Appendix 2.14 Estimation method of future volume of the solid waste by district

(1) Solid waste generation volume by district

Change of the generation volume in a district was forecast based upon comparison of the present and the future (the year 2000) land use patterns of the district. The index g° is defined as the variance index of generation unit by area.

$$g^\circ = a_1 x_1 + a_2 x_2$$

where, g° : Variance index of generation unit by area

x_1 : Share of Mixed use-low density area (%)

x_2 : Share of Mixed use-high density area (%)

a_1, a_2 : Constant

From the above equation, the present value and the value in the year 2000 of g° in each district were calculated and represented by g°_n and g°_f, respectively. Solid waste generation volume of the year 2000 in each district was obtained by multiplying the present generation volume by the ratio g°_f/g°_n. However, the above-obtained generation volume in each district might be proportionally corrected to have the sum of the generation volume in each district tally with already-calculated generation volume of Bangkok city.

For determination of a_1 and a_2, a relation between the present land-use pattern and solid waste generation volume was examined and 1 and 5 were selected as the reasonable figures. For the surrounding districts where shares of high density areas are small, a smaller figure (3) was applied for a_2 for the purpose of reducing the importance of x_2, due to the two reasons that it would be difficult and could cause a negligible error to pick up a few percent of high density area from the future land-use map with certain accuracy and that a difference of generation unit by area between high density area and low density area in the surrounding districts was surmised to be not so large as that in the central districts.

For the districts where the data and information were insufficient (Nong Chok and Nong Khaem), a product of a population growth rate of the district and an average growth rate of solid waste generation volume was assumed as growth rate of solid waste generation volume. The average growth rate of solid waste generation volume per capita per day was obtained as an percentage of solid waste generation unit per capita per day of the city.

The value of the average growth rate was about 1.5.

As for the districts where land-use pattern would be little changed by the year 2000 (Pom prap, Thonburi and Bangkok Yai), change of index calculated by the above equation would be also small.

This would make solid waste generation volume per capita per day in these districts smaller than the average of all districts despite the fact that these districts locate in the city center.

As a general tendency, central districts involve a number of business areas, so that the solid waste generation volume of the inhabitants

per capita per day is larger than the average of all districts.

To be consistent with this tendency, solid waste generation volume per capita per day in these districts were formulated by district based on the character of the district so as not to fall below the average generation volume of all districts (740g/d. person). The future generation volumes in these districts were estimated by multiplying the generation unit by the population.

(2) Solid waste generation volume by zone

Generation volume by zone is estimated by distributing the generation volume in a district to the zones according to the value of g° of each zone, which is calculated by the equation in paragraph (1).

Fig. AP 2.4
EXISTING
BANGKOK LANDUSE, 1977

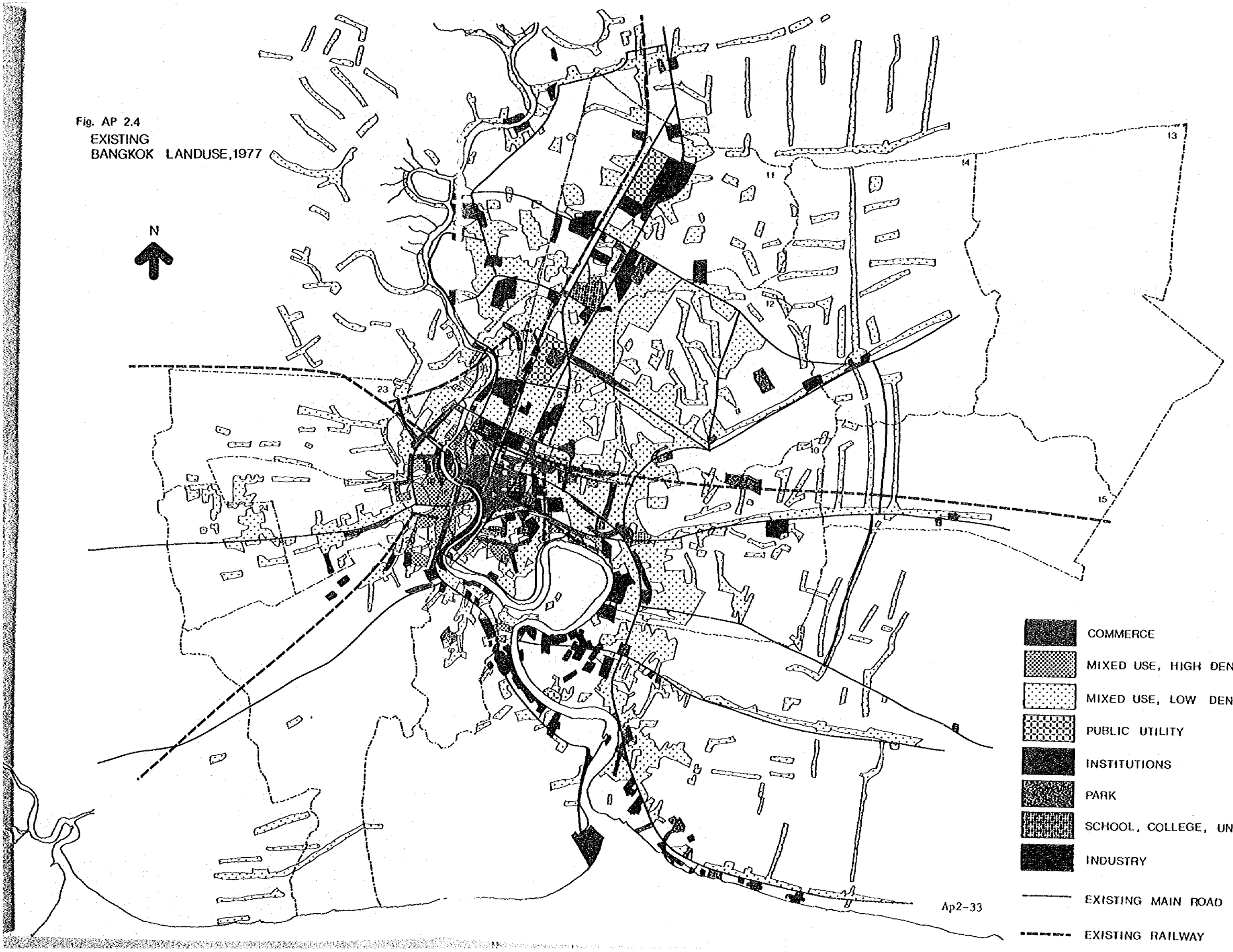
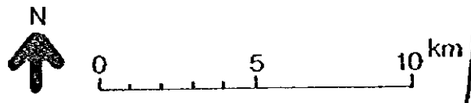


Fig. AP 2.5

FUTURE LAND USE MAP FOR GBA, 2000



Appendix 2.15 Population in urban area and generation volume per capita per day in the year 2000

Table AP 2.16 Solid waste generation volume per capita per day (year 2000)

District Name	Population in urban area (1,000 person)	Generation. Volume per Capita per day (g/d. person)
Phra Nakhon	101	2,770
Pom Prap	173	840
Pathum Wan	284	830
Sam Phan Thawong	71	2,110
Bang Rak	150	1,350
Yannawa	732	690
Dusit	566	570
Phayathai	706	580
Huai Khwang	290	830
Phra Khanong	1,049	860
Bang Khen	627	570
Bang Kapi	491	760
Nong Chok	37	350
Minburi	47	1,020
Lat Krabang	47	620
Thonburi	342	850
Khlong San	141	990
Bangkok Noi	511	850
Bangkok Yai	136	780
Bang Khun Tian	392	390
Phasi Charoen	288	460
Rat Burana	376	470
Taling Chan	97	380
Nong Khaem	74	510
Entire City Area	7,728	740

Forecast by the Study team.

Appendix 2.16 Plan of solid waste collection volume

Table AP 2.17 Plan of solid waste collection volume

(Unit: t/d)

Name of district	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Phra Nakhon	136.7	141.7	147.6	154.9	162.5	170.5	178.4	187.0	195.0	203.2	211.3	220.1	229.2	238.0	247.5	257.2	266.6	277.0
Pom Prap	99.6	101.5	103.7	106.3	109.0	111.8	114.5	117.4	120.0	122.6	125.2	127.9	130.6	133.2	135.9	138.6	141.2	144.0
Phathum wan	125.5	129.5	134.3	140.1	146.2	152.6	158.7	165.5	171.7	178.2	184.4	191.2	198.1	204.8	212.0	219.2	226.2	234.0
Sam Phan Thawong	61.6	64.4	67.8	72.0	76.5	81.2	85.9	91.0	95.9	101.0	106.1	111.6	117.4	123.1	129.3	135.7	142.0	149.0
Bang Rak	102.5	106.1	110.3	115.5	120.9	126.6	132.1	138.2	143.8	149.6	155.3	161.5	167.8	174.0	180.6	187.3	193.8	201.0
Yannawa	141.7	150.7	161.7	175.6	190.7	206.9	223.3	241.8	259.7	278.8	298.2	319.9	342.8	366.1	391.7	418.7	446.1	477.0
Dusit	241.8	245.2	249.1	253.8	258.6	263.5	268.2	273.3	277.8	282.3	286.6	291.2	295.8	300.1	304.7	309.2	313.4	318.0
Phayathai	205.4	212.5	220.9	231.3	242.2	253.5	264.5	276.7	287.9	299.5	310.9	323.2	335.8	348.1	361.2	374.6	387.6	402.0
Huai Khwang	82.2	86.7	92.2	99.0	106.3	114.1	121.9	130.7	139.0	147.9	156.7	166.5	176.8	187.1	198.3	210.1	221.8	235.0
Phra Khanong	281.2	297.9	318.2	343.7	371.1	400.5	430.2	463.6	495.6	529.6	563.9	602.1	642.3	682.9	727.4	774.1	821.2	874.0
Bang Khen	133.8	140.5	148.5	158.5	169.2	180.5	191.8	204.4	216.3	228.8	241.3	255.0	269.3	283.6	299.1	315.2	331.2	349.0
Bang Kapi	87.7	94.3	102.3	112.7	123.9	136.2	148.9	163.3	177.4	192.7	208.4	226.1	245.2	264.8	286.5	309.8	333.8	361.0
Nong Chok	6.3	6.5	6.8	7.1	7.4	7.7	8.0	8.4	8.7	9.1	9.4	9.7	10.1	10.4	10.8	11.2	11.6	12.0
Minburi	27.0	27.7	28.6	29.7	30.8	31.9	33.0	34.2	35.3	36.4	37.5	38.7	39.9	41.0	42.3	43.5	44.7	46.0
Lat Krabang	7.3	7.8	8.5	9.3	10.1	11.1	12.1	13.2	14.3	15.4	16.6	18.0	19.4	20.9	22.5	24.2	26.0	28.0
Thonburi	90.9	96.2	102.7	110.8	119.5	128.8	138.2	148.8	158.9	169.7	180.5	192.5	205.2	218.0	232.0	246.7	261.4	278.0
Khlong San	62.8	65.3	68.1	71.7	75.5	79.4	83.3	87.6	91.6	95.7	99.7	104.2	108.7	113.2	118.0	122.9	127.7	133.0
Bangkok Noi	131.4	139.3	148.8	160.8	173.8	187.7	201.7	217.5	232.6	248.7	264.9	283.0	302.1	321.3	342.4	364.5	386.9	412.0
Bangkok Yai	45.1	47.0	49.2	52.0	54.9	58.0	61.1	64.4	67.6	70.9	74.1	77.6	81.3	84.9	88.8	92.8	96.6	101.0
Bang Khun Tian	57.7	60.5	63.8	67.9	72.3	77.0	81.6	86.7	91.6	96.7	101.7	107.3	113.1	118.8	125.0	131.5	137.9	145.0
Phasi Charoen	54.3	56.7	59.5	63.0	66.7	70.6	74.5	78.8	82.8	87.0	91.2	95.7	100.4	105.1	110.1	115.3	120.4	126.0
Rat Burana	46.4	49.5	53.3	58.2	63.5	69.1	74.9	81.5	87.9	94.7	101.7	109.5	117.8	126.2	135.6	145.5	155.6	167.0
Taling Chan	11.6	12.3	13.1	14.1	15.2	16.4	17.6	18.9	20.1	21.5	22.9	24.3	25.9	27.5	29.3	31.1	32.9	35.0
Nong Khaem	9.5	10.2	11.0	12.0	13.2	14.4	15.6	17.1	18.5	20.0	21.5	23.2	25.0	26.9	29.0	31.2	33.4	36.0
Total	2,250	2,350	2,470	2,620	2,780	2,950	3,120	3,310	3,490	3,680	3,870	4,080	4,300	4,520	4,760	5,010	5,260	5,540

Estimated and planned by the Study team

Appendix 2.17 Forecast of market waste volume

(1) Estimation of growth rate of percapita market waste volume

The volume of group of foodwaste and plant waste is estimated as shown in the following table by using the forecast total volume and the physical composition of solid waste.

	Year	
	1980	2000
Generation volume of total solid waste (t/d)	2,380	5,710
Group of foodwaste and plant waste		
Content in the total solid waste (wt% on wet basis)	53.1	47.0
Volume (t/d)	1,260	2,680
Growth ratio (compared with 1980 volume)	1	2.12

The group of foodwaste and plant waste is estimated to grow 2.1 times of 1980 volume in 2000. The growth of population of the year 2000 compared with 1980 is estimated at 1.56 times (population: 8.03 million persons in the year 2000, 5.15 million persons in 1980), therefore, the generation unit of the foodwaste and plant waste is estimated to grow 1.36 times in the year 2000 compared with 1980. Since the market waste likely grows at the same rate as the foodwaste and plantwaste, the growth rate of percapita market waste is estimated at 1.36 times in the year 2000 compared with 1980.

(2) Forecast of market waste by district in the year 2000

Market waste volumes in each district in the year 2000 can be estimated at the production of the present market waste volume in the district, the growth ratio of population in the district and the percapita market waste.

Table AP 2.18 Forecast of the market waste in the year 2000

(Unit: t/d)

District Name	Market waste	District Name	Market waste	District Name	Market waste
Phra Nakhon	40.7	Bang Khen	25.6	Phasi Charoen	6.5
Pom Prap	5.6	Bang Kapi	17.2	Rat Burana	8.1
Pathum Wan	10.1	Nong Chok	1.3	Taling Chan	4.6
Sam Phan Thawong	4.5	Minburi	1.7	Nong Khaem	1.2
Bang Rak	4.2	Lat Krabang	2.9		
				Total	257.4
Yannawa	11.8	Thonburi	5.7		
Dusit	10.7	Khlong San	5.3		
Phayathai	12.2	Bangkok Noi	14.8		
Huai Khwang	12.6	Bangkok Yai	3.0		
Phra Khanong	36.9	Bang Khun Tian	10.2		

Note: In Phra Nakon, market waste volume is extremely large compared with the estimated volume from its population. The reason is estimated as that large part of market goods is consumed in other districts. Therefore, market waste volume in this district was forecast by modifying the method described in (1) considering these differences.

Appendix 2.18 Forecast method of the future solid waste physical composition (dry basis)

Assuming that:

$G_j(i)$ is volume of solid waste component 'j' in the year 'i',

$G(i)$ is a total solid waste volume in the year 'i', and

$r_j(i)$ is a share (%) of the component 'j' in the total solid waste volume in the year 'i',

the following equation was formulated.

$$G_j(i) = r_j(i).G(i)/100$$

Applying the share of the component 'j' in the total solid waste volume in 1980 r_j (1980) and the total solid waste volume in 1980 G(1980), the volume of solid waste component 'j' in the year 1980 is expressible as follows:

$$G_j(1980) = r_j(1980).G(1980)/100$$

The ratio of solid waste component 'j' in the year 'i' to the solid waste component in the year 1980 is represented by $A_j(i)$ and expressed as $A_j(i) = G_j(i)/G_j(1980)$; accordingly, $r_j(i)$ is expressible as follows:

$$r_j(i) = 100A_j(i)r_j(1980)/\Sigma_j A_j(i)r_j(1980)$$

This means that the percentage of solid waste component in the total solid waste volume in the future can be estimated if the growth rate of solid waste component is obtainable. The growth rate is obtainable by, firstly, formulating a relation between the volumes of consumer goods, which are intimately related to solid waste generation volume, and their waste, then applying the forecast volume of consumer goods to the formulated relation. The relation can be expressed as either (a) a linear equation ($y=ax+b$, y: solid waste volume, x: volume of consumer goods related to the solid waste generation, a,b: constant) or (b) a proportion equation ($y=ax$) derived from the data on the past solid waste composition and the consumption volumes of goods. In the case (b), the growth rate of solid waste volume is the same as that of the related goods, which implies that it is not always necessary to determine the coefficient a. The results of analysis in Tokyo showed that both methods can be used.

In this study the latter method (b) is adopted because there isn't enough data relating to past solid waste composition.

Appendix 2.19 Forecast of consumption volume of materials

Export and import or production volumes of the materials basically related to the generation of individual solid waste are shown in Table AP2.19. Consumption volume is determined by the balance of production volume, trade volume and stock increase. Stock increase can be neglected because of little volume and little chance of getting the statistical data. Trade volume can be neglected for the materials of little trade volume. Production volume can be neglected for the materials of little production. Mescellaneous economic statistics were analyzed and the formulae of forecasting the consumption volumes (actually production volumes in most cases) were established in index as shown in Table AP2.20.

Consumption volume in each area in whole Thailand is likely proportional to the fraction of GPP of the area in GDP. Therefore, consumption volume index in Bangkok can be determined by adjusting that in whole Thailand considering the change of Bangkok's GPP share in GDP.

Consumption of steel and food and plant waste volume were forecast in particular ways, which are described in the following paragraphs.

Future consumption of steel in Bangkok was quoted from the report "Feasibility Study of Truck Terminal Project - 1979, JICA".

Adapting from the report "Socio-Economic Survey 1975-76, Greater Bangkok Metropolitan Area, National Statistical Office", the formula describing the relation between percapita expenditure for food and percapita consumption expenditures was established by cross-section analysis (Table AP2.21 shows the percapita expenditure for food and percapita consumption expenditures).

$$y = 59.6 + 0.3298x$$

where, y = Percapita expenditure for food and beverages (Baht/person)

x = Percapita consumption expenditures (Baht/person)

Percapita expenditure seems to be proportional to the percapita. GPP and the future percapita expenditures was forecast from the future value of percapita GPP, which is estimated from Table 2.8 as shown in Table AP 2.22.

Food consumption volume in Bangkok was forecast in index from the percapita food consumption index and population index.

Plant waste is estimated to have the two generation sources of food source (75%) and garden-and-road source (25%). The future plant waste volume is forecast from the future volumes of the two. Food-originated plant waste increases as the food waste increases. Garden-and-road-originated plant waste is likely to increase as the collection area in the city increases.

Table AP 2.19 Production, imports and exports of materials

Year	Index of GDP	Paper *1 production	Textile *2 production	Plastics *3 production index	Rubber *4 output-export	Leather *3 footwear production index	Aluminum and Articles thereof *5			Copper and Articles thereof *5			Wholesale price index *6	Glass *3 production index	Ceramics *3	
							imports	exports	re-exports	imports	exports	re-exports			pottery & earthenware production index	ceramics production index
	(the year 1972=100)	(t)	(1,000 sq yd)	(the year 1971=100)	(1,000 m^3)	(the year 1971=100)	(million Baht)			(million Baht)			(the year 1968=100)	(the year 1971=100)	(the year 1971=100)	
1970	89.8		495,992		11.6								102.8			
1971	96.0		665,995	100	9.0								103.1			
1972	100.0		800,292	116	19.2	90	297.4	13.2	0.6	184.0	5.1	0.3	111.2	149	100	123
1973	110.5		977,540	110	22.8	109	477.8	48.1	1.5	294.1	13.9	0	136.6	166	102	159
1974	116.0		941,399	77	19.5	108	702.9	90.3	20.8	408.6	30.9	1.5	176.1	166	84	166
1975	125.0	25,075	1,149,714	-	16.5	122	-	-	-	-	-	-	182.6	159	89	173
1976	136.6	26,389	1,324,259	116	19.5	216	-	-	-	-	-	-	189.8	182	105	171
1977	146.6	32,018	1,493,496	196	29.1	190	1,009.0	187.9	0.3	635.1	22.0	0	199.9	241	113	198
1978	163.8	33,392	1,727,640	222	24.8	498	1,116.3	176.6	6.0	662.1	33.5	0	219.8	253	110	182
1979	174.8	42,235	1,839,309				1,674.4	257.9	0.1	984.1	68.0	0	244.5			
1980	187.4		1,968,288				2,146.1	349.8	0.9	983.1	95.1	0.1	293.6			

Source *1 Industrial Economics & Planning Division, Ministry of Industry

*2 Thai Textiles Manufacturing Association

*3 Quarterly and annual industrial production indexes, 1978, National Statistical Office

*4 Office of Agricultural Economics, Ministry of Agriculture and Cooperatives

*5 Foreign Trade Statistics of Thailand, Department of Customs

*6 Department of Business Economics, Ministry of Commerce

Table AP 2.20 Forecast equation of material consumption volume in future

(1) in Thailand

Material	Forecast equation	Variables	
		y	x
Paper	y = -16,200 + 321.52 x	production (t)	index of GDP (the year 1972 = 100)
Textile	y = -725.6 + 14.77 x	production (million sq yds)	index of GDP (the year 1972 = 100)
Plastics	y = -86.3 + 1.7725 x	production index (the year 1971 = 100)	index of GDP (the year 1972 = 100)
Rubber	y = -88.27 + 1.3924 x	output - export ($1,000\ m^3$)	Year - 1900
Leather	y = -1.638 + 23.86 x	production index	Year - 1900
Aluminum and Copper	y = -114.2 + 5.2919 x	imports-(exports + re-exports)(million Baht at 1968 prices)	index of GDP the year 1972 = 100)
Glasses	y = -33.9 + 1.7287 x	production index (the year 1971 = 100)	index of GDP (the year 1972 = 100)
Ceramics, pottery and earthenware	y = 44.9 + 0.6821 x	production index (the year 1971 = 100)	index of GDP (the year 1972 = 100)

(2) in Bangkok

Material	Forecast method		
	Consumption volume growth rate (annual)(%)		
	1977 - 1981	1982 - 1991	1992 - 2000
Steel	8.6	7.4	6.1

Table Ap 2.21 Percapita consumption expenditures - Greater Bangkok Area

Percapita consumption expenditures (Baht)	Household Size (person/household)	Consumption expenditures for Food & Beverages (Baht)
less than 265	7.6	920
266 - 335	7.2	1,151
336 - 396	6.5	1,166
397 - 457	6.0	1,236
458 - 517	5.6	1,273
518 - 589	5.7	1,444
590 - 708	5.3	1,470
709 - 844	4.8	1,512
845 - 1,159	4.3	1,585
1,160 and over	3.4	1,710
average	5.7	1,345

Source : Socio - Economic Survey 1975 - 76, Greater Bangkok Metropolitan Area, National Statistical Office

Table AP 2.22 Percapita GPP

Fiscal year	Percapita GPP at 1972 prices (Baht)
1973	11,200
1974	11,500
1975	11,730
1976	12,490
1977	13,320
1978	14,440
1979	15,620
1980	16,500
1985	21,400
1990	26,900
1995	31,800
2000	37,500

Adapted from Table 2.8

Appendix 2.20 Estimation formulae for moisture content in each solid waste component

Table AP 2.23 Estimation formulae for moisture contents in each solid waste component

Solid Waste Component	Formulae y : Moisture content in each component(wt %) x : Garbage and plant content (dry basis)(wt %)
Paper	$y = 52.50 + 0.1799x$
Textile	$y = 31.00 + 0.4769x$
Garbage	76.6
Grass and wood	64.2
Plastics	$y = 29.68 + 0.3384x$
Rubber, leather	17.9
Ferrous metal	5.5
Non-ferrous metal	1.5
Glass	1.8
Stones, Ceramics	10.1
Bones, Shells	29.4
Miscellaneous	45.4

Determined by the Study team on the basis of the results of "Survey of Properties and Generation of Solid Waste" carried out in 1979 to 1981.

Appendix 2.21 Elemental composition in each component of solid waste

Table AP 2.24 Elemental composition in each component of solid waste

(wt %, dry basis)

	Ash	C	H	N	O	S	Cl	Higher calorific value kcal/kg (dry basis)
1. Paper	15.6	40.2	5.5	0.59	37.7	0.05	0.33	4,040
2. Textile	11.3	45.4	5.4	0.67	36.9	0.04	0.26	4,530
3. Garbage	19.3	39.2	5.2	1.60	34.4	0.10	0.21	3,840
4. Wood and plant	22.8	39.2	4.9	1.15	31.6	0.06	0.26	3,960
5. Plastics	13.2	66.1	10.2	0.70	9.1	0.06	0.63	9,980
6. Rubber, leather	23.8	45.0	5.6	3.03	21.6	0.37	0.61	5,050
7. Miscellaneous(>5)	45.7	28.9	3.3	1.28	20.7	0.05	0.10	2,540
8. Miscellaneous($\leq$5)	59.0	21.7	2.5	0.91	15.8	0.03	0.09	2,231

Determined by the Study team on the basis of the results of "Survey of Properties and Generation of Solid Waste" carried out in 1979 and 1980.

Appendix 2.22 Estimation equation of calorific value of solid waste

For calculation of calorific value, the following formula based on Bomb calorific value was adopted:

$$Hu = Ho - 600\ (9h + W) \qquad \text{(Eq. 1)}$$

where, Hu : Lower calorific value of 1 kg of wet solid waste. (kcal/kg)

Ho : Higher calorific value of 1 kg of wet solid waste (kcal/kg)

h : Hydrogen content in 1 kg of wet solid waste (kg/kg)

W : Moisture content in 1 kg of wet solid waste (kg/kg)

Higher calorific value of wet solid waste was obtained from the following equation applying higher calorific value of each solid waste component.

$$Ho = \sum_i H_{oi} \cdot \frac{Ci}{100}\ (1 - W) \qquad \text{(Eq. 2)}$$

where, Ci : Share of solid waste component 'i' in dry solid waste (wt%, dry basis)

H_{oi} : Higher calorific value of solid waste component 'i' (kcal/kg, dry basis)

Hydrogen content (h) in wet solid waste was calculated from the following equation applying hydrogen contents in each solid waste component:

$$h = \sum_i h_i \cdot \frac{Ci}{100}\ (1 - W) \qquad \text{(Eq. 3)}$$

where, hi : Share of hydrogen in dry solid waste component 'i'

Substituting Eq. 2 and Eq. 3 for Ho and h in Eq. 1, the following equation was formulated:

$$H_u = \alpha \frac{100 - W}{10,000} \cdot \sum_i (H_{oi} - 5,400\ h_i) C_i - 6W \qquad \text{(Eq. 4)}$$

α is the coefficient of adjustment to make the calculated value by the Eq. 4 without α coincide with the actually measured value.

Chapter 3 RECOMMENDATION OF SHORT-TERM INPROVEMENT PLAN

Appendix 3.1 Outline of solid waste management system in Bangkok

1. General

- Bangkok

Table AP 3.1

Areas	1,568.7 km^2	As of
Population	about 5.1 million persons	Jan. 1980
Number of district	24	

- Solid waste collection volume

Table AP 3.2

Collection volume	2,008 t/d	fiscal 1981
Collection percentage	80.6%	

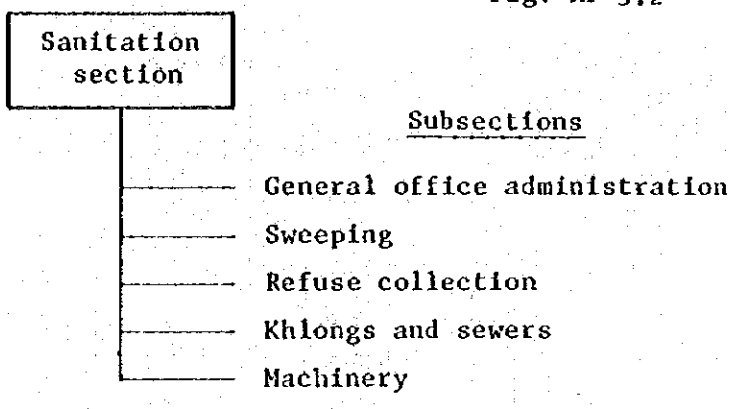
Collection frequency	• places along main street and amusement quater	: every day
	• other places	: 2 or 3 times per week

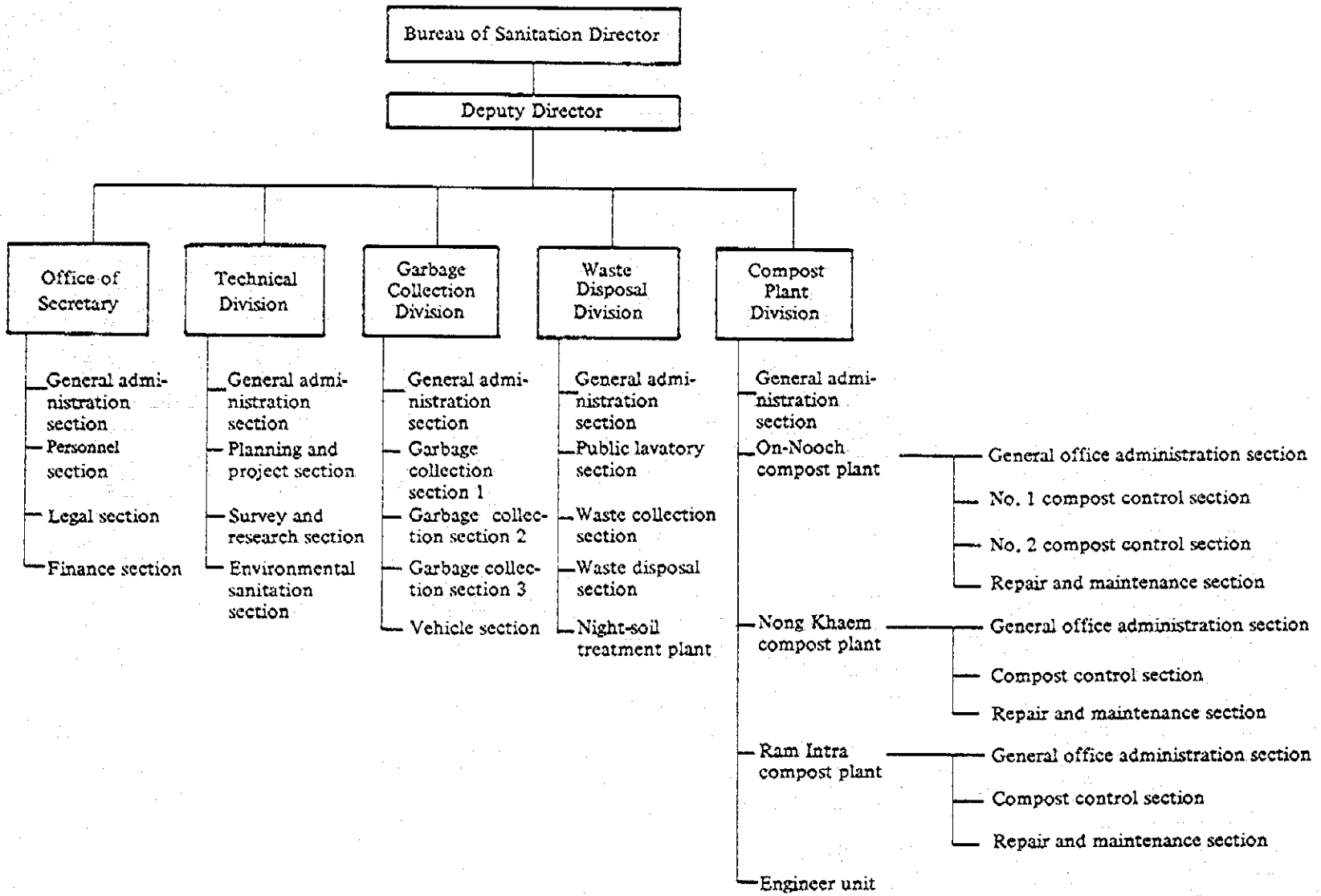
2. Administrative organization

(1) Organization of Bureau of Sanitation
See Fig. AP 3.1 (next page)

(2) Organization of Sanitation Section of district (Jan. 1981)

Fig. AP 3.2




Bureau of Sanitation Director
Deputy Director
Office of Secretary
General administration section
Personnel section
Legal section
Finance section
Technical Division
General administration section
Planning and project section
Survey and research section
Environmental sanitation section
Garbage Collection Division
General administration section
Garbage collection section 1
Garbage collection section 2
Garbage collection section 3
Vehicle section
Waste Disposal Division
General administration section
Public lavatory section
Waste collection section
Waste disposal section
Night-soil treatment plant
Compost Plant Division
General administration section
On-Nooch compost plant
General office administration section
No. 1 compost control section
No. 2 compost control section
Repair and maintenance section
Nong Khaem compost plant
General office administration section
Compost control section
Repair and maintenance section
Ram Intra compost plant
General office administration section
Compost control section
Repair and maintenance section
Engineer unit

(3) List of task allocation by Bureau (Jan. 1981)

Table AP 3.3

Bureau	Division	Allocated task
Bureau of Sanitation (BOS)	Office of Secretary	° General affairs ° Personnel affairs ° Matters relating to the Ordinance and Acts ° Financial management
	Technical Division	° Planning of sanitation work ° Investigation and data compiling on solid waste management ° Maintenance of solid waste disposal facilities
	Garbage Collection Division	° Collection and transportation of solid waste from major markets and hospitals ° Investigation, delivery and control of collection trucks ° Cleaning of roads (trunk roads and the roads in business quarters)
	Compost Plant Division	° Control, operation, contact and coordination with compost plant sites ° Retrieval and sale of ferrous metal ° Control, operation, contact and coordination with final disposal sites ° Disposal of carcasses
	Waste Disposal Division	° Night soil treatment
Bureau of Sewage and Drainage (BSD)	Canal and Maintenance Division	° Removal of solid waste from rivers and Khlongs ° Procurement and control of river and Khlong solid waste collection boats ° Planning, construction and maintenance of wastewater treatment facilities at final disposal site
Bureau of Finance (BOF)	Revenue Division	° Manufacture and sales control of compost ° Revenue control of fees charged for collection of solid waste
	Mechanical Division	° Purchase of collection trucks ° Repair and periodical inspection of collection trucks ° Purchase and control of reserved collection trucks ° Purchase and repair of the registered BMA vehicles

Bureau	Division	Allocated task
District	Sanitation Section	∘ Collection and transportation of solid waste from households and the solid waste not collected by Garbage Collection Division ∘ Control and operation of final disposal site belonging to Administrative District (Tung Kru and Minburi final disposal sites) ∘ Control of collection trucks ∘ Cleaning of public areas (roads, parks, sidewalks, pedestrian bridges, temples, and markets ∘ Collection of carcasses on the road ∘ Collection of sold waste of rivers and Khlongs
	Revenue Section	∘ Collection of fees charged for collection of solid waste

(4) Number of employees engaged in sanitation work (Jan. 1981)

i) BMA

Table AP 3.4 (Unit: Persons)

	General administrative employees	Workers			Total
		Road sweepers	Collection workers	Sub-total	
BOS	183	91	1,045	1,136	1,319
Districts (Sanitary Section)	158	2,762	2,742	5,504	5,662
BSD (River & Canal Control Division)	84	-	817	817	901
Total	425	2,853	4,604	7,457	7,882
Component ratio (%)	5.4	36.2	58.4	94.6	100.0

ii) District See Table AP 3.5 (next page)

(5) Location of the offices and facilities See Fig. AP 3.3

3. Budgets related to sanitation work for fiscal 1980

Table AP 3.6 (Unit: Baht)

Total BMA general budget	3,910,908,404	(A)	
Budget related to sanitation work	329,425,052	(B)	(B)/(A); 8.42%
Night soil treatment	31,235,200		
Solid waste disposal	298,189,852		

Bureau of sanitation	138,229,420
District (sanitation section)	146,994,165
BSD (River & canal control Div.)	1,074,375
BOP (Technical Div. Budget for repair of collection trucks)	*43,127,092
Total	329,425,052

* Estimated by the Study team.

Table AP 3.5 Sanitation sections of district government offices

Jan. 1981
(Unit: person)

	Kind of officials / District	Government Officials	Worker				Total
			Driver	Collector	Sweeper	Surveillant	
1	Phra Nakhon	11	38	138	259	27	473
2	Pom Prap	3	26	125	152	17	323
3	Pathum Wan	25	25	107	140	16	313
4	Sam Phan Thawong	12	14	63	113	9	211
5	Bang Rak	3	20	87	90	6	206
6	Yannawa	10	27	136	186	21	380
7	Dusit	5	38	221	226	22	512
8	Phayathai	14	32	150	230	28	454
9	Huai Khwang	7	23	97	102	11	240
10	Phra Khanong	1	52	206	150	22	431
11	Bang Khen	5	20	99	106	10	240
12	Bang Kapi	10	17	68	90	6	191
13	Nong Chok	3	1	2	17	-	23
14	Minburi	3	7	23	15	2	50
15	Lat Krabang	4	4	16	10	-	34
16	Thonburi	5	18	88	130	7	248
17	Khlong San	8	15	66	145	7	241
18	Bangkok Noi	3	17	99	171	8	298
19	Bangkok Yai	4	8	56	89	2	159
20	Bang Khun Tian	3	11	45	57	6	122
21	Phasi Charoen	7	9	61	136	6	219
22	Rat Burana	3	18	70	65	4	160
23	Taling Chan	7	2	19	20	5	53
24	Nong Khaem	2	3	9	63	4	81
	Total	158	445	2,051	2,762	246	5,662

Source : Sanitation Section of each district.

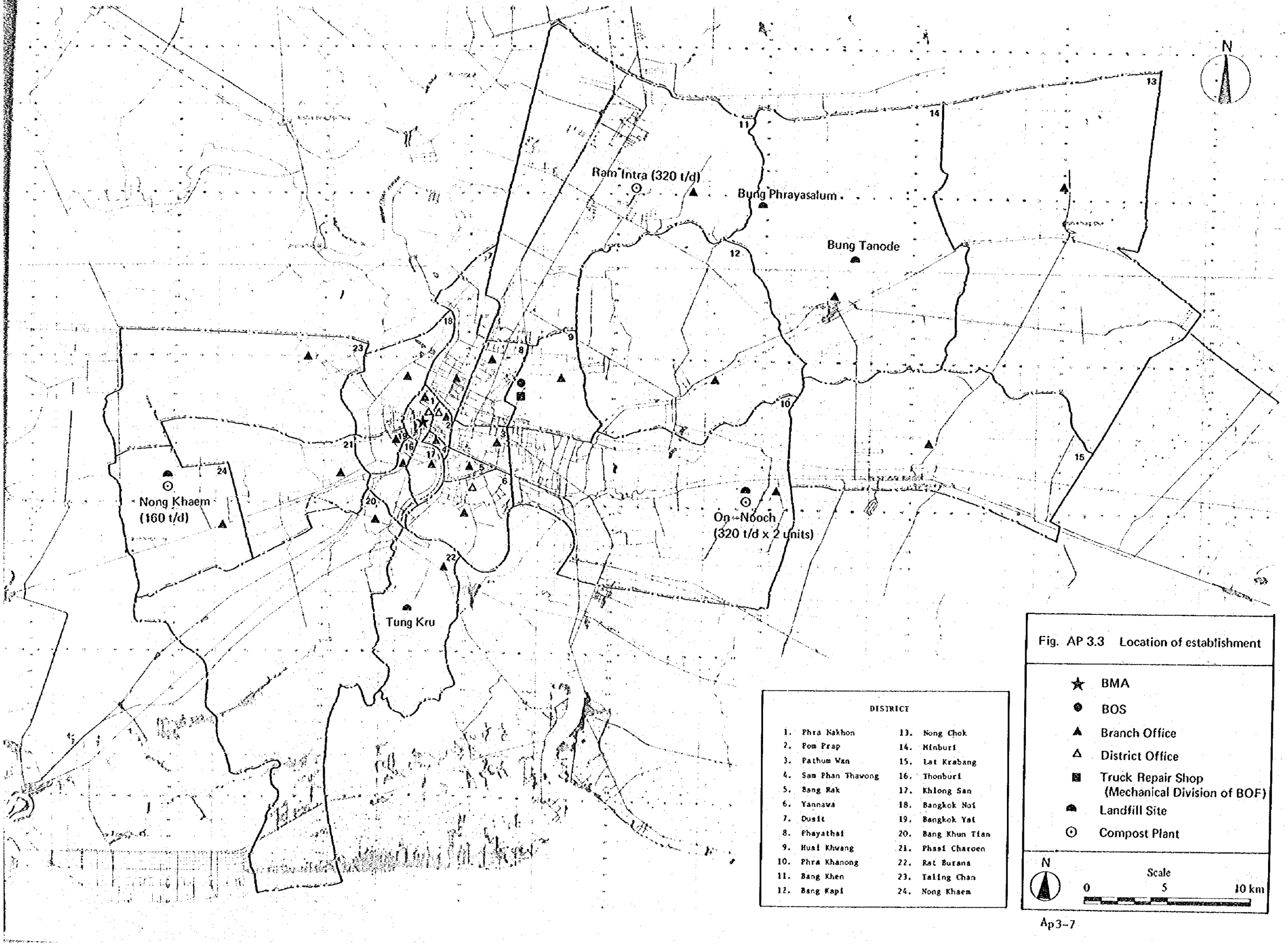


Fig. AP 3.3 Location of establishment

4. Fee system for solid waste collection (Fiscal 1980)

(1) Fee for solid waste collection

Table AP 3.7

Source of fee	Collection volume	Collection fee
House or building	20L/d or less	4 Baht per month
	40L/d or less	6 "
	60L/d or less	8 "
	80L/d or less	10 "
	100L/d or less	12 "
	When the collection volume per day exceeds the contracted collection volume, for each 10L of excess or fraction thereof.	1 Baht
Market, factory and other places	1 m^3/d or less	40 Baht per month
	More than 1 m^3/d; for 1 m^3 or a fraction thereof.	40 "
	When daily collection volume exceeds the contracted collection volume, for each 1 m^3 or fraction thereof.	10 Baht
Periodic collection	1 m^3/once or less	25 Baht per month
	More than 1 m^3/time; for each 1 m^3 or fraction thereof.	25 Baht

Source: Article 6 (3) of Public Health Act.

(2) Levied solid waste collection fee by districts

See Table AP 3.8 (next page)

(3) Levied solid waste collection fee by years

Table AP 3.9

Fiscal Year	Collection Fee Paying Households (No. Households)	Levied Collection Fee (Baht)
1974	24,606 + (Some households which can't fix a households number)	10,055,058
1975	25,512 + (")	9,745,115
1976	-	10,202,020
1977	59,829 + (")	11,038,114
1978	100,699 + (")	11,726,162
1979	116,126	12,507,892
1980	97,752	14,206,631

Source : Revenue Division of Bureau of Finance.

5. Solid waste management cost flow

See Fig. AP 3.4

Table AP 3.8 Levied solid waste collection fee by districts (1980)

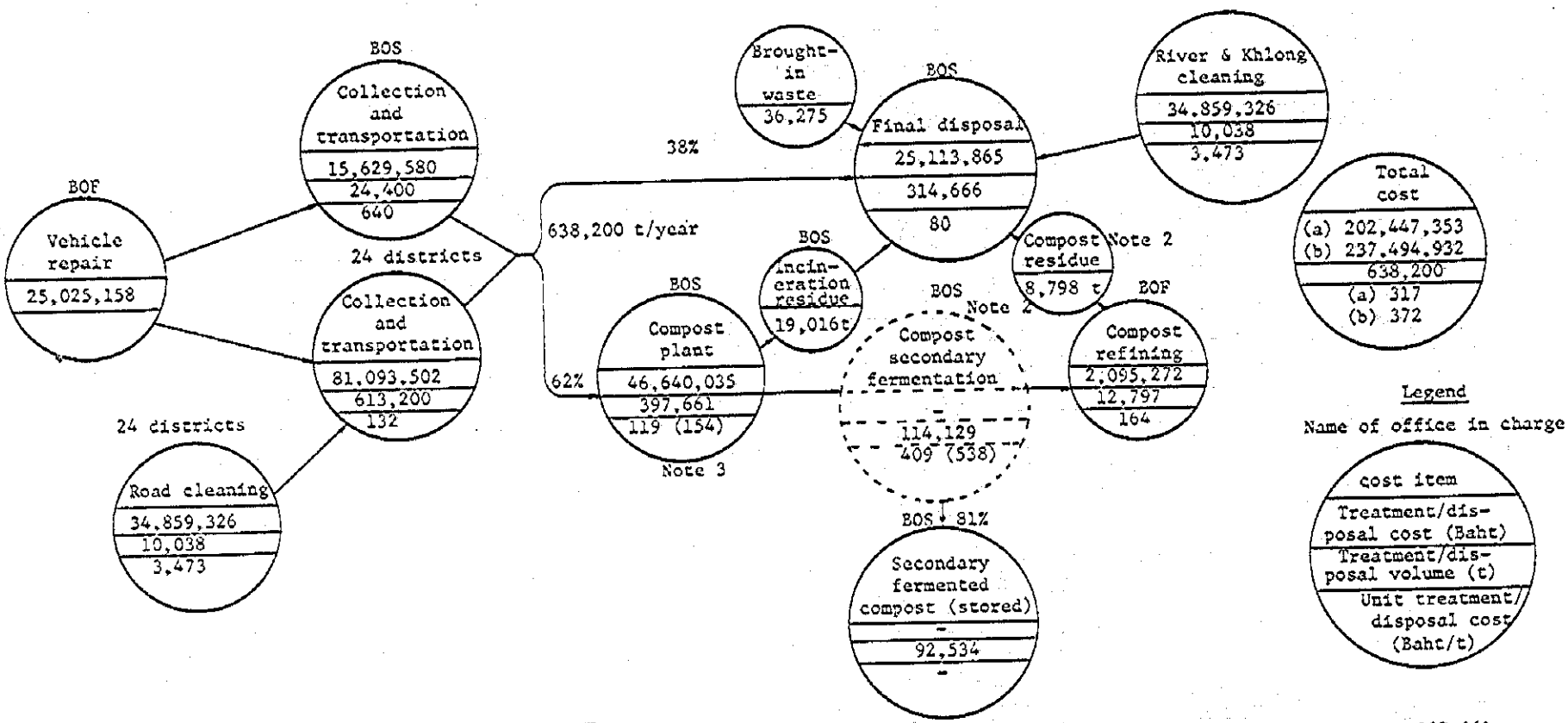
(Unit: Baht)

Item / District	Collection fee paying households (No. Households)	Planned collection fee to be levied (A)	Actually levied collection fee (B)	Difference between (A) and (B)
1. Phra Nakhon	9,521	1,010,000	1,046,137	36,137
2. Pom Prap	463	810,000	892,516	19,516
3. Pathum Wan	3,605	685,000	703,899	18,899
4. Sam Phan Thawong	4,911	800,000	900,000	100,000
5. Bang Rak	4,180	780,000	904,988	124,988
6. Yannawa	13,647	1,410,102	1,518,048	107,946
7. Dusit	880	661,339	947,009	285,670
8. Phayathai	11,146	1,215,000	1,306,748	91,748
9. Huai Khwang	1,545	200,000	236,472	36,472
10. Phra Khanong	12,657	1,450,000	1,737,053	287,053
11. Bang Khen	824	175,000	272,640	97,640
12. Bang Kapi	7,999	350,000	364,492	14,492
13. Nong Chok	2,492	20,000	26,772	6,772
14. Minburi	730	75,000	79,360	4,360
15. Lat Krabang	312	41,110	25,000	Δ16,110
16. Thonburi	4,951	500,000	563,264	63,264
17. Khlong San	4,162	380,000	420,006	40,006
18. Bangkok Noi	5,797	600,000	684,630	84,630
19. Bangkok Yai	2,987	430,000	455,814	25,814
20. Bang Khun Tian	1,902	150,000	330,000	180,000
21. Phasi Charoen	1,919	191,212	330,717	139,505
22. Rat Burana	900	280,000	430,826	150,826
23. Taling Chan	195	150,000	20,232	Δ129,768
24. Nong Khaem	27	6,500	10,008	3,508
Total	97,752	12,370,263	14,206,631	1,773,368

Note: Δ shows the amounts which are not levied yet.

Source: Revenue section of each district.

Fig. AP 3.4 Solid waste management cost flow



Cost item	Cost per ton (Baht/t)	Remark
Total cost (a)	317	Excluding river khlongs and road cleaning
Total cost (b)	372	Excluding river and khlongs cleaning
Collection/ transport cost	152	
Production cost of refined compost	900(1132)	

Note 1. 114,129 tons of secondary fermented compost is produced from 397,661 tons of solid waste. Unit treatment cost is a value converted from compost plant treatment cost.

2. Compost residue means the residue produced at the stage of refining of secondary fermented compost (21,595 tons).

3. Figures in parentheses of treatment cost show the cost including depreciation.

4. Each treatment cost does not include the costs of BOS, Tech. Div., and General Affairs Div.

5. The total costs include the cost of BOS, Tech. Div., and General Affairs Div.

6. Salary

(1) Overtime allowance

Table AP 3.10

Overtime work exceeding 3 hours National holiday work	150% of the ordinary wage rate 200% of the ordinary wage rate
Meal allowance is paid for overtime work exceeding 3 hours and for holiday work.	

(2) The average monthly amount of wage for workers (1980)

Table AP 3.11 (Unit: Baht)

Kind of worker	Wage	Overtime allowance
Drivers	1,880	
Collecting worker	1,500	900
Road sweeper	1,420	

7. Number of personnel accidents on duty and traffic accidents

Table AP 3.12

District	Traffic accident		Personnel accidents on duty	
	Year 1979	Year 1980	Year 1979	Year 1980
1. Phra Nakhon	4	4	10	10
2. Pom Prap	8	6	1	1
3. Pathum Wan	10	10	30	30
4. Sam Phan Thawong	-	-	1	-
5. Bang Rak	10	10	-	5
6. Yannawa	5	5	-	-
7. Dusit	8	8	30	30
8. Phayathai	5	5	10	10
9. Huai Khwang	3	3	2	3
10. Phra Khanong	-	-	-	-
11. Bang Khen	60	60	1	-
12. Bang Kapi	8	2	10	-
13. Nong Chok	-	-	-	-
14. Minburi	-	-	-	-
15. Lat Krabang	3	3	-	-
16. Thonburi	3	3	-	-
17. Khlong San	8	8	10	10
18. Bangkok Noi	3	2	13	22
19. Bangkok Yai	3	4	3	5
20. Bang Khun Tian	1	2	3	2
21. Phasi Charoen	-	-	-	2
22. Rat Burana	-	3	-	3
23. Taling Chan	-	2	-	2
24. Nong Khaem	1	1	1	1
Total	143	141	129	146

Source: Sanitation section of each district.

8. Collection system

(1) Scope of collection

Table AP 3.13

Garbage Collection Div.	Hospital waste from main hospitals, market waste of 17 districts and temporarily discharged solid waste.
District	Household waste and business waste except the above mentioned waste.

(2) Collection area

See Fig. AP 3.5

(3) Estimated discharge volume of business waste (fiscal 1980)

Table AP 3.14

Kind of business	Number of business	Volume of solid waste
Market	217	135 t/d
Hospital	60	40 t/d
Hotel	69	20 t/d

(4) Slum waste

Table AP 3.15

Number of slum	Number of slum household	Volume of solid waste
280	68,000	52 t/d

(5) Solid waste collection volume by district and per worker by district

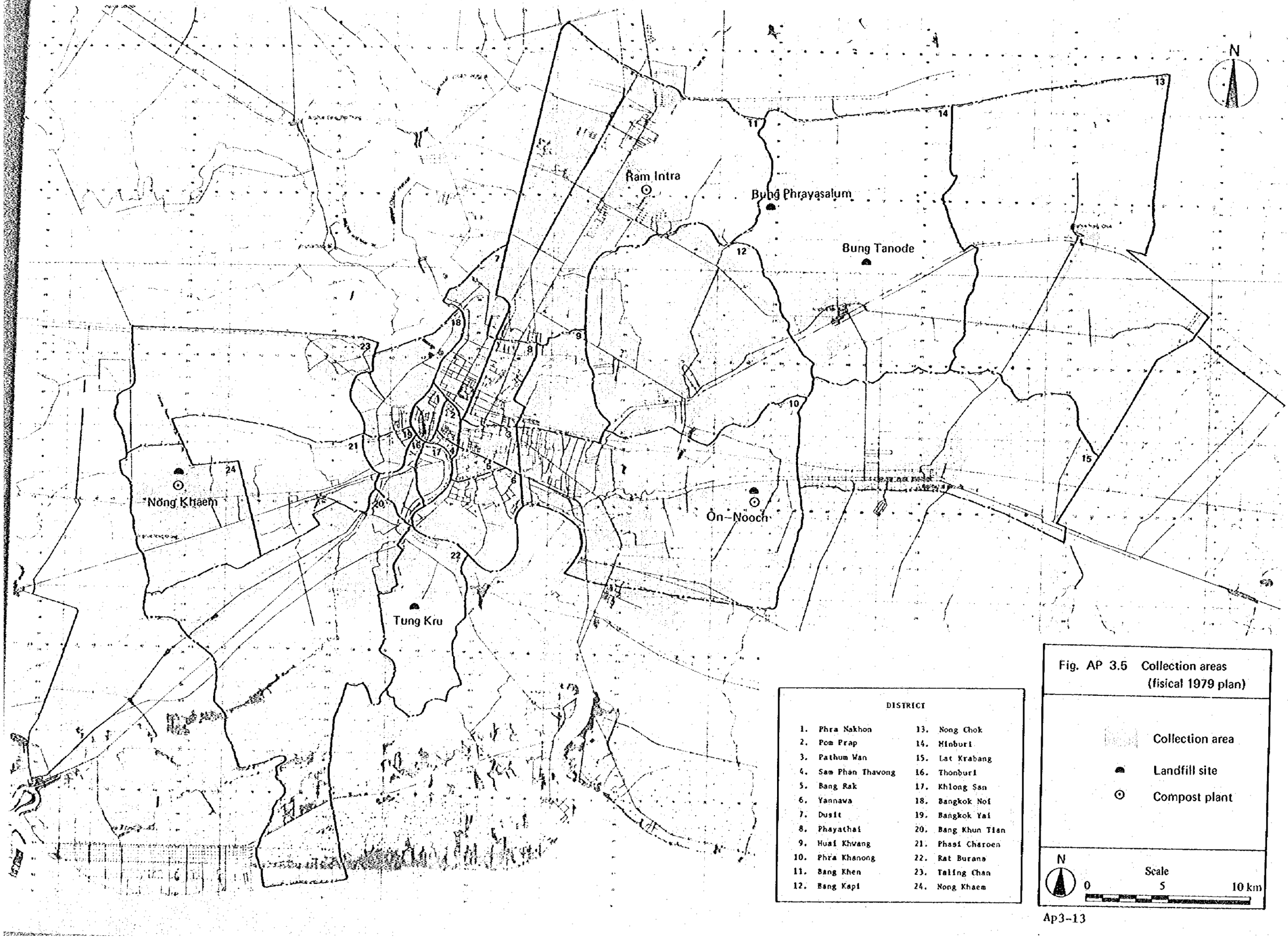
Table AP 3.16

(6) Collection volume per collection truck

Table AP 3.17

(7) Collection volume and percentage by district

Fig. AP 3.6



DISTRICT			
1.	Phra Nakhon	13.	Nong Chok
2.	Pom Prap	14.	Minburi
3.	Pathum Wan	15.	Lat Krabang
4.	Sam Phan Thavong	16.	Thonburi
5.	Bang Rak	17.	Khlong San
6.	Yannawa	18.	Bangkok Noi
7.	Dusit	19.	Bangkok Yai
8.	Phayathai	20.	Bang Khun Tian
9.	Huai Khwang	21.	Phasi Charoen
10.	Phra Khanong	22.	Rat Burana
11.	Bang Khen	23.	Taling Chan
12.	Bang Kapi	24.	Nong Khaem

Fig. AP 3.5 Collection areas (fisical 1979 plan)

Collection area

Landfill site

Compost plant

N

Scale 0 5 10 km

Table AP 3.16 Solid waste collection rate by districts, and collection volume per collection worker (Analisis of 1979 - year data)

No.	Administrative district	Solid waste collection volume		Number of delivered collection truck*2				Number of Workers*3		Collection Volume/Worker	
		Volume C_1 (m^3/d)*1	Weight C_2(t/d) *1	Non-compactor		Com-pactor	Total (vehicle)	Number (person)	Number per collection truck (person/vehicle)	CM = C_1/Wn (m^3/d·person)	CH = C_2/Wn (t/d·person)
				6 m^3	8 m^3	7.5 m^3					
1	Phra Nakhon	420.7	122.9	3	5	20	28	203	7.25	2.07	0.605
2	Pom Prap	275.2	80.4	0	19	4	23	168	7.30	1.64	0.479
3	Pathum Wan	286.5	83.7	2	22	5	29	148	5.10	1.94	0.566
4	Sam Phan Thawong	227.3	66.4	2	4	8	14	86	6.14	2.64	0.772
5	Bang Rak	256.4	74.9	2	18	4	24	113	4.71	2.27	0.663
6	Yannawa	377.5	110.3	4	22	6	32	184	5.75	2.05	0.599
7	Dusit	532.9	155.7	5	29	6	40	281 (max.)	7.03	1.90	0.554
8	Phayathai	530.2	154.9	4	10	15	29	210	7.24	2.52	0.738
9	Huai Khwang	203.0	59.3	2	11	6	19	131	6.89	1.55	0.453
10	Phra Khanong	800.6 (max.)	233.9 (max.)	4	15	21	40	280	7.00	2.86	0.835
11	Bang Khen	347.4	101.5	2	14	5	21	129	6.14	2.69	0.787
12	Bang Kapi	237.5	69.4	3	9	3	15	91	6.07	2.61	0.762
13	Nong Chok	11.0 (min.)	3.2 (min.)	1	0	0	1	3 (min.)	3.00 (min.)	3.67 (max.)	1.067 (max.)
14	Minburi	81.8	23.9	2	4	1	7	32	4.57	2.56	0.747
15	Lat Krabang	28.1	8.2	1	2	1	4	20	5.00	1.41	0.410
16	Thonburi	216.0	63.1	1	14	4	19	113	5.95	1.91	0.558
17	Khlong San	186.5	54.5	2	3	7	12	88	7.33	2.12	0.619
18	Bangkok Noi	268.4	78.4	2	17	4	23	124	5.39	2.16	0.632
19	Bangkok Yai	104.4	30.5	2	4	1	7	66	9.43	1.58	0.462
20	Bang Khun Tian	106.8	31.2	3	4	2	9	62	6.89	1.72	0.503
21	Phasi Charoen	112.6	32.9	2	8	2	12	76	6.33	1.48	0.433
22	Rat Burana	118.1	34.5	3	9	2	14	92	6.57	1.28	0.375
23	Taling Chan	13.3	3.9	1	0	1	2	26	13.00 (max.)	0.51 (min.)	0.150 (min.)
24	Nong Khaem	18.1	5.3	2	0	1	3	16	5.33	1.18	0.331
25	BOS	229.7	67.1	1	5	15	21	381 (max.)	18.14 (max.)	0.60	0.176
	Total	5,990	1,750	56	248	144	448	3,123	–	–	–
	Average ($\bar{x}$)	–	–	–	–	–	–	–	6.97	1.96	0.570
	Standard deviation ($6\bar{x}$)	–	–	–	–	–	–	–	2.73	0.77	0.203

*1 Excluding BOS collection volume (BOS collects from 17 districts) and divided by 365 for calculation of daily volume.
*2 Delivered truck number as of 1980. (Source: Mechanical Division of BOF)
*3 Number of workers (drivers, collection workers and surveillants) are of Jan. 1981. The number in 1979 was approximates the same as 1981.

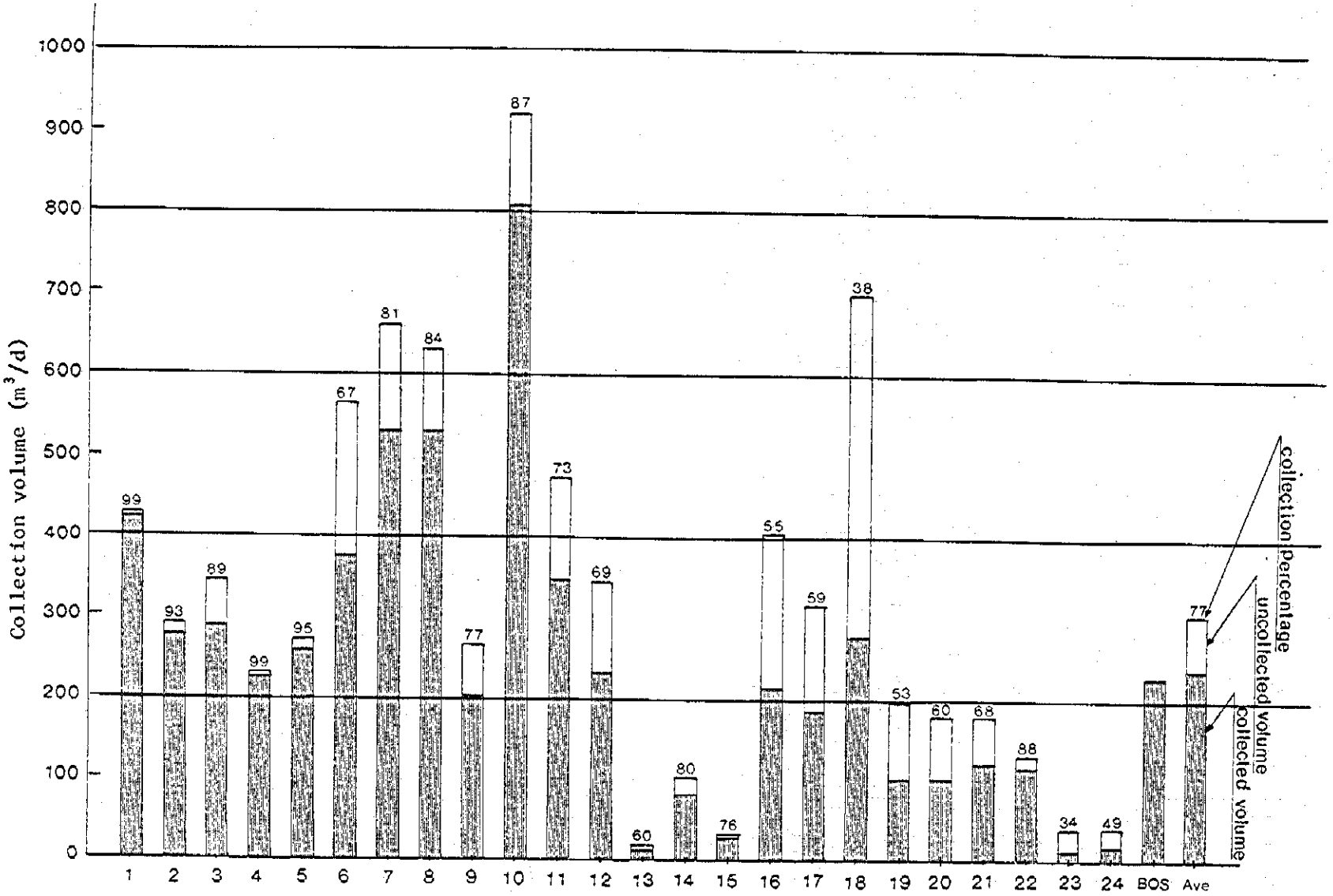
Table AP 3.17 Collection volume per collection truck
(From Feb. 1979 till Jan. 1980)

(From Feb. 1979 till Jan. 1980)

	District Name	Collected Weight (t/d)	Number of Collection Trucks 6m³ Non-Compactor Equivalent vehicles *	Collection Volume per Collection Truck (t/vehicles·d)
1	Phra Nakhon	122.9	43.5	2.8
2	Pom Prap	80.4	31.5	2.6
3	Pathum Wan	83.7	39.1	2.1
4	Sam Phan Thawong	66.4	20.8	3.2
5	Bang Rak	74.9	32.2	2.3
6	Yannawa	110.3	42.8	2.6
7	Dusit	150.7	52.9	2.8
8	Phayathai	154.9	42.5	3.6
9	Huai Khwang	59.3	26.5	2.2
10	Phra Khanong	233.9(max.)	59.2	4.0(max.)
11	Bang Khen	101.5	28.7	3.5
12	Bang Kapi	69.4	19.8	3.5
13	Nong Chok	3.2(min.)	1	3.2
14	Minburi	23.9	8.9	2.7
15	Lat Krabang	8.2	5.3	1.5
16	Thonburi	63.1	26	2.4
17	Khlong San	54.5	17.8	3.1
18	Bangkok Noi	78.4	30.9	2.5
19	Bangkok Yai	30.5	8.9	3.4
20	Bang Khun Tian	31.2	11.6	2.7
21	Phasi Charoen	32.9	15.8	2.1
22	Rat Burana	34.5	18.3	1.9
23	Taling Chan	3.9	2.7	1.4(min.)
24	Nong Khaem	5.3	3.7	1.4(min.)
25	BOS	67.1	33	2.0
	Total	1,750	623.4	-
	Average ($\bar{x}$)	-	-	2.8
	Standard deviation	-	-	0.6

*Note: Loading capacity of a 8 m³ non-compactor was assumed to be 1.3 times as much as loading capacity of a 6 m³, and the loading capacity of a 7.5 m³ compactor was assumed to be 1.7 times as much as a 6 m³ non-compactor.

Fig. AP 3.6 Collection volume and percentage by district (1979)



1. Estimated by the Study team

1. Phra Nakhon 2. Pom Prap 3. Pathum Wan 4. Sam Phan Thawong 5. Bang Rak 6. Yannawa 7. Dusit
8. Phayathai 9. Huai Khwang 10. Phra Khanong 11. Bang Khen 12. Bang Kapi 13. Nong Chok
14. Minburi 15. Lat Krabang 16. Thonburi 17. Khlong San 18. Bangkok Noi 19. Bangkok Yai
20. Bang Khun Tian 21. Phasi Charoen 22. Rat Burana 23. Taling Chan 24. Nong Khaem

* For BOS, only collection volume is shown.

(8) Road cleaning

Table AP 3.18

Duty division	Mechanical road sweepers	Worker	Road sweeper	The territory
BOS	7	91	-	Total of cleaning covering 198 km
Districts (24)	-	-	2,762	1,558,869 m^2

. Road cleaning area of BOS

Fig. AP 3.7

(9) Rivers and khlongs cleaning

Duty division	No. of boats	No. of Worker	Total of cleaning covering	Volume of solid waste
BSD	15	69	42 km	2,700 m^3

. Rivers and khlongs cleaning area of BSD

Fig. AP 3.8

(10) Major parks in Bangkok

Table AP 3.19

Fig. AP 3.7 Roads cleaned by BOS (Territory of BOS road sweeping (Jan. 1981))

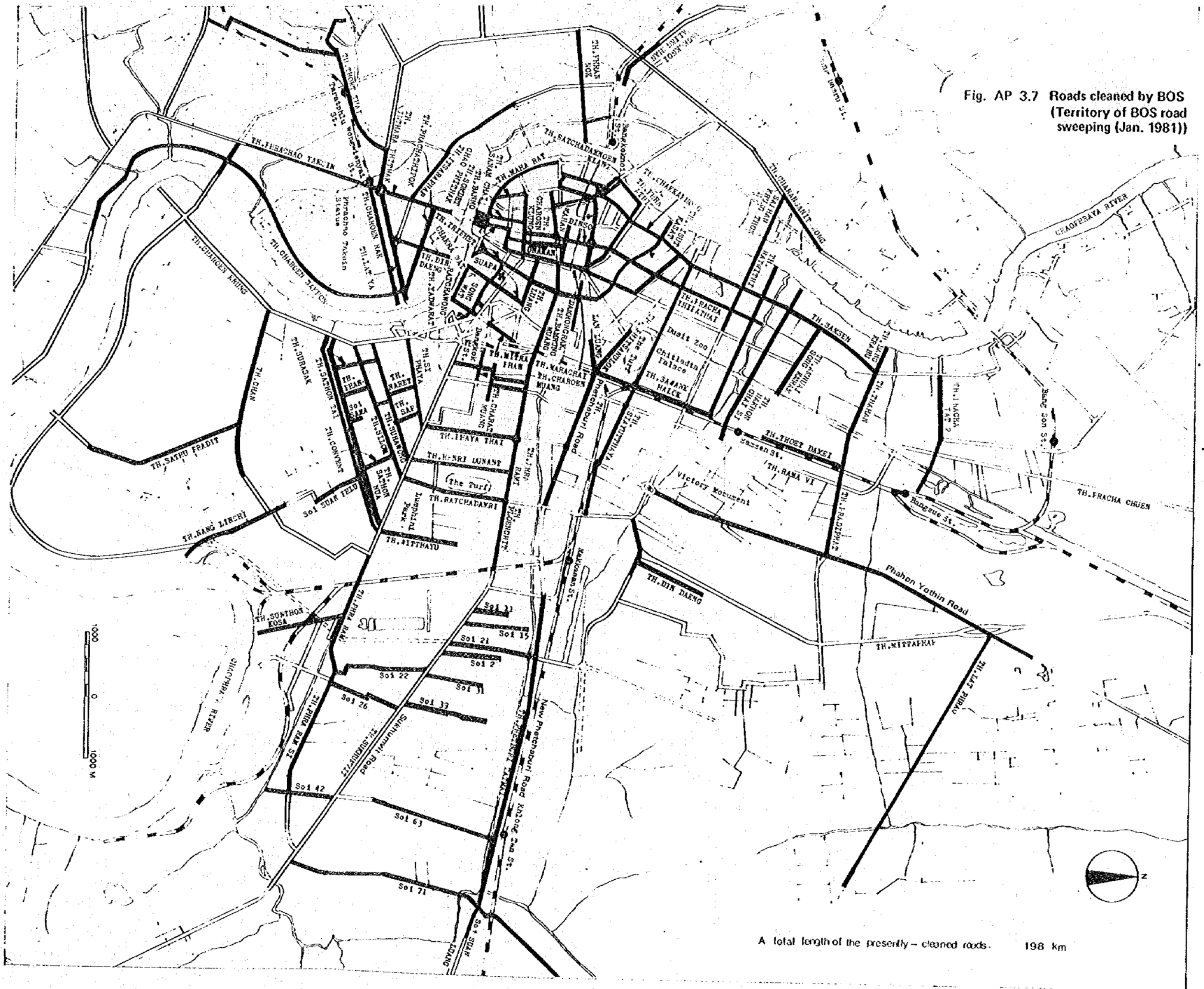


Fig. AP 3.8 Collection territory of rivers and Khlongs (July, 1979)

Table AP 3.19 Major parks in Bangkok

Name of Parks	Location		Area
	District	Address	
1. Lumphini	3. Pathum Wan	Rama 4 Rd. Bangkok	360 rai (596,000 m^2)
2. Chartuchuk	11. Bang Khen	Phahon Yothin Rd. Bangkok	190 rai (304,000 m^2)
3. Phra Nakhon	15. Lat Krabang	Latkrabarg Rd. Bangkok	50 rai (80,000 m^2)
4. Slan Loomp	1. Phra Nakhon	Sanam Chai Rd. Bangkok	23 rai (56,800 m^2)
5. Thonburi	21. Phasi Charoen	Bang Mot Bangkok	63 rai (100,800 m^2)
6. Makasan	9. Huai Khwang	-	92 rai (147,200 m^2)
Total	-	-	778 rai

Note: 1. Parks are under control of Public Park Division of Bureau of Social Welfare.

2. Park cleaning is made between 5.00 a.m. and 10.30 p.m.

3. Source: Public Park Division of Bureau of Social Welfare.

9. Transportation system

(1) Number of collection trucks

Table AP 3.20

Dec. 1981

Name of district and other offices	Non-compactor	Container loader	Compactor	Total
MD (reserved trucks)	56	-	-	56
BOS	4	1	14	19
Phra Nakhon	4	4	27	35
Pom Prap	17	2	4	23
Pathum Wan	19	2	6	27
Bang Rak	14	-	7	21
Yannawa	14	9	11	34
Sam Phan Thawong	6	-	9	15
Dusit	29	1	7	37
Phayathai	14	4	15	33
Phrakanong	18	4	22	44
Bang Khen	13	5	9	27
Huai Khwang	10	1	6	17
Bang Kapi	12	1	4	17
Minburi	5	1	1	7
Lat Krabang	2	1	1	4
Nong Chok	2	1	-	3
Thonburi	12	1	5	18
Khlong San	6	1	7	14
Bangkok Noi	15	2	4	21
Bangkok Yai	7	1	1	9
Phasicharoen	7	2	4	13
Bang Khun Tian	10	1	2	13
Rat Burana	13	1	2	16
Taling Chan	1	1	1	3
Nong Khaem	1	1	1	3
Total	311	48	170	529

(2) Acquisition of collection trucks by year

See Table AP 3.21 (next page)

(3) Number of repaired collection trucks

. Number of breakdown

Table AP 3.22

Fiscal year	Number
1978	3,192
1979	4,035
1980	4,621

Source: Mech. Div., BOP

. Repair rate and repair cost
See Table AP 3.23

. Analysis of repair record
See Table AP 3.24

Table AP 3.21 Acquisition of collection trucks by year

As of Jan. 1981

Purchased (Year)	Number of Purchased Trucks					Total
	Non-Compactor				Compactor	
	6 m^3	Container loader	8 m^3	10 m^3	7.5 m^3	
1960				1		1
1962			2	1		3
1963			22	3		25
1965			1	3		4
1966			31	1		32
1967				7		7
1968	1		2			3
1969	1		7			8
1970			4			4
1971			10	7		17
1972	1		13	1		15
1973			26			26
1974			82	1		83
1975			1			1
1976	43		45		17	105
1977	10				51	61
1978			1	20	6	27
1979	2	1		9	46	57
1980			1		24	25
1981		47			20	67
Total	58	48	248	54	164	552

Source: Mechanical Division, BOF.

Table AP 3.23 (Fiscal 1980)

Survey results of the repair record of trucks by type	
Repair cost per truck	About 45,000 Baht
Repairing rate of truck	About 18%
Operating rate of truck	About 82%

(4) Transport plan, distance and time

Table AP 3.25

(5) Collection and transport cost

. Collection and transport cost (fiscal 1979)

Table AP 3.26 (Unit: Baht/m^3)

BOS	185
24 Districts	39
Average	44

. Collection and transport cost per trip

Table AP 3.27 (Unit: Baht)

	Non-compactor		Compactor
	6 m^3	8 m^3	7.5 m^3
BOS	1,094	1,459	1,771
24 Districts	226	301	365

Table AP 3.24 Survey results of the repair record of collection trucks by type

Items	Unit	A Compactor	B Non-compactor	A/B
Number of samples	vehicles	41	120	-
Repair cost per truck	Baht/year	46,456	44,137	1.05
Times for repair per truck	repairs/ year	16.4	10.8	1.52
Repair period per truck	d/year	60.4	68.5	0.82
Repair cost per repair	Baht/ repair	2,853	4,087	0.69
Repair period per repair	d/repair	3.7	6.3	0.59

Note: The figures in the table are obtained from analysis of the repair record of the Mechanical Division of BOF.

Table AP 3.25 Transport schedule, distance and time

(1979)

District	Schedule			Result of Field Survey *1			
	Number of Territories	Number of Trips	Average Number of Trips (times/d)	No. of trips (times/d)	Transport Distance (km)	Transport Time (min)	Sample Number
1 Phra Nakhon	29	58	2	2.1	21	46	9
2 Pom Prap	22	44	2	1.7	24	56	6
3 Pathum Wan	23	46	2	1.9	23	53	9
4 Sam Phan Thawong	12	24	2	2.0	22	45	6
5 Bang Rak	18	50	2.8	2.0	23	54	6
6 Yannawa	26	58	2.2	2.3	22	54	9
7 Dusit	35	99	2.8	2.8	24	53	12
8 Phayathai	29	82	2.8	2.3	20	40	9
9 Huai Khwang	18	36	2	2.2	17	37	6
10 Phra Khanong	46	136	3	2.5	12	31	12
11 Bang Khen	23	53	2.3	2.1	11	29	9
12 Bang Kapi	19	41	2.2	2.3	15	25	4
13 Nong Chok	2	4	2	1.5	29	41	3
14 Minburi	7	20	2.9	2.1	6	25	3
15 Lat Krabang	4	8	2	2.0	10	26	3
16 Thonburi	17	34	2	2.0	17	33	6
17 Khlong San	11	23	2.1	2.5	19	41	6
18 Bangkok Noi	20	48	2.4	2.2	20	44	6
19 Bangkok Yai	7	14	2	2.0	15	27	3
20 Bang Khun Tian	13	19	1.5	1.3	20	55	3
21 Phasi Charoen	12	27	2.3	1.9	9	20	3
22 Rat Burana	16	28	1.8	2.2	10	24	3
23 Taling Chan	3	6	3	2.0	22	52	3
24 Nong Khaem	3	7	2.3	2.0	3	8	3
Average	–	–					

Source: *1 by the Study team.

10. Compost Plant

(1) Outline of the existing compost plants

Table AP 3.28

		On-Nooch Plant		Nong Khaem Plant	Ram Intra Plant	Total
		1	2			
District		Phra Khanong		Nong Khaem	Bang Khun Tian	
Capacity	Compost plant	320 t/8h	320 t/8h	160 t/8h	320 t/8h	1,120 t/8h
	Incinerator	100 t/12h	100 t/12h	60 t/12h	100 t/12h	360 t/12h
	Trommel (BOF)	-	-	-	100 t/15h	100 t/15h
Starting date of operation		Jan. 1979	Jan. 1979	Jan. 1978	Oct. 1976	
Area	Total area (Including landfill site)	929,600m^2		588,800m^2	89,600m^2	1,608,000m^2
	Compost plant area	62,900m^2	62,900m^2	64,000m^2	89,600m^2	279,400m^2
	Second fermentation area	14,700m^2	14,700m^2	9,760m^2	14,760m^2	53,920m^2

(2) Record of breakdown (Nong Khaem compost plant from March 1979 to August 1980)

Table AP 3.29

Repair point	Number	%
Hammer Mill	358	60
Crane	95	16
Thermo couple	61	10
Conveyer	53	9
Others	30	5
Total	597	100

(3) Incoming solid waste volume to compost plant

Table AP 3.30 (Unit: m^3)

Fiscal year	Din Daeng	On-Nooch-1	On-Nooch-2	Nong Khaem	Ram Intra	Total
1977	407,666				25,581	433,247
1978	110,180	Start		159,380	313,601	583,161
1979	closed	282,357	287,165	163,237	509,933	1,242,692
1980		491,476	493,011	155,505	480,168	1,618,179
Total	*1	773,833	780,176	478,112	1,329,283	4,952,919

*1 Incoming solid waste volume 1,593,483 m^3 from October 1972 to December 1977.

(4) Material balance

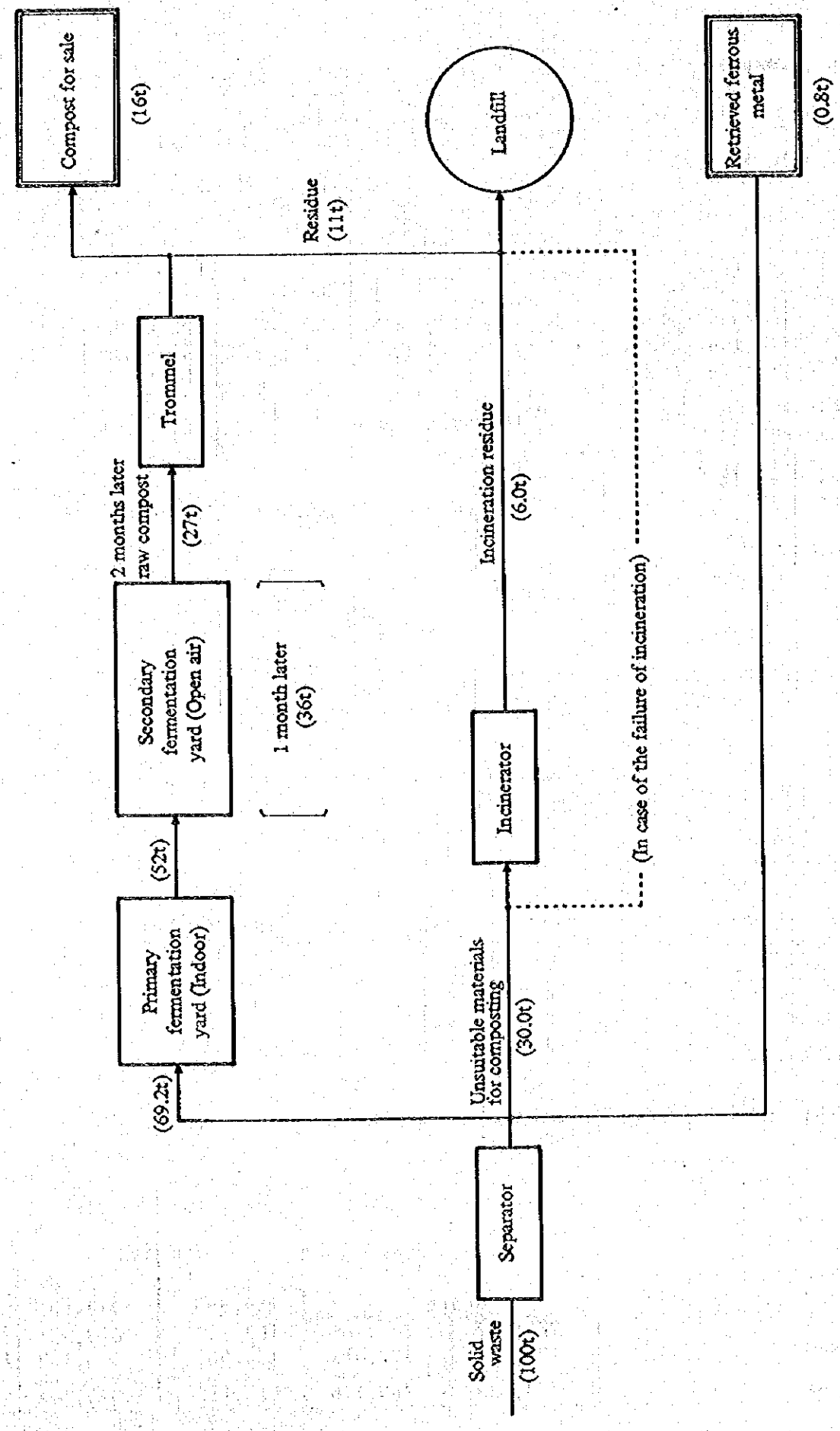
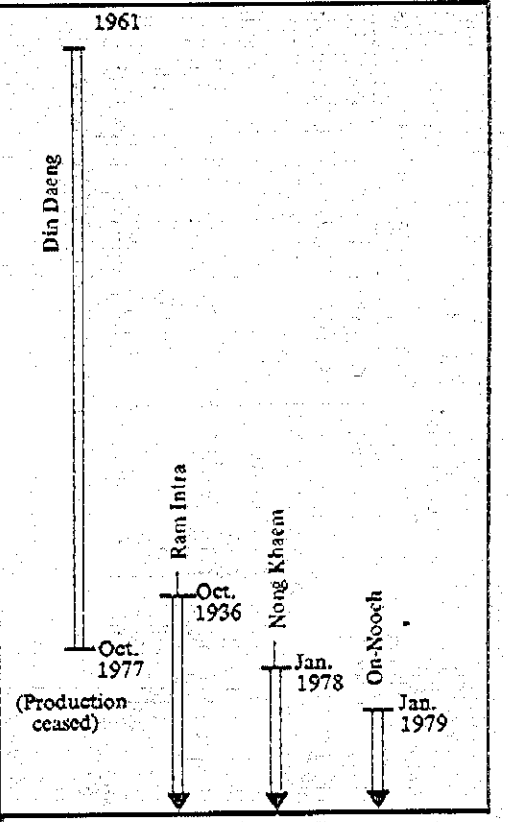


Fig. AP 3.9 Material balance in composting
(For 100 t/d)

Table AP 3.31 Production volume of compost for-sale by years

(Unit: t)

Fiscal year	Compost type						Commencement and cease of compost plant operation
	Compost Type-1	Compost Type-1 (Fine Sieving)	Compost Type-2 (With Night Soil)	Compost Type-3	Compost Type-4 (Low Class)	Chemical Organic Fertilizer	
1961	827.860	–	–	2,668.660	–	–	
1962	3,493.700	–	389.700	1,146.550	78.900	–	
1963	8,468.000	–	1,112.650	24.850	47.700	–	
1964	11,763.200	–	1,012.000	77.500	11.000	–	
1965	8,876.900	–	2,152.250	9.800	80.150	–	
1966	2,315.220	–	13,653.400	(Production ceased)	(Production ceased)	50.000	
1967	1,367.270	–	475.600	–	–	950.000	
1968	947.100	–	840.800	–	–	612.750	
1969	1,466.000	–	1,543.000	–	–	1,368.000	
1970	2,998.100	–	2,658.831	–	–	896.532	
1971	2,148.585	–	1,231.375	–	–	83.300	
1972	7,783.758	–	1,887.517	–	–	734.594	
1973	5,882.855	–	2,295.504	–	–	1,319.520	
1974	6,217.390	1,637.940	2,560.240	–	–	2,459.650	
1975	6,220.245	1,487.520	2,490.710	–	–	1,896.950	
1976	7,405.490	1,193.640	1,613.720	–	–	1,450.200	
1977	11,058.430	542.300	5,174.200	–	–	562.500	
1978	4,793.140	278.000	2,761.500	–	–	185.150	
1979	8,484.500	9.000	4,303.190	–	–	(Production ceased)	
1980	10,201.570	301.300	6,003.850	–	–	–	
TOTAL	118,878.843	5,449.700	53,142.037	3,927.360	217.750	12,569.146	



Note: Figures of 1972 and 1973 include Fine compost Type-1 production volume of 2,416 tons and 1,533 tons respectively.
Figures of 1980 were based on the Field Investigation Report.

Source: Compost plant Division, BOS.

(6) Compost retail price

Table AP 3.32

As of Jan. 1981

Minimum unit of sale		Compost Type-1	Compost Type-1 (Fine Sieving)	Compost Type-2
Packed in bags	5 kg	6 Baht	-	8 Baht
	10 kg	11	-	15
	20 kg	20	26 Baht	30
	50 kg	35	50	55
Bulk sale (unpacked)	1 ton	370 Baht	650 Baht	740 Baht

Source: Compost Plant Div., BOS

(7) Fertilizer sales by year

Table AP 3.33

(Baht)

Fiscal Year	Compost				Chemical Fertilizer	Total Sales Value
	Type-1 Fine Type-1	Type-2	Type-3	Type-4		
1961	116,425.90	-	203,061.98	-	-	319,487.88
1962	496,452.77	164,747.40	514,184.40	70,303.50	-	1,245,688.07
1963	1,072,007.96	561,847.15	138,237.95	25,865.50	-	1,797,958.56
1964	1,401,825.03	420,384.20	42,644.05	26,033.25	-	1,890,886.53
1965	1,093,332.60	804,867.20	21,886.00	52,917.00	-	1,973,002.80
1966	400,898.06	1,278,890.50	-	-	41,585.00	1,721,373.56
1967	305,895.00	415,183.55	-	-	778,291.70	1,499,370.25
1968	322,975.70	716,514.90	-	-	607,362.45	1,646,853.05
1969	426,873.90	634,230.75	-	-	1,604,893.00	2,665,997.65
1970	373,746.30	550,582.75	-	-	1,439,168.70	2,363,497.75
1971	505,331.90	523,410.00	-	-	152,890.00	1,181,631.90
1972	707,833.70	758,305.50	-	-	821,307.50	2,287,446.70
1973	1,571,384.85	1,066,747.50	-	-	1,875,410.50	4,513,542.85
1974	940,466.75	1,512,000.25	-	-	5,827,205.50	8,279,672.50
1975	1,072,320.95	1,448,004.75	-	-	6,514,053.00	9,034,378.70
1976	1,227,919.30	950,589.45	-	-	966,997.00	3,145,505.75
1977	2,265,809.00	1,851,360.80	-	-	1,404,227.00	5,521,396.80
1978	1,799,503.74	2,499,773.60	-	-	1,832,761.25	6,132,038.59
1979	2,302,441.64	2,721,235.50	-	-	45,330.00	5,069,007.14
1980	3,059,871.35	4,632,896.45	-	-	52,200.00	7,744,967.80
Total	21,463,315.65	23,511,572.20	920,014.38	175,119.25	23,963,682.60	70,033,704.08

Source: Compost Plant Div. BOS
Compost Type 1 = Compost after trommel
Fine Type 1 = Compost after fine trommel
Compost Type 2 = The product made by adding night sail to compost Type-1
Compost Type 3, Type 4 = Adding chemical fertilizer to compost Type-1

(8) Recovered ferrous metal

Table AP 3.34

Retrieved ferrous metal	0.8 t/100 tons of solid waste
Weight of retrieved ferrous metal (1980)	About 72,000 t (Sum of four plants) .
Ferrous metal sales in 1980	158,337 Baht

(9) Results of tests on recovered ferrous metal

Table AP 3.35 Results of tests on recovered ferrous metal

Specimen No.	Original Weight of scrap-metal (kg)	Weight of scrap-metal after incineration (kg)	Percentage weight loss (%)
1	34.5	32.2	6.7
2	24.6	23.3	5.3
3	41.1	38.5	6.3
		Average	6.1

11. Final disposal system

(1) Outline of landfill site

Table AP 3.36

	On-Nooch	Nong Khaem	Ram Intra	Tung Kru	Bang Tanode	Bang Phraya-salum
Location (District)	Phra Khanong	Nong Khaem	Bang Khun Tian	Rat Burana	Minburi	Minburi
Total area of site	929,600 m^2	588,800 m^2	89,600 m^2	64,000 m^2	8,000 m^2	8,000 m^2
Compost plant	320 t/8h x 2	160 t/8h	320 t/8h	-	-	-
Landfill method	Open dump					
Year of start of landfill	1964	1972	1972	1977	Unknown	Unknown
Daily incoming volume	850 t	700 t	400 t	72 t	50 t	30 t
Daily landfill volume	415 t	590 t	197 t	72 t	50 t	30 t
Total disposal volume (as of 1980)	12,552,092 m^3	2,935,794 m^3	1,028,252 m^3	332,453 m^3	Unknown	Unknown
Waste water treatment facilities	Equipped	Construction scheduled	Construction scheduled	Not equipped	Not equipped	Not equipped

(2) Solid waste disposal volume at final disposal sites by year

See Table AP 3.37 (next page)

(3) Field work equipment at disposal site

Table AP 3.38

(as of December 1980)

	On-Nooch	Nong Khaem	Ram Intra	Tung Kru	Bung Tanode	Bung Phraya-salum
Bulldozer	4	4	3	-	-	-
Front end loader	5	3	2	-	-	-
Drag line	1	-	-	-	-	-
Excavator	1	-	-	-	-	-
Dump Truck	-	5	2	-	-	-

Table AP 3.37 Solid waste disposal volume at final disposal sites (by fiscal year)

(Unit: m³)

Year	Incoming Volume to Final Disposal Sites								Total
	Din Daeng	On-Nooch	Nong Khaem	Ram Intra	Tung Kru	Bung Tanode	Bung Phrayasalum	Bang Kapi	
1960	Start-up of disposal								
1961	131,400								131,400
1962	121,409								121,409
1963	120,577	Start-up of disposal							120,577
1964	329,387	649,697							979,084
1965	360,947	699,835							1,060,782
1966	351,995	795,526							1,147,521
1967	238,454	1,010,358							1,248,812
1968	374,191	939,310							1,313,501
1969	375,746	854,632							1,230,378
1970	337,151	1,004,201							1,341,352
1971	337,477	931,571							1,269,048
1972	416,054	834,489	Start-up of disposal	Start-up of disposal					1,250,543
1973	Cease of disposal	505,146	438,330	163,957*					1,107,433
1974		486,276	499,022	182,500*					1,167,798
1975	–	625,077	394,426	182,500*					1,202,003
1976	–	848,018	344,560	182,500*	Start-up of disposal			Start-up of disposal	1,375,078
1977	–	763,332	300,220	79,200*	86,078			41,243	1,270,073
1978	–	756,328	325,174	79,200*	82,125*			92,629	1,335,456
1979	–	457,859	314,317	79,200*	82,125*			51,880	985,381
1980	–	360,437*	319,745*	79,200*	82,125*			Cease of disposal	841,507
Total	3,494,788	12,522,092	2,935,794	1,028,257	332,453	Unspecifiable	Unspecifiable	185,752	20,499,136

Note: * Item estimated by the Study team

Source: Compost plant Division, BOS

Appendix 3.2 Solid waste collection manual

For effective performance of solid waste collection and transportation, optimization of the destinations and application of the transfer method should be examined from transportational viewpoint: also from collection work's point of view, examination should be made on various necessities such as alteration of collection method from door-to-door collection to station collection, introduction of newly developed machinery (collection container and equipment), restriction of off-route time, and optimization of the collection route.

In this Manual, a work procedure is described to establish solid waste collection plan and, consequently, to determine the concrete collection routes provided that the current door-to-door collection is continued.

The outline of the procedure is as follows:

Step 1: To make clear distribution of each solid waste generation source and its generation volume

Step 2: To plan collection frequency and collection-work days

Step 3: To assign collection area of each work day

Step 4: To determine collection unit area

Step 5: To designate collection spots

Step 6: To determine collection order

Step 7: To determine collection route

Step 1. To make clear distribution of each solid waste generation source and its generation volume:

For effective performance of the collection, the concerned authorities are required to know solid waste generation volume in his duty area. To this end, the following work should be completed.

1) Preparation of map:

A map on a reduced scale (a map with a scale of 1 to 2,500, for example) should be prepared in which every building in the duty area is indicated. The buildings with a large generation volume should be marked with a particular mark so as to be discerned from the small volume generation buildings.

The small volume generating house is a house discharging approximately less than 1 m^3 of solid waste on the collection day. It may be a residence or a small-size commercial-industrial household, for example.

The large volume generating house is a house discharging approximately more than 1 m^3 of solid waste in a lump from a single place

on the collection day. Generally, the large volume generating house is a large-size building or facility, such as flat, apartment building, hotel, office building, market, department store, supermarket, hospital, school, museum, stadium, theater, factory, etc.

ii) Entry of generation volume distribution on the map:

The generation volume per day should be written on the map. Solid waste volume from the large volume generating houses is recorded. The solid waste container used by the large volume generating house are desired to be an exclusive small-size container (about 1 m^3) from which solid waste is mechanically transferred to the medium-size compator provided the compactor is equipped with container turn-over equipment. At the places where particularly large volume of solid waste is discharged, use of large-size container (about 10 m^3) is desired. It can be carried by the container loader. Administrative guidance may be given to the large volume generating houses for use of the container as mentioned above. The types of the currently used container (or the solid waste depot) should be represented with symbols and recorded with the generation volume on the map.

The volume of solid waste from the small volume generating houses in a certain area should be summarized together and indicated on the map. According to the type of urbanization, the manner of summarization will be classified into the following 4 cases. (Fig. AP 3.10)

(a) Wide city area divided into small blocks:

At the places where the city extends on wide area (like the central district) with division of the area into small blocks by roads, Khlong, etc., the volume of solid waste collected from the small volume generating houses should be recorded on the map in each small block.

(b) Wide city area having large blocks with blind alleys.

The large block with a blind alley is sectioned in such a way that the dischargers in the large blocks are classified into two; one is living along the main street and the other is along the blind alleys. The volume of solid waste discharged from the small volume generating houses in each class should be added up and indicated on the map.

(c) Areas where urbanization progressed along one trunk road and formed a strip city area with many blind alleys (the herringbone type road):

The same as the case (b).

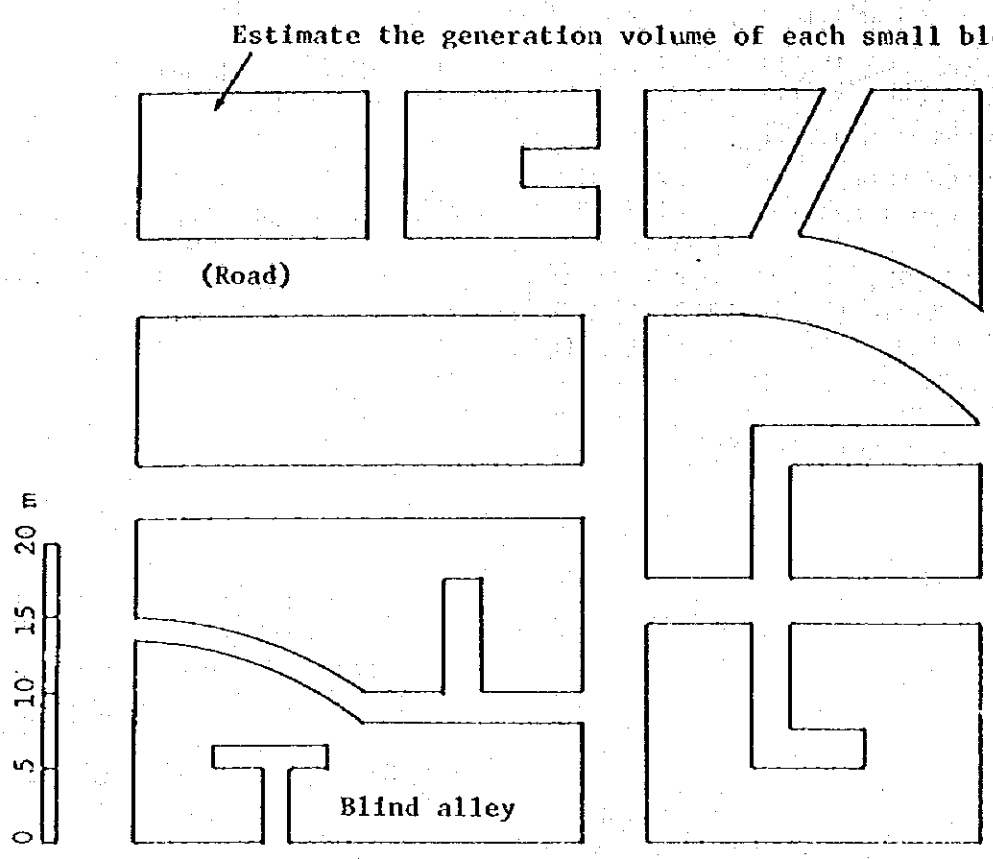
(d) Narrow and long city areas formed along a trunk road:

In this case, the city areas on both sides of the road are sectioned at intervals of about 100 m along the road. The volume of solid waste discharged from the small volume generating houses in each section are added up and indicated on the map.

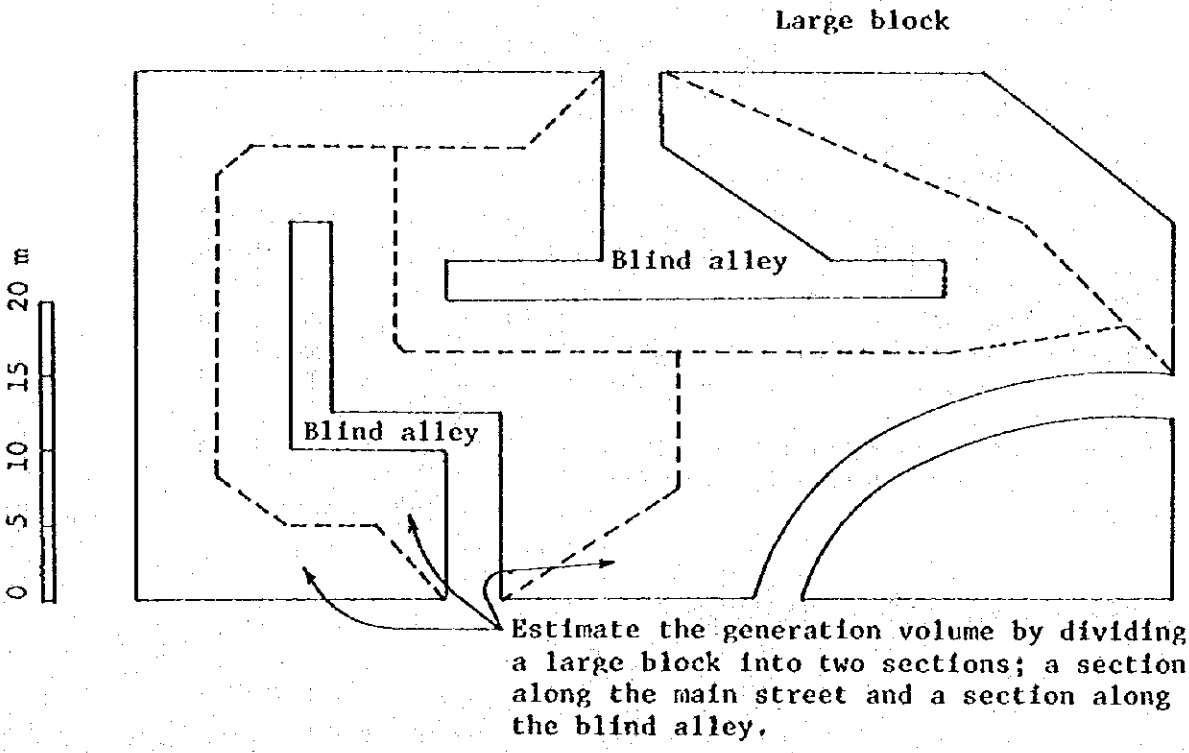
Information of solid waste generation volume in these areas may be obtained from the collection workers who are familiar with the areas.

When collection service is planned to be furnished in some area, the generation volume of the small volume generating houses in the area can be roughly estimated to be 315 g or 1L per capita per day, or 2 kg or 7L per household per day. In the case of large volume generating houses, the actual generation volume can be surveyed through hearing from the dischargers.

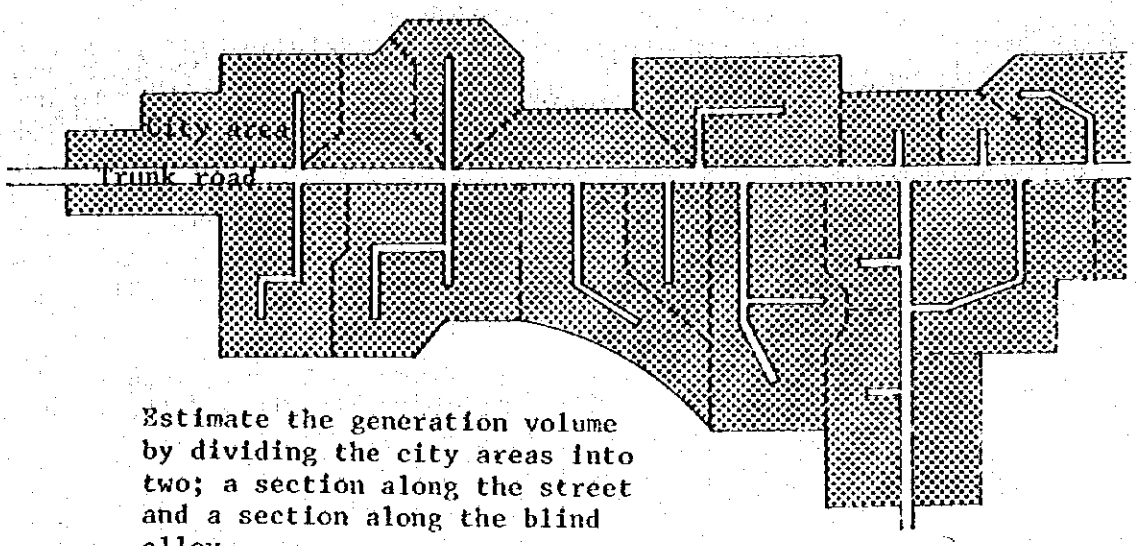
Fig. AP 3.10 Forming pattern of urbanized area



(a) Wide city area divided into small blocks

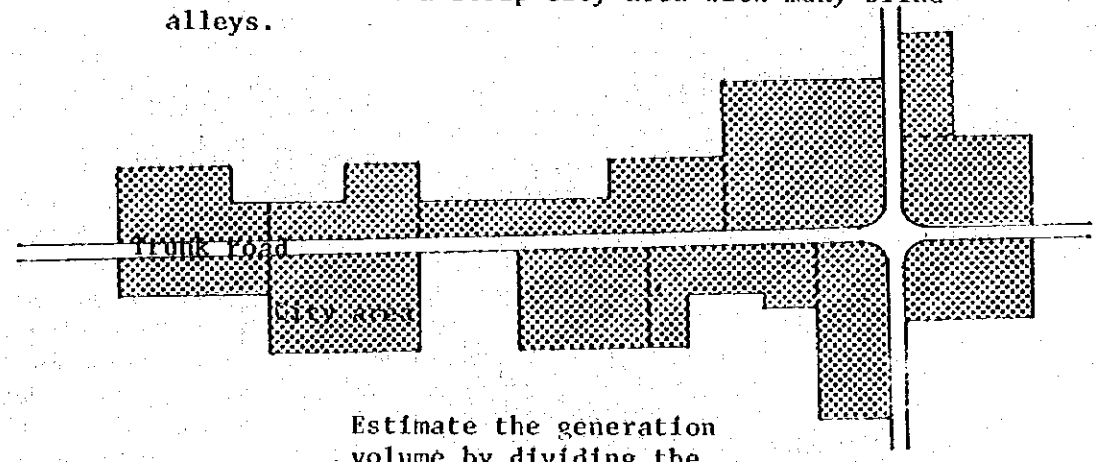


(b) Wide city area having large blocks with blind alleys



Estimate the generation volume by dividing the city areas into two; a section along the street and a section along the blind alley.

(c) Areas where urbanization progressed along a trunk road and formed a strip city area with many blind alleys.



Estimate the generation volume by dividing the city areas at intervals of 50m to 100m along the road.

(d) Narrow and long city areas formed along a trunk road.

Step 2. To plan collection frequency and collection-work days:

On this step, a grade of collection service will be determined.

Frequency of solid waste collection from each discharger in a week and, in this connection, the collection work days in a week (whether or not Saturdays, Sundays and holidays are included in) will be determined.

It is not required to plan even collection frequency for all the dischargers. The collection frequency may be determined according to the indivisual type of dischargers taking availability of the place into consideration where the dischargers can keep the storage container and other factors such as solid waste composition, the generation volume, etc. Solid waste composed only of paper can be stored for a long time, but composed of much garbage like restaurant waste must be promptly collected.

In general, collection frequency is increased for the large volume generating houses, shopping streets and so forth.

The collection days will be fixed on particular day of the week since it is easy to remember for both dischargers and workers.

Although frequent collection is convenient for the inhabitants, it should increase the administrative burden.

A simple model calculation was attempted to examine increase of administrative burden caused by the difference between the thrice a week collection and the twice a week collection, on the assumption that the collection work-days are 6 days a week (from Monday to Saturday), as follows:

An area was assumed where the number of dischargers is represented by N and the daily generation volume per discharger (or per place) by g. When providing the area with three times a week collection service, the area is divided into two sections; A (where the collection is made on Mondays, Wednesdays and Fridays) and B (where the collection is made on Tuesdays, Thursdays and Saturdays). The maximum collection volume in some day of the week could be calculated by multiplying the 3 days generation volume (3 g per discharger) by the number of the objective dischargers (or places), N/2 that is to say, the maximum collection volume is $\frac{3}{2}$ gN.

In the case of the twice a week collection, the area is divided into three sections; A' (where the collection is made on Mondays and Thursdays), B' (where the collection is made on Thursdays and Fridays) and C' (where the collection is made on Wednesdays and Saturdays). In this case, the maximum collection volume in some day of the week is calculable by multiplying the 4 days generation volume (4 g per discharger) by the number of the objective dischargers (or places) (1/3)N.

Accordingly, the maximum collection volume in some day of the week in the case of the thrice a week collection grows approximately 10% larger than the case of twice a week collection.

In short, numbers of both collection trucks and workers should be increased by approximately 10%.

A comparison of the collection costs of different collection frequencies was attempted in U.S.A. The result tells that the once a week collection could reduce the collection cost by 13 ∿ 42%. (Decision-Makers Guide in Solid Waste Management, U.S. EPA 1974)

Therefore, the smaller collection frequency can be said to reduce the administrative burden. However, if difficulties to acquire places of solid waste depots in the city area is considered, the collection frequency should be increased to the maximum extent in so far as the budget permits.

Step 3. To assign collection area of each work day:

After determination of the grade of collection service, the areas to be collected in each collection work day will be designated. The collection work will be planned to be made in specific area in the duty areas on specific day of a week.

When the collection frequency is fixed twice a week under the 6 working day a week, for example, the duty areas are divided into 3 areas A, B and C. In the area A, the collection is made on Mondays and Thursdays; in the area B, on Tuesdays and Fridays and in the area C, on Wednesdays and Saturdays. The area division will be so made as to nearly equalize the generation volume from each area.

In some case, the collection frequency will not be evenly set for all the dischargers in the duty areas. In commercial areas, for example, where large volume generating buildings such as markets and restaurants concentrate, the collection should be made on daily basis, since sufficient space for container depot is hardly obtainable in such area whilst the generation volume is large and the discharged waste contains large volume of easily decomposable garbage. In such case, area D will be formulated other than the areas A, B and C, and the collection will be made according to the following schedule:

The collection in area A and D; on Mondays and Thursdays.
B and D; Tuesdays and Fridays,
C and D; Wednesdays and Saturdays.
(Ref. Fig. AP 3.11)

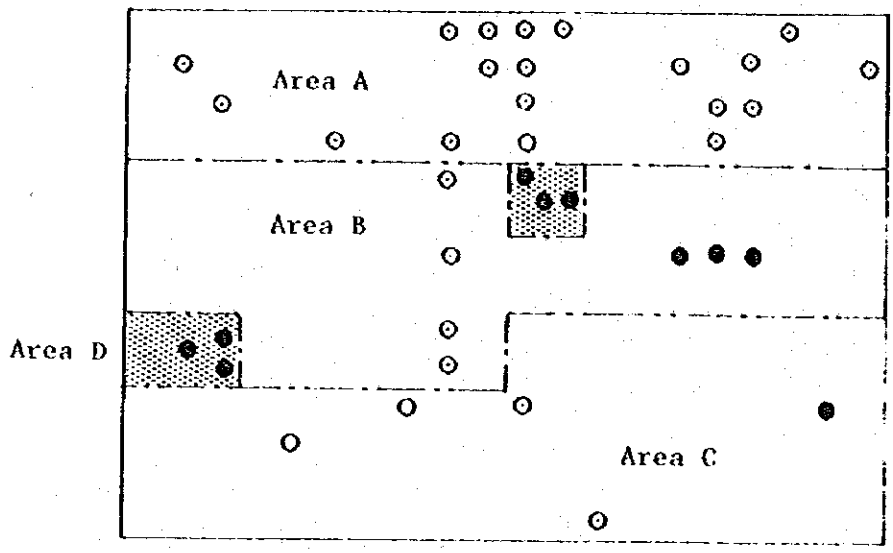
Step 4. To determine collection unit area:

On completion of assignment of collection area of each working day, the area will be further subdivided to the collection unit areas. (Ref. Fig. AP 3.12)

The collection unit area means a duty area of a collection crew in which a total volume of solid waste discharged should be collected in a day.

Some pieces of information are necessitated for determination of the collection unit area, such as distribution of each

Fig. AP 3.11 Collection area assignment for each work day

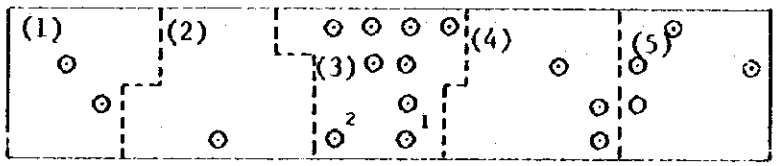


Note: Area A: Collection made on Mondays and Thursdays
Area B: Collection made on Tuesdays and Fridays
Area C: Collection made on Wednesdays and Saturdays
Area D: Collection made every day (from Monday to Saturday)
⊙ : A large volume generating house subject to twice a week collection.
● : A large volume generating house subject to the daily collection.

Fig. AP 3.12 Determination of collection unit area

(Example of Area A)

Collection unit area



(1) to (5): Collection unit area No.
⊙ : A large volume generating house ($⊙^1$: A detached plot of the collection unit area (1) (a large volume generating house), and $⊙^2$: A detached plot (a large volume generating house) of the collection unit area (2).)
As for the reason why $⊙^1$ and $⊙^2$ are located [in the collection unit area (3), refer to Step 6.]

generation volume (Step 1), capacity of collection truck, time needed for full-loading of solid waste onto a collection truck, and time required for the round trip between the collection area and the final disposal site.

The result of the field investigation gives capacity of the existing collection trucks as below.

Compactor truck	7.5 m^3	2.8 t
Non-compactor truck	8 m^3	2.3 t
	6 m^3	2.0 t

The information about time needed for full-loading of solid waste onto the collection truck, time required for a round trip between the collection area and the final disposal site, etc. can be obtained from the workers and drivers engaged in the collection work.

Solid waste in the colllection unit area will be collected once or several times a day and transported to the final disposal site. The trip frequency of a collection truck in the working hours of a day (this is none other than the collection volume) and number of collection trucks will be planned in relation with determination of the collection unit area.

For effective use of collection trucks, the trip will desirably be made with full-loading condition; however, considering the facts that the distribution of each generation volume is given in several tens of kg. and that the generation volume fluctuates every day, the collection unit area would rather be determined so as not to fill up the collection truck but to load about a half or 70% of its carrying capacity.

In principle, one collection unit area is located in a limited area but, to give even work volume to every crew (consisting of a driver and workers) in the different collection unit areas, a collection basic area can be separated into two or more places. Division of collection unit area into multiple numbers of areas will be permitted unless it does not cause any confusion.

However, performance of the collection in the separated two collection unit areas in a single trip may not be advantageous as the travel distance will become too long.

Step 5. To designate collection spots:

When door-to-door collection as a rule is applied to the places having many narrow lanes like the center area of Bangkok city, it takes considerable time to collect solid waste from each discharger (household) and to load it on to the collection truck.

The collection time (the time needed for fill up a collection truck) was reported about 100 minutes.

The collection time is divided into three elements; time for the collection from each discharger and the conveyance to

the waiting collection truck (the take-away time), time to transfer solid waste from container on to the collection truck (the loading time), and time for travel from collection spot to next spot (the travel time).

At the places with many narrow lanes, both the travel distance and the take-away time become long.

The time needed for a return trip to transport the collected solid waste to the final disposal site and come back to the collection unit area (the transportation time) was reported about 90 minutes on the average in the field survey. In the meantime of the absence of the collection truck, door-to-door collection will be made and the collected waste will be brought to the collection spot preparing for the next collection. Thus, when the collection truck returns to the collection unit area, the collected solid waste can be simply loaded on to the collection truck at the collection spot and the truck will be soon filled up only by travelling from spot to spot. Hence, effective use of the daily work hour is realized.

In selection of the collection spots, the following points should be noted:

a. Collection spot sites will be selected at the places where the road has sufficient width (at least 5 m is necessary for the medium size compactor truck currently in use) which permits a collection truck to overtake the other truck standing still or to pass each other.

b. At the places where small houses concentrate, the collection spots will be made at intervals of 50 to 100 m along the road. Too short intervals invite frequent spot of collection truck and, consequently, lowers the loading capacity; to the contrary, too long intervals should force the collection workers to spend long time for carrying out the solid waste from each discharger to the collection spot, so that solid waste volume collected in the collection unit area in the meantime of absence of the collection truck should decrease.

c. Solid waste volume to be gathered at a collection spot will be approximately 1 to 3 m^3. Gathered volume to a collection spot may not be too large: it is determined according to conditions such as the road width, the availability of vacant lots, etc., though.

d. There are no other means than trial and error for selection of the most suitable collection spots; therefore, at the initial stage of determination of the collection spots, suitability of the location should be reviewed once every three months and, even if the location is found suitable, the review should be repeated once in every year.

e. Selection of the collection spots will be made considering the road and traffic conditions and traffic regulations.

f. The collection spots should be selected from overall aspects such as the road conditions and distribution of dischargers and generation volume, but the final decision will be left to judgement of the workers.

Step 6. To determine collection order:

At the first collection of a day, it is unable to gather the collected solid waste at the collection spot in advance of arrival of collection truck.

Therefore, a collection area where the collection time can be shortened will be selected as the first collection area. One of the alternatives will be the collection from large volume generating houses only or the first collection from large volume generating houses and, if the collection truck has still some more room to accept other solid waste, continuation of collection from small volume generating houses.

The above alternative may be effective if many large volume generating houses stand close to one another in the duty area.

In case large volume generating houses are not evenly distributed in the area, division of the collection unit area into one collection area and several areas of large volume generating houses will be also effective means.

Step 7. To determine collection route:

The collection routes will be so determined as to enable collection trucks to visit all collection spots in the collection unit area in the shortest time.

Position of the collection spots and the figures of estimated solid waste volume to be gathered at each spot will be entered in a map drawn on a large scale (for example, a scale of 1/2,500).

The traffic restrictions such as one-way traffic, bus lane, etc. will also be indicated on this map.

In addition, the collection routes will be determined to connect the collection spots with high efficiency based on detailed information about places where the traffic congestion is heavy, the collection trucks are difficult to park or stop, and so forth.

The collection routes will be determined upon the cooperation of the workers and drivers who are familialized with the collection sites.

Cautions for Operation

1) Once the collection days, collection spots and collection routes are determined, they should not be changed frequently.

Regular implementation of collection on the fixed days may impress inhabitants and motivate cooperation of inhabitants with the office in collection work.

ii) Collection of basic data

The information will be obtained from the workers through hearing and recorded once or twice a year concerning place and volume of solid waste generation, distinction of easy or difficult places of solid waste collection, and so on.

iii) Collection unit area and crew

One each crew is assigned to every collection unit area. All the crew members in each area will be changed every other year or so to avoid unfairness caused by difference in the income from tips or in the work load.

Others

i) Station collection

The station collection is more preferable for the higher collection efficiency than the door-to-door collection.

In the station collection method, inhabitants are required to convey their own solid waste container to the place (station) on the collection days specified by the Bureau of Sanitation and bring the emptied containers back home.

In the case of the station collection, the station is equivalent to the previously stated collection spot and the description made on the collection spot is applicable as it is to the station collection.

Appendix 3.3 Minor maintenance of collection trucks

Minor maintenance should be done by the driver of the vehicle. It includes correction of disorders and damages found during daily inspections before or after the work of the day, which can be repaired by using common tools and gauges installed on the vehicle neither replacing any expensive parts nor requiring any special skill; as follows:

i) Engine:
- Idling speed adjustment (applicable only when no exhaust gas emission control regulation is placed.)
- Adjustment or replacement of spark plugs
- Contact point adjustment (or replacement of breaker)
- Duel angle adjustment (only when no exhaust gas regulation is placed)
- Cleaning or replacing of filter and cleaner elements
- Fan belt tension adjustment (or replacement)
- Replacement of pipe, hose or the like
- Tightening of mounting connections
- Adjustment of valve clearances

ii) Brakes
- Adjustment of the gap between drum and shoe
- Adjustment of pull allowance of the side brake
- Air breathing

iii) The driving mechanism
- Adjustment of the clutch lever
- Exchange of transmission oil
- Adjustment of transmission control lever and links
- Tightening the universal joint (propeller shaft fixing bolts)
- Differential gear box oil exchange
- Tightening of wheel nuts
- Tire exchange

iv) Electrical parts
- Replacement of sealed beam, bulb, lense, fuse, flash unit, wiper blade.

Appendix 3.4 Daily inspection and maintenance of vehicle

Daily inspection and maintenance of vehicles should be done twice a day by the driver of each vehicle; before and after the work. Items of the routine inspection and maintenance are as follows:

(1) Start up inspection

i) Check the quantity of fuel. Check the quantity and state of deterioration of engine oil, brake and clutch oil, cooling water, and battery liquid.

ii) See if any sign of fuel, oil or water leakage.

iii) Check air pressure of tires: visually inspect their state of wear and tear. Check tightness of wheel nuts.

iv) Check tightness of battery terminals and other connections of terminals and plugs.

v) Confirm starting performance, warming-up time and idling condition of Engine.

vi) Check function of the headlamps, rear lamps, flasher lamps, number plate lamp, etc.

vii) Check the height of a brake pedal from the floor, and a play of the clutch pedal.

viii) Check pulling allowance of the side brake.

ix) Check the play of the steering wheel.

(2) After work inspection

i) Check quantity of fuel and see any sign of leakage of engine oil, brake and clutch oil, and cooling water.

ii) Check the state of dirtiness of the vehicle and wash if significant dirty is seen.

iii) Check the completeness of condition of the attached accessaries and tools.

iv) Fill in the 'vehicle operation record' and report the result of vehicle inspection.

Appendix 3.6 Regular inspection and maintenance of vehicles

(1) Inspection and adjustment on delivery of new vehicle

Inspection and adjustment of a new vehicle should be done on delivery by the distributor in the presence of the receiver (a driver), to confirm that it satisfies all requirements.

The items of inspection and adjustment are as follows:

i) Confirm whether the vehicle is free of defect and has no missing parts.

ii) Confirm completeness of the attached accessories such as spare tire, tool, jack etc.

iii) Confirm oil quantity in the engine, the transmission unit, the differential gear box, and in the brake and the clutch reservoir tanks.

iv) Confirm quantity of cooling water and battery liquid.

v) Examine the bottom of the vehicle after test running to confirm whether there is any sign of oil or water leaking.

vi) Confirm the performance of head lights, brake indicators, flash lamps and other lighting equipment and indicators.

vii) Confirm the performance of wipers, cooler, radio, and other electrical equipment.

viii) Confirm tension of the fan belt, tightness of the rubber hose fittings, and firmness of battery terminal connections.

ix) Confirm air pressure of tires, including the spare tire.

x) Through test running

- Check the starting, accelerating, operating and braking performance.
- Confirm that the engine, the transmission elements and the differential gear unit are free from abnormal noise.
- Confirm the operating performance of the dumping equipment and other loaded equipment and check if there is any sign of oil leaking from hydraulic equipment.

(2) Major items of 1,000 km inspection and maintenance

Inspection and maintenance of the vehicle should be made when mileage reaches the first 1,000 to 1,500 km to prevent deterioration of oil due to the initial wear, and to adjust the initial loosening of all fittings, joints, etc. Major items include the following.

i) Repeat the same inspection and adjustment process as in the case of a new vehicle on delivery.

ii) Exchange engine oil, transmission gear oil, and differential gear oil, brake and clutch control oil, and replace the oil filters.

iii) Tighten the cylinder head bolts and other fixing bolts.

iv) Adjust the brake and clutch clearances

v) Examine the performance of hydraulic equipment, and detect any sign of oil leakage.

(3) Major items of each 5,000 km inspection and maintenance

An inspection and maintenance is made each time the mileage recorder indicates the total travelled distance of a multiple of 5,000 km, for the purpose of maintaining the vehicle in good condition through discovery of any sign of damage in early stage to prevent the development of any defect.

Inspection covers the following items. Where any irregularity in excess of standardized value is found, adjustment or replacement of defective parts should be made in order to restore the condition to meet requirements of the standard.

i) Inspect oil and water leakage from the following parts. (It should be made after test running, with exchange of oil, water, or liquid in case of remarkable deterioration):

Engine, transmission, differential gear box, brake pipes, wheel cylinders, master cylinder, clutch master cylinder, slave cylinder, radiator, radiator hose, steering power unit, cylinder of oil pressure pump, etc.

ii) Check loosening of fixing, such as:

Cylinder head bolts, manifold mounting flange, engine mounting, tie rod, drag link, propeller shaft mounting flange, rear axle U-bolt, pulling allowance of the side brake etc.

iii) Examine yield or abrasion of the following parts:

Fan belt, starter drive pinion, ring gear, clutch disc, brake linings, tires, propeller shaft universal joint, Fr and Rr wheel bearings, leaf springs, exhaust pipe mounting, silencer mounting, door mounting, front cab mounting, center brake band (drum) etc.

iv) Check the braking power, side slip, and front wheel alignment.

v) Check and replace, if necessary:

Fuel filter, oil filter, air cleaner, etc.

vi) Check battery capacity.

vii) a. Inspect the ignition system (for gasoline vehicles):

All terminals, primary and secondary cords, spark plugs,

coil, condenser, contact point, rotor, generator, relay, ignition timing, etc.

b. Inspect the performance of the carburetor (for gasoline vehicles):

Valve opening angle, jets, acceleration pump, float, needle valve, idling speed adjusting screw, etc.

viii) Inspect the fuel injection pump (for diesel vehicles) including:

Fuel injection volume and timing. Function of governor, nozzles, plungers, preheating system etc.

ix) Through test running, check:

a. Facility of engine start, accelerability (at low speed and high speed), operation stability (play and shimmy of steering wheel), and braking performance.

b. The noise from engine, transmission system, propeller shaft, differential gear, suspension, etc.

c. Conditions and operating performance of the loaded equipment.

d. Exhaust noise and colour of the exhaust gas.

x) Check the brightness and light beam angles of head lights.

(4) Thorough examination and major maintenance

Thorough inspection and maintenance is necessary from the following considerations:

i) In a country where periodical vehicle examination is not legally compulsory, the implementation of a regular examination and maintenance to a reasonable standard is the minimum requirement for sound operation and control of a vehicle fleet.

ii) For safe travel, overhaul of the safety devices (driving and braking system etc.) and driving system is required.

iii) To maintain satisfactory performance, major maintenance of fast wearing parts is required including replacement or overhaul of the relevant element.

iv) Whether or not the implementation of ii) and iii) above is economically justifiable from viewpoint of investment efficiency should be analyzed based on results of the thorough examination.

Whether or not a thorough examination and major maintenance is required is judged from the records of daily maintenance and the results

of 5,000 km inspection and maintenance. It is not meaningfull to prefix the schedule for implementation of the examination and maintenance. The examination and maintenance items vary depending on the actual condition of the vehicle. As a conceptual indication, however, the following cases can be considered to require a thorough examination:

a. When the vehicle completes a total mileage of 100,000 km without undergoing any major maintenance.

b. When the compression pressure of the Engine falls below 80% of the standard value.

c. When consumption of fuel or lubrication oil under normal operating conditions goes beyond 40% in excess compared with that of the initial period of use of the same vehicle.

d. When the adjustment allowance of any element significantly decreases or becomes zero.

e. When working noise of any element becomes abnormally loud.

f. When operability of steering wheel becomes abnormal, or the brakes work unevenly, or some other abnormal phenomenon occurs.

Appendix 3.6 Contents of the "Compost Plant Operation Control Manual"

Section	Contents
1 Plant Operation Manual	Work procedure, operation process, limits and scope of control, work allocation, and responsibilities and authorities with regard to plant operation including preparations for plant operation, starting of operation under normal and subnormal conditions, preparation for halting of plant operation, halting of operation, etc.
2 Machine Operation Manual	Specification, theories, structures and method of operation of individual machine and container units not dealt with in the plant operation manual
3 Daily Inspection Manual	Daily and regular patrol and inspection of operating conditions of the equipment is necessary in order to early discover the development of irregularities, and to contribute to stability of operation. The period, course, items, method etc. of inspection are dealt with and a check sheet is attached here.
4 Emergency Actions Manual	Contacting and instruction hierarchy system, plant management and action guidelines to be followed during emergency of machine disorder, natural disasters, etc.
5 Pollution Control Manual	Plant management guideline and control system for the prevention of secondary pollution.

Appendix 3.7 Contents of the "Compost Plant Maintenance Control Manual"

Section	Contents
1 Analysis and Survey Manual	For sound planning, maintenance and control of intermediate treatment facilities, the analytical data for quality of waste, properties of treatment residue, concentration of harmful substances in the exhaust gas and effluent are required. The survey for the attaining such data.
2 Treatment Plant Functional Performance Appraisal Manual	In judging the propriety of facility maintenance and control, it is necessary to appraise the functioning performance of the facility. For this reason, this section presents the methods and process of such appraisal.
3 Inspection and Maintenance Manual	This section presents the methods of periodical and detailed inspection of the facility at static state, with the use of guages and tools and the methods of maintenance including cleaning, oil filling, adjusting and parts exchanging etc.
4 Periodical Maintenance Manual	This section deals with the management system, safety measures as well as contents and method of works involved, with regard to periodical maintenance implemented at fixed time interval.

Appendix 3.8 Vehicle operator training (Draft program)

(1) Standard of skill (as a targets of the training):

Able to perform minor repair which requires only the use of common hand tools and simple gauges without any special skill.

(2) Duration and frequency of training:

Desirably 10 days for each session, one session per year in 3 consecutive years for every operator. Operators completing this 3-year training course in good result will be qualified to attend a higher grade training course designed for candidates of the qualification of vehicle mechanic.

(3) Implementation system of the training course

The 500 vehicle operators will be divided into groups of 10 members each, and 3 groups a time will attend a training session. The total number of operating days of the training course will be 170 days per year and, if the time for preparation is included, the total working days for the training staff will amount to 220 days per year. Taking this into consideration, it is desirable to establish a permanent training facility operated by permanent personnel for the implementation of the training course.

(4) Training curriculum

The training curriculum will be constituted of 40% lectures and 60% practical training. One session constitutes of 80 hours (= 8h/d x 10d) which will be allocated as shown in the following table:

(figures in parentheses indicate the number of hours allocated for lectures)

Subject	1st Year	2nd Year	3rd Year
Vehicle operation/Laws and regulations	16 (6)	8 (4)	4 (4)
Vehicle structure/ Theoretical study	16 (6)	16 (6)	16 (8)
Troubleshooting	12 (6)	20 (10)	20 (10)
Maintenance and repair	36 (12)	30 (12)	40 (12)

(5) Content of training subjects

i) Vehicle operation/laws and regulations:

a. Lecture:

° First year: - Manner of correct operation
- Traffic laws and regulations

- How to cope with emergencies
- Daily inspection

° Second year:
- Traffic laws and regulations
- Daily inspection

° Third year:
- Traffic laws and regulations
- Method of instruction in vehicle operation

b. Practical training:

° Performance of practice on the basis of the lectures.

ii) Vehicle structure and theory

a. Lecture:

° First year: - Basic structure of vehicles and loaded equipment

° Second year: - Structure of individual systems of vehicle.

° Third year: - Basic theories of vehicle structure

b. Practical training:

° Confirmation on the field training of what has been taught in the lectures.

iii) Troubleshooting

a. Lecture:

° First year: - Troubleshooting in daily inspection

° Second year: - Troubleshooting with emphasis on problems with electrical systems

° Third year: - Troubleshooting about the engine, the driving system, the steering system and the brake system.

b. Practical training:

° Fist year: - Simple troubleshooting without use of guages

° Second year: - Troubleshooting with use of simple guages.

° Third year: - Comprehensive troubleshooting

iv) Maintenance and repair

a. Lecture:

° First year: - Maintenance and repair in daily inspection.
- Correct manner of tool handling

- Second year: - Inspection and maintenance based on the maintenance standard
  - Correct manner of guage handling
- Third year: - Disassembly and maintenance of engine and driving system (beginner's grade)

b. Practical training:

- Practice of what has been taught in the lectures

(6) Training facilities and staff

By operating 17 times of 10-day sessions a year, all the 500 vehicle operators will be provided with the opportunity of training once a year and will complete the three-year courses within three years time; however, the demand for the training facilities and personnel will still remain even after that for the following reasons:-

a. New operators will be recruited to fill the vacancies caused by the resignation and to meet requirement of the additional personnel for expansion of the organization.

b. Provision of higher grade training courses will be required in order to produce trained mechanics.

c. Operators who have completed the 3-year training course will be required retraining once in every three years on an average.

A permanent training facilities will be established and operated by permanent staff.

i) Facilities requirements

a. Training hall:

- To be large enough to accommodate two groups of trainees, each consisting of 10 persons engaged in different two groups of activities.
- To be attached with an injection pump test room, an electrical device inspection room, a material and spare parts storage, a tools control room, a rest lounge, etc.

b. Lecture rooms:

- Two rooms should be provided, each is sufficient for the accommodation of 10 trainees.

c. Staff room:

- The same size to a lecture room.

d. Other facilities:

- Shower rooms, lavatory areas, dinning hall, etc.

The training facilities will desirably be located in or near to the site of the existing vehicle maintenance workshop, of which the equipment can be shared by the training center, and the vehicles under maintenance and repair can be utilized as teaching materials.

It is also desired for the training facilities to provide with open air test courses, car parks and vehicle washing area.

ii) Staff

The minimum staff number should be 8, consists of 2 lecturers for classroom lessons, 2 instructors and 4 assistant instructors to provide practical trainings.

The lecturers will desirably be college graduates with minimum 5-year practical experience.

The instructors should be selected from foremen class workers of BOF workshop or the similar workshop in the private sector.

The assistant instructors should consist of two mechanics with at least 5-year practical experience and two operators with also at least 5-year practical experience, having excellent working and training records.

Chapter 4 SOLID WASTE MANAGEMENT SYSTEM MASTER PLAN ALTERNATIVES

Appendix 4.1 Solid waste container for storage and discharge and manner of the discharge

(1) Solid waste container

Solid waste containers or the storage are required to bear the following functions:

From viewpoint of public health:

a. Protective from flies, rats and wild dogs

b. preventive of diffusion of rank odour

c. preventive of leakage of leachate

d. easy to keep container clean (easily washable, for instance)

From viewpoint of use:

e. easy to put solid waste in and out

f. strong and durable

g. in the case of portable type,

. moderate in size

. light in weight

. easy to carry

Taking the above requirements into account, advantages and disadvantages of miscellaneous type of containers including solid waste depots were examined as follows:

a. Fixed-type container

Many of them are made of concrete.

Collection workers have to transfer solid waste from the fixed container to their collection containers with hand scrapers or even with bare hands; that increases the collection time and exposes collection workers to health hazards. Fixed-type containers are difficult to keep clean.

From all aspects, this type of container is not recommendable.

b. Bamboo basket (capacity of 20 to 80 liters)

Though it is light in weight, it has many disadvantages such as leakage of leachate, non-coverable, difficult to wash, etc.; therefore, use of bamboo baskets should be avoided.

c. Drum can (approx. 200 liters capacity)

In the most cases, no lids are attached.

The drum is bulky, heavy and often has sharp edges that make discharge of solid waste from a drum dangerous

A drum is not a suitable container for solid waste storage.

d. Metal can and plastic pail (50 to 100 liters capacity)

Both a metal can (galvanized) and plastic pail are light, strong and resistant to corrosion. Convenient to carry and easy to dump.

Sealable with a lid and easy to wash.

e. Solid waste depot

The depots are usually made of brick, concrete blocks or reinforced concrete with roof and doors. They are installed at places where solid waste generation volume is large.

For collection, solid waste stored in the depot must be conveyed using a portable transfer container that necessitates longer collection time and increased manpower. Solid waste depots do not suit storage of decomposable waste like garbage.

f. Paper bag and plastic bag

Easily transportable.

As they are one-way containers (no need to be returned), they contribute to improvement of collection efficiency and a sanitary environment. On the other hand, they do not suit storage of bulky, heavy or sharp solid waste. Cost of the bags could be a burden for solid waste dischargers.

g. Small size machine-loading container (approx. 1 m^3 capacity)

These containers, made of metal or FRP, are placed in the area where considerable volume of solid waste is discharged.

Solid waste in the container is dumped into collection trucks wherever they are located by mechanical means. This method is aimed at improvement of collection efficiency.

h. Large size hauled type container (4 m^3 or larger capacity)

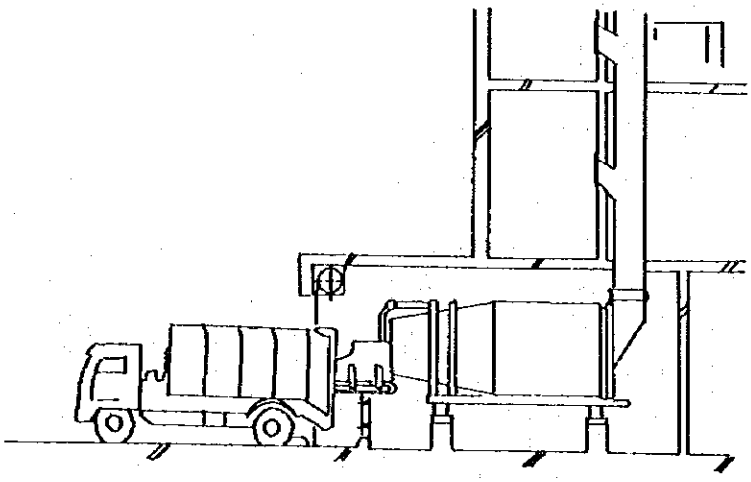
These containers, made of metal or FRP, are distributed to each large-volume discharger. Solid waste in the container is transported by collection truck together with the container.

The container picked up with solid waste is transferable to other transport, therefore, it can be said to be an intermodel storage method. Though this method is effective for improving the collection efficiency of solid waste from large-volume dischargers, it requires purchase of special vehicles exclusively designed for transportation of the vehicle containers.

i. Storage tank with compaction equipment

Construction of high-rise buildings should include plans for a highly effective solid waste collection system, such as a combination of dust chute or pipeline and a large storage tank called as a rotary equipment. An example of a rotary drum is shown in Fig. AP 4.1.

Fig. AP 4.1 Rotary drum



(2) Separate collection and combined collection

Separate collection is a method which requires dischargers to classify their solid waste into separate containers (combustibles and incombustibles, for example). The collection service then collects the separated solid waste by category. Combined collection, on the other hand, does not require the classification by the dischargers.

All kinds of solid waste can be discharged together in the same container. In separate collection, increase of collection frequency cannot be avoided, which causes collection cost to rise; however, it does have material recycling benefits.