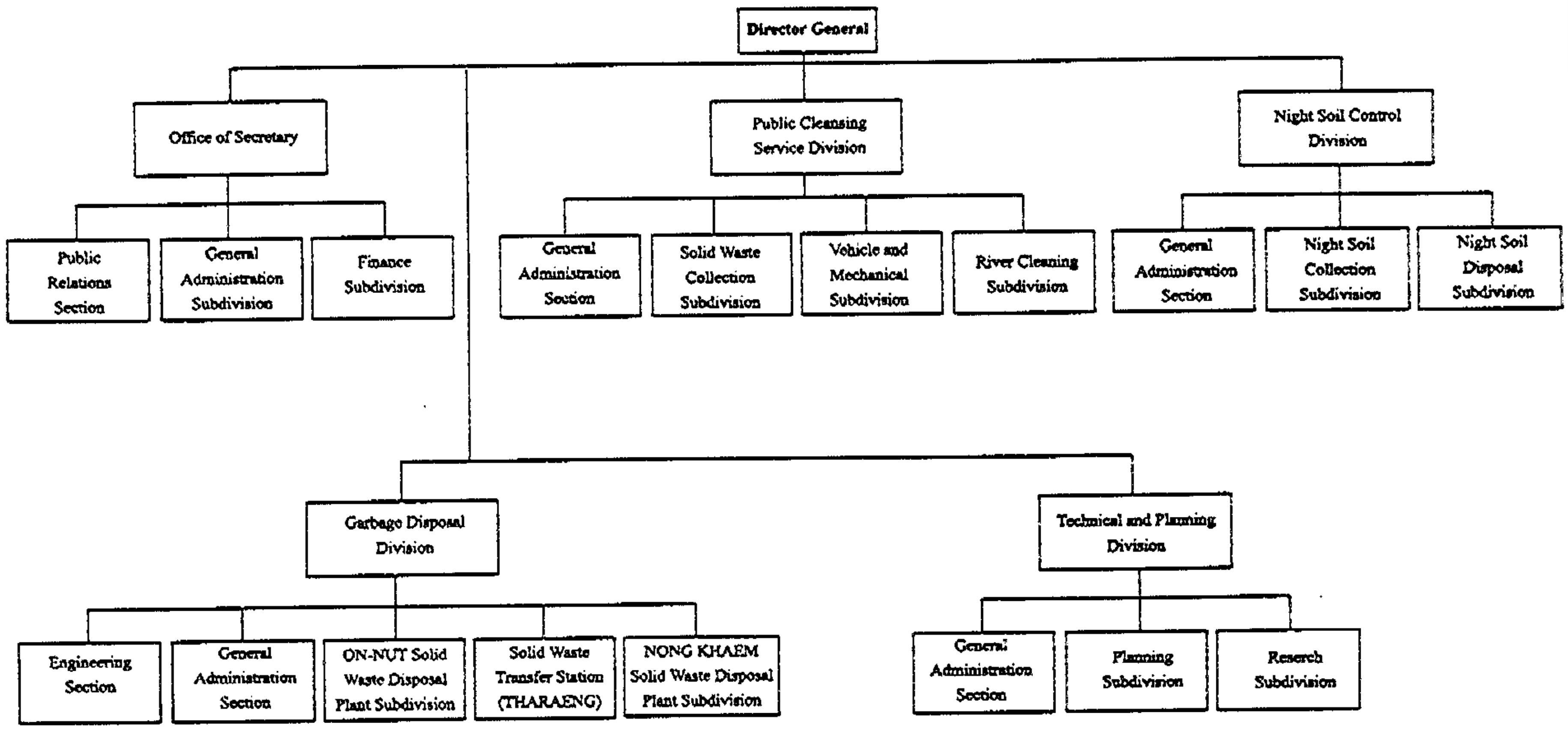
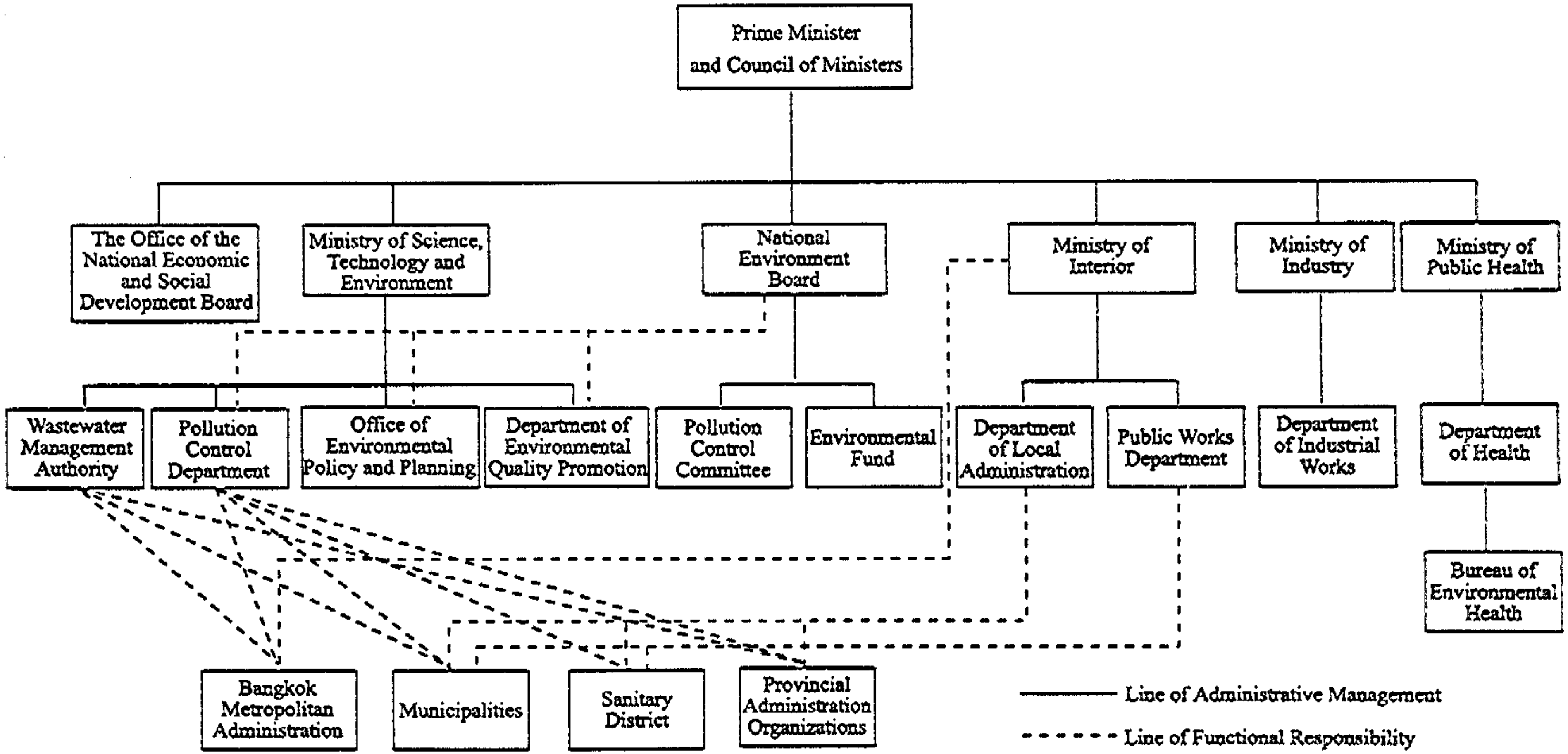
Figure 5.1.1.1
EXISTING ORGANIZATION OF BANGKOK METROPOLITAN ADMINISTRATION



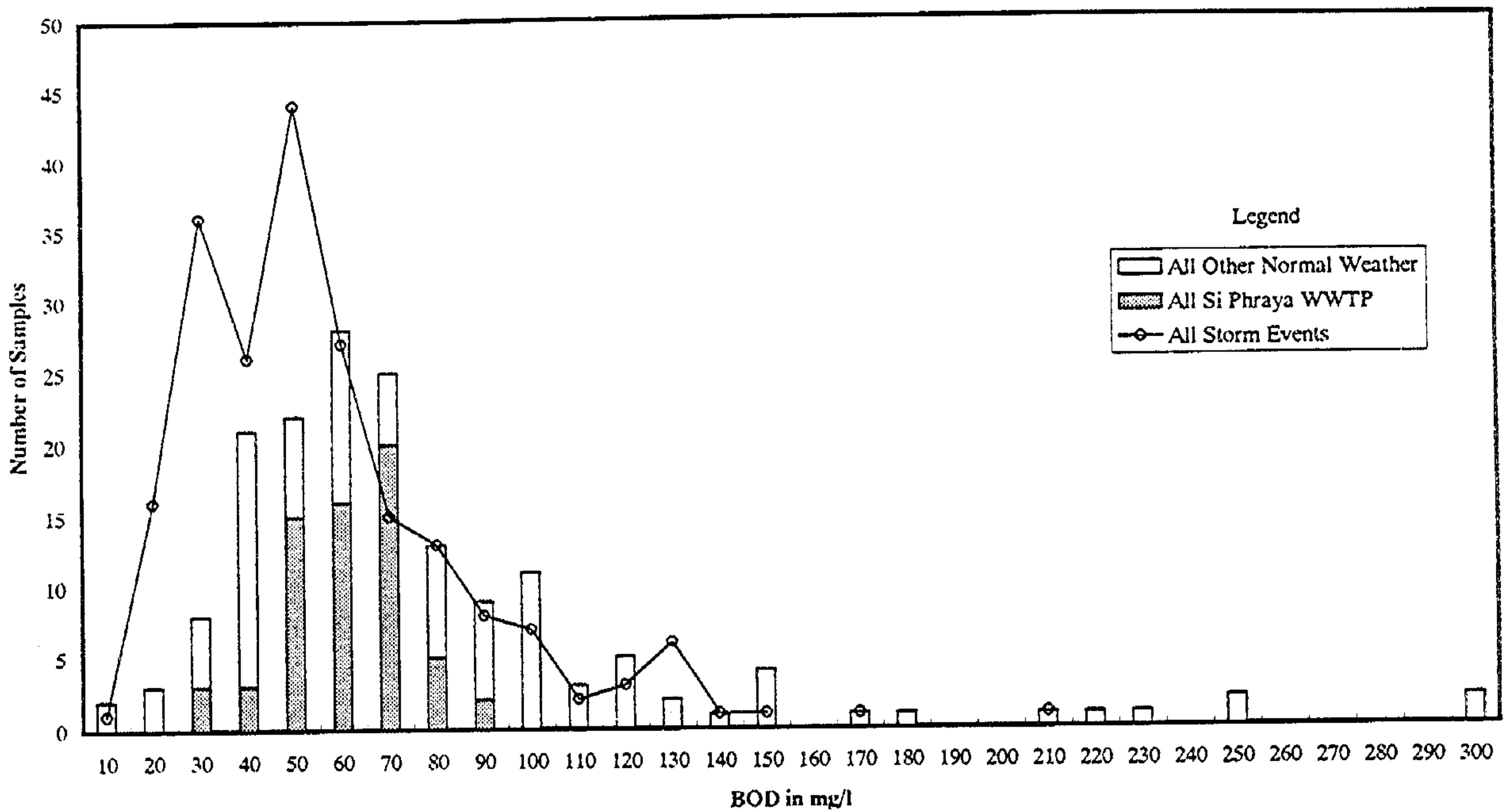
THE STUDY FOR MASTER PLAN ON SEWAGE SLUDGE TREATMENT / DISPOSAL AND RECLAIMED WASTEWATER REUSE IN BANGKOK	Figure 5.2.1.1 EXISTING ORGANIZATION OF DEPARTMENT OF DRAINAGE AND SEWERAGE
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY FOR MASTER PLAN ON SEWAGE SLUDGE TREATMENT / DISPOSAL AND RECLAIMED WASTEWATER REUSE IN BANGKOK	Figure 5.2.2.1 EXISTING ORGANIZATION OF DEPARTMENT OF PUBLIC CLEANSING
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY FOR MASTER PLAN ON SEWAGE SLUDGE TREATMENT / DISPOSAL AND RECLAIMED WASTEWATER REUSE IN BANGKOK	Figure 5.3.1.1 ORGANIZATIONAL NETWORK OF THE GOVERNMENT ON WASTEWATER MANAGEMENT IN BANGKOK METROPOLITAN REGION
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY FOR MASTER PLAN ON SEWAGE SLUDGE TREATMENT / DISPOSAL AND RECLAIMED WASTEWATER REUSE IN BANGKOK

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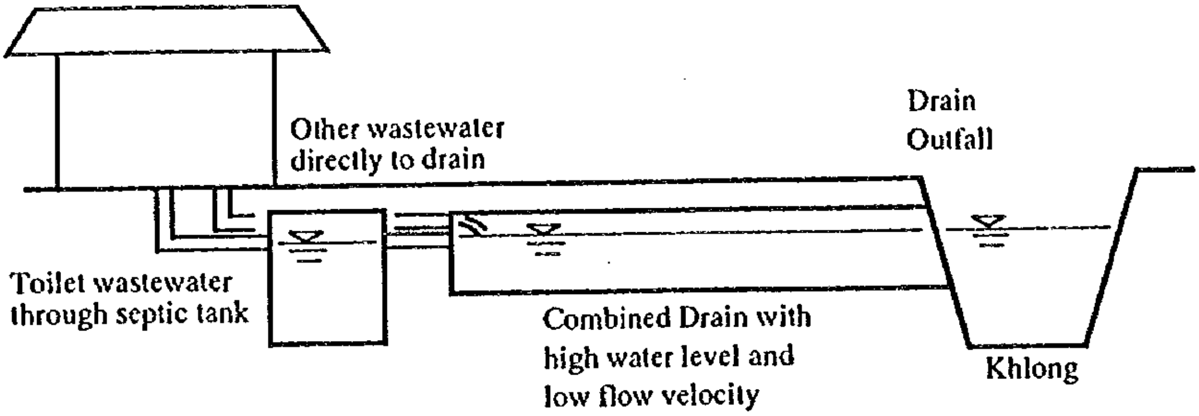
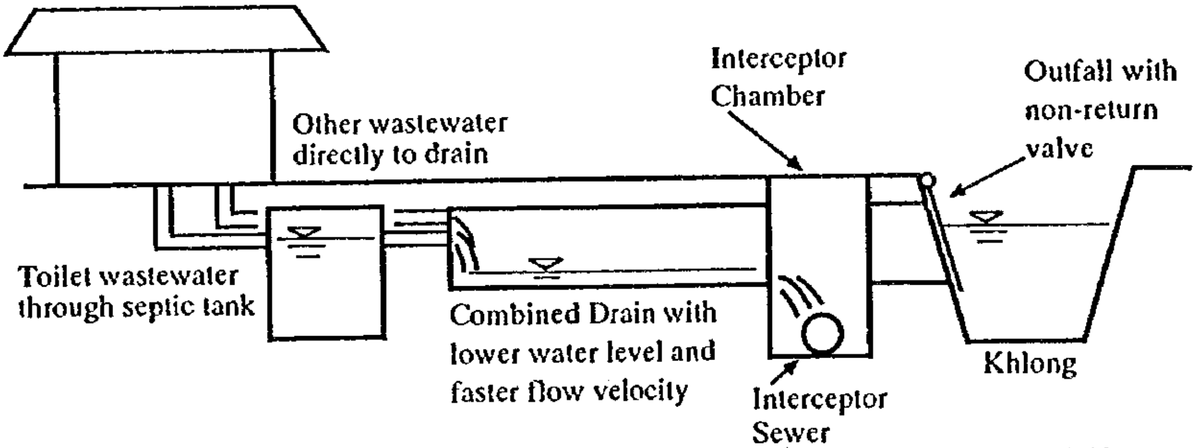
Figure 6.1.1.1
DISTRIBUTION OF WASTEWATER BOD FROM COMBINED DRAINS



CURRENT WASTEWATER LEVELS IN COMBINED DRAINS



EXPECTED FUTURE WASTEWATER LEVELS IN COMBINED DRAINS

THE STUDY FOR MASTER PLAN ON SEWAGE SLUDGE TREATMENT / DISPOSAL AND RECLAIMED WASTEWATER REUSE IN BANGKOK	Figure 6.1.12 WASTEWATER LEVELS IN COMBINED DRAINS FOLLOWING INTERCEPTOR SEWER CONNECTIONS
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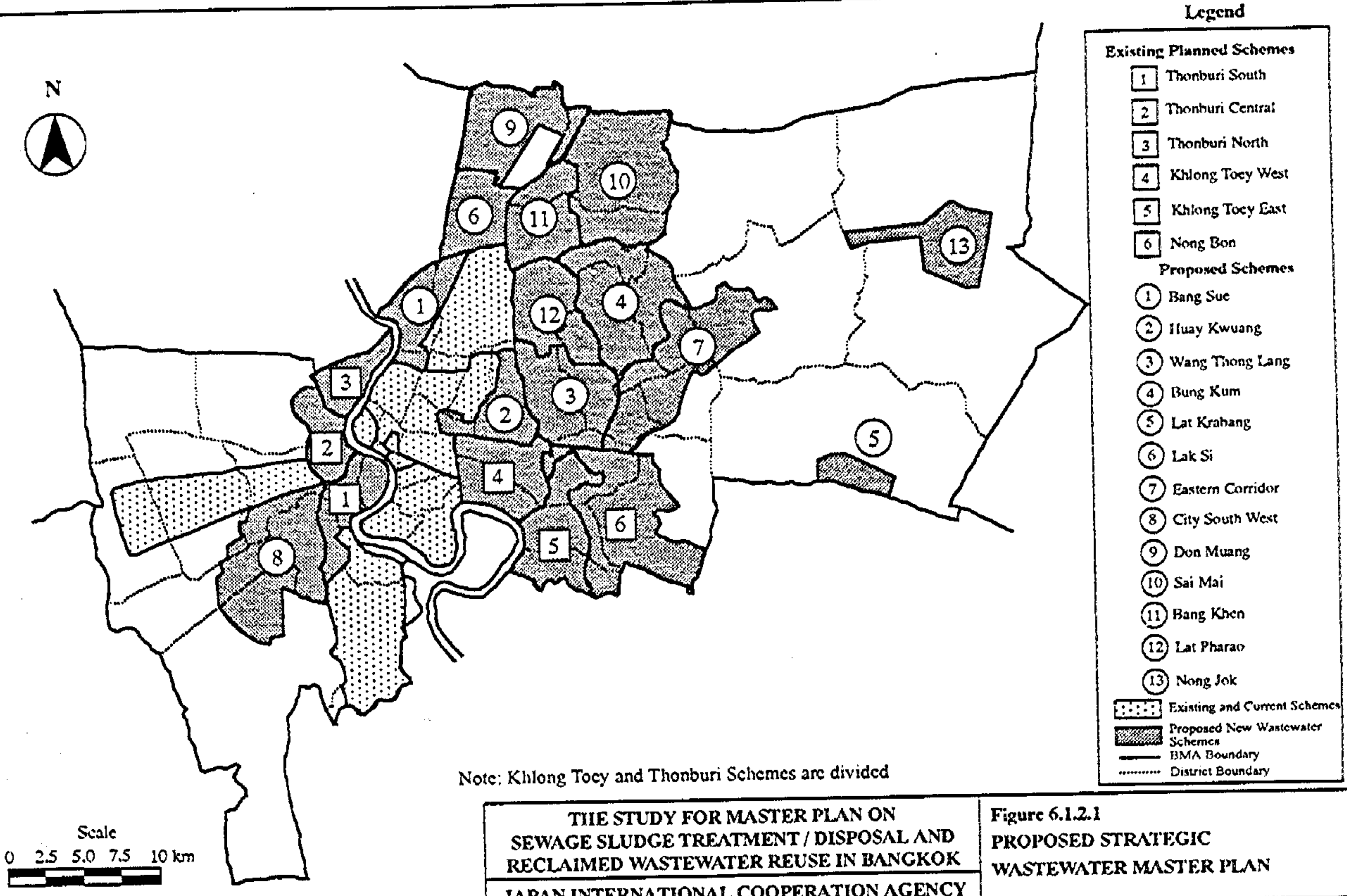
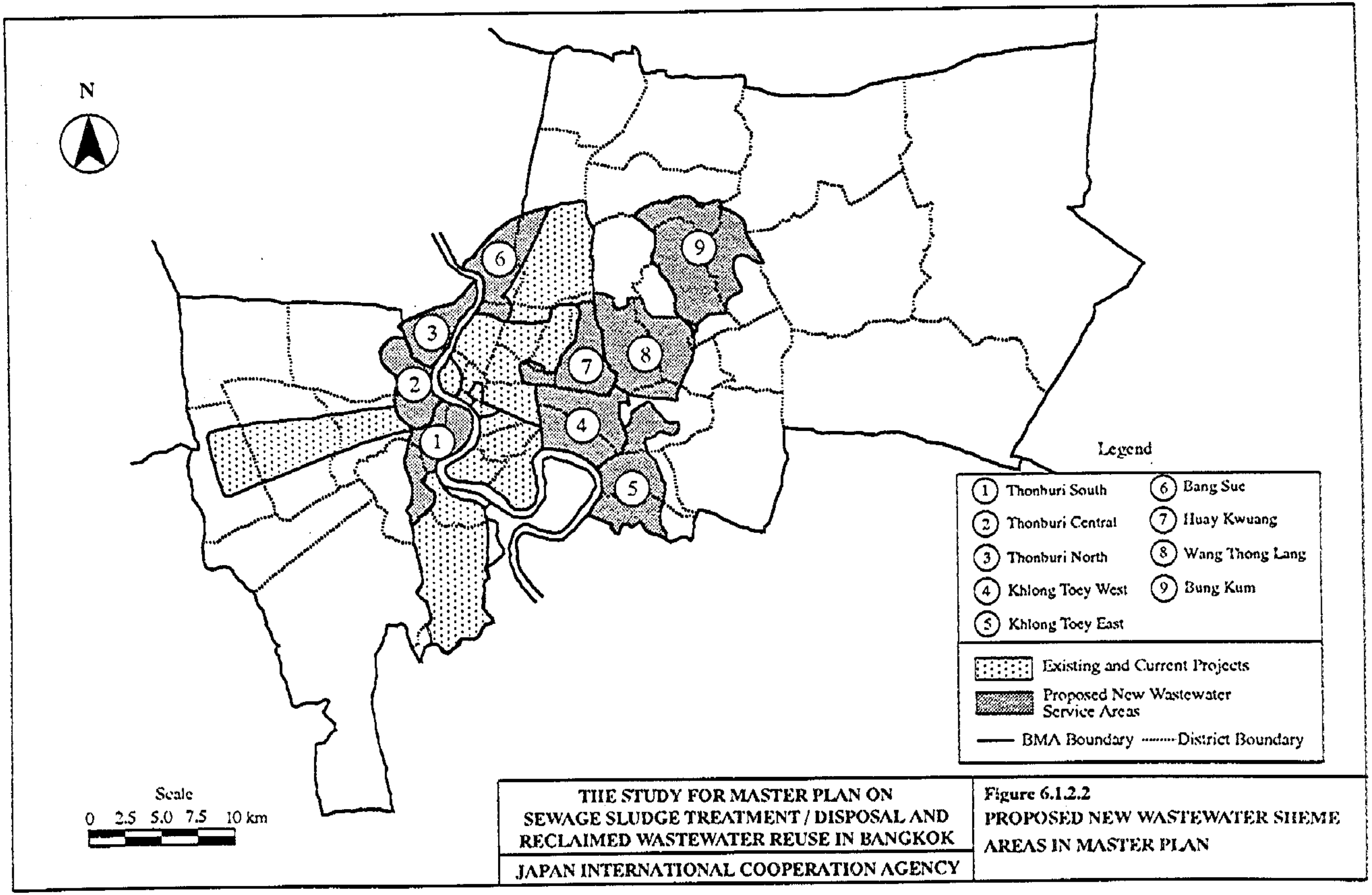


Note: Khlong Toey and Thonburi Schemes are divided

THE STUDY FOR MASTER PLAN ON SEWAGE SLUDGE TREATMENT / DISPOSAL AND RECLAIMED WASTEWATER REUSE IN BANGKOK	Figure 6.1.2.1 PROPOSED STRATEGIC WASTEWATER MASTER PLAN
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY FOR MASTER PLAN ON SEWAGE SLUDGE TREATMENT / DISPOSAL AND RECLAIMED WASTEWATER REUSE IN BANGKOK

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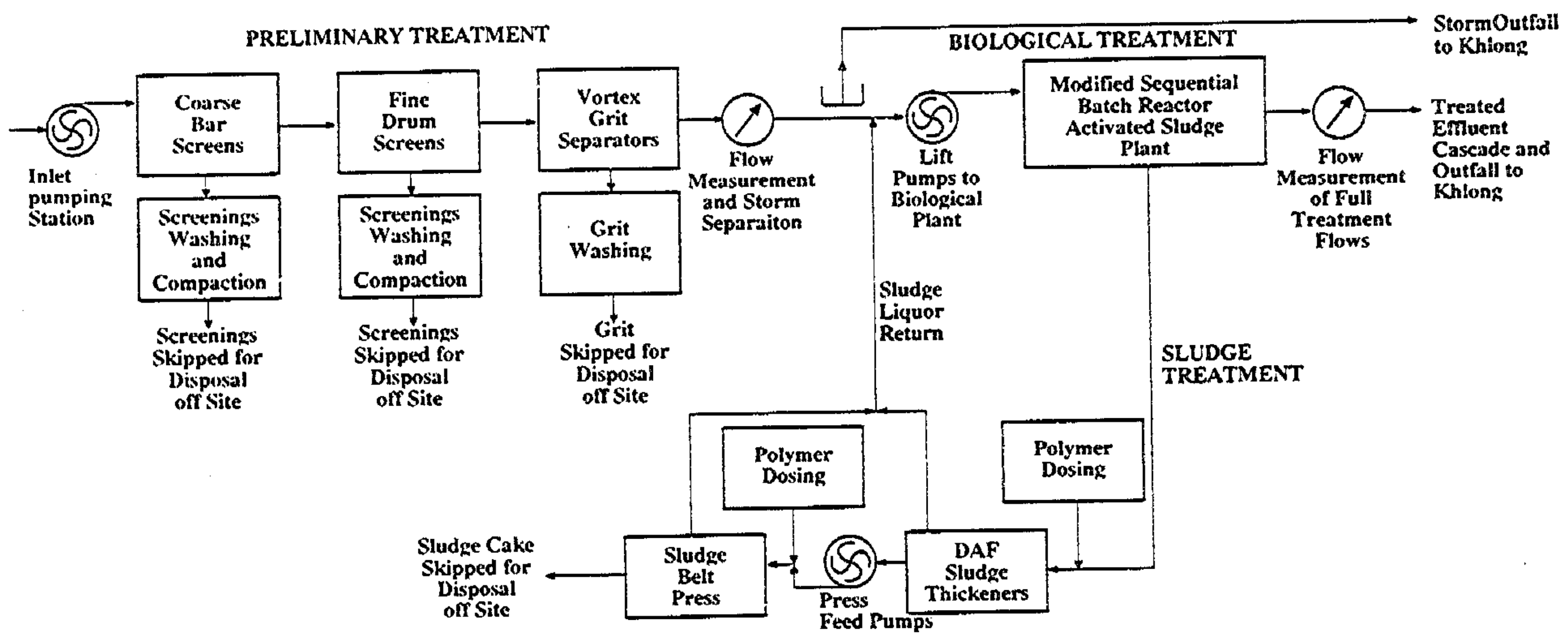
Figure 6.1.2.2
PROPOSED NEW WASTEWATER SHEME AREAS IN MASTER PLAN



THE STUDY FOR MASTER PLAN ON SEWAGE SLUDGE TREATMENT / DISPOSAL AND RECLAIMED WASTEWATER REUSE IN BANGKOK

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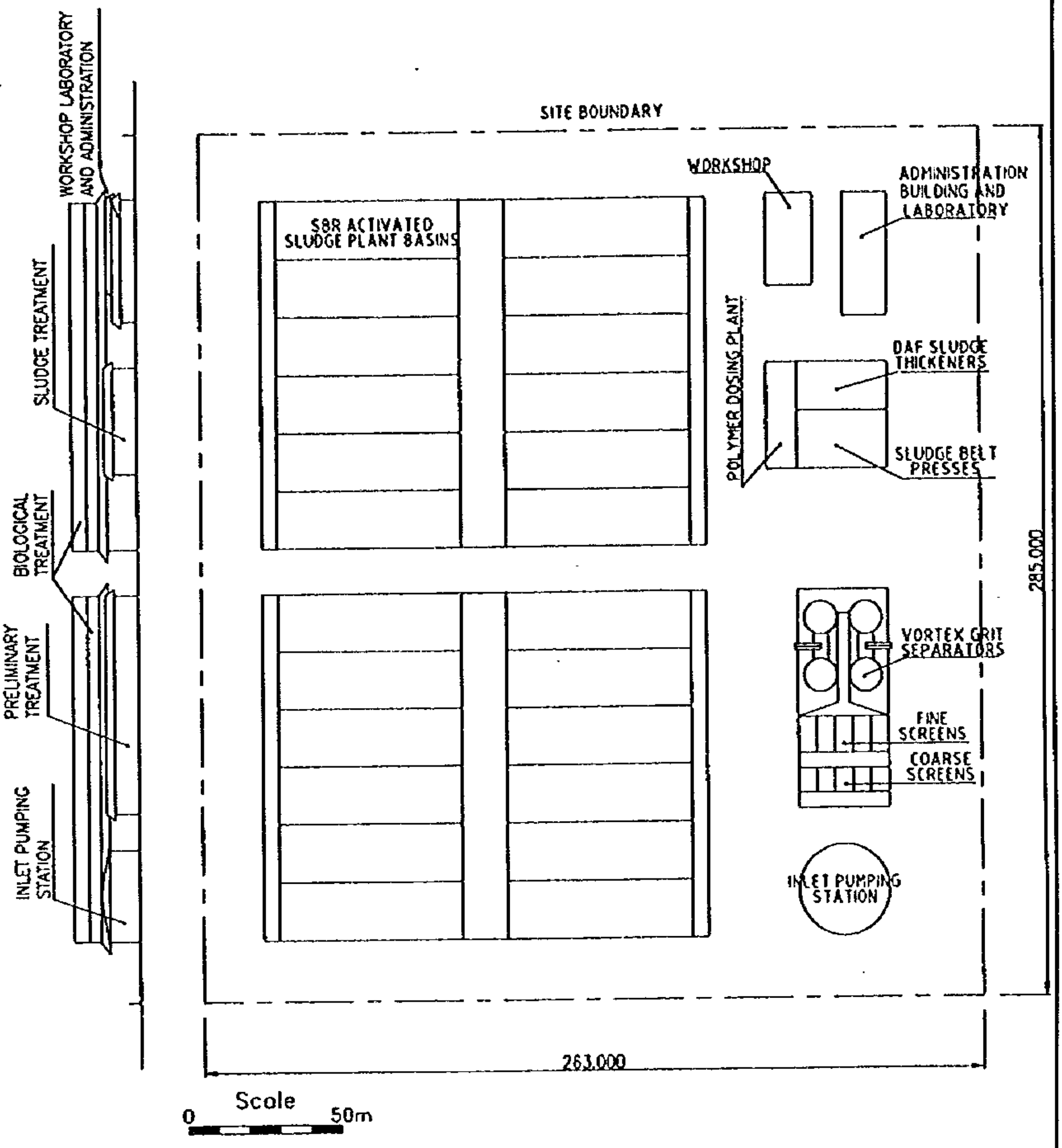
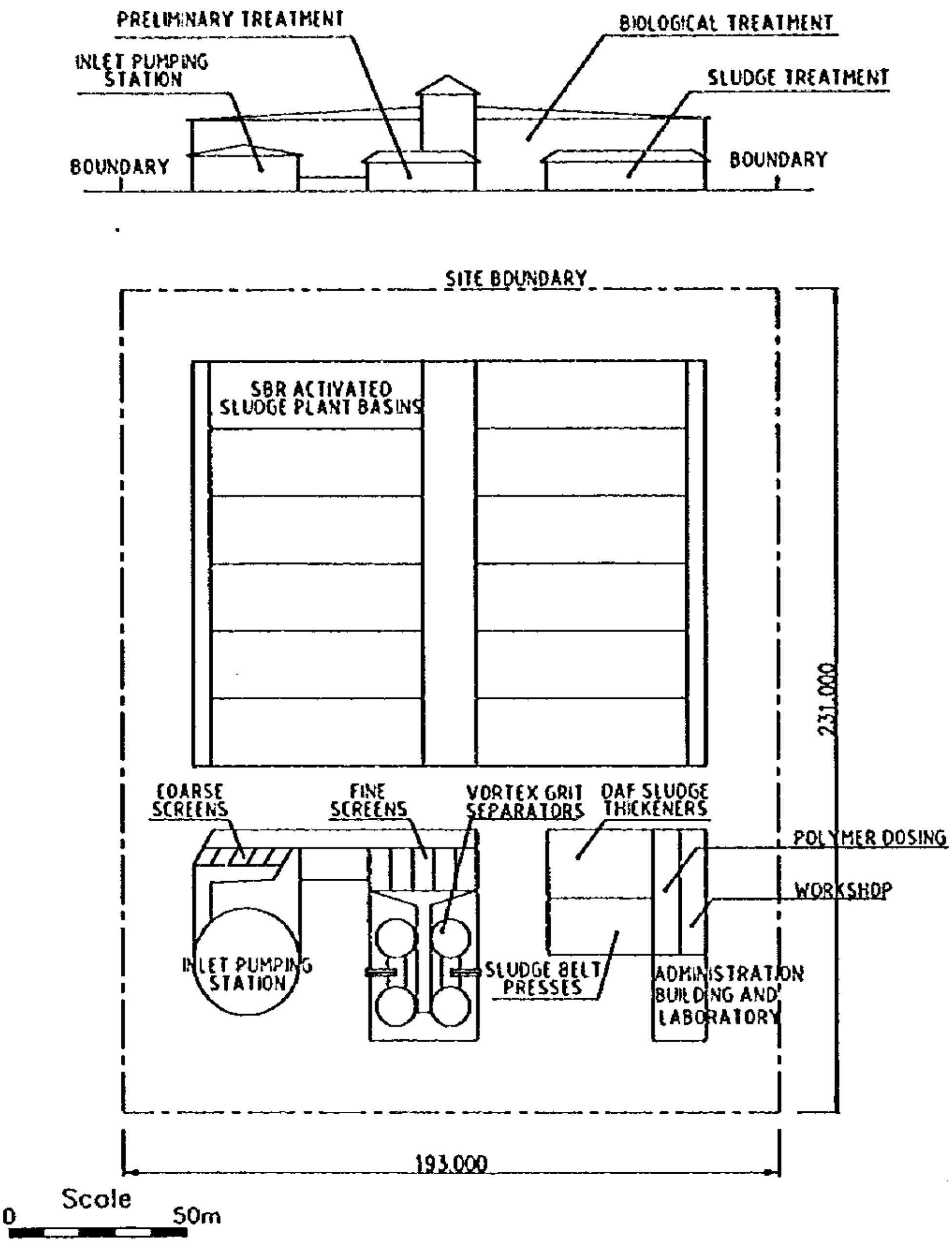
Figure 6.1.3.1 PROVISIONAL WWTP PROCESS DIAGRAM FOR PROPOSED WWTPs



THE STUDY FOR MASTER PLAN ON SEWAGE SLUDGE TREATMENT / DISPOSAL AND RECLAIMED WASTEWATER REUSE IN BANGKOK	Figure 6.1.3.2 TYPICAL COMPACT SINGLE LEVEL WASTEWATER TREATMENT PLANT
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY FOR MASTER PLAN ON SEWAGE SLUDGE TREATMENT / DISPOSAL AND RECLAIMED WASTEWATER REUSE IN BANGKOK	Figure 6.1.3.3 TYPICAL COMPACT WASTEWATER TREATMENT PLANT WITH TREATMENT ON TWO FLOORS
JAPAN INTERNATIONAL COOPERATION AGENCY	