(6) Average Annual Amount of Waste Hauled by a Truck

Average annual amount of garbage hauled is estimated based upon the JICA Study Team's field survey on both rainy season and dry season. Refer to Table 2.6-12.

(7) Cost of Use of Contractors

The unit cost for KMS to Use contractors haulage service is estimated to be Rp 5,447/t based upon:

1. Contract price is Rp 1,100/m^3
2. The JICA Study Team's field survey as same as (6)

b. Operational Efficiency

The results of time and motion study are shown in Table 2.6-23 The time and motion study was carried out to examine the operational efficiency of each type of trucks during May 22 to 24, 1992.

Comparing the gross collection efficiency of different types of vehicles in terms of time spent for collection of waste of 1 ton, the container truck is found very effective. It ranges from 2 to 6 minutes. 10 m^3 and 12 m^3 containers trucks are more efficient than 6 m^3 container trucks due to the scale of economy. On the other hand, the compactor truck takes 30 minutes to 2 hours to haul 1 ton waste. The dump truck seems to be more efficient than the compactor truck in view of gross collection efficiency.

Table 2.6-23 The Result of Time and Motion Study

1	Date of Study	May 22	May 22	May 22	May 22	May 22	May 23	May 23	May 23	May 23	May 24	May 24	May 24	May 24
2	Police Number	L-9687-CH	L-9687-CH	L-9670-CG	L-9654-CG	L-9694-CG	L-9682-CF	L-9660-CE	L-9614-CH	L-9674-CF	L-9681-CF	L-9684-CF	L-9611-CB	L-9610-CB
3	Type of Truck	6m3 Container	6m3 Container	6m3 Container	6m3 Container	10m3 Container	10m3 Container	12m3 Container	6m3 Compactor	10m3 Compactor	10m3 Compactor	10m3 Compactor	Open Truck	Open Truck
4	Total No. of Workers	1	2	2	2	2	2	2	2	3	3	3	7	7
5	Total No. of Containers hauled	8	5	12	14	10	8	7	11	40	28	45	-	-
6	Total Running Distance	?	?	242.8 km	248 km	175.4 km	185.2 km	172.4 km	69.5 km	106 km	56.2 km	39.7 km	?	6.7 km
7	The Beginning of Work	08:00	15:28	07:45	07:50	08:38	07:30	07:35	07:40	07:30	07:45	08:12	07:40	08:02
8	The End of Work	15:25	20:50	19:45	23:30	17:53	18:11	17:05	16:30	13:30	13:07	16:48	14:50	10:17
9	Total Time (Grabe to the end) (8-7)	7h 25 m	4h 17m	12h 0m	15h 40m	9h 15m	10h 31m	9h 30m	8h 50m	6h 0m	5h 21m	8h 36m	7h 10m	2h 15m
10	Total Working Time	7h 10m	3h 9m	10h 49m	14h 40m	7h 15m	9h 21m	8h 22m	7h 20m	5h 17m	5h 6m	8h 16	6h 55m	2h 15h
11	Total Net Loading Time	1h 40m	1h 8m	59m	1hr 43m	1h 4m	1h 27m	1h 26m	2h 27m	2h 28m	2h 48m	4h 11m	1h 50m	41m
12	Mean Collection Time (11/5)	12.5m	13.6m	4.9m	7.4m	6.4m	10.8m	12.3m	13.4m	3.7m	6.0m	5.6m	-	-
13	No. of visitors LPA	8	5	12	14	9	8	7	3	2	2	2	4	1
14	Average round trip Time (10/13)	53.8m	37.8m	54.1m	62.9m	48.3m	70.1m	71.7m	146.7m	158.5m	153.0m	248.0m	88.8m	135m
15	Net Trip Speed (km/hour)	?	?	32.7	34.6	28.2	24.0	22.7	-	30.0	17.1	9.7	-	20
16	Waste Amount hauled / day	* 16.9	* 10.6	47.6	20.0	31.5	52.9	49.3	2.7	4.7	1.4	* 2.6	* 2.4	-
17	Gross Collection Efficincy (min/ton) (11/B)	5.9	6.4	1.24	5.15	2.03	1.6	1.74	162.96	31.6	120	109	47	-
18	Net Efficency (man*min/ton)(15x4)	5.9	12.8	2.48	10.3	4.06	3.29	3.49	325.92	94.8	360	323	329	-
19	Mean Weight of a Container	* 2.11	* 2.11	3.97	1.43	3.15	6.61	7.04	0.9	0.11	0.05	0.06	-	-
20	Total Travelling Time (10-11)	5'30"	2'01"	9'51"	12'57"	6'18"	9'04"	6'57"	5'53"	2'48"	3'02"	4'08"	5'48"	1'34"
21	Average Time / Trip/Container(18/5)	41.25 min	24.2 min	49.25 min	55.5 min	37.8 min	68.0 min	59.57 min	32.9 min	4.2 min	6.5 min	49.6 min	-	94.0 min
22	LPA	Lakarsantri	Lakarsantri	Kenjeran	Keputih	Keputih	Kenjeran	Keputih, Kenjeran	Kenjeran	Kenjeran	Kenjeran	Kenjeran	Kenjeran	Kenjeran

6) Major issues

(1) The number of waste vehicles is insufficient. Therefore eight container trucks (6 m3) have been operated on 2 shift working.

(2) There are many troubles while the trucks are operated because of lack of spare parts, especially tire tubes, bad condition of roads leading to the final disposal sites, and no execution of preventive maintenance.

(3) Working conditions differ so much by trucks but they are never corrected. The work of the compactor trucks is relatively easier than the container trucks in terms of working hours. Among the container trucks, 6 m^3 container trucks are harder than the others because the increases of waste cause the number of trip to increase.

(4) Efficiency of compactor trucks, especially 6m^3 compactors is very low because the compaction system is very badly designed. In addition the net working time is short because the number of containers served by a truck is small.

(5) The number of containers is not enough to store the waste collected by collection workers. Therefore, collection workers often have to wait until a truck comes and empty the container. This makes the working time of collection workers much longer than otherwise.

(6) In Depo/LPS, it takes a long time for collection workers to transfer waste from a handcart to a container .

(7) There are problems with some Depo/LPS; leachate flows to the roadside due to lack of ditch, the wall is damaged, the gates are broken, etc. Some local people complain about bad smell and ugly sight.

(8) Three are no regular day-off. So the truck drivers take day-off by their own decision. If there is no driver to substitute absent driver the waste vehicle cannot be operated on that day.

2.7 Street Sweeping

2.7.1 Street Sweeping System

1) Responsibility of Street Sweeping

Table 3.7-1 shows the responsible body for street sweeping by type of roads. The Cleansing Department of KMS has responsibility to clean relatively important roads, i.e., the primary and the secondary roads, while RT/RW sweep the local and Kampung roads. The Ministry of Public Work has to clean the highway by using their mechanical road sweepers. The street sweeping includes waste collection activity from road sides and berm (the shoulders of roads).

The street sweepers have three status: the permanent employee of KMS, the temporary employee of KMS, and the contractor employed by the private firms. The KMS workers, both the temporary and the permanent, usually sweep relatively important streets, while the contractors sweep the remaining roads designated by KMS.

Table 2.7-1 Responsible Body for Street Sweeping

Type of Roads	Body Responsible for Street Sweeping
1. Primary Roads	KMS
2. Secondary Roads	KMS
3. Local and Kampong Roads	RT and RW
4. Highway	Ministry of Public Works

2) Frequency of Sweeping

Based on the traffic condition and the importance to the society as a whole, the Cleansing Department determines the street sweeping frequency. It ranges from one time per day up to four times a day. The working time is into the following 4 shifts:

- Shift 1 midnight (0:00) to morning (6:00)
- Shift 2 morning (6:00) to noon time (12:00)
- Shift 3 noon time (12:00) to evening (18:00)
- Shift 4 evening (18:00) to midnight (0:00)

The number of sweepers by Kecamatan is shown in Table 2.7-2.

Table 2.7-2 The number of KMS sweepers for street sweeping by the Cleansing Department

No.	Name of Kecamatan	Total No. of KMS Workers	Shift 1	Shift 2	Shift 3	Shift 4
1.	Genteng	200	43	77	65	12
2.	Tegalsari	80	29	33	14	4
3.	Bubutan	153	45	54	54	0
4.	Simokerto	74	7	43	24	0
5.	Krembangan	125	41	39	40	5
6.	Semampir	66	10	31	26	0
7.	Pabean Cantikan	106	26	52	28	0
8.	Kenjeran	0	0	0	0	0
9.	Tambaksari	79	10	41	18	10
10.	Gubeng	126	17	47	43	19
11.	Sukolilo	11	0	6	5	0
12.	Rungkut	0	0	0	0	0
13.	Sawahan	66	27	16	21	0
14.	Wonokromo	101	21	54	20	6
15.	Wonocolo	0	0	0	0	0
16.	Karang Pilang	0	0	0	0	0
17.	Tandes	21	11	5	5	0
18.	Benowo	0	0	0	0	0
19.	Lakarsantri	0	0	0	0	0
	TOTAL	1,208	287	498	363	56

Source : The Cleansing Department

Note : The contractors are not included in this number because the contractors' sweeping areas are designated not by Kecamatan but by the area of streets. In addition, the number of sweepers in each designated streets is determined by the contracted firm.

The number of sweepers per shift and the sweeping length per road, the use of the private contractors are determined by the Cleansing Department for each road of each Kecamatan. An important thing to note is that the street sweepers are given a general instruction to keep the street clean. The sweeping frequency per each shift and each street per person is not instructed.

3) Sweeping Length & Service Coverage

The road length of the primary road in total is 85 km and that of the secondary road is 215 km. Hence, the total road length that KMS has a responsibility to sweep is 215km. The street sweeping length by Kecamatan is shown in Table 2.7-3.

Table 2.7-3 Street Sweeping Length by Kecamatan

No.	Name of Kecamatan	Primary Road (a)	Secondary Road (b)	Total Road Length (c) = (a)+(b)	Road Sweeping Length by KMS (d)	Road SweepingLength by Contractors		Total Road Sweeping L *(g)	Service Coverage Rate (%)
						Road (e)	Berm (f)		
1	Genteng	10,933	12,271	23,204	18,447	6,787	6,787	23,204	100
2	Tegalsari	2,257	18,197	20,454	16,222	5,207	5,207	21,429	100
3	Bubutan	13,213	22,398	35,611	30,138	4,783	4,783	34,921	98
4	Simokerto	4,391	7,292	11,683	8,385	3,419	3,419	11,804	100
5	Krembangan	6,350	13,620	19,970	13,250	7,700	7,700	20,950	100
6	Semampir	1,100	9,800	10,900	5,300	5,600	5,600	10,900	100
7	Pabean Cantikan	1,600	10,200	11,820	9,670	3,200	3,200	12,870	100
8	Kenjeran	0	4,050	4,050	0	3,300	3,300	3,300	81
9	Tamboksari	3,400	10,300	13,700	13,700	0	0	13,700	100
10	Gubeng	9,900	29,100	39,000	25,500	16,500	16,500	42,000	100
11	Sukolilo	0	13,100	13,100	10,300	2,800	2,800	13,100	100
12	Rungkut	0	13,291	13,291	2,800	10,491	10,491	13,291	100
13	Sawahan	1,900	17,300	19,200	8,700	10,500	10,500	19,200	100
14	Wonokromo	3,940	20,000	23,940	13,640	10,300	10,300	23,940	100
15	Wonocolo	18,050	1,500	19,550	3,500	16,050	16,050	19,550	100
16	Karang Pilang	0	2,800	2,800	0	2,800	0	2,800	100
17	Tandes	2,100	9,980	12,080	1,600	0	0	1,600	13
18	Benowo	6,030	0	6,030	0	0	0	0	0
19	Lakarsantri	0	0	0	0	0	0	0	0
	Total	85,164	215,199	300,383	181,152	109,437	106,637	290,589	94

*(g) = [(d)+(e)] or (c) whichever is smaller.

The total KMS' sweeping road in length is 181km, while the contractors sweeps 109km of which 8 km roads are swept by both KMS and the contractors. The estimated total sweeping length is 282 km or 94% of the total road length(the primary and the secondary).

The Cleansing Department provides street sweeping services for all Kecamatan except for Benowo and Lakarsantri. Most of Kecamatan receive 100% sweeping service. Among Kecamatan receiving street sweeping service, the service coverage rate in Tandes is still low (13%). The streets with sweeping service in Surabaya is shown in Fig. 2.7-1.

a. Responsibility of Manual Sweeper

The Cleansing Department says the length and width of street sweeping area per worker is determined, in principle, as follows :

- Length : 750 m/sweeper/day
- Width : 0.75 m/side/day
- Side : 2 side

However, the sweeping length per person is actually so different depending on roads. It seems that man power alocation is not always reflect the amount of waste discharging in the roads or sweeping length.

b. Mechanical Road Sweeper

KMS has three mechanical road sweepers. They sweep main roads from around 4:00 am to 8:00 am or 9:00 am every day. However, sweeping workers also sweep the same roads.

The dumping site for the mechanical sweepers is at a place near the garage in Asemrowo, not at the official final disposal sites, because the mechanical road sweepers mostly collect dust sand, but not waste in general meaning.

4) Work System

Street sweepers usually work on a team-work base. A team composition varies by shift and street. A typical sweeping team consists of 4 to 5 workers as shown below:

- 2 sweepers with brooms
- 1 to 2 workers who collect waste swept
- 1 handcart puller

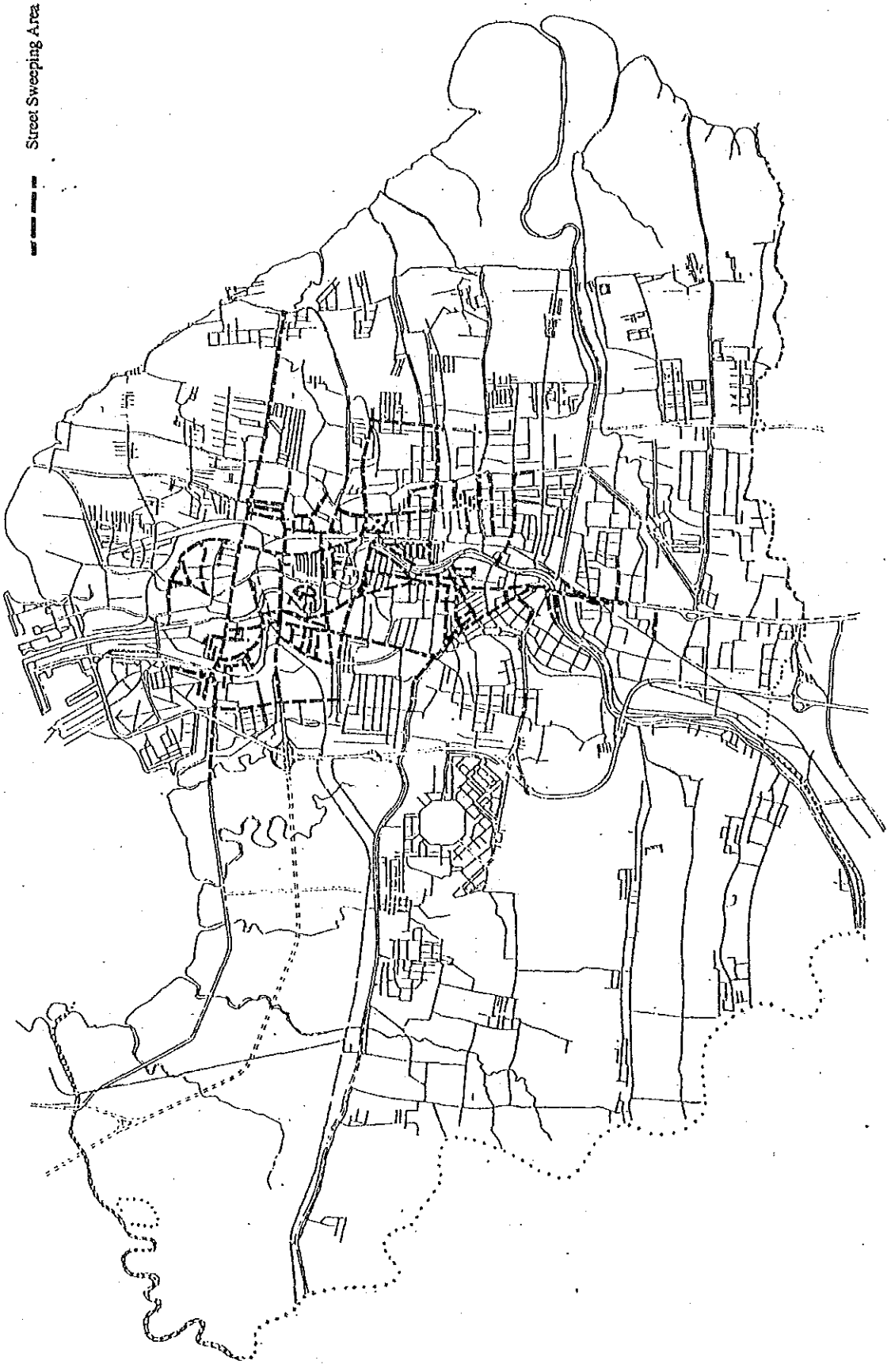

FIG. 2.7-1 STREET WITH SWEEPING SERVICE IN SURABAYA

5) Amount of Waste Collected.

According to the interview to street sweepers and the field observation, it is estimated that the volume of waste collected by a group per shift is a half to three quarters of a handcart, i.e., 56~84 Kg per shift per day. See note below for calculation.

Note:

- Volume of a handcart:	1.5m (length) x 1.0m (height) x 0.5 m (width)	=	0.75 m^3
- Waste amount collected:	0.75 m^3 x 1/2 (a half) x 0.15 (bulk density)	=	56 kg
	0.75 m^3 x 3/4 (three quarters) x 0.15 (-do-)	=	84 kg

2.7.2 Private Sector Involvement

1) Number of the Private Contractors

KMS actively uses the contractors for street sweeping. It is estimated that the contractors sweep more streets in length than the Cleansing Department does (refer to Table 2.7-3). KMS at present uses 25 sweeping contractors, which use 404 sweepers in total. The contract sweeping area is divided into 33 sweeping zones. As shown in Table 2.7-4, the total sweeping contract amount is Rp 927 million, about 40 % of KMS' total street sweeping expenditure Rp 2,391 million except for costs of mechanical sweeping.

Table 2.7-4 The number of workers and contract price by the private contractor

No.	Name of Firms	Assigned Kecamatan	Contract Price	No. of Workers
1.	CV. Pratiwi	Wonokromo	30,384,000	16
2.	CV. Mayangkara	Gubeng	16,404,000	6
3.	CV. Teguh Karya Abadi	Krembangan	15,708,000	8
4.	CV. Karunia Pertama	Wonocolo, Wonokromo Genteng, Pabean Cantikan, Simokerto, Krembangan	125,832,000	38
5.	CV. Prawira Utama	Tegalsari	22.056,000	9
6.	CV. Dwi Arti	Gubeng	16,752,000	6
7.	CV.Derina	Gubeng	36,072,000	22
8.	CV. Indoraya	Karang Pilang, Rungkut	33,216,000	15
9.	CV. Jaya Putra	Rungkut, Wonocolo	13,080,000	8
10.	CV. Margo Emas	Wonocolo, Rungkut	36,468,000	18
11.	CV.Kencono Wungu	Gubeng, Genteng, Simokerto	33,132,000	20
12.	CV. Target	Tegalsari, Sawahan	32,616,000	16
13.	CV. Arta Niaga	Sukolilo	18,204,000	9
14.	CV. Tirta Kencana	Kenjeran	17,364,000	8
15.	CV. Asean Raya	Simokerto, Semampir, Pabean Cantikan	19,884,000	12
16.	CV.Karya Muda	Gubeng, Sukolilo, Pabean Çantikan, Semampir, Kenjeran	87,516,000	37
17.	CV. Tri Jaya	Tambaksari, Sukolilo	41,556,000	12
18.	CV. Duta Prajaka	Tegalsari, Wonokromo, Tandes, Sawahan, Tambaksari	92,472,000	34
19.	CV. KMKS Agung Jaya	Simokerto, Semampir	19,104,000	6
20.	CV. Interna	Gubeng	24,756,000	12
21.	CV. Karya Nyata	Sukolilo	21,192,000	10
22.	CV. Herlia	Sawahan, Sukolilo	66,300,000	38
23.	CV. Tanjung Sarana	Wonocolo, Rungkut	61,776,000	16
24.	CV. Krishna Karya	Wonokromo	15,228,000	8
25.	CV. Harapan Subur	Wonokromo, Gubeng, Rungkut	29,724,000	20
	TOTAL		926,796,000	404

2) Major Contract Conditions

a. Contract Price

The contract price is decided based on 1) unit sweeping price (Rp. 5/m^3) and 2) sweeping area. The contract sweeping areas include not only road sides but also drainage and green belts of major streets. The road sweeping area is determined as follows:

[Roadside width (0.75 m per one side) x sweeping length] +
[Drainage and green belt area to be swept]

b. Sweeping Hours

The contract sweeping hours are from 7:00 a.m to 5:00 p.m. During these hours sweepers work on two (2) shifts.

2.7.3 Cost of Manual Street Sweeping

The annual cost of manual street sweeping is estimated at Rp 1,480,758,400/year with the following breakdown:

1. Personnel Expenditure: Rp 1,464,302,400

   Breakdown:
   - Salary of permenent employees: Rp 892,118,400/year
   - Salary of daily workers: Rp 572,184,000/year

2. Handcart: Rp 27,225,500

   Breakdown:
   - Rp 225,000/handcart/year*1 x 121 handcarts*2 =

   *1: - Depreciation (3 years): Rp158,000
   - Interest (9% of purchase price): Rp 43,000
   - Maintenance (5% of purchase price): Rp 24,000
   - Total: Rp225,000

   *2: 121 handcarsts derives from the following:
   242 sweeping teams/2 = 121 (2 teams share one handcart.)
   The number of sweeping teams (242) is estimated as follows:
   Total sweeping workers 1,208 /5 workers/team = 242 teams
   (It is assumed that one sweeping team consists of 5 workers.)

3. Basket: Rp 8,228,000

   Breakdown:
   Rp 8.500/unit x 4 units/team/year x 242 teams = Rp 8,228,000

4. Grass Cutter: Rp 3,872,000

Breakdown:
Rp 4,000/unit x 4 units/team/year x 242 teams = Rp 3,872,000

5. Broom: Rp 1,633,500

Breakdown:
Rp 270/unit x 25 units/team/year x 242 teams = Rp 1,633,500

2.7.4 Efficiency Analysis

1) Unit Cost of Manual Sweeping

Unit cost of the manual sweeping of 1 km road per year is estimated at Rp 4,090,500/km/year based upon the total annual sweeping cost and total road sweeping length as shown below:

Rp 1,480,758,400/year divided by 362 km = Rp 4,090,500 / km.year

The unit cost of the manual sweeping of 1 km per day is calculated at Rp 11,200/km/day.

2) Efficiency of Mechanical Sweepers

a. Operational Efficiency

Table. 2.7-5 shows the result of time and motion study on mechanical road sweepers conducted on May 25, 1992. It is found that the sweeping length of a mechanical sweeper is 20 km/day on average. The most important findings of the study are as follows:

1. "Waste " collected by the mechanical sweepers is not waste in general sense. It is mostly sand dust.

2. The streets swept by the mechnical sweepers are also swept by sweeping workers, which make doubtful the meaning of the mechanical sweeping.

Table 2.7-5 Result of Time and Motion Study on Mechanical Road Sweepers

1.	Date of Study	25-5-1992	25-5-1992	24-5-1992
2.	Police Number	L-9624-CH	L-9625-CH	L-9626-CH
3.	Type of Truck	Road Sweeper	Road Sweeper	Road Sweeper
4.	Total No. of Workers	1	1	1
5.	Total Running Distance	37.8 km	29.2 km	21 km
6.	Sweeping Length	15.8 km	24.8 km	20.0 km
7.	The Beginning of Work	4:16 am	4:20 am	4:35 am
8.	The End of Work	9:12 am	8:47 am	9:55 am
9.	Total Time (from garage to the end)	4 hr 56 min	4 hr 27 min	5 hr 20 min
10.	Total Working Hours	4 hr 1 min	4 hr 21 min	5 hr
11.	Total Net Collection Time	2 hr 47 min	3 hr 46 min	3 hr 28 min
12.	Collection Speed (6 / 11)	5.7 km / hr	6.6 km / hr	5.7 km / hr
13.	Waste Amount Collected / day	3.9 Ton	2.4 Ton	1.4 Ton
14.	Gross Collection Efficiency (Min/t)	42.8	94.2	148.6
15.	Net Efficiency (Min*person/t) (14*4)	42.8	94.2	148.6
16.	Total Trip Time (10 - 11)	1 hr 14 min	35 min	1 hr 32 min
17.	No. of Trips	1	1	1
18.	Dumping Site	Asemrowo	Asemrowo	Asemrowo

b. Cost of Operation

Mechanical road sweeper's annual cost is estimated to be 51.75 million based upon the *IUIDP report (1991) with the following details :*

	Annual Cost (Rp. Million)
- Loan repayment over 7 years	35.71
- Interest (15 % of purchase cost)	3.75
- Repair and maintenance	7.00*
- Annual road tax (STNK)	0.25
- 2% insurance	0.50
- Fuel	2.70
- Labor cost	1.84
- Total	51.75

* The repair and maintenance cost Rp 7 miillion was estimated based upon the JICA Study.

It is recognized in KMS that the mechanical road sweepers' operation and maintenance costs are very high. The road brush which is imported from the US needs to be changed every 3-4 months. Hydraulic system often has troubles.

The unit sweeping cost is estimated at Rp. 7,089/km/day from the following information:

- Total daily cost (Rp 51,750,000 / 365 day) Rp 141,781

- Average daily sweeping length/sweper 20 km
  (Based upon the result of time and motion study)

3) Private Contractors

It is estimated that private contractors swept (109.5 km x 2) + (106.5 s 2) = 432 km. Note: (Roadside sweeping length 109.5 km = shoulder length 106.5) x 2 sides. The sweeping length (432 km) divided by the total number of private contractors 404 workers is 1,069m/person.

So it is clear that per person sweeping area of the private contractors is much longer than that of the Cleansing Department, KMS. Contract price for 1 kerb km is estimated at Rp. 7,789 based upon the following information:

Total Contract Price Rp 926, 796,000 / 365 day / 432 km = Rp 5,878km

4) Conclusion

The result of the efficiency analysis is as follows:

- Unit cost of sweeping by KM S workers:	Rp.	9,228 / km
- Unit cost of use of the Contractor:	Rp.	5,878 / km
- Unit cost of mechanical sweeping:	Rp.	7,089 / km

The study results indicate that the use of the contractors is the most cost-effective, and therefore advisable. KMS' cost of manual sweeping is 57 % higher than the cost of use of the contractors, and 21 % higher than the cost of mechanical sweeping.

Besides the mechnical sweepers actually collect sand dust mostly, and sweeping workers sweep the same streets as swept by mechanical sweepers. Therefore, the use of the mechanical sweepers is not recommended. Instead, the increasing use of contractors is advisable.

2.7.5 Major Issues

1) The following table shows number of street sweeping workers used per 1 km length of road sweeping in Indonesia. Among 15 major cities, Surabaya uses 7 workers for sweeping 1 Km of sheet which is the largest number in the 15 major cities. Average number of workers is about three in Indonesia, a half of Surabaya. Streets of Surabaya are clean. However, it is also reported that streets of Bandung, Cirebon, etc are also clean. Therefore, the number of street sweepers in Surabaya can possibly be reduced by improving the sweeping efficiency, while maintaining the same level of cleanliness..

Table 2.7-6 The Number of Sweepers in 15 Major Cities in Indonesia

No. of Workers Used for Sweeping 1 km of Road	n<2	2<n<4	4<n<6	6<n<8
Number of Cities	3	8	2	2
Name of cities and No. of Sweepers	Jambi 1 DKI Jakarta 0.5 Kupang 0.1	Kediri 3 Banjarmasin 3 Bogor 3 Jember 2 Cirebon 2 Pekanbaru 2 Banda Aceh 2 Bandung 2	Surakarta 4 Semarang 4	Surabaya 7 Medan 6

Source: Waste Management Statistic in Indonesia (Feb. 1987), Cipta Karya

2) 56 workers of the Cleansing Department are assigned to 4th shift sweeping from 18:00 - 24:00 am, and 287 is on 1st shift (0:00-06:00). Midnight working is not considered necessary since people do not pay attention to the little amount of waste on the streets at night.

3) The composition of a road sweepers team and number of workers used per unit road length is not fixed. The composition and number of workers of a team should be determined so that sweeping load of each worker is identical.

4) The three mechanical road sweepers are useless for the road in Surabaya doe to the following two reasons :

   a. They sweep the same roads as swept by sweeping workers.
   b. They can work for 4 hours only, and collected "waste" is not actually waste, but dust. It is desirable that three mechanical road sweepers are given to Dinas Marga, which has responsibility to sweep highways. It makes a sense to use mechanical road sweepers for highways because it is dangerous to sweep highways for sweeping workers.

2.8 Incineration and Other Intermediate Treatment

2.8.1 General

It was in 1986 that KMS started seriously considering the introduction of an incinerator.

In July 1989, KMS signed the contract with P.T. Unicomindo for the construction and operation of the incinerator after obtaining an approval from both the governor of the East Java Provincial Government and the Minister of Home Affairs. The contract is based on BOT (Build Operate, and Transfer) system. This is the first incinerator constructed for municipal solid waste in Indonesia. KMS's stated reason for the introduction of an incinerator was the difficulty in land acquisition for final disposal sites.

The construction took about 1.5 years. The operation of the incineration plant commenced in August 1991.

The plant has 6 furnaces with the total design capacity 200 ton/day (33.6 ton/day/furnace x 6 furnaces). It is Cadoux Inc., a French company which manufactured and supplied the plant under a separate contract with P.T. Unicomindo.

According to the contract between KMS and P.T. Unicomindo, KMS will pay a total of approx. US$ 18.6 million to the P.T. Unicomindo during the period 1989/90 - 1998/99, of which US$ 13.1 million is the construction cost of the incineration plant, and the remaining US$ 5.5 million is the amount of interest to be paid.

There are 92 employees involved in the operation and maintenance of the Incinerator, of which 16 persons are from KMS Cleansing Department, and the remaining 76 are from P.T. Unicomindo.

2.8.2 Specifications of the Incineration Plant

The incineration plant is a continuous combustion type with stoker furnaces. It has pits and cranes for waste feeding. Major specifications of the plant are shown below :

1. Refuse Waste Storage

1.1	Waste storage	
	- Capacity	625 ton
	- Number of pit	2
	- Dimensions (L x W x H)	18 x 9 x 6 m

1.2 Over Head Crane

- Quality	4 units
- Grapple capacity	250 kg
- Maximum hoist lift	12 m
- Crane Span & travel length	18 m, 30 m

2. Combustion Furnace

2.1 Charging Hopper

- Size (L x W x H)	1.5 x 1.8 x 0.6 m
- Capacity	1.5 m^3
- Feed Rate	5 ~ 6 loads/hour

2.2 Furnace

- Number of Units	6
- Type	Refractory
- Rated Capacity	33.6 tons/day/unit
- Capacity for Indonesian Waste	25.2 tons/day/unit
- Type of Grate	Oscillating grate

1) Primary Chamber

- Inside dimension	3.2 x 2.0 x 2.2 m
- Volume	15 m^3
- Shell thickness	6 mm
- Shell material	Steel A 283 gr B (ASTM Norms)
- Refractory	
• Top (vault)	Bricks MU42SC, 230 mm, 1400°C
• Hearth (Second Wall)	Bricks ARKAL 60, 230 mm, 1500°C
• Loader Entrance	Refractory concrete DA 60, 240 mm 1650°C
- Insulation	
• Walls	Isobloc 9, 60 mm Heat insulating concrete
• Vault	Bricks APB, 60 mm, 950°C

2) Secondary Chamber

- Inside Dimensions	1.6 x 2.0 x 3.0 m
- Volume	9 m^3
- Shell Thickness	6 mm
- Shell Material	Steel A 283 gr B (ASTM Norms)
- Refractory	
• Type	Bricks
• Thickness	135 mm
• Temperature	1500°C
- Insulation	
• Walls	Isobloc 9, 60 mm
• Vault	Bricks AP8, 60 mm, 950°C

3) Grate

- Width of grate	2 m
- Effective grate area	6.7 m^2
- Rated grate heat release	541,000 Kcal/m^2
- Vertical drag	22.5°
- Strokes/min	variable
- Retention time in furnace	45 minutes
- Total furnace volume	22.5 m^3
- Volumetric heat release	160,000 Kcal/hr/m3

4) Ash Handling System

- Number of ash conveyor	one per three furnaces
- Type of system	Wet drag
- Capacity per unit	2.5 ton per hour
- Drive type and size	geared; 5 Horse Power
- Design density of bottom ash	960 kg/m3

5) Stacks

- Number of visible stacks	1 per furnace
- Total stack height	21 m
- Inside diameter	1 m
- Materials	
• Walls	A 36
• Common stack	A 242

2.8.3 Performance and Evaluation

1) Operation

The operation of the incinerator started in June 1991. The performance record is available from August 1991, and summarized in the table below :

Table 2.8-1 Operation Record of Keputih Incineration (Aug. 1991 - Jan. 1992)

No.		Aug '91	Sep '91	Oct '91	Nov '91	Dec '91	Jan '92	Average
1.	Incineration Amount (ton/month)	2,921	5,358	5,769	5,619	4,100	3,235	4,500
2.	Daily Average (ton/day)	94	178	186	187	132	104	147 ton/day
3.	Hourly Average per operating furnace (ton/hour/furnace)	1.70	1.79	1.54	1.48	1.00	0.93	1.41
4.	Monthly Fuel Consumption (liter/month)	47,079	70,287	59,406	57,460	95,909	73,240	67,230
5.	Unit Fuel Cost (Rp/liter)	292	292	292	292	292	292	292
6.	Fuel Cost (Million Rp/ month) (4 x 5)	13.7	20.5	17.3	16.8	28	21.4	19.6
7.	Unit Consumption per ton of Waste Incineration (liter/ton) (4/1)	16.1	13.1	10.3	10.2	23.4	22.6	15.95
8.	Fuel Cost per ton of Waste Incineration (Rp/ton) (6/1)	4,690	3,830	3,000	2,990	6,830	6,620	4,660
								Operation Rate (%)
9.	Number of Operation Days (day/month)							
	- Furnace 1	14	27	31	30	30	24	85
	- Furnace 2	17	26	17	24	30	24	75
	- Furnace 3	18	17	31	30	30	24	82
	- Furnace 4	11	28	31	28	31	23	83
	- Furnace 5	11	20	30	27	19	26	83
	- Furnace 6	0	7	16	20	30	25	53
	TOTAL	71	125	156	159	170	146	75
10.	Rate of Operation (calculated from Item 9)	38.2%	69.4%	83.9%	89.0	91.5	78.5%	74.9%

a. Rate of Furnace Operation

The furnace operation record (number of monthly operation days per furnace) and the monthly average rate of furnace operation are shown in items 9 and 10 in the table above. The monthly operation rates ranged from 38.2% in August 1991 to 91.4 % in December 1991. (Monthly operation rate is calculated by using the following formula: Aggregate number of operating days of 6 furnaces per month divided by either 180 furnace-days (6 furnaces x 30 days in September & November) or 186 furnace-days (6 furnaces x 31 days in Aug., Oct,. Dec., & Jan.)). The average operation rate was 75 % during the 6 months from August 1991 to January 1992.

b. Incineration Amount

The average daily incineration amount was 147 tons/day, 73% of the design rated capacity of the 6 furnaces. On the other hand, the average furnace operation rate was 75% as shown in the above item a. This means that the furnaces performed at nearly 97 % (73%/75%) of the design rated incineration capacity when they were in operation.

c. Fuel Consumption

Item 7 of the table shows the monthly average fuel consumption used for incineration of 1 ton of waste. During the dry season of August - November, it ranged from 10.2 liter/ton to 16 liter/ton. During the rainy season (December and January), it increased to 23.4 liter/ton and 22.6 liter/ton respectively. The fuel cost spent for incinerating 1 ton of waste ranged Rp 3,000 to Rp 7,000 averaging at Rp 4,660 as shown in Item 8 of the table.

Note : The average fuel cost Rp 4,660/ton of waste incineration is larger than the unit cost of the sanitary landfill (approximately Rp 4,000).

d. Combustion Temperature

Until September 1991, the combustion temperature was set at 500°C, it was then increased to 600°C since October 1991. Actual variation of the temperature is ± 30°C over the set temperature. In April 1992, the combustion temperature was reset to 800 °C to avoid the corrosion of the grates due to low temperature.

e. Incineration Ash

The incineration ash amounts to about 10 % of the incoming waste. A 15% of the incineration ash is the organic matter according to the Report "Investigation of Air, Water, and Land Pollution from the Waste Incineration Plant in Surabaya" issued by the Cleansing Department in 1991.

2) Environmental Impacts

a. Emission of Flue Gas

The flue gas emitted from the Incineration plant was measured by the Institute Technology Surabaya (ITS) on 10 November 1991. The measurement results and the Indonesia's emission standard are shown below.

Table 2.8-2 Flue gas Emitted from the Incineration Plant

Unit: mg/m^3

Substance	Results of Measurement		Emission Standard *		
	At 500°C	At 750°C	High	Middle	Low
Cl	0.385	0.090	400	500	600
SOx	2.800	0.733	1,700	250	300
NOx	0.852	1.037	1,700	4,600	4,600
CO	232.228	232.228	1,000	1,000	1,000
Particulate	0.025	0.022	400	500	500

Source: Investigation of Air, Water and Land Pollution from the Waste Incineration Plant In Surabaya, Cleansing Dept., KMS

* The emission standard shown in the table is KEP.02/MENKLH/1/1988 issued by the Minister of the Population and Environment on 19 January 1988.

The densities of the measured flue gas emissions are extremely low compared to the Indonesia's emission standard, which makes it difficult to accept the measured densities as they are. The densities are also very low compared to the Japanese typical municipal waste incineration flue gas emissions (before treatment) as shown below:

Japanese Typical Municipal Waste Incineration Flue Gas Emissions
(before treatment)

Cl:	800 - 1,300 mg/m^3
SOx:	60 - 230 mg/m^3
NOx:	140 - 270 mg/m^3
Particulate:	2,000 - 5,000 mg/m^3

The densities of flue gas emissions of the Keputih incinerator must be about same as those in Japan because the chemical compositions (N, S & Cl) of Surabaya waste is similar to those of Japanese municipal waste. Therefore, it is advised that KMS should have the measurement results reviewed by some experts.

b. Waste Water

Leachate coming from the waste collection pit of the incinerator is treated by the night soil treatment plant located adjacent to the Incinerator. The other waste water generated from human activities and the area cleaning services is discharged to the public sewage system.

c. Ash

The incineration ash is about 10 % of the incoming waste. The ash is dumped nearby the Incineration Plant.

2.8.4 Cost of Incineration

1) Investment Expenditure and Payment Conditions

KMS's contract price of the incinerator is US$ 18,617,966 which comprises of two components: the construction of the incinerator, and interest. The construction price of the incinerator US$ 13,122,888 is repaid in 10 equal installments starting in 1989/1990 and ending in 1998/99, and the interest accrued on the remaining amount of the incinerator cost is also paid during the same period. Payment conditions are summarized below :

Payment Conditions of the Keputih Incineration Plant:

a. Contract Amount

1) Equipment price	US$ 13,122,888
2) Total Interest	US$ 5,495,078
TOTAL (1+2)	US$ 18,617,966

b. Duration of Payment

1st payment : Fiscal year 1989/90
Last payment : Fiscal year 1998/99

c. Annual payment amount

10% of the equipment price + Interest on the remaining amount

d. Annual Interest Rate

1) Interest	:	8.50 %/year
2) Installment insurance	:	1.00 %/year
3) Fire insurance	:	0.47 %/year
TOTAL (1+2+3)	:	9.97 %/year

e. Exchange Rate to be Applied

(A) - (B) = (C)
where
(A) : Market exchange rates applied at the time of payments
(B) : Rp 1,792/$ (market exchange rate at the time of signing the contract in 1989) x 5% = Rp 89.6/$

f. Payment Schedule

Table 2.8-3. Payment Schedule for the Incinerator

Unit: US $

No.	Year	Repayment of Principal (A)	Payment of Interest (B)	Total (C) = (A) + (B)
1.	1989/1990	1,312.288.80	0	1,312,288.80
2.	1990/1991	1,312.288.80	588,758.37	1,901,047.17
3.	1991/1992	1,312.288.80	1,471,895.93	2,784,184.73
4.	1992/1993	1,312.288.80	883,137,56	2,195,426.36
5.	1993/1994	1,312.288.80	752,302.36	2,064,591.16
6.	1994/1995	1,312.288.80	621,467.17	1,933,755.97
7.	1995/1996	1,312.288.80	490,631.98	1,802,920.78
8.	1996/1997	1,312.288.80	359,796.78	1,672,085.58
9.	1997/1998	1,312.288.80	228,961.79	1,541,250.59
10.	1998/1999	1,312.288.80	98,126.40	1,410,415.20
	Total	13,122,888.00	5,495,078.34	18,617,966.34

Average annual repayment amount is US$ 1,861,797,000 (10% of the total contract price) which is Rp 37,235,932,000 at the exchange rate Rp 2,000/US$.

2) Costs

It is estimated that the annual average cost of the incineration is Rp 4,593 million, and the unit incineration cost is Rp 85,600 per ton assuming that:

1) the operation period would be 15 years, and
2) the average incineration amount will be 53,655 ton/year (147 ton/day, the average daily incineration amount x 365 days/year)

The breakdown of the costs are shown below.

Table 2.8-4 Cost of Incineration

COST ITEMS	ANNUAL COST	UNIT COST
a. Repayment (Depreciation and Interest)	Rp 2,482 million	Rp 46,260/ton
b. Operation	Rp 930 million	Rp 17,330/ton
c. Maintenance	Rp 1,181 million	Rp 22,010/ton
d. Total	Rp 4,593 million	Rp 85,600/ton

It is anticipated that the cost Item a. (Depreciation and interest) and Item c. (Maintenance) will increase in the future, in terms of local currency, due to the continuing appreciation of US dollar against Rupiah. During the past few years, US dollar appreciated 5 % per year on average.

Explanation on the Respective Cost Items:

a. Repayment (Depreciation Cost and Interest)

Assuming that the incinerator will be used for 15 years, the annual sum of the depreciation and interest payment is estimated at Rp 2,482,396,000 (the contract amount Rp 37,235,932,000 divided by 15 years).

b. Operation Expenditures

According to the contract, KMS is responsible for payments of all the operation expenses such as salary and fuels. The annual operation expenditures in 1991/92 and 1992/93 budget is approx. Rp 930,000,000/year.

c. Maintenance Expenditures

According to the contract, P.T. Unicomindo is responsible for payments of the maintenance costs (procurement of spare parts, and overhaul) during the first two years following the commencement of the operation of the incinerator. KMS is responsible for the payments of the same cost in and after the third year.

Annual maintenance cost greatly varies depending on years. Annual maintenance costs may reach over 12% of the construction cost of the incinerator if a major overhaul has to be done, while annual costs without a major overhaul may range from 2 - 3% of the construction cost.

On average, annual maintenance cost through the operation period may be 4 - 5% of the construction cost. Assuming that the average annual maintenance cost is 4.5%, the maintenance cost is estimated at Rp 1,181 million/year at the exchange rate of Rp 2,000/year. (US$ 13,122,288 x 4.5% x Rp 2,000/US$ = Rp 1,181 million).

2.8.5 Composting

KMS does not have any intermediate treatment facilities other than the incineration plant.

In Surabaya, a private company called PT Kurnia Pelita, a sister company of Mercu Buana Group used to operate a compost plant in Tandes, north part of Surabaya during the period 1976 - 1986. The company's purpose for construction of the compost plant was to fulfill internal needs of Mercu Buana Group.

The composting business was in good shape for about 4 years from 1979 to 1983 during which the company had a compost-supply-contract with the State Plantation Company. PT Kurnia Pelita produced 40 - 50 tons/day of compost product from 100 ton/day of waste during the period.

In 1986, the State Plantation Company terminated the contract with PT Kurnia Pelita as the State Company found that the Company's need for the compost had been satisfied. It is said that once compost is supplied to a plantation field, the field does not need compost for the next several year. With the termination of the contract, and also upon the satisfaction of internal need, PT Kurnia Pelita was obliged to close its compost plant in 1986. The company's compost plant has never resumed its operation since then.

It is considered that the composting is not feasible in Surabaya judging from the past experience of PT Kurnia Pelita, and also in view of the following points :

1) Although there is a demand for compost products particularly during the expansion of some plantations, such demand can be quickly satisfied once the compost product is supplied to the plantations.

2) There are not many plantations in the East Java. And, due to relatively high transportation costs of the compost product, it cannot be transported to distant places.

3) Mechanical composting facilities are costly, and require a large initial investment and high operation costs.

4) The experience of the Bangkok Metropolitan Administration which has over 20 years of the experience in the compost production shows that the compost production is not feasible from either economic or financial view point unless the following conditions are met :

   a. Manual production methods with the use of old waste is applied. (There is no way to be feasible for compost producers using expensive mechanical facilities).

   b. There exist a market constantly needing compost products nearby compost plants.

2.9 Final Disposal

2.9.1 Location

KMS currently uses three final disposal sites (LPAs), in Keputih, Lakarsantri and Kenjeran among which the former two belong to KMS, while the LPA in Kenjeran belong to a private developer. These LPAs are assigned a group of Kecamatans as the target area as shown in Table 2.9-1 with the approximate distance to their target area.

1) Keputih

Keputih LPA is located on a flat area in the southeast part of Surabaya, 2 km from the seashore. It is surrounded by ponds on the north, east, and south sides. On the west side there are some water farm lands, a few residential areas and schools. Keputih LPA receives the waste from 12 Kecamatans in the southeast part of Surabaya.

2) Lakarsantri

Lakarsantri LPA is located in the gently hilly area in the southwest part of Surabaya surrounded by farm land. There are no residential area within 500 m radius of the LPA. In rainy season, the lower area of the farm land is used for paddy field. The LPA receives waste from 7 Kecamatans in the western part of Surabaya.

3) Kenjeran

Kenjeran LPA is located on a shoaling beach in the northeast part of Surabaya. In this LPA the seaside area was being reclaimed. There is an on-site road across the mangrove bush growing along the coast in a line. The sea bed around the LPA is of silty sand, and runs dry during the ebb tide period. There are several small wharves for coastal fishery and for pleasure in the northward coast. This LPA receives waste from 12 Kecamatans in the east part of Surabaya.

Table 2.9-1 Assignment of LPA to each Kecamatan and Approximate Distance

Kecamatan	Distance to LPA (km)		
	Kenjeran	Lakarsantri	Keputih
1. Sukolilo	4	-	3
2. Kenjeran	5	-	10
3. Tambaksari	7	-	15
4. Simokerto	7	-	11
5. Gubeng	13	-	7
6. Rungkut	15	-	11
7. Semampir	11	-	16
8. Pabean Cantikan	12	-	17
9. Bubutan	-	18	-
10. Krembangan	-	24	-
11. Tandes	-	17	-
12. Benowo	-	15	-
13. Lakarsantri	-	2	-
14. Karang Pilang	-	4	-
15. Wonocolo	17	-	14
16. Wonokromo	15	-	12
17. Sawahan	-	22	-
18. Tegalsari	14	-	10
19. Genteng	11	-	14

2.9.2 Disposal Operation

1) Method of Landfill

KMS applies a traditional landfill method of open dumping: the waste has been piled up with no cover soil by the time of completion.

The dumping point is not strictly controlled, so the wide area of the LPA is used as the working face where the waste is kept exposed for long time.

There are no leachate retention pond and leachate treatment facility provided. Dumping areas not well designated. There are very wide areas left uncovered both in Keputih and Lakarsantri.

Scavengers are working in the LPA, and live in or just next to LPA with temporary sheds. Heavy equipments are used for gathering and carrying scattered solid waste to designated places and covering soil for over layer.

2) Inventory of Final Disposal Site(LPA)

(1) Facilities

The inventory of the LPA facility are shown below.

Table 2.9-2. Inventory of LPA Facility

	Keputih	Lakarsantri	Kenjeran
Entrance gate			Ada (1)
Weigh bridges			
Office (2)	Ada	Ada	
Leachate collection			
Leachate treatment			
On site road		Ada	Ada
Fencing			
Embankment			Ada

Note: Ada means that the facility is installed.

(1) : use the gate of the neighboring recreation center

(2): not always occupied by the person in charge

(2) Heavy Equipment

The heavy equipment used in the LPA is shown below.

Table 2.9-3 The Number of Equipment in each LPA

	Keputih	Lakarsantri	Kenjeran
Bulldozer	4 (3)	1 (1)	3 (2)
Soil Compactor	2 (0)	0	0

Note : Figure in the bracket ( ) indicates the number of working equipment

The waste delivered to the LPA is very wet, so the carrage and the other parts of the heavy equipment are liable to be damaged by corrosion due to the moisture of waste.

(3) Working Hour

The working hour at each site is basically designated for seven (7) days as shown in the Table 2.9-4. According to this schedule, during midnight to early in the morning the LPAs are closed, however, since there is no enclosing fence or gate, it is possible to dump waste at LPA during its closed time.

Table 2.9-4 Working Hours

Disposal Site	Working Hour
Keputih	5:00 AM - 10:00 PM
Lakarsantri	6:00 AM - 8:00 PM
Kenjeran	5:00 AM - 12:00 Midnight

2.9.3 Structure of Final Disposal Site(LPA)

1) Keputih LPA

Landfill operation started in 1982. The LPA is divided into three partitions, namely I,II and III. The landfill is executed one by one. The space between the partition I and II is used also as the part of landfill site although it belongs to private person(s). The partition I has already been finished landfilling, and covered with sea sand conveyed by the pipe line.

The Cleansing Department has a plan of the site improvement that consists of construction of the retention pond and on-sit road as shown in Fig. 2.9-1. At the partition I, the thickness of waste was planned at 2.5 m with the cover soil of 0.4 m thick.

Since the fence or any other barrier are not provided, the dumped waste is spilling out beyond the boundary.

On-site roads are not provided inside the LPA. On the north and west side, there are paved approach road, however, the road on the West side is too seriously damaged to use it in rainy season.

Drain system is connected directly to the neighboring river with no leachate water treatment. The heavy equipment are parked without any shelter on the ground.

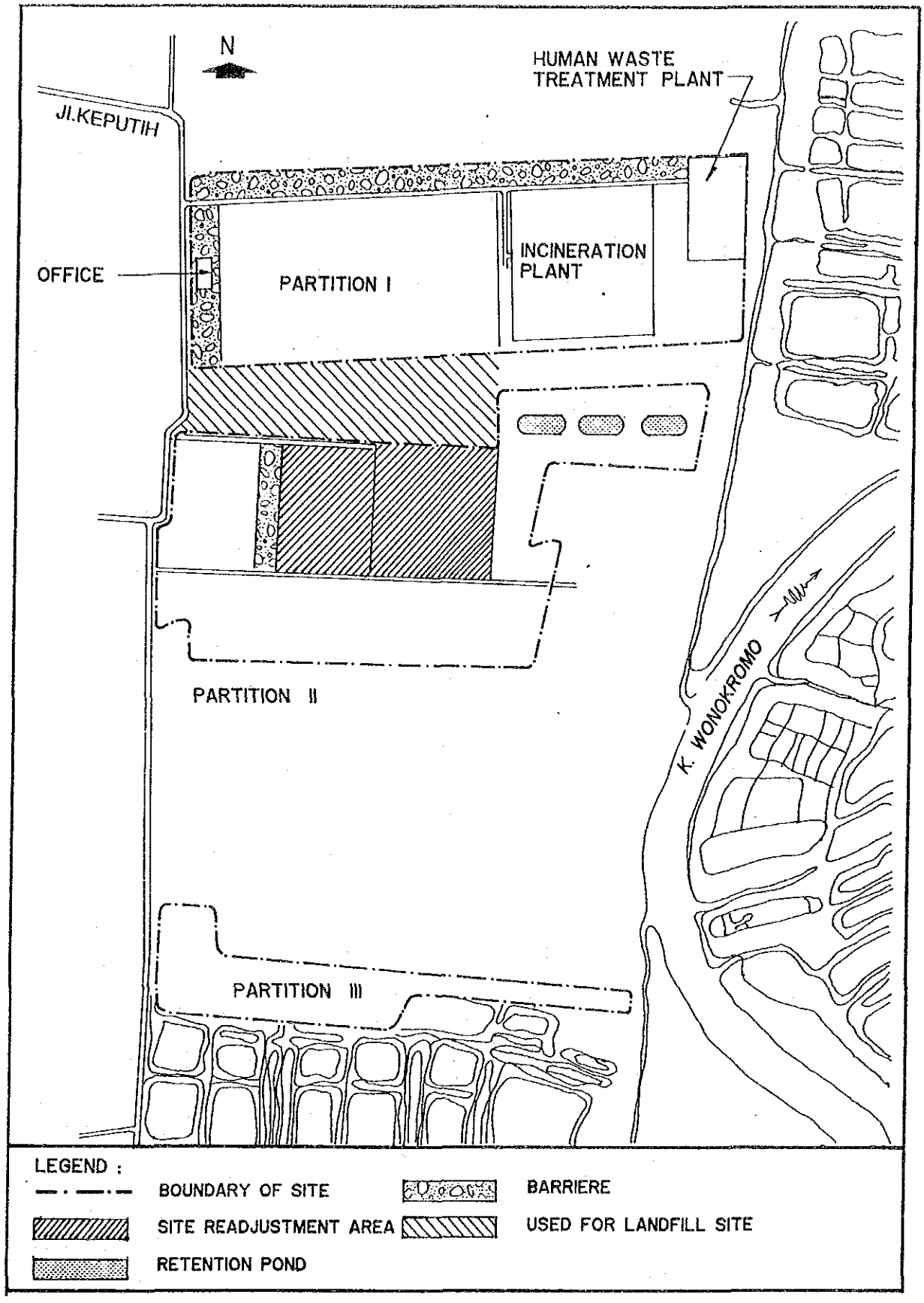

FIG. 2.9-1 THE PLAN OF KEPUTIH FINAL DISPOSAL SITE

THE STUDY ON THE SOLID WASTE MANAGEMENT IMPROVEMENT FOR SURABAYA CITY

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2) Lakarsantri

The operation started in 1988. The LPA is divide into two partition A (7.6 ha) and B (0.5 ha), however, B has not been used as the landfill site so far. The main landfill area A is divided into two parts by an improved river, and provided with some on-site paved roads as shown in Fig. 2.9-2.
The difference between the lowest part (bottom of the river) and the highest parts(top of the hill) is 14 m.
Concrete poles are provided with an interval of 10 m on the boundary and steel wire are provided between the poles, but the wires are broken and wastes are spilled out beyond the boundary in many places.

There is no particular drain system, so run-off and leachate water flow into the river that goes down through the site without any treatment. Heavy equipment is not used for the ordinary operation of dumping.

3) Kenjeran LPA

The operation started in 1984. The landfill site is surrounded by the breakwater and the dike connected to the seashore. The dike is made of macadam which has a permeable structure. The waste is dumped directly in the water as shown in Fig. 2.9-3.

On-site roads are provided just inside the breakwater and dike. The roads are made of sandy soil transported from outside Surabaya city. The Cleansing Department operates heavy equipment on the site.

There is no particular drain system and leachate treatment system, so the run-off and leachate flow directly into the sea without any treatment.

According to the progress of landfill operation, the site has been almost filled with solid waste as of November 1992, consequently the water surface within the breakwater has already disappeared and mangrove forest beside the landfill site has also been cut down at all. Provided that the operations is continued at the present pace, the lifetime of this site seems to be exhausted within the year 1992.

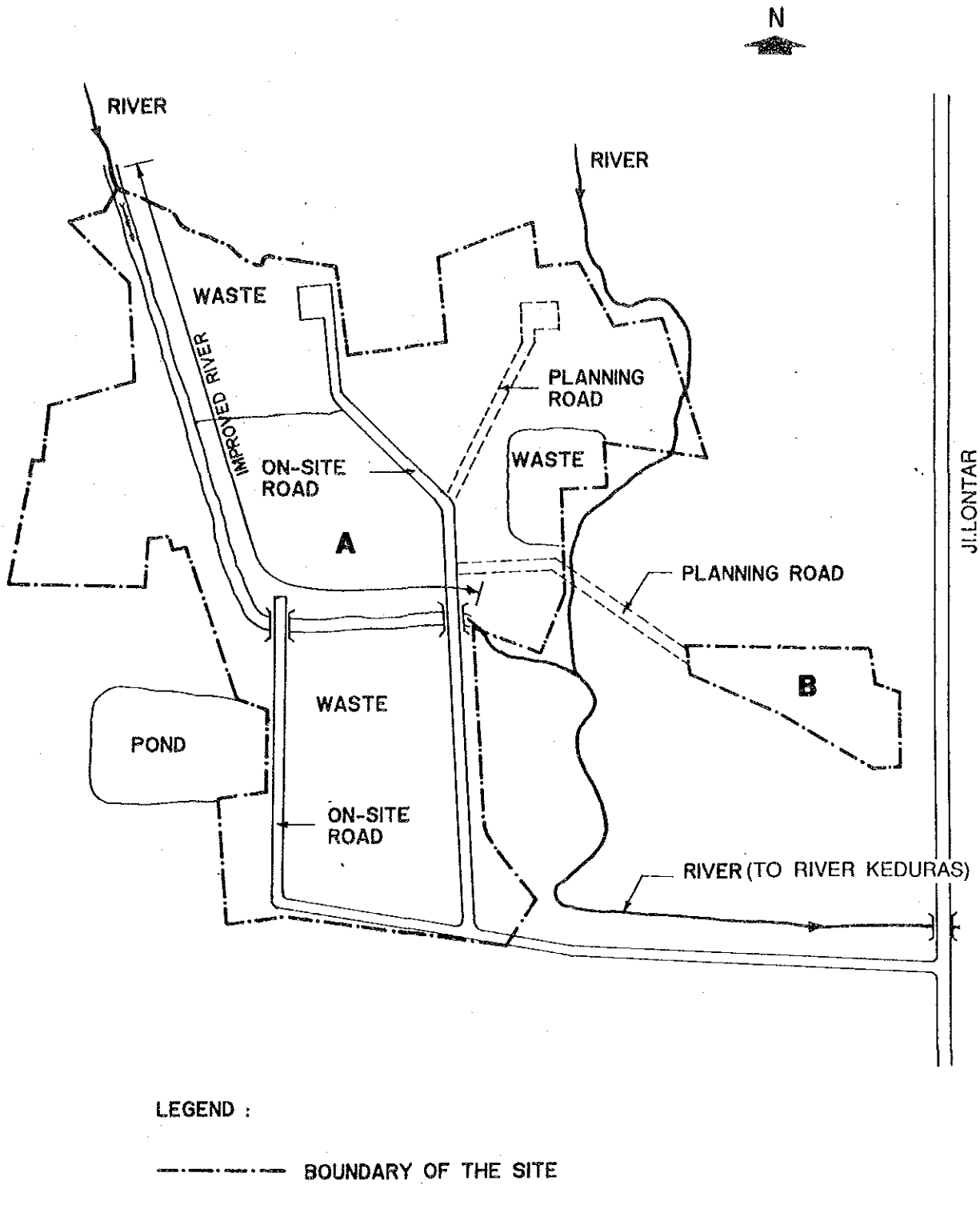

FIG. 2.9-2	THE STRUCTURE OF LAKALSANTRI FINAL DISPOSAL SITE

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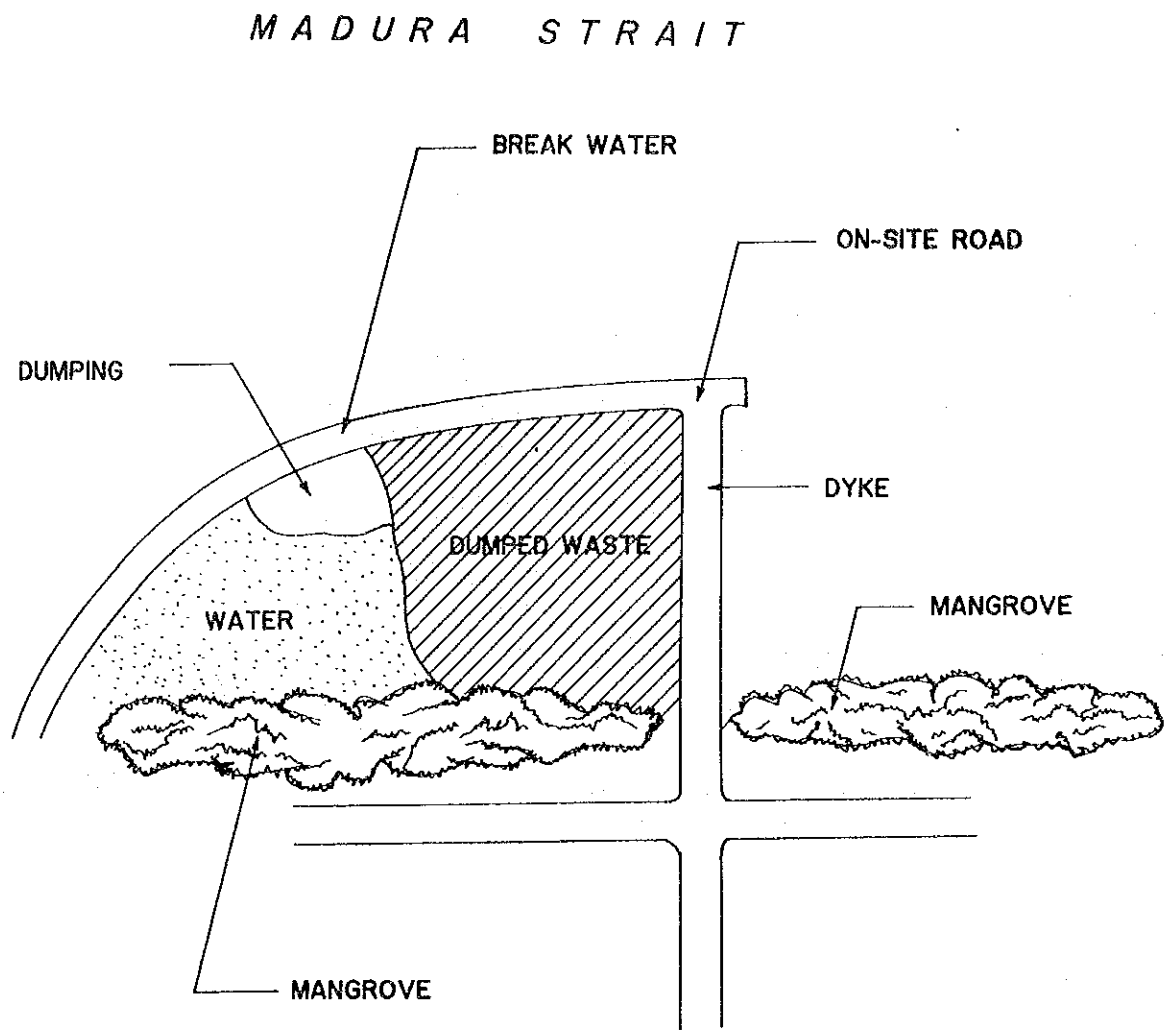


FIG. 2.9-3 THE STRUCTURE OF KENJERAN FINAL DISPOSAL SITE

THE STUDY ON THE SOLID WASTE MANAGEMENT IMPROVEMENT FOR SURABAYA CITY

4) Access Road

(1) Keputih

The access road Jalan Keputih, paved with asphalt, has a 6 to 8 m width. One side is provided with an open drainage channel, and opposite side is residential area. In the morning, this road is very crowded by commuter traffics.

(2) Lakarsantri

The access road Jalan Wiyung, Jalan Babatan, Jalan Lidah Kulon and Jalan Lontar have a 4 to 8 m width, and are paved with asphalt. The roads have a large traffic volume all day long and as a result, they are seriously damaged in almost all the way.

(3) Kenjeran

The access road Jalan Kenjeran and Jalan Tempurejo have a 5 to 6 m width and, are paved with asphalt. The roads do not have a large traffic volume. The road condition is better than that of the other disposal sites.

2.9.4 Dimension of Final Disposal Site (LPA)

The dimension (Size of area, Assumed capacity, Dumped amount, Settled amount and Remaining capacity) of existing LPA is shown below.

Table 2.9-5 The Dimension Existing LPA

	Size of Area (ha)	Assumed Capacity ($x10^3$ m^3)	Cumulative Dumped Amount by the end of 1991 ($x10^3$ m^3)	Cumulative Settled Amount by the end of 1991 ($x10^3$ m^3)	Remaining Capacity at the End of 1991 ($x10^3$ m^3)	Remaining Capacity at the End of 1992 ($x10^3$ m^3)
Keputih	29.6	1,480	5,392	841	-	1,024
Lakarsantri	7.6	380	1,058	165	-	431
Kenjeran	24	1,200	4,780	746	454	321
Remark	Note 1	Note 2	Note 3	Note 4		Note 5

Note 1: Size of area

During the current study, the Keputih LPA and Lakarsantri LPA were surveyed their topography and the boundary, then prepared a series of maps. The sizes of the above two disposal sites, calculated on the map, does not include the land which is located out of boundary of the LPAs through, it is used for dumping area practically. The size of Kenjeran disposal site was quoted from the SUDP report.

Note 2: Assumed Capacity

The total capacity of the LPA is calculated by multiplying the area and the average thickness of waste. The average thikness of waste is assumed at 5 meters for each site.

Note 3: Cumulative Amount of Dumped Waste

The data on the cumulative amount of dumped waste have been recorded by KMS since the beginning of each disposal site as shown in Table 2.9-6. The cumulative amount of dumped waste is given at 5,392,000 m^3, 1,058,000 m^3, 4,780,000 m^3 for Keputih, Lakarsantri and Kenjeran disposal site respectively.

Table 2.9-6 Waste Amount Delivered to LPA

a) Keputih LPA

Unit: m^3

	1983	1984	1985	1986	1987	1988	1989	1990	1991
January		36,592	38,970	48,873	41,492	47,192	43,096	59,239	63,941
February		36,463	39,581	50,112	43,534	47,382	35,981	57,235	57,006
March		34,509	39,672	45,218	42,975	46,143	41,307	57,498	58,615
April		35,894	37,890	46,343	39,588	47,561	43,918	56,579	58,614
May		36,921	38,635	46,918	43,796	48,391	45,019	57,678	62,860
June		36,783	40,118	47,624	47,569	46,430	46,125	61,890	61,928
July		36,926	39,386	39,998	45,325	47,097	47,032	57,691	57,691
August		38,672	42,199	40,654	47,874	45,333	44,857	44,609	57,716
September		35,594	41,639	39,972	47,984	40,055	43,945	65,967	62,370
October		37,561	46,487	41,348	50,378	39,737	48,004	53,143	64,093
November		37,292	47,394	44,214	49,709	44,431	48,114	65,341	62,085
December		37,816	47,684	48,866	51,384	44,970	47,347	69,719	63,982
Total	852,617	441,023	499,655	540,140	551,608	544,722	534,745	706,589	730,901
									5,392,000

b) Lakarsantri LPA

Unit: m^3

	1983	1984	1985	1986	1987	1988	1989	1990	1991
January							23,777	24,427	24,469
February							24,357	25,120	23,459
March							25,735	24,253	23,718
April							26,592	24,781	23,062
May							26,854	25,875	23,648
June							27,585	26,524	26,036
July							27,694	25,968	25,789
August						24,659	26,951	27,488	26,625
September						22,588	27,583	27,567	26,994
October						23,723	28,776	29,218	27,246
November						24,596	27,485	28,350	26,229
December						25,473	23,729	26,370	26,594
Total						121,039	317,118	315,940	303,869
									1,057,966

c) Kenjeran LPA

Unit: m^3

	1983	1984	1985	1986	1987	1988	1989	1990	1991
January			46,124	49,412	50,912	50,659	52,889	54,081	54,519
February		19,486	46,286	47,855	51,272	51,923	52,438	53,123	55,564
March		39,145	46,469	49,325	50,881	51,212	50,010	55,081	56,743
April		39,317	46,458	49,983	51,054	51,610	53,154	51,671	55,653
May		39,834	47,680	50,155	51,445	51,140	54,146	55,210	60,418
June		39,662	46,641	50,490	51,617	51,789	53,690	55,122	57,509
July		39,490	46,296	50,663	51,007	52,572	53,221	54,214	55,914
August		42,532	47,328	49,675	51,398	51,789	53,594	52,602	55,440
September		40,562	49,237	50,835	51,828	52,001	50,662	53,743	52,094
October		40,390	49,628	51,170	52,400	51,563	52,995	53,987	54,916
November		40,171	47,672	51,343	51,618	52,259	52,096	55,148	56,139
December		40,735	47,500	51,283	52,477	52,649	53,088	53,841	55,273
Total		421,325	567,319	602,189	617,910	621,167	631,984	647,824	670,183
									4,779,901

d) Total Waste Amount Delivered

Unit: m^3

	1983	1984	1985	1986	1987	1988	1989	1990	1991
January		36,592	85,094	98,285	92,404	97,851	119,763	137,747	142,929
February		55,949	85,867	97,967	94,806	99,305	112,776	135,478	136,029
March		73,654	86,141	94,543	93,856	97,355	117,052	136,832	139,076
April		75,211	84,348	96,326	90,642	99,171	123,664	133,032	137,329
May		76,755	86,315	97,073	95,241	99,531	126,020	138,764	146,926
June		76,445	86,759	98,114	99,186	98,219	127,400	143,537	145,473
July		76,416	85,682	90,661	96,332	99,669	127,947	137,873	139,394
August		81,204	89,527	90,329	99,272	121,781	125,403	124,699	139,781
September		76,156	90,876	90,807	99,812	114,643	122,190	147,277	141,458
October		77,951	96,115	92,518	102,778	115,023	129,774	136,348	146,255
November		77,463	95,066	95,557	101,327	121,285	127,695	148,839	144,453
December		78,551	95,184	00,149	103,861	123,092	124,164	149,930	145,849
Total	852,617	862,347	1,066,974	1,142,329	1,169,517	1,286,926	1,483,847	1,670,354	1,704,952
									11,239,864

Note 4: Cumulative Amount of Settled Waste

The density of the waste changes bigger, in general, depending on the measuring points in the course of the waste treatment flow, namely, discharge, collection, haulage, dumping and compaction.

For planning and design purpose, the density of settled waste is assumed 1,000 kg/m^3 according to the Demonstration Project in Bandung. In the said project, the compaction ratio of dumped waste and settled waste was surveyed and acquired an experimental value of 2.8. This means the density of waste after settling becomes 2.8 times as large as the initial state of dumping.

The total waste amount buried during the Demonstration Project was 40,087 m^3 in volume and 14,399 ton in weight, namely the average density can be given at 0.359 ton/m^3.

Combining the average density of dumped waste and the compaction ratio, the final density of settled waste can be estimated at about 1.0 ton/m^3 according to the following calculation:

359 kg/m^3 x 2.8 = 1,005 kg/m^3 ------- 1,000 kg/m^3

Assuming the density of generated waste at 156 kg/m^3 according to the SUDP report, the compaction ratio of settled waste in Surabaya is estimated at 6.41 as shown below:

Density of settled waste (1,000 kg/m^3) ÷ Density of generated waste (156 kg/m^3)
= Compaction ratio (6.41)

The cumulative settled amount can be taken by dividing the cumulative dumped amount by the compaction ratio.

Note 5: Remaining Assumed Capacity at the End of 1992

For the inland disposal sites, the output of topographical survey can be adopted to calculated the remaining capacity directly. The results are as follows:

Remaining Capacity	: Keputih	=	1,024 x 10m^3
	: Lakarsantri	=	431 x 10m^3

The remaining assumed capacity of Kenjeran LPA at the end of 1992 is estimated by assuming the share of respective LPA and monthly disposal amount at present as shown below:

a. Assumed Share of LPA

- January and May to December (9 months)

Keputih	43 %
Lakarsantri	18 %
Kenjeran	39 %

- February to April (3 months)

Keputih	0 %
Lakarsantri	25 %
Kenjeran	75 %

b. Monthly Disposal Amount at Present

Daily Disposal Amount 776 x 365 d/12M = 23,600 t/M

Thus the remaining assumed capacity of Kenjeran LPA at the end of 1992 is estimated as follows:

Kenjeran	(1,024 - 23.6 x 43% x 8) x 10^3	=	943 x 10^3 m^3
Lakarsantri	(431 - 23.6 x 18% x 8) x 10^3	=	397 x 10^3 m^3

2.9.5 Sanitary Condition

1) Keputih and Lakarsantri

In those two landfill sites, the fairly wide area of several hectares are still left uncovered so that many flies proliferate of the surface of garbage layer and offensive odor is also generated particlarly from recent dumped layers. Odorant substances such as ammonium (NH_3) and hydrogen sulfide (H_2S) were deteced at surrounding areas.

The leachate water flows directly into adjacent surface water and affects the water quality cintinously. According to the reults of chemical analysis of sample water, an excessive amount of BOD and colibacillus were found, which indicate the pollution is caused by organic matters, in comparison to the ambient water quality standard in East Java. It was also found that the water contains very little dissolved oxygen, and almost no oxygen at the downstream just below the landfill sites. It means that the water body polluted by leachate water is not suitable for any aquatic creatures to live in. As for heavy metal ions, they were not detected , therefore the ambient water quality standard is satisfied in this regard. Agricultural chemical were not detected either.

In Keputih, a serious pollution by leachate water was observed in limited passage of downstream only: from landfill site to Pojokan Semampir River, a tributary of the Wonokromo River. The influence of leachate water cannot be discriminated any longer in the Wonokromo River. Along the tributaries of Pojokan Semampir River, there are no residential areas or water intake possibly affected by water pollution.

In Lakarsantri, the leachate water affects the water quality of a tributary of the Kedurus River which goes through the landfill site. Specific items show the same pattern as in Keputih, namely the items of organic pollution show bad conditions whereas the items of non-organic pollution comply with the water quality standard. The water quality of the stream is apparently affcted between the landfill site and the downstream about 500 m below. However, at the point about 1km below the landfill site, no sign of leachate water was found any longer. Along the affected water body, there are no residential areas or water intake possibly affected by water pollution.

Around the downstream area in Keputih, there are no wells used to collect ground water for daily life or other purpose. According to the results of the chemical analysis of the sample water taken from the neighboring wells which belong to the other catchment area, no significant sign of pollution by leachate water was found. In Lakarsantri there are several wells used for dailly life around the downsteram of the tributary from the landfill

site. According to the result of the chemical analysis, no significant sign of pollution by leachate water is found. Originally, the ground water in both sites have so high salinity that it does not suit for drinking use. They get thier drinking water at the neighboring water tap installed by PDAM(Municipal Water Authority), therefore it is not likely that the landfill site directly affects the health of neighbours.

2) Kenjeran

This landfill site has no facilities for controlling leachate so that the leachate water seep out through permeable stone fence or directly into the sea. The color of the enclosed part of sea surface has changed into brown and the neighboring surface is also colored with this seepage water. According to the result of chemical analysis of water sample taken from the sea surface around the landfill site and 200 m off shore, the water seemed to be polluted to a certain extent, however, it was not verified how much the leachate had affected the surrounding sea water quality. Though the BOD and COD level were higher than the ambient water quality standard at all sampling points, the diffusion pattern of discharged pollutant from the landfill site could not be found in the difference between off shore and nearby beach. Heavy metal ions and other toxic chemicals were not detected or very slight enough to comply the water quality standard.

2.9.6 Costs

The unit disposal cost in 1991 is estimated at about Rp3,300/ton by assuming the following items:

1	Loan interest	10.5	%
2	Depreciation	7	years
3	Insurance	2	%
4	Maintenance cost	12.5	% years of purchase
5	Fuel cost	450	Rp/liter
6	Salary	100,000	Rp/month /cap
7	Number of bulldozer	6	units
8	Bulldozer cost	300,000,000	Rp/unit
9	Number of staff	34	persons
10	Equipment cost (Bulldozer) Rp 300,000,000 x 6 = Rp 1,800,000,000		

Thus the calculation is conducted as follows:

1	Loan interest	Rp.1,800,000,000 x 10.5 %	= Rp. 189,000,000/y
2	Depreciation	Rp.1,800,000,000 / 7 years	= Rp. 257,143,000/y
3	Insurance	Rp.1,800,000,000 x 2 %	= Rp. 36,000,000/y
4	Maintenance cost	Rp.1,800,000,000 x 12.5 %	= Rp. 225,000,000/y
5	Fuel cost	20 liter/hour x 7 hour/day x 365 days x 450 Rp. x 6 unit	
			= Rp. 137,970,000/y
6	salary	34 person x 100,000 x 12	= Rp. 40,800,000/y
	Total	Annual cost	Rp. 885,913,000/y

After all the unit disposal cost is given by dividing the total annual cost by the total waste amount of 1,705,000 m^3/year, or 266,000 ton/year (density 0.156 ton/m^3), as follows:

Unit cost	Rp. 520 /m^3
	Rp. 3,331 /ton

2.9.7 Major issues

1) Sanitary condition

a. Since the leachate treatment plant and leachate retention pond are not provide in each LPA, leachate flows into the river or the sea, and contaminates the neighbouring water body.
b. Because of no fence or barrier, the waste is spilling out beyond the boundary of the sites.
c. Most of the wastes are left uncovered for long time at two inland disposal sites, therefore many flies proliferate and offensive odor is emitted.
d. There are no entrance gate (Keputih and Lakarsantri), so it is likely that wastes are dumped uncontrolled.

2) Land Status

(1) Keputih LPA

It is divided into three areas, and the pieces of land between each area do not belong to KMS. KMS intends to obtain the land between area I (north area) and area II (central Area) to use as a LPA (Refer to Fig. 3.9-4) that has the area of approximately 11 ha, and half of the area has been used as a part of

dumping site so far. The south part of the area II is planned to be used as a graveyard and also as a LPA.

(2) Lakarsantri LPA

It is divided into two parts, and the smaller part is too small to use for the disposal site and furthermore the partition has no contact to any public road. This site also has an annexed area that has been used as a part of disposal site as it belongs to the other private owner. There is no space inside to improve the sanitary condition at all.

(3) Kenjeran LPA

Since Kenjeran LPA is a private-owned property, KMS is not sure until when it can be used. It is reported that the private owner is planning to close Kenjeran LPA at the end of the 1992, though KMS hopes to continue the landfill operation.

(4) Access Roads

Since the condition of access road to the Lakarsantri is awfully bad with many holes, the vehicles subject to serious damages in spite of careful drive along the road. In Keputih, the west side road is so muddy that garbage vehicles are sometimes stuck their tire in the mud. These road condition affect the efficiency of cleansing service very much.

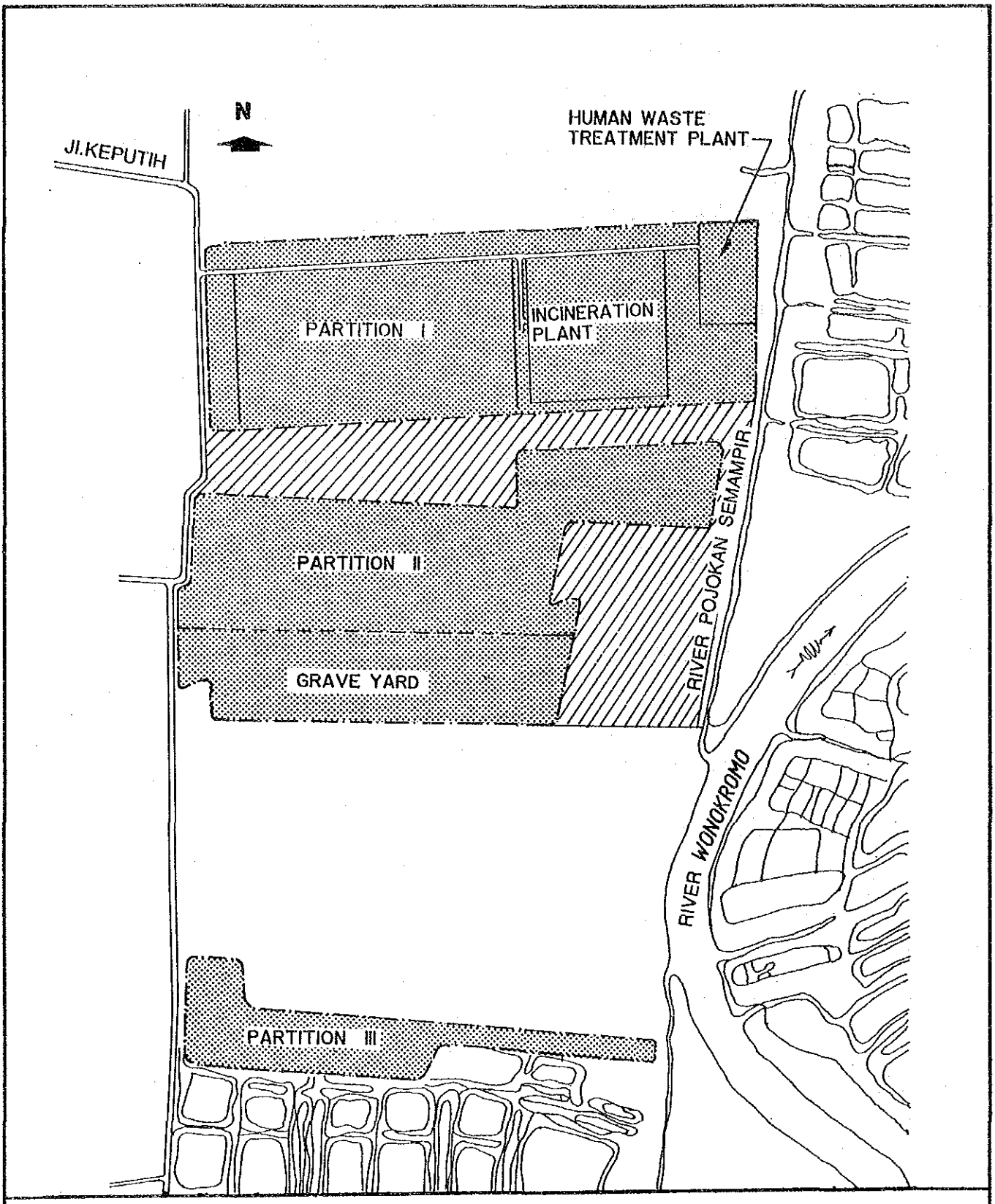


FIG. 2.9-4 THE PLANNING LANDFILL SITE OF KEPUTIH FINAL DISPOSAL SITE

2.10 Vehicles Maintenance and Repair

2.10.1 General

The Cleansing Department has a place in Asemrowo that is used as a workshop for vehicle maintenance and repair, car parking, and storage area for containers, handcarts and abandoned vehicles. The total area is about 1 ha.

The Workshop sub-section of the Haulage Section of the Cleansing Department is responsible for the management and operation of this place. There are about 39 employees involved in the vehicle maintenance as shown below:

Table 2.10-1 Personnel Involved in Vehicle Maintenance and Repair

Type of Job	Number of Employers
- Workshop Chief mechanic:	1
- Mechanic section (5 group)	16
- Tire man:	2
- Paint	1
- Accessory section	2
- Crease man	1
- Container maintenance	6
- Container repair	2
- Welding	3
- Heavy equipment	2
- Administration	2
Total	39

In addition, Haulage Section has the following two sub-sections:

- Operation sub-section (Drivers assistants supervisors belong to this sub-section)
- Warehouse sub-section

2.10.2 Current Maintenance Conditions

1) Current Practice

Maintenance services such as changes of engine oil and filter are made once every 7,000 - 10,000 Km of the vehicle running which happen to be once very 5,000 Km according to the manufactures' guideline. There is no plans for systematic repair and maintenance services.

2) Current Problems

The current problems may be summarized as follows:

a. Lack of regularity and planning in the vehicle maintenance and repair

b. Lack of priority to the maintenance which results in inadequate fund and poor spare parts procurement.

c. Existence of many abandoned vehicles (37) in the Workshop area, which causes obstacles to the in-site traffic.

3) Operation and Maintenance Expenditures

The Cleansing Department spent about Rp 790,500,000 for the vehicles operation and maintenance in the fiscal year 1991/92, of which two thirds were used for fuel and oil while the remaining one third only were used for the maintenance and repair.

Table 2.10-2 1991/1992 Expenditures for Maintenance and Repair

Item	Amount	Percent
1. Fuel	Rp. 476,200,000	60.2%
2. Oil	Rp. 47,732,000	6.0%
3. Tire & Battery	Rp. 91,658,000	11.6%
4. Other spare parts	Rp. 104,900,000	13.3%
5. Others	Rp. 65,010,000	8.2%
6. Tax	Rp. 5,000,000	0.6%
Total	Rp. 790,500,000	100.0%

2.11 Resource Recycling

Resource recycling discussed in this section is limited to that related to solid waste management.

2.11.1 Description of Recycling Activities

All the scavengers in Surabaya are subject to registration at the Association of Friend of Pasukan Kuning (PMPK: Paguyuban Mitra Pasukan Kuning). There are 2,700 to 3,000 registered scavengers engaged in resource recycling in Surabaya in 1991. In addition, there are some unregistered scavengers working in Depo, LPS and door to door. In 1989, the number of scavengers who were observed actually operating by the place of work are shown below.

Table 2.11-1 Number of Operating Scavengers (1989)

Place of Work	Area	Number of Scavenger		
		Male	Female	Total
	North Surabaya	159	26	185
Door to Door	East Surabaya	80	62	142
	South Surabaya	216	48	264
	Subtotal	455	136	591
	North Surabaya	105	20	125
LPS	East Surabaya	68	7	75
	South Surabaya	69	47	116
	Subtotal	242	74	316
	Kenjeran	34	42	76
LPA	Keputih	63	84	147
	Lakarsantri	62	46	108
	Subtotal	159	172	331
	Total	856	382	1,238

Source: Dinas Kebersihan

According to the interview of scavengers on site, they have the various origins of homeland. Majority of them are immigrants from neighboring cities, and out of 25 scavengers interviewed only five people were form in Surabaya, four from Lamongan and another four from Madura, so forth.

There are many dealers, shops close to Depo and LPS, where scavengers visits and sell, in cash, recyclable materials collected through door-to-door or at LPS. At the final disposal site (LPA), scavengers collect resource materials from fresh dumped waste and sort them by kinds and quality of material collected. Then some dealers come to the site to buy the packed materials once a week.

Scavenging activities at the door-to-door and LPS are usually done in the morning. Many scavengers have another job such as becak (tricycle taxi) driver. Scavengers working at the final disposal sites live beside the sites and work fully during the daytime for collection and sorting of the materials.

Another group of people involved in the scavenging activity is the garbage collectors employed by RT/RW. They collect garbage from their assigned areas and haul it to depo and LPS. Through their collection and reloading work they pick up recyclable materials out of garbage collected. Therefore they have the same function as that of the registered scavengers in view of resource recovery.

The dealers of recycled matter has a pyramid structure according to the size of dealer. Small dealers sell recyclable materials to bigger delayers after sorting and simple processing such as washing them. Bigger dealers, then, process the purchased materials in accordance with the requirement of the material blokers or the manufactures who purchase recycled materials from the dealers. Workers of the haulage contractors also do some scavenging activities.

2.11.2 Recycling Market

1) Recycling Materials

Kinds and prices of recycling materials observed in Depo/LPS and LPA are shown in Table 2.11-2. Compositions of recycling materials is shown in Table 2.11-3 and Fig. 2.11-1. The composition of materials is a bit different depending on places. For example, paper shares as much as 30% of recyclable materials in depo/LPS and door-to-door while it is not collected at all in LPA. Bones are collected only at LPA. Plastics and glass are collected at all scavenging places.

Table 2.11-2 Recycling Materials and Prices

Kind of Materials		Prices of Material Collected at LPA (Rp/Kg)	Prices of Materials Collected at Depo/LPS and Door to Door (Rp/Kg)
Paper	paper	-	25 - 60
	cardboard	-	100 - 150
Plastisc	plastisc	200 - 250	200
	rope	-	40
	bottle	-	75
Glass	glass	30 - 40	10 - 20
	aqua bottle	-	40
	Copper	2,500	-
	aluminum	600 - 1,000	-
Metal	can	30	25
	iron	75	-
	brass	1,500	-
Rubber Sole		300	-
Bone		100	-

Source hearing on site by the Study Team

- : no information

Table 2.11-3 Composition of Recycling Materials

Site Material	LPA (%)	Depo/LPS and Door to Door (%)
Plastisc	27	18
Paper	0	30
Glass	27	38
Metal	12	14
Rubber	23	0
Bone	11	0
Total	100	100

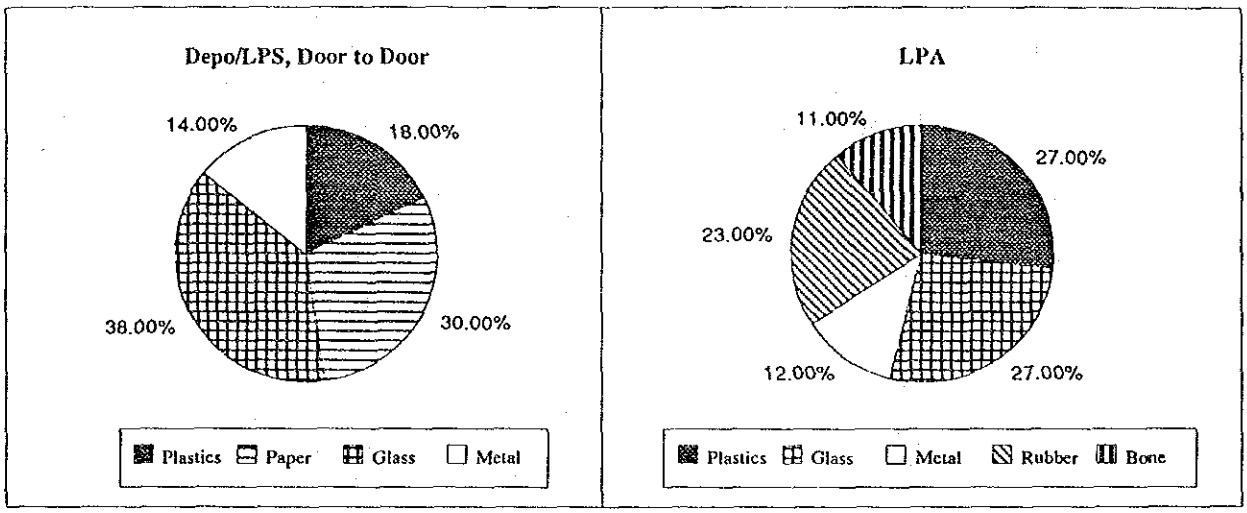


Fig. 2.11-1 Composition of Recycling Material

2) Amount Recovered

It is estimated that the total recyclable amount recovered is about 189 tons/day, which represents about 12% of the estimated total waste amount 1,626 tons/day generated in Surabaya.

The amount recovered by scavengers is estimated by the calculations shown in the note below :

Note : Estimation of the Recyclable Amount Recovered by Registered Scavengers (RAR)

RAR = a + b + c + d = 9.9 ton/day + 19.0 ton/day + 34.3 ton/day + 125.7 ton/day
= 189 ton/day

Where :

a = Daily amount recovered at LPA = 30 kg/day/scavenger x 316 scavengers working at LPA = 9.9 ton/day.

(Daily per capita collection amount 30 kg was calculated as follows : Average daily income Rp 3,000/scavenger/day divided by an average unit price of collected material Rp 100/kg).

b = Daily amount at LPS = 60 kg/day/scavenger x 316 scavengers = 19.0 ton/day.
(Daily amount at LPS = 60 kg was calculated as follows : Average daily income Rp 4,000/scavenger/day divided by an average unit price of collected material Rp 66.7/kg).

c = Daily amount recovered by door to door 34.3 ton/day kg was calculated in the same manner as described in the above item b).

d = Daily amount collected by the other scavenger = daily amount collected by scavenger (calculated as a + b + c = 63.2) x rate of other scavenger and observed operating scavenger (3,700 - 1,238) / 1,238 = 125.7 ton/day.

2.11.3 KMS Policy Regarding Scavengers

Both KMS and the Central Government have a policy to support scavengers morally, socially and economically in the short and medium term, and encourage them to change their occupation to more-socially respected ones in the longer term.

KMS has published a few reports and books regarding the present situation of and policy for the scavengers. Such publication activity indicates that KMS is very much interested in scavengers. KMS uses the word "Mitra Pasukan Kuning" or Yellow Troop Partner to refer to the scavengers. (Yellow Troop refers to street sweepers and garbage collection workers). By using this word, KMS expresses its idea that it should be considered that scavengers are involved in the solid waste management activities.

KMS has the following policies regarding scavengers:

a. To acknowledge and recognize scavengers as a socially-useful group helping KMS in the solid waste management.

   Remarks : It is expected such positive recognition will be helpful to the reduction of crimal activities that might otherwise occur.

b. To make scavengers form a Scavengers' Association in order to strengthen their status, and to facilitate the communication between the scavengers and the government.

Remarks : Such association has already been established. KMS financed the construction of the head office building of the Association.

c. To make the relationship between the scavengers and the yellow troop (sweepers and garbage collection workers) closer and friendlier to facilitate the cooperation between them for better and efficient job results.

Remarks : KMS hosted some gatherings and events for this and other purposes.

d. To guide the scavengers to change the job in the future, and guide also their children not to follow their parents' job.

Reamrks : Bandung and Jakarta municipal governments in cooperation with GTZ conducted a project to find the best guidance to them.

JICA study Team considers that these policies are very good policies. It seems that KMS been implementing these policies successfully.

CHAPTER 3.

COLLECTION, HAULAGE PLAN AND STREET WEEPING

CHAPTER 3 PLAN FOR COLLECTION, HAULAGE, AND STREET SWEEPING

3.1 Policy and Target

3.1.1 Waste Collection

1) Collection Policy

Surabaya has attained the top level cleanliness among the cities in Indonesia. Hence, the city was awarded with Adipula 5 times so far. The citizens' awareness of the importance of the cleanliness is very high. And, both RT (neighborhood units) and RW (community units) perform important roles in the city cleanliness in Surabaya.

In Surabaya, RW/RW are responsible for the waste collection. Because their collection system works very well, there is no reason to change it. It should be maintained in view of the following advantages:

(1) People can choose level of collection service suitable to their needs and financial capacity.

(2) Beneficiary Pay Principle (BPP) can be best realized.

(3) The local people can supervise waste activities of collection workers.

(4) In addition, it is easy for RT/RW to cope with increases in waste discharge volume, for example, by increasing the number of Pasukan Kuning, handcarts, etc.

(5) Waste collection services of RT/RW create the employment opportunity for many people.

The current collection responsibility system should be maintained provided that the socio-economic conditions would remain unchanged. However, they might change in a remote future. If so, it might be difficult for RT/RW to continue to be responsible directly for waste collection, and it might be more suitable for KMS to take over the collection responsibility of RT/RW. Potential changes in the socio-economic conditions may include the following:

- Owing to the upgrading of the economic standard, it might become more economical in the future to use capital intensive collection systems (trucks) than using the current labor intensive system. The operation and maintenance of the collection trucks require professional skills which may be difficult for local and neighborhood communities (RT/RW) to secure.
- It might be increasingly difficult for RT/RW to recruit collection workers in the future.

In this sense, it is necessary for KMS to be sensitive to the future changes in socio-economic conditions that may affect the current collection responsibility system.

2) Collection Target

At present, 85 % of the waste generated in Surabaya is either collected or recycled. The remaining 15 % is neither collected nor recycled. A portion of this kind of waste is used to feed animals, which is not considered to be a problem. The remaining portion of this type of waste may be dumped at backyards of houses or seashore, which may pollute the environment.

Target Collection Coverage

It is proposed that waste collection service by RT/RW should increase so that waste neither collected nor recycled should be reduced to 5 % of the total generation amount from the current 15 % by the year 2010.

3) Measures to Achieve the Targets

In order to achieve the waste collection target (increase of collection coverage) as proposed in the previous item, the following actions will be required:

1. KMS should provide Depo or LPS or small containers wherever needed.

2. KMS should discourage citizens' use of concrete bins, and encourage use of plastic bins or other bins in view of the following:

Disadvantages of the Use of Concrete Bins

a. It takes a long time for waste collection workers to take waste out of concrete bins.

b. Concrete bins are not sanitary. They are small open dumping sites. They sometimes serve as breeding beds of mice.

Advantages of the Use of Plastic Bins

a. It is easy for waste collection workers to empty plastic bins as they are movable and can be lifted up easily.

b. Use of plastic bins is more sanitary than the use of concrete bins.

c. Use of plastic bins with covers can prevents bad smell from diffusing.

d. Plastic bins are more beautiful than concrete bins.

In Bandung, the use of concrete bins has already been prohibited. In Surabaya, there are some RT such as Kel Kalirungkut RT III/ RW I which use plastic bins. People who use concrete bins are mainly high-income residents. It would not be difficult for them to purchase plastic bins.

3.1.2 Waste Haulage

1) Hualage Policy

KMS should haul all waste collected by RW/RT. The currently generated annual average waste is divided into the following categories:

1. Collected by RT/RW and hauled by KMS	889 ton/day (55%)
2. Collected and transported by generators	137 ton/day (8%)
3. Collected by RT/RW but disposed at unidentified places	171 ton/day (11%)
4. Recycled	180 ton/day (11%)
5. Not Collected	249 ton/day (15%)
Total	1,626 ton/day (100%)

Of the above-classified waste, KMS should pay attention to the third type of waste, 171 ton/day (collected by RT/RW but disposed at unidentified places). It is considered that most of this type of waste could be hauled and disposed if KMS provided Depo or LPS or small containers.

It is considered that the fifth type of waste, i.e., "not collected" (249 ton/day) can be divided into two: 1) waste used to feed for domestic animals or compost, and 2) waste dumped at the backyards of houses or seashore. The former type of waste does not cause problems, while the latter type of waste pollute the environment.

As a conclusion, it is proposed that KMS will increase its haulage capacity so that it will haul all waste collected by RT/RW without exception.

According to KMS and the JICA Study, the present haulage coverage level is 79 % in terms of population. 21 % does not receive the haulage service. It is proposed that KMS should provide waste haulage service for 90 % of the people by the year 2010.

The proposed responsibility system for waste collection and haulage is shown in Fig. 3.1-1.

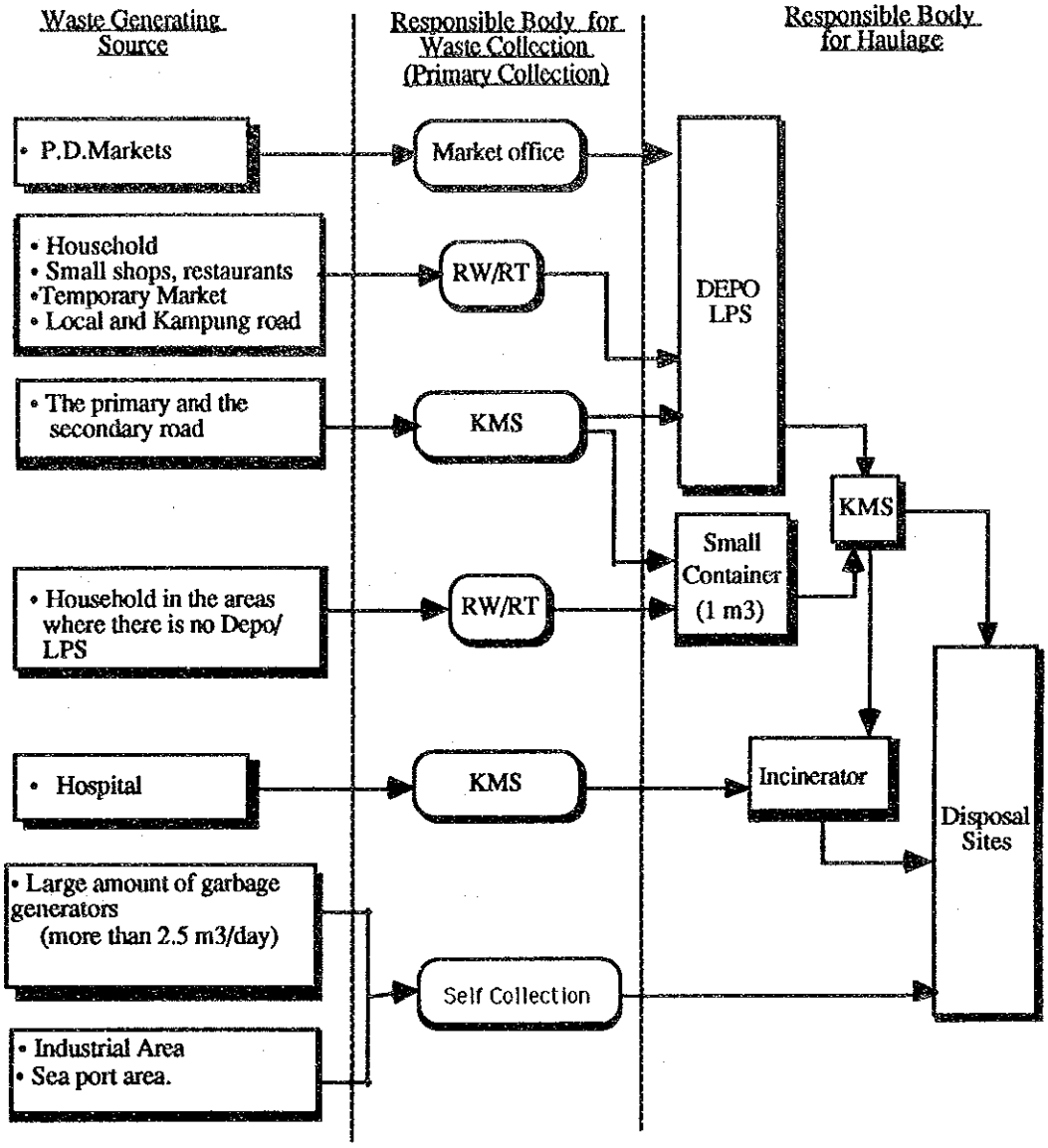


Fig. 3.1-1 Recommended Waste Flows and Responsible Bodies for Collection and Haulage

2) Target Service Level

As explained in the chapter 4 of Master Plan, it is assumed that the waste generation amount will increase by 5 % each year considering the past economic growth and population increases.

The prime target of KMS' haulage service is that KMS should haul all waste collected by RT/RW. It is proposed that KMS should increase its haulage service so that waste neither hauled nor recycled will be reduced to 5 % of the waste generation amount by the year 2010 from the current 26 %.

Note: The current 26 % (percentage of waste neither hauled nor recycled) derives from the following calculation: (a+b)/c
where,
a: waste not collected 249 ton/day (15 %),
b: waste collected but dumped at unidentified places 171 ton/day (11 %),
c: total waste generated 1,626 ton/day (100 %)

As a short term target, it is proposed that KMS should haul all waste that is currently collected by RT/RW but dumped at unidentified places (171 ton/day in 1992). It is also proposed that RT/RW will increase its collection capacity so as to reduce the percentage of waste uncollected (249ton/day or 15 % in 1992). With the increases in collection amounts, demand for haulage service will increase accordingly.

Table 3.1-1 shows KMS' target haulage amounts by the year 2010. KMS' target haulage amount will be 1,312 ton/day in 2000, and 2,313 ton/day in 2010, which are 1.5 times and 2.6 times lareger respectively than the curent haulage amount of 889 ton/day.

Table 3.1-1 KMS' Target Haulage Amounts

(ton/day)

Year	Waste to be Gene-rated	Waste That May not be Colle-cted	To gbe Recycled before being hauled to LPA	To be Collected by RT/RW but Disposed at Unidenti-fied Places	To be Collected and Hauled by Waste Generators	To be Hauled under KMS' Respon-sibility	To be Hauled by KMS' Trucks	To be Hauled by KMS' Cont-ractows
	(1)	(2)	(3)	(4)	(5)	(6)=(1)-(2)-(3)-(4)-(5)	(7)	(8)=(6)-(7)
1992	1,626	249	180	171	137	889	621	268
1993	1,707	246	188	146	202	925	621	304
1994	1,793	243	197	121	267	965	621	344
1995	1,882	240	207	96	332	1,007	621	386
1996	1,976	237	217	71	397	1,054	621	433
1997	2,075	234	228	46	462	1,105	621	484
1998	2,179	231	240	21	527	1,160	621	539
1999	2,288	228	252	0	572	1,236	621	615
2000	2,402	225	264	0	601	1,312	621	691
2001	2,522	222	277	0	631	1,392	621	771
2002	2,649	219	291	0	662	1,477	621	856
2003	2,781	216	306	0	695	1,564	621	943
2004	2,920	213	321	0	730	1,656	621	1,035
2005	3,066	210	337	0	767	1,752	621	1,131
2006	3,219	207	354	0	805	1,853	621	1,232
2007	3,380	204	372	0	845	1,959	621	1,338
2008	3,549	201	390	0	887	2,071	621	1,450
2009	3,727	198	410	0	932	2,187	621	1,566
2010	3,913	195	430	0	978	2,310	621	1,689

3) Measures to Achieve Haulage Targets

KMS should take the following measures in order to achieve the master plan targets as proposed in the previous section:

a. Provide new Depo or LPS needed, (This is the condition for increasing waste collection service as well.) and rehabilitate or improve the existing depo and LPS.

b. Provide small containers (1 m^3) in areas where it is difficult to place Depo or LPS.

c. Select and use most cost effective trucks and containers, and purchase required number of trucks.

For the collection of waste from Depo and LPS, the following types of containers and trucks are recommended:

- 14 m^3 containers with 14 GVW chassie
- 8 m^3 containers with 7 GVW chassie

d. To increase the use of contractors from the present level of involvement (30%) to 73% in 2010, while KMS keep the waste amount to be hauled by KMS' own trucks at a constant level of 621 ton/day same as to 1992 level throughout the Master Plan period.

e. To make necessary arrangements to make it compulsory for generators of large waste amount (over 2.5 m^3/day) to haul waste by themselves.

3.2 Equipment and Operation Systems for Haulage

3.2.1 Type and Capacity of Equipment Recommended

1) Arm-Roll Trucks and Compactor Trucks

Arm-roll trucks and compactor trucks are two major types of trucks currently used by KMS. The former type of truck hauls waste-filled-containers from Depo or LPS, while the latter type of truck collects waste from small containers placed on the roadsides. These two system are considered effective, and should continue in the future.

However, it is proposed that KMS will purchase only arm-roll trucks, and none of compactor trucks on the base of agreed policy that KMS will use contractors for haulage of waste from small containers in view of the expected cost advantage of using contractors for this purpose.

2) Types and Capacity of Containers and Arm-Roll Trucks

The recommended types and capacity of containers and arm-roll trucks are as follows:

a. Containers

a. 8 m^3 containers (closed type)
b. 14 m^3 containers (closed type)

Note: Open type containers are suitable for markets in view of ease of waste loading work. .

b. Trucks (Chassis)

a. 7 GVW chassis with single rear axle for 8m^3 containers
b. 14 GVW chassis with single rear axle for 14 m^3 containers

3.2.2 Reasons for Recommendations

The particular capacity of the containers (8 m3 and 14 m3) are selected based on the following conditions and factors:

1. Capacity of the recommended chassis (7 GVW and 14 GVW) that have been chosen based upon operational reliability)

2. Road regulation that restricts dimensions of trucks and freight (Maximum dimensions of trucks including freight) are as follows:

   Height: 3.5m
   Width: 2.5m
   Length: 9.0m

3. Cost-effectiveness

4. Sizes of and access to the existing Depo and LPS

1) Reliability of Operation

In Indonesia, two types of chassie are available for waste collection, i.e., 7 GVW and 14 GVW. In addition, there is an idea to modify a 7 GVW to 10 GVW by using two rear axles. The appropriate container size for each type of truck is shown below.

Table 3.2-1 Estimated Appropriate Container Capacity by Truck

		7 GVW with Single rear axle	10 GVW Uprated from 7 GVW with Two rear axle	14 GVW with Single rear axle
Weight of Chassie & Equipment (1)		2.7 t	3.5 t	5.0 t
Weight of empty container (2)		0.9 t	1.3 t	1.5 t
Dead Weight (3) = (1) + (2)		3.6 t	4.8 t	6.5 t
Maximum Pay Load (4) = GVW - (3)		3.4 t	5.2 t	7.5 t
Container Dimension (5)				
(Inside)	L	3.6 m	4.2 m	4.5 m
	W	1.9 m	2.1 m	2.1 m
	H	1.2 m	1.4 m	1.5 m
Appropriate container capacity (6)		8 m^3	12 m^3	14 m^3
Maximum Waste Amount per Container (7)=(6)x0.367		2.9 t	4.4 t	5.1 t

Note 1. For the estimation of the body capacity, the waste bulk density 0.367 is used based on the JICA study conducted in rainy season.

Note 2. It is assumed that the two rear axle truck including arm-roll will be 30% heavier than a single rear axle truck.

Note 3. Container dimension is decided by the road regulations and safety operation ; a truck will be tumbled if the center of gravity is too high due to the high container.

It is anticipated the use of 10 GVW truck modified from 7 GVW with two rear axle will have the following problems :

a. There is no guarantee that the uprated 10 GVW truck satisficactorily performs its function. The local manufactures have never modified a 7 GVW truck to a 10 GVW by using two rear axle.

b. Troubles may occur to a driving system such as an engine, a transmission, a clutch due to augment payload.

c. There is a question to the strength of a chassie because basic design of 7 GVW truck itself is not changed although GVW is increased to 10 ton.

Thus, the reliability of 10 GVW (uprated from 7 GVW) is so uncertain. In addition, the durability may be short, and the maintenance cost may increase. Without constructing a prototype of 10 GVW truck and making sure the reliability of operation, 10 GVW trucks cannot be recommended.

The IUIDP Solid Waste Sector Report recommended 10 GVW chassis uprated from 7 GVW by providing 1 additional rear axle in view of its low cost. However, the current study cannot recommend the 10 GVW chassis uprated from 7 GVW chassis due to the reasons shown below unless KMS produces a prototype, and verifies its operational reliability through the test operation.

a. There is no guarantee that the uprated 10 GVW chassis satisfactorily performs its function. The local manufacturers in Surabaya have never modified a 7 GVW chassis to a 10 GVW chassis.

b. Troubles may occur to brake system and driving system such as engine, transmission, clutch due to the augmented payload because they remain unchanged.

c. There is uncertainty as to durability. Durability may become shorter than regular chassis. In addition, it may require higher maintenance costs than regular chassis.

2) Road Regulations

The relevant road regulations are summarized below :

(1) Maximum loading limit is 8,000 kg/axle. (KM. 461/AJ. 403/Phb-62)

(2) Maximum total length of freight truck is 9 m.
(Section 2, Sub-section 1, KM 7/AJ 005/Phb-84)

(3) Maximum length of the rear overhang is 0.625 x wheel base.
(Section 4, Sub-section 1, KM 7/AJ 005/Phb-84)

(4) For a truck which has three axles or more, maximum length of rear overhang 0.475 x wheel base.
(Section 4, Sub-section 3, KM 7/AJ 005/Phb-84)

(5) Maximum width and the height of a vehicle including load is 2.5 m and 3.5 m respectively. (Section 31, Sub-section a, b, and of PPL (Peraturan Pemerintah Lalu-Lintas))

(6) Maximum exceeding length of load on the truck :
- At the back : 2 m.
- In the front : not exceeding front glass

(Section 4, Sub-section 3, KM. 7/AJ 005/Phb-84)

(7) For a vehicle which is used for special purposes, the maximum limits issued in this decree can be changed after the written agreement of the communication minister is obtained.
(Section 4, KM 7/AJ 005/Phb-84)

3) Cost of Arm-Roll Truck

The unit haulage cost per ton of waste by type of Arm-Roll truck is shown in Table 3.2-2. In view of the unit cost comparison, 14 m^3 container truck using 14 GVW truck is the most cost-effective, followed by 12 m^3 container truck of 14 GVW and 8 m^3 container truck of 7 GVW.

Table 3.2-2 Unit Cost of Arm-Roll Trucks and Containers per Ton of Waste Hauled

Size of Container	Truck Purchase Price	Cost of Containers Needed per Truck			Total Cost	Wate Amount Hauled by a Truck/day	Unit Haulage Cost per Ton
		Units	Unit Price	Cost			
	(1)	(2)	(3)	(4)=(2)x(3)	(5)=(1)+(4)	(6)	(7)=(5)/(6)
6 m^3	50,000,000	6	5,000,000	30,000,000	80,000,000	10.8 ton	7,407,000
10 m^3	81,300,000	6	5,500,000	33,000,000	114,300,000	18.0 ton	6,350,000
12 m^3	81,300,000	6	6,000,000	36,000,000	117,300,000	21.6 ton	5,431,000
14 m^3	58,300,000	6	6,250,000	37,500,000	95,800,000	25.2 ton	3,802,000

Note: Wate amount hauled by a truck/day =
(Size of container) x (unit number (6)) x (bulk density 0.3)

2) Compactor Trucks Serving for Small Containers

It is planned that the future waste haulage service with compactor trucks and small containers will be contracted out to contractors. Therefore, KMS will not purchase compactor tracks serving for small containers.

It is advised that KMS will either sell or lease the existing REL compactor trucks to contractors by 1995 if they are still usable.

It is expected that contractors will choose the most cost-effective type of trucks. The JICA Study Team recommend 14 m^3 REL trucks so far due to the reason shown in Appendix of the report.

3.2.3 Working Shift

The trucks and containers procurement plan is prepared based upon 1 shift working system due to the following reasons:

1) Although the cost of haulage with two working shift is lower than that with one shift, the difference is not so large (about 10%).

2) Night shift work may cause the following problems:

   a. Safety problem

b. Operational problem
c. Noise and other environmental problems to the residents

3) Responsibility problem may occur if some damages occurred to a truck that are operated by two drivers on two working shifts (one responsible for operation during day time, the other during night time)

3.2.4 Use of the Contractors

At present, KMS and its contractors hauls 889 ton/day, 55 % of the total waste generation amount in 1992, of which 621 ton/day, 70 % of the said 889 ton/day is hauled by using KMS' own trucks, the remaining 30 % is hauled by KMS' contractors.

KMS agreed to keep the waste amount to be hauled by KMS' own trucks at a constant level of 621 ton/day same as the 1992 level throughout the Master Plan period till 2010, and all the remaining waste to be hauled under KMS' responsibility should be hauled by KMS' contractors.

As a result of implementing the above policy, waste amount to be hauled by contractors will increase. Increasing use of contractors is rational and advisable as it will bring about great cost saving for KMS.

Target waste amount to be hauled by KMS' contractors is 386 ton/day (38%) in 1995, 691 ton/day (53%) in 2000, and 1,689 ton/day (73%) in 2010.

In order to achieve the above target, KMS should make the following arrangements:

Arrangements to be Made by KMS for Successful and Increasing Use of Contractors

1. Longer contract - at least one year
2. Increases of the contract prices to a level enough to attract more contractors
3. Use of actual tonnage base (Rp/ton), instead of volume base (Rp/m3) in order to give incentives to contractors to haul more waste. (For this purpose, KMS needs to purchase truck scales to be placed at entrances of LPA.)
4. Sales or lease of KMS' used trucks (arm-roll trucks and compactor trucks) and containers to contractors if they accept.

3.2.5 New Depo/LPS Construction plan

1) Possible New Depo/Lps Construction Site

KMS has the following criteria to construct Depo/LPS: 1 Depo is needed for a Kelurahan with population 20,000-30,000, and at least 1 Depo and 1 LPS should be constructed if the population of Kelurahan is more than 30,000.

In order to achieve the target that KMS should expand its haulage service to include waste which is collected by RW/RT but dumped at undesignated places, the following 16 Kelurahan need haulage service in the future.

Table 3.2-3 Kelurahan with No Haulage Service

	Kecamatan	Kelurahan	Present Population	Estimated Population in 2010
1	Kenjeran	Kedung Cowek	3,600	4,700
2		Tambak Wedi	2,300	3,000
3		Sukolilo	4,200	5,500
4	Sukolilo	Kej. Putih Tambak	2,900	4,000
5	Rungkut	Gunung Anyar	8,000	11,900
6		Wonorejo	3,300	4,800
7	Wonocolo	Dukuh Mananggal	8,100	10,400
8	Tandes	Asemrowo	17,800	24,400
9		Buntaran	1,300	1,800
10		Tubanan	3,500	4,700
11	Benowo	Benowo	4,500	5,600
12		Klakah Rejo	3,000	3,700
13		Kandangan	2,700	3,400
14	Lakarsantri	Bangkingan	4,500	5,900
15		Sumur Welut	2,800	3,600
16		Sambi Kerep	10,450	13,700

Among 16 Kelurahan, only Asemrowo will be entitled to construct Depo if the KMS policy is applied. There is no rational reason that only Kelurahan of which population is over 20,000 can construct Depo.

The construction of Depo is going to be difficult in the future. Therefore, if the land for Depo is available at present, the land should be acquired. Acquired land will be asset to KMS.

Fig 3.2-1 shows the locations of proposed Depo/LPS sites that have been confirmed by the chief of Kelurahan through the interviews conducted by KMS and P.T. Indulexco. 43 Depo and 11 LPS should be constructed in the near future.

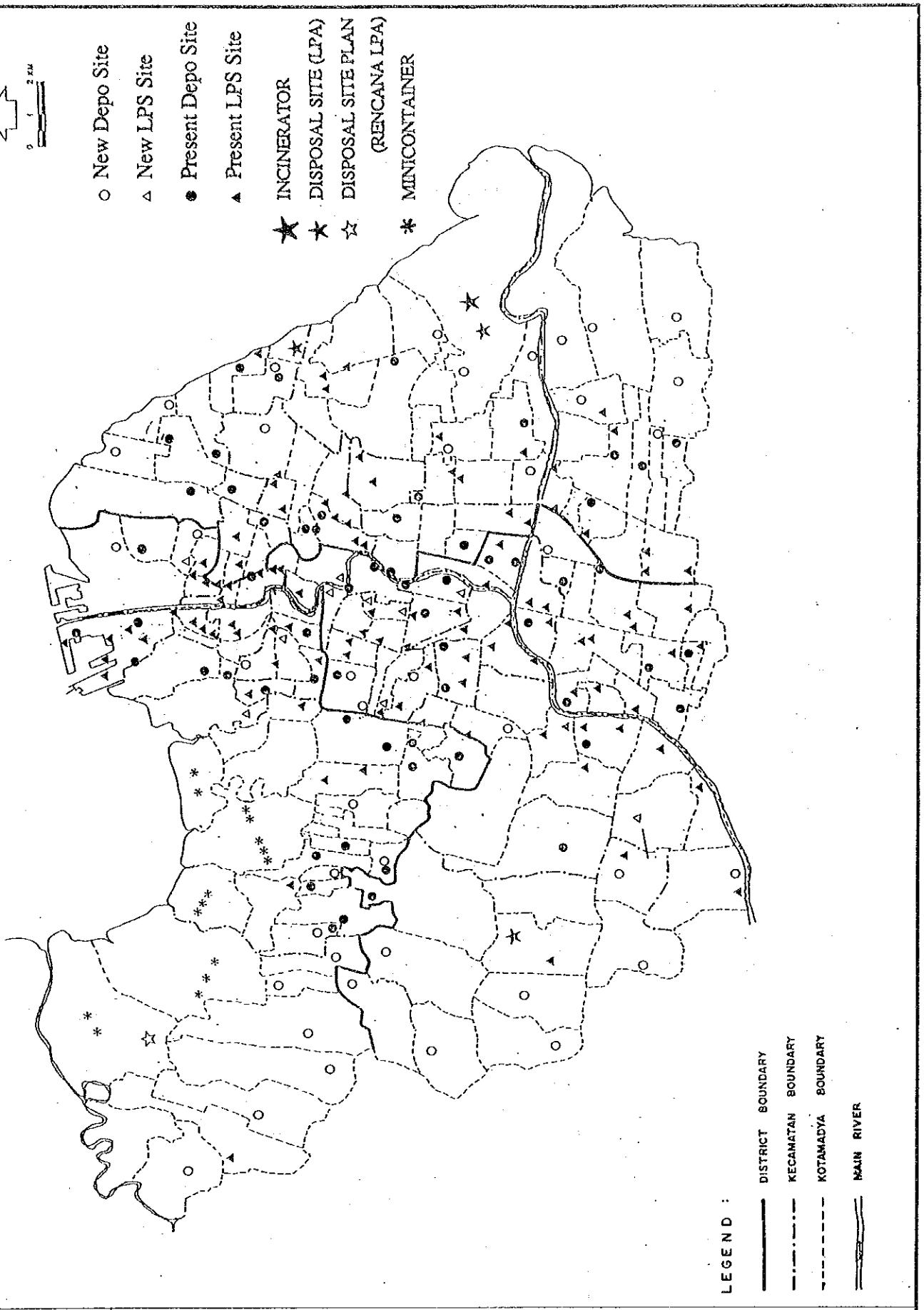


FIG. 3.2-1 PROPOSED NEW DEPO/LPS CONSTRUCTION

THE STUDY ON THE SOLID WASTE MANAGEMENT IMPROVEMENT FOR SURABAYA CITY

2) Problems with Depo/LPS and Proposed Countermeasures

There are two major problems with Depo/LPS: smell and ugliness of site, especially bad smell from the Depo/LPS makes it difficult for residents to accept Depo/LPS. To mitigate the problems, the following measures are recommended.

a. Countermeasures against Smell

The following is proposed as countermeasures against bad smell of Depo/LPS:

- To provide water supply to clean the floor after finishing the haulage.
- To coordinate the waste collection time to meet with the garbage truck arrival.
- To close lids of containers and,
- To construct drainage in LPS as well as Depo

b. Countermeasure to Ugly Site

The following is proposed as a countermeasure to ugly site.

- To plant trees around Depo.

3) Rehabilitation of the Existing Depo/LPS

a. Necessary Rehabilitation for Depo/LPS

Based upon the Depo/LPS survey conducted by the JICA Study Team in May 1992, it was identified that 30 Depo and 34 LPS need rehabilitation.

The following Depo and LPS need rehabilitation :

(1) Depo/LPS with damaged walls.
(2) Depo with damaged office building : (wall damage, leak in the roof, lack of furnitures, etc)
(3) Depo with damaged drainage
(4) Depo with damaged gate
(5) Depo/LPS with damaged floor
(6) Depo/LPS with damaged water pipe and electricity equipment.
(7) Depo/LPS that need enlargement of entrance for trucks

(8) LPS that need expansion
(9) Depo/LPS with no or insufficient plants

As for Item (9) tree planting, it is estimated that about 90% of the existing Depo and LPS need tree planting. It is advised that KMS should identify exact Depo and LPS that ned tree planting, and select suitable types of trees.

3.3 Street Sweeping Plan

3.3.1 Basic Policy

Without having dismissal or lay-off of sweeping workers, the efficiency of road sweeping should be improved. All the primary and the secondary roads should be provided with sweeping service by 2000 as follows:

- Total road length(the primary roads + the secondary roads)	300,383 m
- The present sweeping service coverage	282,383 m (94%)
- The roads not provided sweeping service	18,000 m (6 %)
- New roads planned to be constructed by 1997	34,000 m

As KMS plans to construct new roads in the future, some road sweepers can be transferred to new roads. The number of new employment of workers should be stopped. Instead, more contractors should be used to expand the sweeping service within the KMS' budget.

Types of roads to be swept by KMS should be the same as the present streets; the primary and the secondary roads should be swept by KMS and contractors under the supervision of KMS, and the local and Kampung roads by RT/RW.

3.3.2 Sweeping Plan

1) Sweeping Work Assignment

a. Sweeping Length, Frequency and Time

The difference between waste collected from streets and other waste is that the quality of street waste is mainly leaves and sands and quantity is very little. Because of the quality and quantity of street wastes, nobody will be harmed even waste is not collected for a day or so, for example. Therefore, street waste is very different from waste generated from households and hospitals which make troubles such as bad smell and breeding bed for fry and mice.

It is very difficult to understand the necessity of road sweeping at night time. Nobody pays attention to litter waste on the street at night. It is quite possible to reduce the collection frequency. To provide all the primary and the secondary roads with

sweeping service is more important in view of fairness than providing frequent service for selected streets.

The present street sweeping is inefficient; road sweeping distance per person or per team is so different without reasonable reasons. Minimum road sweeping length should be decided as 750m/side/group/day, and collect waste from both sides of road.

It is desirable that the road sweeping should be done either before or after traffic jam time.

b. Composition of a Sweeping Team

It is proposed that a typical sweeping team should have the following composition.

(1) Sweeping of the primary roads
- 3 Sweepers with broom
- 2 for pulling a handcart and waste collection

(2) Sweeping of the secondary roads:
- 2 Sweepers
- 2 for pulling a handcart and waste collection

2) Mechanical Road Sweepers

It does not any sense that three mechanical road sweepers sweep the roads sweeping workers sweepers can sweep cheaper and better than the mechanical sweepers. Operation and maintenance cost for three mechanical road sweepers are so expensive. It is estimated that Rp 37 million is spent for annual operation and maintenance cost for three mechanical road sweepers. Therefore, three mechanical road sweepers should be leased to Dinas Marga which will be responsible for highway sweeping from 1994.

Note:		
	Repair and maintenance	7 million x 3
	annual road tax	0.25 million x 3
	2 % insurance	0.5 million x 3
	Fuel	2.7 million x 3
	Labor cost	1.84 million x 3
	Total Operation and Maintenance	12.29 million x 3 = 36.87 million

3) Use of Contractors

As studied in Section 2.7 the use of contractors is the most cost-effective way for street sweeping. The number of contractors should be increased.

4) Conclusion

The most important thing for KMS is to increase the use of sweeping contractors because the increasing use of contractors will enable KMS to lower the total sweeping costs substantially while providing sweeping services for all the primary and secondary roads.

CHAPTER 4

TREATMENT AND DISPOSAL PLAN

CHAPTER 4. TREATMENT AND DISPOSAL PLAN

4.1 Estimated Cost Comparison of Disposal Method

4.1.1 Sanitary Landfill

1) Land Acquisition Cost for Sanitary landfill

According to the Decree No. 101 Mayor of Surabaya Municipal government, 1991, the basic price of land is determined as the basis of the tax assessment as follows:

Table 4.1-1 Official Land Price for Open Area

Type	Class	Land Price (Rp/m^2)
Rice Field	1	23,000 to 41,000
	2	12,000 to 23,000
	3	2,000 to 12,000
Dry Cultivation	1	17,000 to 31,000
	2	8,400 to 17,000
	3	2,000 to 8,400
Pond	1	12,000 to 23,000
	2	8,400 to 12,000
	3	2,000 to 8,400

The candidate landfill site is mainly used as fish pond or salt farm and is now operated normally. Then the unit price for land acquisition is suitably presumed at the highest class of pond, namely Rp23,000 per m^2 for both candidate sites, namely Kecamatan Benowo and Kecamatan Sukolilo/Rungkut.

In proposed sanitary landfill site, it is assumed that 70% of the land can be utilized for substantial reclamation area, where the solid waste is piled up with the height of 10m.

Therefore, the land acquisition cost by unit waste volume can be calculated as follows:

Unit land Cost = Rp23,000/(0.7 x 10) = Rp3,300/m^3

2) Construction Cost for Sanitary Landfill

The land availability of disposal site is assumed at 70% in the cost calculation. The assumption is based on the information taken from the other operating facilities as shown in Table 4.1-2. The sampled sanitary landfill sites satisfy the condition: the size is bigger than 1ha and the expected lifetime is below 15 year. The average utilized rate of these samples is 66%. however, it is possible to adopt bigger rate in this study because the candidate site is far bigger than that of samples. The bigger size of disposal site enables to take an economic scale into consideration.

Table 4.1-2 Sample of Sanitary Landfill Site

Name	City/State	Area Utilized			Topography
		A Total (ha)	B Landfill (ha)	Rate A/B (%)	
Grenjeng	Cirebon	5.4	3.6	67	hilly
Sukamiskin	Bandung	3.6	2.1	58	hilly
Kosigaya	Japan	1.8	0.9	67	plane
Misato	Japan	1.2	0.9	75	plane
Yasio	Japan	1.4		64	plane
Average				66%	

At the same time, the final height of waste layer is assumed at 10m because it is already adopted at the existing disposal site of Lakarsantri where the waste layer has been kept stable so far with that height even in a hilly and inclined site. The final height will be formed under the effect of the ground subsidence by the load of solid waste. The amount of subsidence is estimated about three (3) meter in the final condition of settlement, therefore the height of original waste layer can be set three (3) meter higher than the final state, namely the capacity can be calculated according to the height of 13 m.

To calculate the unit construction cost, a piece of landfill site is assumed in an flat area under a similar condition to the coastal area of Surabaya city. The size of the site is assumed at ten (10) ha with an oblong shape as shown in Fig. 4.1-1. The total volume of landfill is estimated at about 767,000 m^3. The quantity of the construction cost is summarized at about Rp3.6 billion as shown in Table 4.1-3.

Table 4.1-3 Construction Cost Estimates for an Assumed Sanitary Landfill

Works & Material	Quantity	Unit	Unit Price (Rp)	Sum (Rp million)	Remarks
1. Excavation	37,700	m^3	5,600	211	B
2. Banking	154,700	m^3	5,600	866	B
3. Soil haulage	37,700	m^3	4,760	179	A (haulage distance 250 m)
4. Clay lining	36,500	m^2	14,000	511	B
5. Clay	3,650	m^3	8,400	30	B
6. Sand foundation	2,680	m^3	6,860	18	A
7. Sand	2,680	m^3	12,000	32	A
8. Drain pipe installation	12,200	m	5,250	64	B
9. Cobble foundation	15,940	m^3	15,420	245	A
10. Gas vent	312	m^3	15,420	4	A
11. Pump	2	set	16,000,000	3	B
12. Crushed stone	16,212	m^3	20,900	338	A
13. Paving	7,724	m^2	21,000	162	B
14. Soil material	117,000	m^3	5,000	585	A
Subtotal				3,277	
Auxiliary works				328	
Total				3,605	

Note : A means the unit price is quoted from the "Unit Price List of Wage and Material 1992/1993" issued by Local Public Works Department, KSM.

: B means the unit price is set by hearing of the private contractors.

The unit construction cost is presented by dividing the total cost for the assumed sanitary landfill by its expected capacity as follows:

Unit Construction Cost = Rp 3,605 million/767,000 m^3= Rp 4,700/m^3

Besides this cost, the supposed location of landfill site has a very soft surface soil, therefore it is required to adapt some reinforcement to the surface soil and its cost. The cost for surface soil reinforcement is estimated at about 69% of the above unit construction cost. Consequently the modified unit cost is calculated as follows:

Unit Construction Cost (modified) = Rp 4,700/m^3 x 1.69 = Rp 7,930/m^3

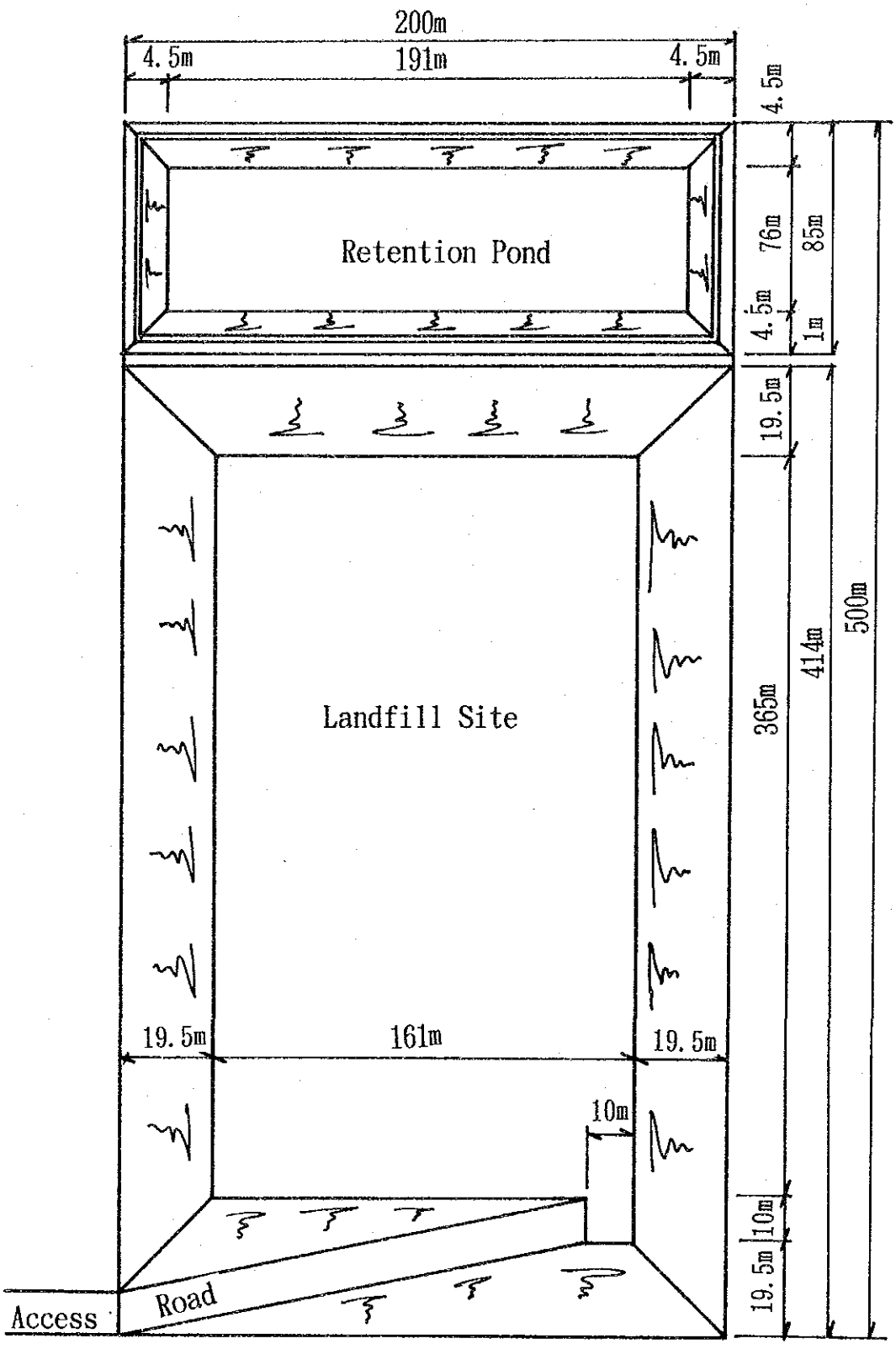


FIG. 4.1-1 ASSUMED STRUCTURE OF SANITARY LANDFILL

THE STUDY ON THE SOLID WASTE MANAGEMENT IMPROVEMENT FOR SURABAYA CITY

3) Operation Cost

According to Sub-section 2.9.6 , the unit operation cost of sanitary landfill is estimated at 3,330 Rp/m^3. Additionally, the cover soil cost should be considered with 10% of settled waste volume, namely 0.1 m^3/m^3 (waste). Unit price of cover soil is estimated at Rp7,000/m^3, therefore the unit cost of cover soil and the total operation cost can be calculated as follows :

Unit cover soil cost = Rp5,000/m^3 x 0.2m^3/m^3 = Rp1,000/m^3
Unit operation cost = Rp(3,330 + 1,000) /m^3 = Rp4,330/m^3

4) Land Value Created

After completion of landfilling, the disposal site can be used for the other new purpose of land use in proportion to the physical and chemical settlement of waste layer. When the site has once been changed its topography from steep terrain or swampy condition to dry and flat land, the site will acquire a higher value of market price because its possibility of utilization is greatly developed : in other word, a new land value is created by reclamation.

A sample of land value creation can be found in existing Lakarsantri disposal site. The land for Lakarsantri disposal site was purchased in 1984 with the area of about 7.6 ha, and is now estimated its value same as 40 ha in Kelurahan Romo Kalisari, Kecamatan Benowo under the negotiation of land exchange between KMS and private developers. This means the value of completed landfill site of Lakarsantri is evaluated several times as much as that of original state of the land. In comparison of the present value, the rise of land price in original state can be negligible because the rise is thought to be common for both sites, Lakarsantri and Romo Kalisari. Thus the rate of area of the said two sites with equivalent value can be thought as the index of created value of land. The magnification of created value to the original land price can be calculated as follows:

Magnification = 40 ha/7.6 ha = 5.26 = 5

The new land value after completion of landfilling can be estimated by using the magnification stated above, however, it seems a bit risky to apply the value directly to the calculation of the future price. Therefore it is better to adopt the magnification of two (2) at a moderate estimate; thus the future land price can be given as follows:

Future Land Price = Present Price * Magnification (2)
(after completion of landfilling)
$= Rp3{,}300/m^3 * 2$
$= Rp6{,}600/m^3$

4.1.2 Incineration Plant and Sanitary Landfill

1) Assumption on the Size of New Incinerator

A new incinerator is assumed as a substitute of the sanitary landfill facility. The size of the new incinerator is planned to have the equivalent capacity to the imaginary landfill site in Romo Kalisari, Benowo, whose area is supposed to be 110 ha as defined below:

Imaginary Landfill Site = Proposed Total Acquisition by KMS (150 ha)
= Proposed Assignment to Dinas Kebersihan (40 ha)
= 110 ha

It is desirable to acquire the whole area of 150 ha as a candidate new landfill site, however, KMS does not have to policy to assign more than 40 ha to Dinas Kebersihan for final disposal at present. Therefore, the remaining area with an area of 110 ha is regarded as an imaginary landfill site.

In this consideration, the demand of final disposal that would be accepted at the imaginary landfill site is assumed to be treated at a new incineration plant. The total capacity of the imaginary landfill site is estimated at about 7.7 million m^3 as shown below:

Estimated Capacity of Imaginary Landfill Site
= Area (110 ha) * Efficiency (70%) * Depth (10m)
$= 7{,}700 \times 10^3\ m^3$

This capacity should be, at the same time, the required capacity that the new incinerator will treat through its entire lifetime. Assuming the lifetime of an incinerator as 20 years, the required capacity of the incineration plant is estimated at around 1,050 t/d as shown below:

Required Capacity of Incineration Plant
$= 7{,}700 \times 10^3\ m^3 / 20$ year / 365 day = 1,050 t/d

2) Equipment Cost for Incineration plant

It is considered that the following two types of incineration plants are recommendable as the candidate incineration plant.

1. Case 1 With Boiler
2. Case 2 No Boiler

The specification of the plant are presumed as follows

Table 4.1-4 The Specification of the Plant

Gas Cooling Method Specification	Case 1 Boiler type	Case 2 No Boiler
1.Operation	24 hours/day	24 hours/day
2.Rated capacity	1,050 ton/day	1,050 ton/day
3.Average incineration amount	800 ton/day	800 ton/day
4. Annual amount treated	292,000 ton/year (800 ton/day x 365 days)	292,000 ton/year (800 ton/day x 365 days)
5. Gas cooling system	Boiler	-
6. Heat recovery system	Power Generation (steam turbine)	-
7. Flue gas treatment	Electrostatic Precipitator (EP)	Electrostatic Precipitator (EP)

Assuming that the main equipment for Case 1 (furnace, grate, boiler, EP, steam turbine, generator etc.) are imported from Japan, the equipment cost is estimated according to the average unit cost of the practical plant price confirmed in the contracts during 1991/92 fiscal year.

Totally 27 incineration plants with bigger capacity than 100 ton/day were contracted in 1991/92 fiscal year in Japan. The average unit price of those plants are reported in a monthly magazine "City and Wastes" Vol. 22, No. 7, 1992; as follows:

Average unit cost = ¥50 million/ton/day
of Incineration Plant (> 100 ton/day)

Emission gas standards are so strict in Japan that the incineration plants are required to install sophisticated pollution control measures besides electrostatic precipitator (EP). Those additional pollution control measures are not necessarily obliged to be installed in those plants constructed in Indonesia because the existing incineration plant in Keputih can comply the air quality regulation in Indonesia without any pollution control measures. From this point of view, the plant price can be reduced by the share of the more sophisticated control measure than EP. On the other hand, the plant price will be added some import related costs such as shipping charge, import tariff and that like. Therefore the average unit cost in Japan can be adopted by offsetting the rising factor of the price against the reduction factor.

Thus, the plant price are estimated as follows:

$$\text{Plant price (Case 1)} = ¥50 \text{ million d/t} * 1{,}050 \text{ t/d} * 16\ R_p/¥$$
$$= Rp840 \text{ billion}$$

The total investment cost is calculated by adding the total interest cost that reaches about 30% of the plant price in the contract of the existing incineration plant in Surabaya:

$$\text{Total investment cost} = R_p840 \text{ billion} * 1.30 = R_p1{,}092 \text{ billion (Case 1)}$$

As to Case 2 (No Boiler), the cost for the boiler and power generator can be removed. The composition of incineration plant will be similar to that of the existing plant. Then the price will be estimated in analogy of the unit plant cost of the existing plant including interest cost:

3) Operation and Maintenance Cost

a. Operation Cost

The operation cost will be estimated in analogy of the unit cost of the existing plant cost.

$$\text{Operation Cost (Case 2)} = \text{Operation cost of existing plant} \times \frac{\text{Capacity of proposed plant}}{\text{Capacity of existing plant}}$$
$$= Rp930 \text{ million/year} \times \frac{1{,}050 \text{ t/d}}{200 \text{ t/d}} \times 1.5$$
$$= Rp7{,}324 \text{ million/year}$$

Unit cost: Rp25,080/ton (Rp7,324 million ÷ 292,000 ton)

As to Case 1 (Boiler Type), it is no necessary to pay electricity cost because boiler type has power generation equipment.

$$\text{Operation Cost (Case 1)} = (\text{Operation cost of existing plant} - \text{Electricity cost}) \times \frac{\text{Capacity of proposed plant}}{\text{Capacity of existing plant}} \times f(\text{factor of upgrading})$$

$$= (\text{Rp930 million} - \text{Rp128 million}) \times \frac{1,050}{200} \times 1.5$$

$$= \text{Rp6,316 million/year}$$

Unit Cost: Rp21,630/ton (Rp6,316 million ÷ 292,000 ton)

b. Maintenance Cost

On average, annual maintenance costs through the operation period may be 4.5% of the construction cost. Assuming that the average annual maintenance cost is 4.5%.

The maintenance cost is estimated as follows:

Case 1	Rp840,000 million x 4.5% = Rp37,800 million/year Unit cost: Rp129,450/ton
Case 2	Rp206,000 million x 4.5% = Rp9,270 million/year Unit cost: Rp31,750/ton

4) Electricity Value Created

There is power generation plant in the incineration plant and it generated electricity power. Electricity amount of consumption and generation of incineration plant are shown below.

To calculate the power generation, calorific value of waste is estimated as 1,200 kcal/kg. This value is average calorific value of residential waste because it accounts for about 70% of generated waste in Surabaya.

The condition of the furnace and boiler are presumed as follows:

1.	Calorific value	1,200 kcal/kg (1.58 x 10" J/h)
2.	Furnace temperature	800 - 850°C
3.	Steam pressure	18 kg/cm^2
4.	Steam temperature	265°C
5.	Steam turbine	Back pressure type
6.	Electricity generation	100 kWh/ton (efficiency 7%)
7.	Electricity consumption	70 kWh/ton*

*: According to the "Guideline of Structure of Waste Treatment Plant", Electricity Consumption of Boiler Type Incinerator is 50 - 90 kWh/ton, therefore electricity consumption is regarded as 70 kWh/ton average of the value.

Table 4.1-5 Electricity Amount of the Plant

Waste (ton/day)	Electricity (KWh/day)		
	Generation (A)	Consumption (B)	Surplus (A-B)
800	80,000	56,000	24,000

Assuming that surplus electricity is sold, earning is estimated as follows:

24,000 kWh/day x 365 day/year x Rp130 = Rp1,138,800,000/year

Note: Electricity price: Rp130/kWh

Unit earning is about Rp3,900/ton (Rp1,138,800,000 ÷ 292,000 ton)

5) Comparison of Unit Cost

Comparison of unit cost of two type incineration is shown below.

Table 4.1-6 Comparison of Unit Cost

	Case 1 Boiler Type	Case 2 Non Boiler
Construction Cost	Rp187,000/ton	Rp 50,200/ton
Operation Cost	Rp21,630/ton	Rp25,080/ton
Maintenance Cost	Rp129,450/ton	Rp31,750/ton
Electricity Earning	D Rp3,900/ton	0
Total	Rp334,180/ton	Rp107,030/ton

After all, no boiler type is more economy than boiler type, therefore incineration type of Alternation 3 is considered as no boiler type.

4.1.3 Sea Reclamation

1) Proposed Function

A final disposal facility located in the sea is assumed to be provided with such function as shown below:

1. To have enough stability to resist the erosion by sea wave and the pressure caused by the pile of waste and the operation vehicles.

2. To have enough resistance to permanence of leachate water from inside to outside.

3. To have a leachate water treatment plant with enough capacity to accept all the leachate water discharged within the reclamation site.

4. To have a rainwater discharge facility with enough capacity to keep the internal water level lower than the surrounding sea level.

5. To have an appropriate unloading facility and an access road from adjacent coastal area.

2) Assumed Capacity of the Unit Facility

Total capacity of the final disposal site should be defined through the consideration on the total demand of final disposal and the assignment for the sea reclamation, however, a concept of unit facility is adopted because the necessary information cannot be clarified at this moment.

It is assumed that a unit facility can be used for five years under the following operational condition :

1. Annual reclamation volume is 400,000m^3 that corresponds to the half of the annual demand of final disposal at the year of 2,000.

2. All the reclamation site can be used for dumping site with the layer of 10 m in depth.

Consequently, the required area of a unit facility is calculated as follows:

$$A = Q/10(m) = 200{,}000\ (m^2) = 20\ (ha)$$

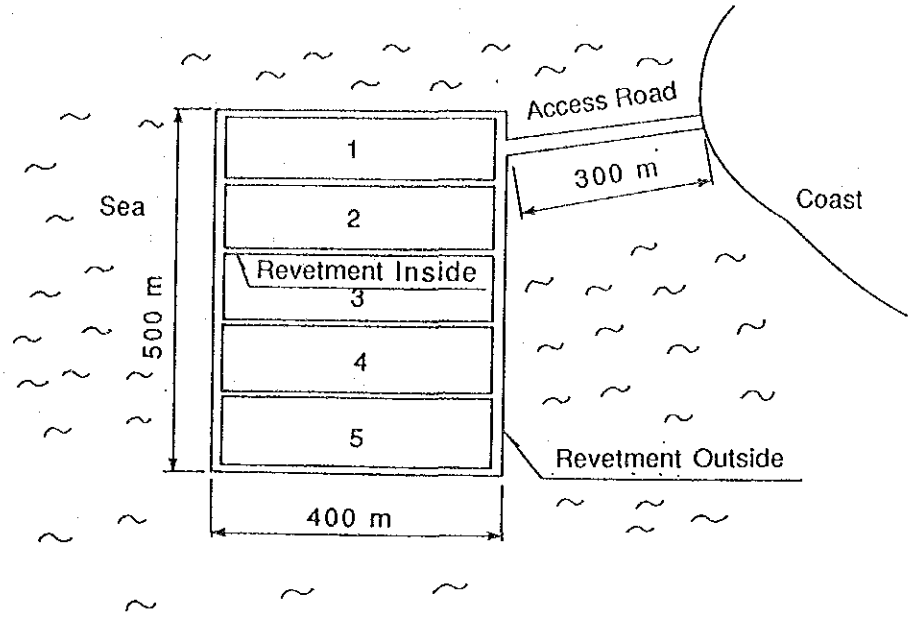
while A: Area required for unit reclamation (m^2)
Q: Assigned volume to be dumped (m^3)
$= 5y \times 400{,}000\ m^3/y = 2{,}000{,}000(m^3)$

As a result, the capacity of the unit facility is assumed to be 2,000,000m^3 with the area of 20 ha.

3) Structure Assumed

The structure of the revetment for enclosing the reclamation site and the access road is assumed as shown in Fig. 4.1-2. The reclamation area is enclosed by double sheet pile wall with sand fill between the walls, which separates the ground water and surface water inside from the surrounding sea water. The reclamation areas is also divided into several partitions to restrain the diffusion of leachate water within as small areas as possible. The landfill operation is planned to be carried out at each partition from one after another according to the order shown in Fig. 4.1-2.

PLAN



SECTION OF REVETMENT

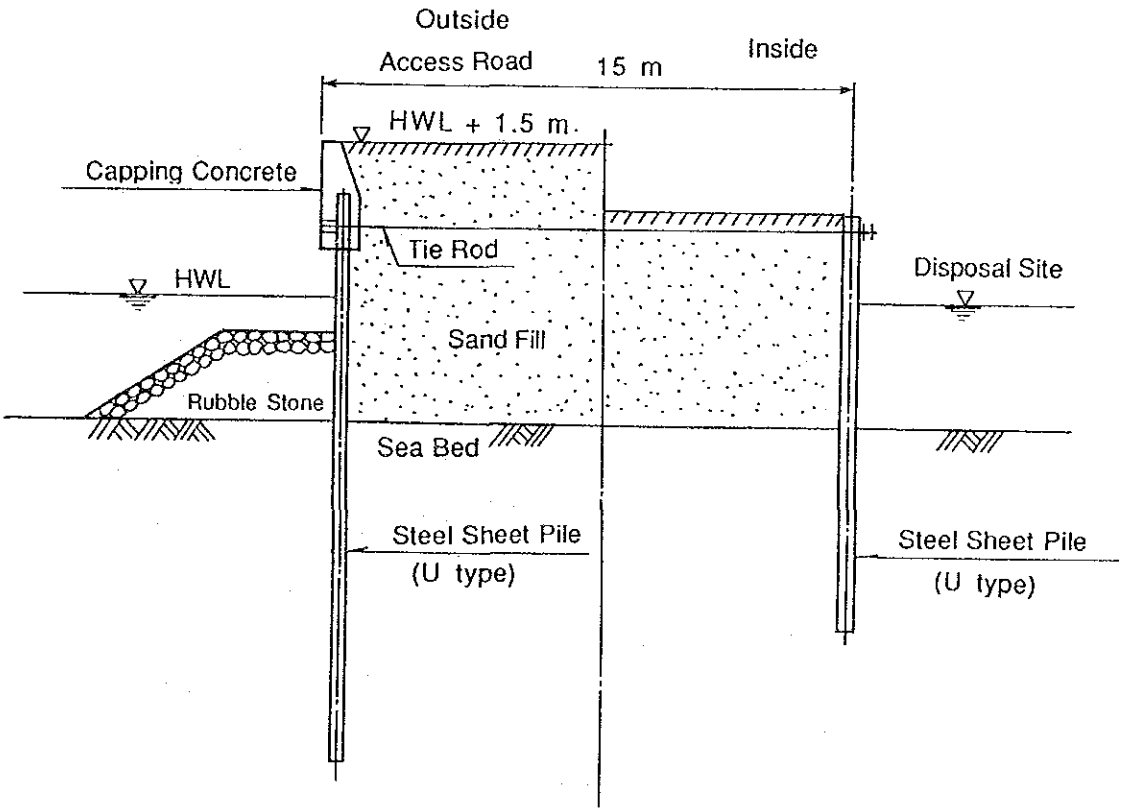


FIG. 4.1-2 ASSUMED STRUCTURE OF RECLAMATION LANDFILL

4) Water Treatment

a. Concept

The leachate water is collected at each partition and sent to a concentrated treatment plant installed at the partition that will be reclaimed in the last stage of the whole sites operation.

Therefore the plant is to be designed to meet the maximum demand of leachate treatment that arises at the final stage of the operation. Thus the leachate water is discharged from the treatment plant in order to comply the environmental requirements.

Concerning the rainwater run-off can be separated by dividing revetments and other appropriate drain system from polluted leachate water. Therefore the run-off is planned to be discharged to the sea without any treatment at a terminal pump station.

By using this pump station, the water level inside the reclamation site can be controlled not higher than the surrounding sea water level even after the heavy rain.

b. Assumed Capacity

The demand of leachate water treatment is estimated by the following formula :

$$q = C * I * A/1{,}000 \quad (m^3/day)$$

while q : Daily effluent amount of leachate water (m^3/day)
C : Coefficient of percolation
I : Average daily precipitation (mm/day)
A : Catchment area (m^2)

Concerning the coefficient of percolation, there is no data available in Surabaya; so that the figure of 0.4, which was obtained in Japan, is applied to the estimation. The average precipitation is given in Table 1.2-1 in the main report at 1,567 mm, then the average daily precipitation is calculated at 4.3 mm/day.

Consequently the demand is defined at about 350 m^3/d as shown below:

$$q = 0.4 * 4.3 \text{ mm/d} * 200{,}000 \text{ m}^2/1000 = 344 \text{ m}^3/\text{d}$$

As to the capacity of drainage pump, it may be designed to have such capacity as is possible to discharge the runoff of the heaviest rain in two days. According to the rainfall

observation record at Larangan, northern part of Surabaya, the most intensive rainfall a day during the period from 1979 to 1988 is about 100 mm.

Based on this information, the capacity of drainage pump is calculated as follows:

$$V = \frac{1}{2} * I * A/1{,}000 * 24 * 60 \quad (m^3/min)$$

while	V	:	Capacity of pump (m^3/min)
	I	:	Maximum daily rainfall (mm/day)
			= 100 (mm/d)
	A	:	Catchment area (m^2)
			= 200,000 (m^2)

As a result, the capacity of drainage pump is estimated at about 7 m^3/min as follows:

$$V = \frac{1}{2} * 100 * 200{,}000/1{,}000 * 24 * 60 = 7 \ (m^3/min)$$

5) Cost Estimation

a. Revetment

Referring to the similar case of construction, the unit construction cost is assumed at Rp5 million per 1 m in the length of revetment. Total length of revetment is calculated as follows:

• Access road: l_1	= 300 x 2	=	600 m
• Revetment outside: l_2	= (500 + 400) x 2	=	1,800 m
• Revetment inside: l_3	= 400 x 5 + 500 x 2	=	3,000 m
• Total : l	= $l_1 + l_2 + l_3$	=	5,400 m

Consequently, the total construction cost is estimated as follows:

• Construction cost	= 5,400 m x Rp5 million/m =	Rp27.0 billion*

*Note : does not include tax

b. Leachate Treatment Plant

Referring to the similar case of facility, the cost of installation per unit disposal capacity is assumed at Rp11 million per m^3/d including the supplementary pipe works. Combining the design capacity of 350 m^3/d and the unit installation cost, the installation cost of leachate treatment is estimated at about Rp4 billion as shown below:

- Installation cost = 350 m3/d * Rp11 million / m^3 / d= Rp3.85 million

c. Drainage Pump

According to the capacity of 7 m^3/min and the assumed pump head of 5 m, the appropriate pump unit is estimated the rated output at 15 KW. An approximate cost of pump unit with the capacity of 15 KW is Rp16 million/unit, and the required number of unit is two including a spare. Consequently the total installation cost of pump unit is estimated at around Rp32 million.

d. Unit Cost for Unit Volume of Disposal

The total cost should be divided by the total disposed amount to calculate the unit cost for unit disposed volume. The total disposed amount is 2,000,000 m^3 as stated above.

(1) Land Acquisition

Through the process of getting a permission of the sea reclamation, there is no transaction of land purchase. Therefore the cost of land acquisition can be neglected for this case.

(2) Construction Cost

The construction cost is summarized as follows :

• Revetment	Rp27.0 billion
• Leachate treatment plant	Rp 3.85 billion
• Drainage pump	Rp 0.03 billion
• Total	Rp30.88 billion

Consequently the unit construction cost is estimated at around Rp15 thousand per m^3 as follows:

Unit construction cost = Rp31 * 10^9 / 2 * 10^6 m^3 = Rp15,500 /m^3

(3) Operation Cost

The operation cost of waste handling is estimated just same as the inland sanitary landfill at Rp4,030/m^3

Additionally, the annual cost of water treatment plant operation can be estimated at about 3% of construction cost as shown below:

Cost of Plant Operation = Construction Cost * 3%
= R_p3.85 billion* 0.03
= R_p116 million/y

The unit cost of plant operation is estimated by dividing the annual cost by the annual disposal amount of 400,000 m^3:

Unit Cost of Plant Operation = Rp116 million/0.4 million m^3
= Rp290/m^3

Thus the total operation cost is estimated at around R_p4,600/m^3:

Operation Cost = Waste handling cost + Plant operation cost
= R_p4,330/m^3 + R_p 290/m^3 = R_p 4,620/m^3

(4) Land Value Created

The created value of land formed by sea reclamation cannot exceed that of inland reclamation because the access to the new site is limited only one point. This inconvenience may cause the disadvantage, so that the value is assumed to be less than the future price of inland disposal site. On the other hand, the new site must have much more availability for various purposes than the swampy area. Therefore, the future price is assumed at the same value to that of the inland disposal site, namely R_p3,300/m^3.

4.2 Composition of Hauled Waste by Five (5) Rayons

4.2.1 Present Situation

Based on the count survey at three (3) landfill sites and incinerator in the previous period of this study, the share of each Rayon in Waste hauled amount was as shown in Table 4.2-1.

Table 4.2-1 Present Composition of Hauled Waste by Rayon

Rayon	Hauled Amount (t/d)				Population Share
	Rainy Season	Dry Season	Average	Average Share (%)	(%)
Center	137	167	152	20.9	15.3
North	134	120	127	17.6	18.1
East	232	206	219	30.1	27.6
South	171	177	174	23.8	26.7
West	57	54	55	7.6	12.3
Total	731	724	727	100	100

Note : Waste from factories are excluded due to its large fluctuation by season and its small share.

According to Table 4.2-1, Central and East Rayon have bigger share of waste hauled amount than that of population. the tendency is remarkable in Central Rayon.

On the contrary, the other rayon have smaller share of waste hauled amount than that of population, particularly in West Rayon.

This phenomenon explains that a large amount of waste is generated by those who come from outside the Rayon besides that generated by its own inhabitants in Central and East Rayon. On the other hand, there are some waste generated but not hauled in North, South and West Rayons. It seems that the portion of waste not hauled occupies about 40% of generated amount in West Rayon.

It is assumed that the average share of observed haulage amount is applied to estimate the present distribution of disposal amount by Rayon.

4.2.2 Future Composition of Five (5) Rayons

In 2010, Surabaya will be urbanized in almost all Rayons except small marginal part of East and West Rayon. Excluding these marginal area, the haulage service is assumed to cover all the area.

Comparing to the present coverage in each Rayon, the future coverage and the share of haulage amount in 2010 are deducted as shown in Table 4.2-2.

Table 4.2-2 Assumption of Coverage and Hauled Amount by Rayon in 2010

Rayon	Population Share (%) in 2010 A	Present Coverage * (%) B	Hauled Amount Share (%) C=AxB	Assumed Coverage (%) D	Hauled Amount Share (%) E=AxD	Percentage (%) Ex100/95
Center	11.0	100	11.0	100	11.0	11.6
North	15.1	85	12.8	100	15.1	15.9
East	31.8	70	22.3	92.2**	29.3	30.8
South	25.8	85	21.9	100	25.8	27.2
West	16.3	40	6.5	84.4**	13.8	14.5
Total	100	-	74.5	-	95***	100

Note : * is taken from Table 2.6-2 of this Report

** is calculated by the following formula

$$D = B + \frac{(100-B)}{100} \cdot x$$

: where x gives the total of E a value of 95

*** is set as the target coverage for long term plan

4.2.3 Change of composition during Intermediate years

The annual change of haulage amount composition by Rayon is assumed as linear according to the tendency of population growth. Based on this assumption, the projection of share in haulage amount is presented in Table 4.2-3.

Table 4.2-3 Projection of Hauled Waste Share by Rayon

Year	Population of Rayon (1,000 person)						Share of Hauled Waste (%)					
	Central	North	East	South	West	Total	Central	North	East	South	West	Total
1990	399	459	665	661	289	2,473	-	-	-	-	-	-
1991	396	462	686	671	303	2,518	-	-	-	-	-	-
1992	393	464	707	683	316	2,563	20.9	17.6	30.1	23.8	7.6	100
1993	391	467	729	694	330	2,611	20.4	17.5	30.1	20.4	8.0	100
1994	385	470	750	705	343	2,653	19.8	17.4	30.2	24.2	8.4	100
1995	382	473	771	716	357	2,699	19.3	17.3	30.2	24.4	8.8	100
1996	379	475	792	726	370	2,742	18.8	17.2	30.3	24.6	9.1	100
1997	377	478	813	737	384	2,789	18.3	17.1	30.3	24.8	9.5	100
1998	374	481	835	748	397	2,835	17.8	17.0	30.4	24.9	9.9	100
1999	371	483	856	759	411	2,880	17.3	16.9	30.4	25.1	10.3	100
2000	371	486	877	770	424	2,928	16.8	16.8	30.4	25.3	10.7	100
2001	371	489	897	780	437	2,974	16.3	16.7	30.4	25.5	11.1	100
2002	371	491	917	790	449	3,018	15.7	16.7	30.5	25.7	11.4	100
2003	371	494	937	801	462	3,065	15.2	16.5	30.5	25.9	11.8	100
2004	371	496	957	811	475	3,110	14.7	16.5	30.5	26.1	12.2	100
2005	371	499	978	821	488	3,157	14.2	16.4	30.6	26.2	12.6	100
2006	371	501	998	831	500	3,201	13.7	16.3	30.6	26.4	13.0	100
2007	371	504	1,018	841	513	3,247	13.2	16.2	30.7	26.6	13.3	100
2008	371	506	1,038	852	526	3,293	12.6	16.1	30.7	26.8	13.8	100
2009	371	509	1,058	862	538	3,338	12.1	16.0	30.8	27.0	14.1	100
2010	371	511	1,078	872	551	3,383	11.6	15.9	30.8	27.2	14.5	100

4.3 Potential Capacity of Existing Landfill Sites

There exist three (3) landfill sites under operation in Surabaya city at present; Keputih, Lakarsantri and Kenjeran Landfill Sites. The potential capacities of these landfill sites are examined as described below.

4.3.1 Keputih Landfill Site

The Keputih Landfill Site of which topography is flat consists of three (3) partitions as shown in Fig. 4.3-1, and used for disposing and incinerating wastes and treating human wastes at present. Total area available for disposal of wastes is measured to be about 29.56 ha except for the areas for incineration plant, human waste treatment plant and offices. Since the average elevation of the original ground surface is considered to be about EL.+2.50 m, and the present ground elevation varies from EL+2.50 m to EL.+7.00 m due to waste disposal having been performed so far, the potential capacity as of April 1992 is calculated to be about 1,024,000 t assuming that the maximum landfill height would be 5.0 m above the original ground surface. Considering the landfill operation after April, the remaining capacity will be reduced by 81,000 t to 943,000 t at the end of 1992.

It is clearly understood that it is impractical to treat all of the waste estimated in future with only the existing landfill sites due to their limited capacity. it is, therefore, necessary to consider some extent of expansion of the present disposal sites. In case of the Keputih Landfill Site, the site is divided into three (3) isolated partitions, resulting in mal-function of the disposal site. In order to facilitate the function of this disposal site, it is recommended to include the narrow tracts of land between Partitions 1 and 2, and Partition 2 and the adjacent river as shown in Fig. 4.3-1. The area of the said tracts is measured to be 11.51 ha, and it is possible to expect the additional capacity of 535,000 t for the Keputih Landfill Site.

The potential capacity of the Keputih Landfill Site is, therefore, calculated to be 1,478,000 t totaling the above original and additional capacities.

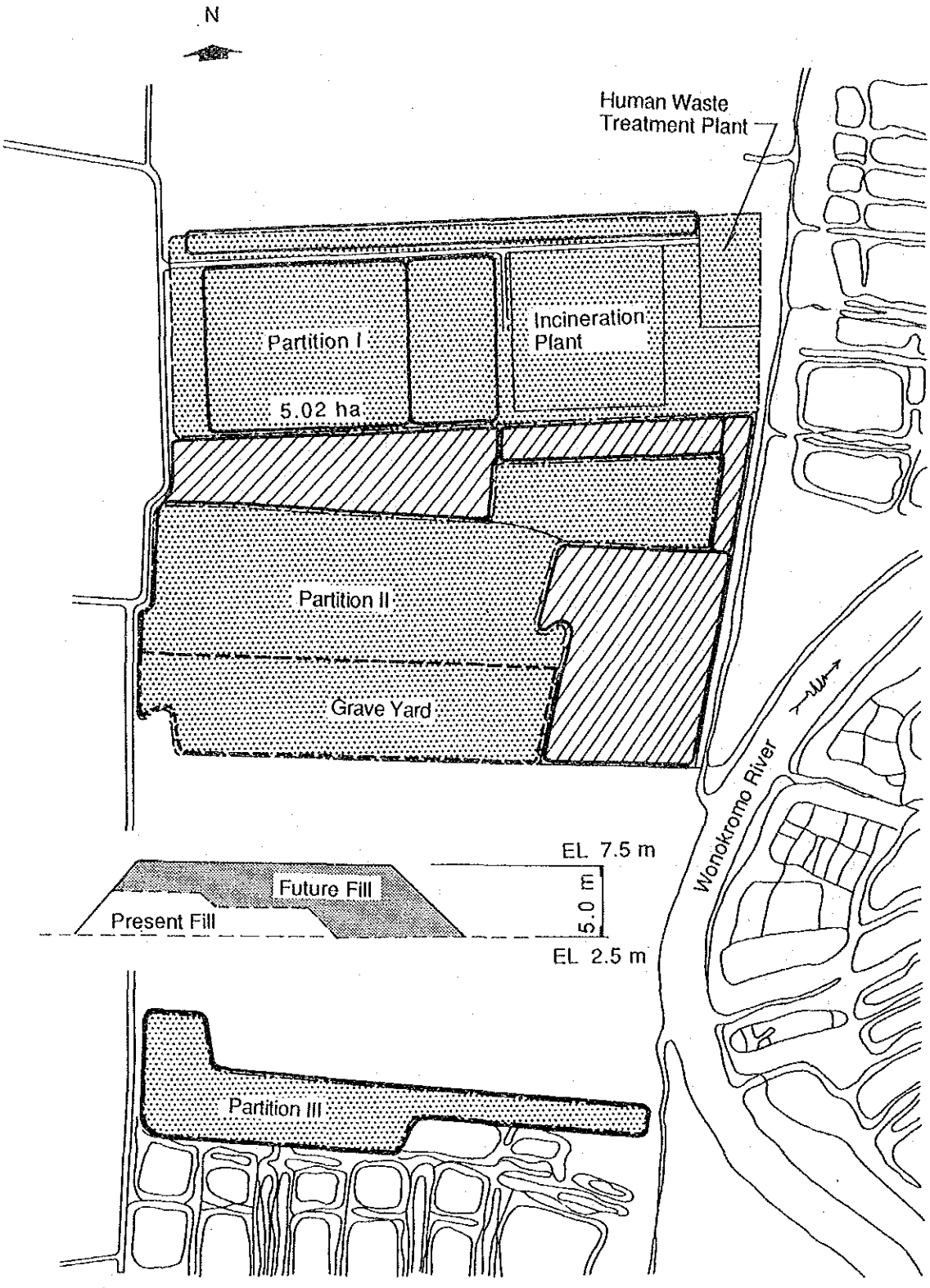


FIG. 4.3-1 ASSUMPTION FOR CAPACITY OF KEPUTIH FINAL DISPOSAL SITE

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