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Japan International Cooperation Agency (JICA)
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The Municipality of Bucharest
Romania

The Study on the Solid Waste Management System for Bucharest Municipality in Romania

Final Report

Volume 3

Appendices to the Master Plan

December 1995

EX Corporation
Yachiyo Engineering Co., Ltd.

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16. Laws and Regulations

1. WASTE QUANTITY

The Study Team conducted the following surveys concerning quantity of waste generated and hauled in Bucharest.

Surveys conducted in October and November 1994

1. Household Waste Generation Survey
2. Street Waste Generation Survey
3. Waste Weight Survey Loaded on Collection Vehicles by Type
4. Trip Counting at Glina Landfill Site

Surveys conducted in July 1995

1. Household Waste Generation Survey
2. Waste Weight Survey Loaded on Collection Vehicles by Type

1.1 Household Waste Generation

1) Sample Selection, Collection and Measurement

150 households of different family sizes was selected throughout Bucharest. Composition of these household was as follows:

Table 1.1-1 Type and Number of Samples of the Survey

Type	Number of Rooms	Number of Samples
1. Apartments	One room	30 samples
(120 samples in total)	Two rooms	30 samples
	Three rooms	30 samples
	Four rooms or more	30 samples
2. Individual houses		30 samples
Total		150 samples

Waste samples were collected by plastic bags from each house every day for 8 consecutive days, and their weight were measured. Data of the first day of the survey is excluded because the sample on first day may contain waste generated before the previous day.

2) Method of Estimation

Collected data were sorted by family size(number of people living in households) and waste generation quantity per capita by the family size was estimated as follows:

$Qn = An \div 7 \div Bn$ Where;

(n = 1, 2, 3, 4 or more)
Qn: Waste Generation per Capita of household with n persons
An: Total waste quantity discharged from household with n persons for seven days
Bn: Total number of persons living in households with n person

Total daily household waste generation amount in Bucharest (C) will be estimated by using the following formula:

$C = Qn \times Pn$ where,

Qn: Daily waste generation per capita in households with n person(s)
Pn: Total number of person living in households with n person

a. Results of Household Waste Generation Survey in 1994

The data obtained in 1994 is shown in Table 1.1-2. Since per capita generation of household with 4, 5 , 6 and more persons is fluctuated due to small number of samples, averaged data of these households is adopted. According to these data, average daily waste generation is estimated to be 496.15 grams/day.

Table 1.1-2 Data used in the Estimation of Household Waste Generation in 1994

	Qn: Waste generation per Capita (kg)	Pn: Population by family size (persons)	C = Qn × Pn: Waste Quantity by family size (kg)
Households with 1 person	0.695	165,855	115,269
Households with 2 persons	0.599	390,520	233,921
Households with 3 persons	0.489	513,321	251,014
Households with 4 to 6 persons	0.424	965,964	409,569
Total		2,035,660	1,009,998

b. Results of Household Waste Generation Survey in 1995

Since the population data by the family size in 1995 is not available, it is assumed that the composition by the family size does not change while total population in 1995 is 2,050,000, which is 0.7 % increase of 2,035,600 in 1994. The data used in the estimation is shown in Table 5.1-2. According to these data, average daily waste generation is 489.5 grams/capita. Considering seasonal fluctuation of waste quantity, the results obtained in this survey indicates 111 % of quantity compared to annual averaged quantity. Annual average of daily waste generation is calculated to be 440.5 grams/capita. Besides, it is considered that the household waste loses 10 % of its weight because of water loss during storage until collection and during haulage.

Table 1.1-3 Data used in the Estimation of Household Waste Generation in 1995

	Qn: Waste generation per Capita (kg)	Pn: Population by family size (persons)	C = Qn x Pn: Waste Quantity by family size (kg)
Households with 1 person	0.639	165,855	105,981
Households with 2 persons	0.580	390,520	226,502
Households with 3 persons	0.443	513,321	227,401
Households with 4 to 6 persons	0.452	965,964	436,616
Total (based on 1994 population)		2,035,660	996,450
Estimation by 1995 population		2,050,000	1,003,518

1.2 Business Waste Generation

Business waste includes the following category of waste:

1. Commercial Waste
2. Market Waste
3. Office Waste

It is difficult to estimate the generation quantity of business waste because unit generation varies wide according to the Study Team's Survey. Therefore, generation quantities of these waste are estimated from the truck scale data by assuming the collection ratio. In Bucharest, commercial waste and office waste (from small offices) are collected together with household waste, because residents live in upper floors of the buildings while business sources such as shops and offices are in the ground floor. The Study Team estimated the waste quantity of commercial waste contained in the collected household waste by the method as described in the following section. Then, the collection ratio of commercial and office waste are assumed to be 82,8 % which is the same ratio as that of household waste. As for market waste, the ratio was assumed to be 95 % because much accumulation of waste could not be found in the market places. Assumed collection ratio and the data used for this estimation is as follows:

Table 1.2-1 Business Waste Generation by Categories

	Assumed Ratio collection / generation	Estimated generation quantity (tons/day)	Collection quantity (Truck scale data) (tons/day)
Commercial Waste	82.8 %	138	114
Market Waste	95 %	30	28
Office waste	82.8 %	48	40

1.3 Truck Scale Data - Waste Quantity hauled into Glina Disposal Site

(1) Definition of the data

The data from the truck scale at Glina landfill site express the waste quantity hauled into the site. The Study Team considered that this quantity is equal to that of collection, since no illegal dumping was recognized except for occasional cases.

(2) Operation Schedule of the Truck Scale

Since it was impossible to measure all the trips of trucks incoming into the site by only one truck scale, the incoming trucks were divided into two groups and these groups were measured alternatively. In the first week, all the trucks belonging to RASUB and RGR were measured for five consecutive weekdays. Then, all other trucks including ADP were measured in the second week.

(3) Assumption for Daily Quantity

It is assumed that waste quantity hauled on Saturday and Sunday are 10 % and 3 % of weekdays quantity, respectively. This assumption was made by trip number of incoming trucks on Saturday and Sunday.

(4) Categorization of the Truck Scale Data

In principle, household waste and business waste are collected by RASUB and RGR while street waste is collected by ADP, but in reality ADP collects some of business waste while RASUB collects the waste container placed on streets. This complication is also shown in the data sheet of the truck scale. Besides, a part of business waste is collected together with households waste, because residents live in upper floor while shops are in the ground floor in many buildings. The Study Team re-categorized the truck scale data as shown in the Table 1.3-1. In this categorization, the business waste was divided into three categories, commercial, market and office waste, and assumed that commercial waste are collected together with household waste, while office waste is collected separately by ADP. Market waste is collected by ADP and RASUB.

Table 1.3-1 Categorization of the Truck Scale Data

Categorization		Categories noted in the data sheets	Hauler	Hauled Quantity	Category Total
Household waste		Major part of household waste	RASUB	568,954	
			RGR	104,078	673,032
Business waste	Commercial	Minor part of household waste	RASUB	91,262	
			RGR	22,846	114,108
	Market	Market waste	ADP	7,581	
		Street waste	RASUB	20,532	28,113
	Office	Household	ADP	27,552	
		Industrial waste	ADP	12,136	39,688
Street Waste		Street Waste	ADP	50,758	
Waste From Large Offices		Household Waste	Others	8,472	
Industrial Waste		Industrial Waste	RASUB	56,067	
			Others	122,816	178,883*
Demolition Waste		Demolition Waste	RASUB	4,028	
			ADP	101,021	105,049*

Note: * For Industrial and Demolition waste, collection quantity in July 1995 is considered to be 110 % of annual average, because of the high activity in summer season.

(5) Separation of Business Waste from Household Waste

Since the commercial waste is mixed with the household one for the reason mentioned above, the study Team estimated commercial waste quantity by separating it from household waste. This estimation was made based on the number of service contracts and waste bins capacity sold by RGR in 1994. Procedure of estimation is as follows:

1) According to the waste bins capacity sold by RGR in 1994, ratio between household and business is 82% : 18 %.
2) 126,924 tons, total quantity of RGR collection for household (and commercial) waste was divided into 104,078 tons and 22,846 tons by this ratio on assumption that the bins capacity can be an index of waste quantity.

Table 1.3-2 Total Capacity of Waste Bins sold by RGR in 1994

	No. of units	Total capacity in litter	Ratio by total capacity
Capacity of household			
240 litter bin	14,200	3,408,000	
120 litter bin	1,600	192,000	
1,100 litter container	25	27,500	
Household Total		3,627,500	82 %
Capacity of business sources			
240 litter bin	2,500	600,000	
120 litter bin	100	12,000	
1,100 litter container	150	165,000	
Business sources Total		777,000	18 %
Grand Total		4,404,500	100 %

3) RASUB and RGR have 2,996 and 750 contracts for collection services with business agency, while total quantity of RASUB collection for household (and commercial) waste was 660,216 tons. According to these data, quantity of commercial waste collected by RASUB was estimated to be:

   91,262 = 660,216 x 2,996/750

4) Quantity of household waste collected by RASUB was obtained by reducing the commercial waste quantity from total quantity collected by RASUB:

   660,2160 - 91,262 = 568,954

Table 1.3-3 Estimated Quantity of Household and Commercial waste

		RASUB	RGR	Total
Household	Waste Quantity	568,954	104,078	673,032
Commercial		91,262	22,846	114,108
	(Number of Contracts)	(2,996)	(750)	
Total		660,216	126,924	787,140

(6) Industrial Waste / Demolition Waste

Collection quantity of industrial and demolition waste in this period (July 1995) is considered to be 110 % of annual average, when the seasonal fluctuation of collection quantity is taken account.

1.4 Average Weight of Waste Loaded on Collection Vehicles

As basic data of waste quantity hauled to Glina landfill, the Study Team weighed waste loaded on collection vehicles used by RASUB. 3 to 5 collection vehicles of all the types used by RASUB were assigned and requested to come over to a truck scale in REMAT, a material recycling factory. For their first measurement, each collection vehicles are weighed with loaded waste, then they discharged the waste at Glina landfill site, and came back to be weighed as empty weight. Average load of waste by type of the collection vehicles is shown in Table 1.4-1.

Table 1.4-1 Average Load of Waste by Type of Collection vehicles

Mechanical Type	Vehicle Type	Average Load (kg)	Sampled vehicles	Total Number of Data
Rotary Compactor Type A	R10135 (Pelican)	4,387	3	14
Rotary Compactor Type B	Liaz	4,060	4	18
Compactor	R10135	3,295	3	12
Container	SRDAC	1,186	4	19
Arm Roll for Containers	R10215	4,465	3	14
Dump Car		6,424	3	9
Tractor	RB-3, RM-7	4,203	2	6
Road Sweeper Type A	Johnston	5,153	1	3
Road Sweeper Type B	Fawn	4,780	1	3
Road Sweeper Type C	IFA	3,487	1	3

1.5 Trip Counting at Glina Landfill Site

To estimate the waste quantity hauled to Glina landfill site, The Study Team counted trip number of collection vehicles by collectors and vehicle type. The counting survey was conducted for 3 days in weekdays. Items recorded are shown in table 1.351. In case of Collectors other than RASUB, RGR or ADP, waste sources were also recorded. Average daily trip number is shown below. Detail of trip number of the vehicles by collectors and type of vehicles are shown in Table 1.5-2.

Average daily trip number = 588 trips per day

Table 1.5-1 Items Recorded in Trip Counting

1. Vehicle Type
2. Car Number
3. Incoming Time
4. Sector where waste was collected
5. Type of Collectors
6. Waste type (if hauled by collectors other than RASUB, RGR of ADP)

Table 1.3-2 Trip Number of Collection Vehicles by Type and Collector

Date	Collector	Liaz	Pelican	Arm Roll	Com-pactor	SRDAC	Dump	Tractor with 1 wagon	Tractor with 2 wagons	Road Sweeper	Others	Total
24.Nov.	RASUB	80	43	17	150	82	28	8	5	0	0	413
1994	RGR	17	3	2	6	3	3	1	0	0	0	35
(Thu)	ADP	0	0	0	2	10	7	12	0	0	0	31
	Otehrs	0	0	0	2	22	66	11	2	0	3	106
	Total	97	46	19	160	117	104	32	7	0	3	585
25 Nov.	RASUB	78	43	13	157	86	16	14	8	0	0	415
1994	RGR	15	5	0	10	4	0	0	0	0	0	34
(Fri)	ADP	0	0	0	0	10	2	21	1	0	0	34
	Otehrs	0	0	0	1	18	74	14	2	0	4	113
	Total	93	48	13	168	118	92	49	11	0	4	596
26 Nov.	RASUB	76	35	18	158	95	23	12	8	0	0	425
1994	RGR	13	3	0	11	1	0	1	0	0	0	29
(Mon)	ADP	0	0	0	0	6	5	22	1	0	0	34
	Others	0	0	0	0	13	78	5	0	0	0	96
	Total	89	38	18	169	115	106	40	9	0	0	584
Grand	Total	279	132	50	497	350	302	121	27	0	7	1,765

2. WASTE QUALITY

Waste quality analysis was conducted in November 1994 and July 1995 for waste samples in Autumn season and Summer Season respectively.

2.1 Samples

Analyzed samples are the following four types:

Table 2.1-1 Samples Analysed in this Study

	November 1994	July 1995
1) Household Waste	5 samples	5 samples
2) Market Waste	1 sample	1 sample
3) Business Waste	1 sample	1 sample
4) Street Waste	2 samples	None

As for samples of household waste, waste collected through household waste generation was utilized. 4 plastic bags containing the waste are chosen from each type for five types of household referred in the pervious chapter. 20 plastic bags chosen in total were opened and the waste was combined, mixed together and prepared as samples. Samples from market and business waste in 1994 are collected at Glina landfill site when the waste was discharged from a collection vehicle, while in 1995 those from market and business waste are sampled from a waste container in a market and waste yard of a business building respectively. Samples of street waste were obtained on street from waste gathered by ADP's street sweeping in 1994, but these were not sampled and analysed in 1995 because of its wide variation of contents.

2.2 Methods and Results of Analysis

(1) Bulk Density

Waste samples are put into a plastic bin of 40 litters and the bin was dropped down from 30 cm height 2 or 3 times. Waste was added into the bin to be full, if waste volume reduced. This procedure was repeated until the volume was constant, then weigh the waste samples and weight per volume was calculated. Bulk density of the samples are shown in Table 2.2-2.

(2) Moisture Content

Samples were dried for 3 to 4 days in a dryer at 105° C until Their weight became constant, and were weighed. Loss of weights is expressed in percents. Moisture content of the samples are shown in Table 2.2-3.

Table 2.2-2 Bulk Density

Unit: t/m^3

	November 1994	July 1995
Household 1	0.32	0.26
" 2	0.33	0.20
" 3	0.31	0.24
" 4	0.32	0.22
" 5	0.31	0.21
Household Average	0.32	0.23
Market	0.26	0.18
Business	0.27	0.17
Street 1	0.93	-
" 2	1.05	-

Table 2.2-3 Moisture Content

Unit: %

	November 1994	July 1995
Household 1	58.6	51.5
" 2	41.0	55.2
" 3	35.0	66.7
" 4	56.1	55.1
" 5	56.8	45.7
Household Average	49.5	54.8
Market	56.8	57.4
Business	13.2	6.7

(3) Physical Composition

After drying of samples, components were segregated. Results of the segregation are presented in Table 2.2-4 and 2.2-5.

Table 2.2-4 Physical Composition in November 1994

(Unit: % on wet base)

	Paper	Textile	Garbage	Wood	Plastics	Leather	Other combust	Sub Total	Glass	Metal	Sand	Other Incomb	Sub Total	Grand Total
Household 1	11.66	1.66	58.33	0	2.08	0	0	73.73	0	3.33	0	22.91	26.24	99.97
Household 2	10.43	7.83	30.65	0	0.87	0	0	49.78	20.65	6.08	0	23.47	50.2	99.98
Household 3	9.61	11.54	36.73	0	3.85	0	0	61.73	14.8	16.15	0	7.31	38.26	99.99
Household 4	12.5	5.88	58.82	0	5.88	0	0	83.08	0	2.2	0	14.7	16.9	99.98
Household 5	12.5	0	70.83	0	6.66	0	0	89.99	0	8.33	0	1.66	9.99	99.98
Household Average	11.34	5.382	51.07	0	3.868	0	0	71.66	7.09	7.218	0	14.01	28.32	99.98
Market	1.84	7.63	83.15	0	6.31	0	0	98.93	0	1.05	0	0	1.05	99.98
Business	54.55	3.03	6.67	0	3.64	0	0	67.89	12.12	17.27	0	2.73	32.12	100

Table 2.2-5 Physical Composition in July 1995

(Unit: % on wet base)

	Paper	Textile	Garbage	Wood	Plastics	Leather	Other combust	Sub Total	Glass	Metal	Sand	Other Incomb	Sub Total	Grand Total
Household 1	19.38	1.56	25.31	0	9.37	0	0.94	56.56	11.56	0.94	0	30.93	43.43	99.99
Household 2	21.54	5.77	49.61	0	5.16	0	1.54	88.46	0	6.54	0	5.0	11.54	100.0
Household 3	33.09	10.08	33.41	0	5.16	0	1.67	83.41	0	2.67	0	13.92	16.59	100.0
Household 4	28.9	1.29	24.52	0	10.0	0	1.29	66.0	25.16	5.55	0	3.29	34.0	100.0
Household 5	21.15	1.37	8.16	0	5.79	0	1.06	37.53	8.42	6.32	0	47.73	62.47	100.0
Household Average	24.8	4.0	13.80	0	8.1	0	1.3	66.4	9.0	4.4	0	20.2	33.6	100.0
Market	4.14	0.0	13.8	0	6.9	0	47.24	72.08	14.48	3.10	0	10.34	27.92	100.0
Business	17.86	16.90	2.86	0	14.29	0	0.71	52.62	14.76	25.24	0	7.38	47.38	100.0

(4) Ash Content

After the segregation of components, combustible components were combined and mechanically crushed. Small portion are sampled from this crushed samples and were heated intensely in a electric furnace. Ash content of the samples are shown in Table 2.2-6 and 2.2-7.

Table 2.2-6 Ash Content in November 1994

(Unit: %)

	Solid in Sample	Combustible in Solid	Ash in Combustible	Incombustible in Solid	Total Ash content in Wet Base
Household 1	41.4	73.7	28.2	26.3	19.5
" 2	59.0	49.8	12.4	50.2	33.3
" 3	65.0	61.7	13.8	38.3	30.4
" 4	43.9	83.1	20.3	16.9	14.8
" 5	43.2	90.0	12.3	10.0	9.1
Household Ave	50.5	-	-	-	21.4
Market	43.2	98.9	53.3	1.1	23.2
Business	86.8	67.9	7.7	32.1	32.4

Table 2.2-7 Ash Content in July 1995

(Unit: %)

	Solid in Sample	Combustible in Solid	Ash in Combustible	Incombustible in Solid	Total Ash content in Wet Base
Household 1	48.5	56.6	12.1	43.4	24.4
" 2	44.8	88.5	8.9	11.5	9.1
" 3	33.3	83.4	11.5	16.6	9.4
" 4	44.9	66.0	9.3	34.0	19.5
" 5	54.3	37.5	2.7	62.5	35.4
Household Ave	45.2	-	-	-	19.5
Market	42.7	72.1	13.5	27.9	17.7
Business	93.3	52.6	3.1	47.4	48.7

(5) Calorific Value

Dried and crushed samples are ignited in a Berthelot-Mahler type adiabatic calorimetric bomb and heat generated was measured by Beckman Thermometer. Calorific value of dried samples, higher calorific value, Low calorific value and estimated value by major three or four components equation are summarized in Table 2.2-8 and 2.2-9.

Table 2.2-8 Calorific Value in November 1994

(unit; kcal/kg)

	(A) Calorific value of dried sample	(B) High calorific value Calculated from (A)	(C) Low calorific value Calculated from (B)	Estimation by three major components equation 1)	Estimation by four major components equation 2)
Household 1	4753	1412	986	634	664
Household 2	4523	2336	1895	911	929
Household 3	4847	2716	2262	1346	1434
Household 4	5135	1795	1322	969	1060
Household 5	4774	1918	1425	1208	1315
Household Average	4806	2035	1578	1014	1080
Market	5054		619	566	662
Office	4012		1850	3529	3640

Table 2.2-8 Calorific Value in July 1995

(unit; kcal/kg)

	(A) Calorific value of dried sample	(B) High calorific value Calculated from (A)	(C) Low calorific value Calculated from (B)
Household 1	2533	1228	823
Household 2	3997	1792	1319
Household 3	3331	1111	621
Household 4	2908	1306	859
Household 5	1761	956	597
Household Average	2906	1279	844
Market	2800	1194	757
Office	3082	2877	2628

Note: 1) Three major components equation is:

$$Hl = 45V - 6W$$

Where,

Hl : Low calorific value (kcal/kg)

V : Percentage of combustible in dried samples (%)

W : Moisture Content (%)

2) Three major components equation

$$Hl = 45b + 88.45R - 6W$$

Where,

Hl : Low calorific value (kcal/kg)

B : Percentage of combustible other than plastics in dried samples (%)

R : Percentage of plastics in dried samples (%)

3) These estimation by equations are not indicated for 1995, since the equations do not give good estimation.

(6) Elemental Analysis

Dried and crushed samples were analyzed by using a elemental analyzer (Carlo Erba model 1106). Concerning carbon, Hydrogen and nitrogen, the samples were ignited in oxygen at 1080° C and generated gas is separated by chromatography. Chlorine and sulphur were detected by volumetric titration after Schoniger combustion. Oxygen content is calculated by subtracting these analyzed elements from total combustibles. Element contents in wet base are summarized in Table 2.2-9 and 2.2-10.

Table 2.2-9 Element Contents in November 1994

(Unit: % in wet base)

	Carbon	Hydrogen	Nitrogen	Sulphur	Chlorine	Oxygen
Household 1	6.9	1.4	0.3	0.9	0.6	11.9
" 2	17.3	3.6	0.9	0.3	1.2	2.4
" 3	18.7	4.5	1.0	0.3	1.4	8.7
" 4	12.2	2.5	0.5	1.4	0.8	11.6
" 5	12.8	3.1	0.7	0.2	1.1	16.2
Household Average	13.6	3.0	0.7	0.6	1.0	10.1
Market	4.4	0.9	0.1	0.1	0.4	14.0
Business	26.1	4.7	0.1	0.4	0.4	22.7

Table 2.2-10 Element Contents in July 1995

(Unit: % in wet base)

	Carbon	Hydrogen	Nitrogen	Sulphur	Chlorine	Oxygen
Household 1	11.0	1.8	0.5	0.0	0.3	11.3
" 2	16.6	2.6	1.2	0.0	0.0	14.9
" 3	10.6	1.7	0.7	0.0	0.1	10.7
" 4	13.9	2.2	0.7	0.0	0.3	9.6
" 5	9.6	1.6	0.4	0.0	0.0	7.0
Household Average	12.4	2.0	0.7	0.0	0.1	10.7
Market	10.9	1.7	0.8	0.0	0.0	9.3
Business	24.8	3.9	1.1	0.0	0.0	14.0

3. ASSUMPTIONS USED FOR PROJECTION OF WASTE QUANTITY

Following assumptions were used for projection of the future waste quantity for Bucharest.

1 Current Waste Quantity

It is estimated that average waste generation in Bucharest is 1,906 tons/day, of which 1,044 tons/day is household waste. Average per capita discharge is 496.15 grams/day. Average per capita generation including recyclable material sold to REMAT is 513 grams/day. Average collection is 1,675 tons/day, of which 869 tons/day is household waste. Estimated recycling quantity is 45 tons/day excluding recycled industrial or demolition waste. See Appendix 1 for details.

2. Waste Generation Increase Rate

Generation amount will increase with the Romanian GDP growth which may be decomposed into 2 factors; per capita growth and population growth. Assumed correlation between annual waste increase rate (a) and annual GDP growth rate (b) is as follows: $a = 0.7\ b$. It is assumed that the same correlation (0.7) will hold for per capita waste generation rate and per capita GDP growth.

Remarks:

The above assumption is used based on the Japanese experience during the period 1965 - 1980. During this period, average annual waste increase rate was 4.7 %, while average annual GDP growth rate was 6.6 % over the same period.

3. Population

According to the Statistical General Division Bucharest Municipality, the population of Bucharest in 1993 was 2,035,660. In 1989, the population was 2,127,194, which is historically the highest. Since then, population growth was negative. Average annual population growth from 1980 to 1993 was 0.722 %/year.

For the current Study, it is assumed that 1) population in 1994 is same as 1993. Population growth from 1994 to 2010 is 0.722 %/year. Table 3.1-1 shows projected population form 1994 till 2010.

Table 3.1-1 Projection of Population 1994 - 2010

Year	Population
1,994	2,035,660
1,995	2,050,357
1,996	2,065,161
1,997	2,080,072
1,998	2,095,090
1,999	2,110,216
2,000	2,125,452
2,001	2,140,798
2,002	2,156,254
2,003	2,171,822
2,004	2,187,503
2,005	2,203,297
2,006	2,219,205
2,007	2,235,227
2,008	2,251,366
2,009	2,267,620
2,010	2,283,993

4. Economic Growth

The Romanian GDP growth rates projected in the World Bank report *ROMANIA An Economic Update, April 1994* are used for the waste projection. The projected annual GDP growth rates are as follows: 1.2 % in 1995, 1.5 % in 1996, 2.5 % in 1997, and 4.0 % from 1998 to 2002. No projection is shown for 2003 and thereafter. The Study Team assumes that GDP growth rate for period 2003 - 2010 would be 4 %. Annual projected economic growth rates are shown in Table 3.1-2.

Table 3.1-2 Projection of GDP Growth Rate 1994 - 2010

Year	Economic Growth Rate
1,994	1.0 %
1,995	1.2 %
1,996	1.5 %
1,997	2.5 %
1,998	4.0 %
1,999	4.0 %
2,000	4.0 %
2,001	4.0 %
2,002	4.0 %
2,003	4.0 %
2,004	4.0 %
2,005	4.0 %
2,006	4.0 %
2,007	4.0 %
2,008	4.0 %
2,009	4.0 %
2,010	4.0 %

Per Capita Economic Growth: It is assumed that annual per capita economic growth (a) is: b ÷ c, where b is annual GDP growth and c is annual population growth. (Eg. per capita economic growth rate in 1995 = 1.012 ÷ 1.00722 = 1.0047, i.e. 0.47 %.)

5. Future Waste Quantity

Future waste quantities (generation, recycling, collection and disposal) estimated based on the assumptions explained above are shown in Table 3.1-3.

6. Recycling

Rate of recycling of municipal waste will increase from 3.1 % of generated municipal waste excluding street waste in 1994 to 5 % in 2000. Projected rates between 1995 and 2000 are as follows: 3.1 % in 1994, 3.3 % in 1995, 3.4 % in 1996, 3.5 % in 1997, 4 % in 1998, 4.5 % in 1999 and 5 % in 2000. After 2000, it will remain constant at 5 %. Recycling of industrial waste is excluded from the projection.

Table 3.1-3 Projection of Economic Growth and Waste Quantity

Year	GDP Growth (%/year) a	Waste Generation (ton/day) b	Recycled (only household waste) (ton/day) c	Non-Recycled (b-c) d	Target Collection Rate relative to Non-recycled (%) e	Target Daily Collection (ton/day) (d x e/100) f	Daily Disposal (ton/day) (f-h) g	Daily incineration (t/day) h	Neither Recycled Nor Collected (t/d) (d-f) i	Collection Index (1994=100) j	Annual Disposal (ton/year) (g x 365days) k	Cumulative Disposal Amount (ton) l
1,994	1.0%	1,906	45	1,861	90%	1,675	1,672	3	186	100	610,280	610,280
1,995	1.2%	1,922	47	1,875	90%	1,687	1,684	3	187	101	614,735	1,225,015
1,996	1.5%	1,942	49	1,893	92%	1,741	1,738	3	151	104	634,528	1,859,543
1,997	2.5%	1,976	53	1,923	94%	1,808	1,805	3	115	108	658,667	2,518,210
1,998	4.0%	2,032	63	1,969	96%	1,890	1,887	3	79	113	688,832	3,207,041
1,999	4.0%	2,088	72	2,016	98%	1,976	1,973	3	40	118	720,051	3,927,092
2,000	4.0%	2,147	83	2,064	100%	2,064	2,061	3	0	123	752,357	4,679,449
2,001	4.0%	2,207	85	2,122	100%	2,122	2,122	0	0	127	774,548	5,453,997
2,002	4.0%	2,269	87	2,181	100%	2,181	2,181	0	0	130	796,236	6,250,232
2,003	4.0%	2,332	90	2,243	100%	2,243	2,243	0	0	134	818,530	7,068,762
2,004	4.0%	2,398	92	2,305	100%	2,305	2,305	0	0	138	841,449	7,910,211
2,005	4.0%	2,465	95	2,370	100%	2,370	2,370	0	0	141	865,010	8,775,221
2,006	4.0%	2,534	98	2,436	100%	2,436	2,436	0	0	145	889,230	9,664,451
2,007	4.0%	2,605	100	2,504	100%	2,504	2,504	0	0	150	914,128	10,578,579
2,008	4.0%	2,678	103	2,575	100%	2,575	2,575	0	0	154	939,724	11,518,303
2,009	4.0%	2,753	106	2,647	100%	2,647	2,647	0	0	158	966,036	12,484,339
2,010	4.0%	2,830	109	2,721	100%	2,721	2,721	0	0	162	993,085	13,477,424

4. WASTE PREVENTION AND UTILIZATION

4.1 Proposed System using Collection Boxes

As generation waste of household increases along with economic growth in future, recyclable material contained in the household waste will increase. In a proposed system of collection box referred in the Master Plan, installation of 1,540 units of boxes are proposed according to the following planning scheme. In this section, recyclable material means material which is accepted by collection boxes.

<u>**Planning Scheme**</u>

a. Waste category collected by collection boxes:	Glass bottles and metal cans
b. Averaged daily quantity of recyclable material brought into the collection boxes: (from 2 million population)	110 tons/day
c. Average bulk density of the recyclable materials:	0.25 tons/m^3
d. Capacity of collection box:	2 m^3
e. Collection frequency by collectors:	Once a week for every box

From the planning scheme above, necessary unit of collection boxes is calculated as follows:

f. Total daily capacity of recyclable material discharged from 2 million of population:	440 m^3/day (b. + c.)
g. Total weekly capacity of recyclable material discharged from 2 million of population	about 3,080 m^3/week (f.× 7)
h. Necessary unit of collection boxes:	**1,540 units** (g + d)

4.2 Material Collected by REMAT

REMAT collects recyclable material such as ferrous metal, non-ferrous metal, paper, glass and textile. These material is collected through collection points from citizens. From industry, REMAT' vehicle visits industry and collects recyclable material on contract.

Table 4.2-1 and 4.2-2 show total quantity of recyclable materials collected by REMAT Sud (South) from citizens and industry, respectively. Quantity of Glass and Textile from citizens are not available.

Table 4.2-1 Recyclable material Collected from citizens

(Unit: tons)

	Ferrous Metal	Non-ferrous Metal	Paper
1993	12,024	822	3,413
1994	24,756	1,592	3,595
1995 (Until June)	10,343	854	1,962

Table 4.2-2 Recyclable material Collected from industry

(Unit: tons)

	Ferrous Metal	Non-ferrous Metal	Paper
1993	77,897	3,040	4,911
1994	72,921	2,027	4,642
1995 (Until June)	35,103	769	1,733

At national level, recycling rates of major material thorough REMAT are as follows:

- Scrap iron 51%
- Waste paper 32%
- Aluminum 42%
- Lead 48%

4.3 Features of Proposed Recyclable Materials Law

Formerly, recycling activity was provided in the Decree no.465/1979, but this was formulated based on command economy and now it is not functional. In autumn 1994, Ministry of Industry proposed a new law titled "Recyclable Materials Law", which was examined by the ministries involved in such as Ministry of Commerce, Ministry of Local Public Administration and Ministry of Water, Forest and Environmental Protection, then promulgated in summer 1995.

Features in this law are as follows:

1) Local Administration (municipality) has authority to apply this law to its own territory, and local administration's cooperation with NCMR is stated.
2) Obligations of each participants in recycling process are defined.
3) Incentives such as tax exemption for recycling facility are provided.
4) Sanctions to those who do not deal with recyclable material properly are provided.
5) NCMR's authority is empowered.
6) The law gives a due consideration not only to economy of recycling but also to environmental protection.
7) Package is included in category of recyclable material.
8) Office activity is nominated in category of economic activity under the law.

4.4 Recyclable Material Collection

4.4.1 Scavengers

A "Scavenger" means person who pick up useful articles among waste at collection, transport or disposal site, and sell them to earn money. In some Asian countries, many scavengers exist . In these countries, reuse or recycling is supported by their activity. Even, in some cases, the scavengers are organized to be incorporated to solid waste management system of the municipality. Whereas, it is problem that scavenging activity of collectors disturbs efficient collection. Sometimes scavenging is inherit as an occupation by his children, but such inheritance should be abolished because of unsanitary activity in picking up articles among waste.

4.4.2 Waste Material Buyer

Since old time in many countries, waste material has been collected by buyers who visit households. As waste collection has began to be managed by public sector, waste material collection also came to be organized in public activity. The buyer purchase waste material at households and sell them to manufacturer as secondary material. Therefore, this buying and selling has been done in market when such waste material has a certain value. If virgin material from abroad can be imported at lower price than domestic secondary material due to development of transportation system, incentives for recycling of waste material is lost and these buyers cannot continue their business. In some countries, these buyers contributes to recycling chain. Fostering of such buyers of waste material is one of options in strengthening recycling activity.

4.4.3 Citizen's Voluntary Activity

One of major power to promote recycling is citizen's voluntary activity. Usually citizens form groups like a residents association and work cooperatively. This organized activity is also favorable of efficient material collection. In Japan, citizens associations of zone collect glass bottle s and metal cans of drinks and hand them to a buyer approved by city government. As shown here, formation of citizens association is good way to promote citizens voluntary activity for recycling.

4.5 Recycling System in the Countries Promoting Recycling

4.5.1 Germany

"The Act for the Prevention of and Disposal of Waste" defines responsibilities of manufacturers, transporters and sellers in its articles. Corresponding to this provision, 600 (1993) of manufacturers of packaging material, containers and transporters established a company "Dual System Deutschland (DSD)" which manages recycling route for packaging waste through contract with private collectors and recoverers. In this collection and recycling system, 17,142 (1994) of manufacturing company make contracts with the DSD and licensed with fee to use "Grüne Punct (Green Point)" to be attached their products. On the other hand, material collection companies under contract with the DSD collect packaging waste with Green Points the DSD, as the Green Points acts as evidences of member companies' products. The collected waste is sorted and recyclable material is utilized by the manufacturers of packaging material who finance to the DSD. Recycling chain in the system is shown in Fig. 4.5-1. The Fees for using Green Point is shown in Table 4.5-1.

Fig. 4.5-1 Recycling Chain in the DSD System

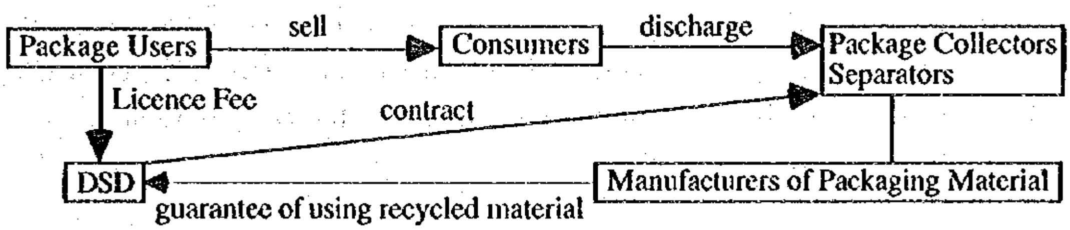


Table 4.5-1 Fee of Grüne Punct (Green Point)

	Fee
Glass	15 Pfennig/kg
Paper and cardboard	40 Pfennig
Tin plate	56 Pfennig
Aluminum	1.5 Mark
Plastic	2.95 Mark
Natural textile as cotton	20 Pfennig
Container for drink	1.69 Mark
Liquid containers other than drink	2.10 Mark

4.5.2 France

Actual conditions of recovery and reuse of packaging materials are described in the following table.

Table 4.5-2 Recovery and Reuse of Packaging Materials

	collection	recovery rate (%)	reuse rate (%)	annual increase (%)	comments
glass (households / industry)	1100000t (1992)			1992: 11.4 1993: 9 1994: 12	Establishment of Eco-Emballage in 1992, of Adelphe in 1993
metals (ferrous)	7852000t (1992)			1992: -2.3 1993: -3 1994: 2	
paper / cardboard	3133000t (1992)	34.3% (1992)	45.8% (1992)	1992: 4.1 1993: 3.5 1994: 3	
plastics	150000t (1992)			1992: -25 1993: -7 1994: -5	mainly Valorplast company

Case of paper / cardboard: recovery % is the % of collected old paper / cardboard compared with consumption of paper (weight); reuse % is the % of consumption of old paper / cardboard compared with production of paper (weight)

Recycling of household packaging materials is basically managed by contracting between industrials and collectivities through the action of intermediate companies. These companies receive fees from concerned industries for setting separate collection and for finding out recycling routes.

There are 3 such companies, established with the purpose of collecting funds and organizing collection and reuse of waste materials:
- Eco-Emballage company is the most important and is semi-public. It provides financial aid and finances cost overrun of separate collection;
- Adelphe company has been established by wines and spirits producers for collection and reuse of bottle glass;
- Cyclamed company has been established by medicines producers for collection and reuse of medicines packages.

Eco-Emballage is a company established in 1992 by the joined capitals of packing related industry, namely the packaging sector, importers, and producers of packaging materials or products. The role of Eco-Emballage is to financially assist the municipalities for developing selective collection systems of packaging waste. The objective has been set by decree in 1992 and provides that 75% of packaging waste must be recovered and valorized by 2002. The following general conditions are applied:

- Financial support toward municipalities for developing or grading up their existing separate collection systems, through acquisition of the waste materials at a determined price. These waste materials must be in conformity with a pre-determined set of quality conditions.

- Guaranty of supplying such materials to the recycling firms themselves engaged to take and reuse them.

- Price of the materials supplied to the recycling firms will be adjusted to the current prices under way in other countries of the EU. Price is fixed to a zero value at the starting phase.

- Perception of a fee from the packing industry, giving it the right to process a mark on packs for collection and recycling. The fee is actually payable for each pack without differentiation between materials. Rate of the fee payable for each pack has been fixed as follows:
- 0.01FF during the first year
- 0.02FF during the second year
- 0.03FF during the third year

- Funds collected from the packaging fee is used by Eco-Emballage for buying the collected packaging waste to municipalities, and more exceptionally within the limit of a 3 years period for developing new methods of recycling for materials that are still incinerated.

In 1993, about 4000 companies have joined the system, with a funding of 400 million FF. This number has been increased to about 7000 companies in 1994. During the 3 years period of starting the program, 15% of the funds perceived by Eco-Emballage are being used for initiating pilot operations for separate collection, and for setting up information campaigns at national, regional and local levels. The collected fees have been partly used for investment in 37, increased to 41 pilot sites in 1994. These collectivities have received a special financial aid of 180 million FF for 3 years. Eco-Emballage has however bound contracts with 100 collectivities (10 millions inhabitants) by 1994, which represents 2 million persons concerned with separate collection of waste. The objective is to attain 15 million persons by 1996.

Actual problems of the recycling system are as follows:

- Contracting between Eco-Emballage and collectivities:
Among the 41 pilot sites, 21 have technical, financial and policy problems. The objective of extending selective collection of waste to 15 million people in 1996 seems now not possible to achieve. One difficulty is to satisfy the industrials' requirement for high quality of recovered materials. Since Eco-Emballage gives its guaranty for price and quality of materials, if agreement with collectivities was not reconducted, recovery conditions would change and the system itself could be compromised.

- Cost of recovered materials:

- Cost of separate collection:
Eco-Emballage has launched an evaluation study of separate collection in 6 pilot sites in 1993 (see Table following). Additional cost due to separate collection varies from 800 to 2000FF/t. Cost overrun is variable according to factors like types of residential area, frequency of collection, technical alternatives of collection, types of containers, sorting alternatives, and others. In the following table, cost overrun is the necessary additional cost of waste collection in comparison with traditional collection. Traditional collection net costs include costs of containers, separate collection, sorting, elimination of recoverable part, and takes into account the possible benefits of the system.

Table 4.5-3 Cost evaluation of separate collection in selected 6 pilot sites in France

	Etrechy	Grenoble	Geugnon	Romans	Dunkerque	Ecouflant
starting of project (year)	1990	1992	1992	1992	1989	1991
population (1992)	15000	21000	10000	17000	120000	3000
total cost of separate collection (FF)	1154	1488	1076	1822	1220	2497
cost overrun per usable ton (FF)	700	1987	639	838	247	1372
cost overrun in % of cost of classic collection	140%	390%	124%	130%	30%	304%
cost overrun per habitant (FF)	28	73	13	19	32	145

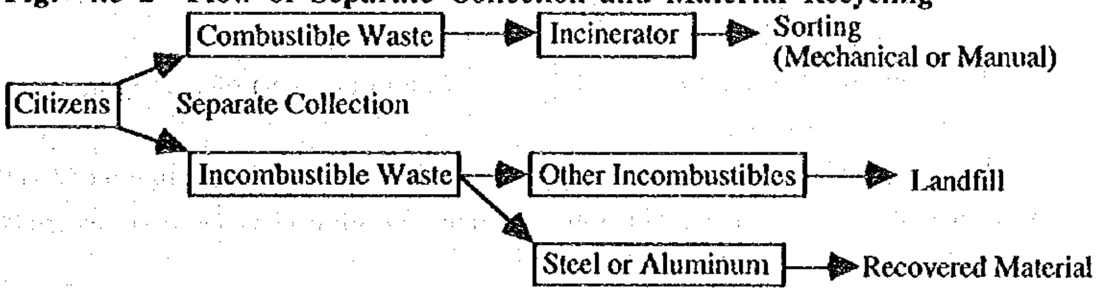
4.5.3 Japan

In Japan there are two major recycling methods for household waste, one is separate collection as public services and the other is citizens association's activity for material collection. Besides, private collectors gather material from household on market basis.

1) Separate Collection of Household Waste

In many cities in Japan, combustible waste and incombustible waste are collected separately. That is, dates of combustible waste and incombustible waste are assigned separately. Correspondingly, citizens places their combustible or incombustible waste which are already sorted by citizens themselves. Incombustible waste such as glass, steel, aluminum etc. is collected and sorted by its type by a mechanical sorter or manual sorting , while combustible waste is incinerated. After sorted, steel or aluminum is briquetted by pressing machine for easy handling and are sold to secondary material dealers, while other incombustible components are crushed and transported to a landfill site.

Fig. 4.5-2 Flow of Separate Collection and Material Recycling



2) Citizens Association's Activity for Material Collection

In some cities and villages, citizens form associations for cooperative activity in various fields. Recently such associations have an interest in environmental protection and they have started to collect recyclable material in cooperation with municipalities. Citizens voluntarily accumulates recyclable material such as waste newspaper of magazines, glass bottles, steel or aluminum cans of drinks, bring them to collection points on an assigned date. These material are placed separately at collection points which are managed by secretariats of the association. Secondary material dealer visits these collection points to gather the materials under instruction of the municipalities. This system starts with the municipality's initiative, but the voluntary cooperation of citizens is indispensable.

4.6 Legal and Administrative Requirements

4.6.1 EC/EU directives for recycling of packaging

- Council Directive of 27 June 1985 on containers of liquids for human consumption:

This directive, published in 1985, is more specifically focusing on beverage packs, and provides that member countries must take favorable measures for the reuse or recycling of packaging waste, arrange themselves for setting and using new appropriate packs, and maintaining or increasing the rate of reusable or recyclable packs.

- Council Directive of 14 December 1994 on packaging and packaging waste:

This directive aim at the harmonization of member countries' measures for management of packaging and waste packaging. Application of the directive is planned for beginning of 1996. Member countries must provide legal requirements within 18 months. Recycling and reuse objectives are:
- Valorization of 50% minimum and 65% maximum (weight) of packaging waste before the year 2001 (June);
- Within the precedent range, recycling of 25% minimum and 45% maximum (weight) of waste materials as a whole, with a minimum of 15% for each category of materials, before the year 2001 (June);
- The % of packaging waste to be recovered and recycled will be redefined before year 2006 in view of increasing the target.

4.6.2 Legal Requirements (France member country)

- Waste Law of 13 July 1992:

The Waste Law of 13 July 1992 is completing the law of 1975 on waste and classified installations, and gives the scope of waste management. This law provides the obligation of valorization of waste materials since it requires that only ultimate waste could be deposited in landfill sites by 2002.

- Decree on packaging wastes of 1 April 1992:

The decree on packaging waste provides that suppliers, namely importers and wholesale sellers or retailers have legal obligation for taking back packaging products they have put on the market. In practice, this obligation translates into obligation for them to co-manage and finance the collecting and separating activities of Eco-Emballage.

- Decree for reduction and recycling of industrial / commercial packaging waste of 13 July 1994:

This decree provides that packaging industrial users (including hotels and restaurants for example) are responsible for valorization of their packaging wastes. Are not concerned by this decree the individuals and enterprises that produce less than 1100 littres of industrial / commercial packaging wastes per week. In this case, they are however responsible for keeping these wastes separate from other wastes in order to permit valorization by local collectivities. This decree does not set priorities amongst valorization options, nor amongst quantitative targets. Application has been set for 21 September 1994 in the case of papers and cardboard, and is planned for 21 July 1995 in the case of other materials.

5. COLLECTION AND HAULAGE

5.1 Basic Data and Assumptions

5.1.1 Foreign Exchange Rate Used

The following rate was used:

US$ 1.0 = Lei 2,000 = DM 1.57 = Swiss F 1.33 = £1.56 = ¥100.3

5.1.2 Coverage

1) Population 2,050,357 (1995)

2) Estimated population served by services providers

1.	RASUB contracted population:	1,404,754
2.	RGR contracted population:	370,800
3.	Total (1 + 2):	1,775,554
4.	Not covered by contracts:	274,803
5.	Total population in Bucharest:	2,050,357

5.1.3 Quality of municipal waste

1) Quality

Quality	Household waste:	0.32 ton/m^3
	Market & Business waste:	0.27 ton/m^3
	Street waste:	0.95 ton/m^3

2) Convertion

1 year = 12 month = 52.143 week

1 month = 4.345 week

1.0 week = 1.167 weekday (Mon. to Sat.)

Collection [RASUB] : weekday (1), Saturday (0.2), Sunday (0.1)
[RGR] : Weekday (1), Sunday (0.1)

RASUB:	7 days quantity/5.3 = collection/weekday
RGR:	7 days quantity/6.1 = collection/weekday

Discharge: 0.496 kg/capita/day
0.32 kg/litre 1.55 litre/capita/day

110 litre bin = 10.1 people/week
240 litre bin = 22.1 people/week

5.1.4 Haulage record

Whole number of trucks inflowed to Glina disposal site in the observation days is shown as follows.

Table 5.1-1 Number of inflowed trucks in observation days

Observation date	RASUB	RGR	ADP	Other	Total
Nov. 24 (Thursday), 1994	413	35	31	106	585
25 (Friday)	415	34	34	113	596
28 (Monday)	425	29	34	96	584

5.1.5 Discharge

There are several kinds of container used for interface of discharge and collection. The following table shows more details on containers.

Table 5.1-2 Container's Variation

Types of container	Dura-bility	Price (US$)	Number of distributed containers for:				
				House-hold	Business	Street	Total
1). 4m^3 s-con.	8 year	417	by RASUB	275	486	-	761
			RGR	5	12	-	17
			ADP	-	65	118	183
2). 7m^3 s-con.	8 year	580	by RGR	-	13	-	13
3). 1.1m^3 s-con.	8 year	130	by RGR	-	6	-	6
4). 110 l s-bin.	8 year	22	by RASUB	170,000	55,000	-	225,000
5). 240 l p-bin	4 year	25	by RGR	11,700	3,300	-	15,000
6). 120 l p-bin	4 year	18	by RGR	1,000	-	-	1,000
7). 70 l p-bag	-	0.2	by RASUB	300,000	-	-	300,000
8) 10 l p-bag	-	0.04	by user*				
9). 30 l p-bag	-	0.07	by user*				

Note) 1) S-con.: Steel Container
2) p-bin: Plastic bin, s-bin: steel bin
3) p-bag: Plastic bag
4) Number of ADP's container is excluded Sector 1 and Sector 6
5) *: Not countable
6) 240 ℓ plastic bin's price is on a used bin.

5.2 Collection

5.2.1 Cost Estimation on Collection Trucks

Cost = [Depreciation + O/M Cost + Interest] + Indirect Cost ([----] × 0.05)

=D A (Depreciation + O/M Cost); 0.0545D (Interest); Di ([Depreciation + O/M Cost + Interest]); B (Indirect Cost)

Interest = 8% (compound interest), 8 years repayment

Principles: D

Net interest = 1.436 D– D = 0.436D Per year: 0.436D/8 = 0.0545D/yr

Table 5.2-1 Detail Costs by Existing Collection System

[unit: US$]

Type of System	(1) Price	(2) Costums & commission	(3) Value Added Tax (1+2)× 18%	(4) Sub-total (1)+(2)+(3)	(5) Interest/yr (8% yr, repayment in 8 yrs)	(6) Depreciation/yr (8 yrs, straight line) (4)/8+(5)	(7) Maintenance cost/yr	(8) Fuel cost /yr	(9) Crew & Mechanic Salary /yr	(10) Container cost /yr	(11) Total direct cost/yr (6)+(7)+(8)+(9)+(10)	(12) Overhead & Indirect cost/yr (11)×0.05	(13) Total cost /yr (11) + (12)
1 Compactor RGR-16 +240ℓ p-bin	87,000	26,535	20,436	133,971	7,301	24,047	1,600	4,510	3,790	6,750 *	37,057	1,853	38,910
2 Compactor PELICAN +110ℓ s-bin	48,330	0	8,699	57,029	3,108	10,237	1,110	2,850	10,730	5,060	29,987	1,499	31,486
3 Compactor LIAZ +110ℓ s-bin	52,230	15,930	12,269	80,429	4,383	14,437	1,110	2,700	9,430	4,660	32,337	1,617	33,954
4 Compactor MEDIAS +110ℓ s-bin	44,800	0	8,064	52,864	2,881	9,489	2,110	3,040	9,430	3,800	27,869	1,393	29,262
5 Container-compactor PELICAN-C +4m³ cont.	50,920	0	9,166	60,086	3,275	10,786	1,220	4,930	8,140	4,220	29,296	1,465	30,761
6 Container SRDAC +4m³ cont.	26,400	0	4,752	31,152	1,698	5,592	1,390	2,570	6,840	1,630	18,022	901	18,923

Note *: 240 ℓ plastic bin's cost is on a used bin.

Table 5.2-2 Comparison of Cost Efficiency by Existing Collection System

Type of Truck	(13) Total cost /yr (11) + (12) [US$]	(14) Collected waste/yr [ton]	(15) Unit cost of collection & haulage (13)/(14) [US$/ton]	(16) Rank (Index)
1 Compactor RGR-16 +240ℓ p-bin	38,910	3,838	10.1	1(100)
2 Compactor PELICAN +110ℓ s-bin	31,486	2,376	13.3	3(132)
3 Compactor LIAZ +110ℓ s-bin	33,954	2,187	15.5	4(153)
4 Compactor MEDIAS +110ℓ s-bin	29,262	1,782	16.4	5(162)
5 Container-compactor PELICAN-C +4m^3 cont.	30.761	2,403	12.8	2(127)
6 Container SRDAC +4m^3 cont.	18,923	945	20.0	6(198)

Table 5.2-3 Average Unit Costs for the Whole Trucks

Type	Collected waste/yr /truck (ton) (W)	Nos. of Trucks (exists) (a)	Total Collected Waste/yr (ton/yr) (w×a)=(b)	Annual Costs/ truck (US$) (c)	Total Costs /year US$ (a×c)=(d)	Average Unit Cost /ton Σ(d)/Σ(b)
1 Compactor RGR-16	3,838	5	19,190	38,910	194,550	5,794,389/379,316 =US$15.3/ton
2 R-container PELICAN	2,376	26	61,776	31,486	818,636	
3 R-compactor LIAZ	2,187	45	98,415	33,954	1,527,930	
4 Compactor MEDIAS	1,782	79	140,778	29,262	2,311,698	
5 C-Compactor PELICAN-C.	2,403	14	33,642	30,761	430,654	
6 Container SRDAC	945	27	25,515	18,923	510,921	
Total	--	196	379,316	--	5,794,389	

Table 5.2-4 Collection Truck's Data by TMS

	Collected Waste/Day		Trip /Day	Net Load. Time	Net Coll. Haul. Time	Crew	Fuel /Day	Work Day/ Year	Maint . Cost/ Yr	Fuel Cost /Yr	Wage Crew & Mechan. /Yr
	at TMS (ton)	at WWS (ton)		(min)	(min)		(ℓ)		(US$)	(US$)	(US$)
MEDIAS	11.0	6.6	2	247	465	2	45	270	2,110	3,040	9,430
PELICAN-R	11.6	8.8	2	244	398	3	62L	270	1,110	2,850	10,730
LIAZ	9.7	8.1	2	249	374	2	40	270	1,110	2,700	9,430
SRDAC	3.8	3.5	3	44	359	1	38	270	1,390	2,570	6,840
PELICAN-C	16.7	8.9	2	273	456	2	73	270	1,220	4,930	8,140
RGR-C-16	12.3	12.3	3	123	314	3	85L	312	1,600	4,510	3,790

Note) 1) TMS: Time and Motion Study done in Novemebr, 1994

2) WWS: Waste Weight Survey done in November, 1994

3) 62L: 62ℓ of Light oil

5.3 Cost Data for Estimation

1) Salary

1. Workers salary in RASUB	- Driver:	US$1,580/person/year
	- Collection Worker:	US$1,295/person/year
	- Inspector:	US$1,273/person/year
	- Mechanic:	US$1,309/person/year
2. Workers salary in RGR	- Driver:	US$1,333/person/year
	- Collection Worker:	US$1,133/person/year
	- Mechanic:	Not applicable (RGR contracts out repair to a contractor)
3. Workers salary in ADP	- Driver:	US$1,293/person/year
	- Sweeping Worker:	US$ 540/person/year

2) Fuel Cost

- Gasoline: US$0.3/litre
- Light oil: US$0.2/litre

3) Maintenance Cost

1. RASUB - Number of mechanic and repair worker: 819 persons (in all of 4 workshops)

   - Parts, reproduction of material, oil exchange, tyre, etc./year:
     - US$2,110 (MEDIAS Compactor)
     - US$1,110 (PELICAN Compactor)
     - US$1,110 (LIAZ Compactor)
     - US$1,390 (SRDAC Container)
     - US$1,220 (PELICAN Container)

2. RGR - From June to September 1994, RGR paid to contractor: US$10,000 (as a total payment)

5.4 Cost Calculation

5.4.1 Container Cost (4 m^3)

Total containers: 761 ....(A)

SRDC:

1 container × 3 trips/day × 27 trucks = 81.0 containers/day ....(B)

PELICAN-C:

3.8 containers × 2 trips/day × 14 trucks = 106.4 containers/day ....(C)

How many containers are allocated for one SRDC and one PELICAN-C respectively?

SRDC: (A) × (B)/{(B) + (C)}/27 trucks = 761 × 81/(81+106.4)/27

= 12 conts./truck ....(D)

PELICAN-C:

(A) × (B)/{(B) + (C)}/14 trucks = 761 × 106.4/(81+106.4)/14

= 31 conts./truck .... (E)

Depreciation of 4m^3-container/yr: US$136/yr (4 yr depreciation).... (F)

Container cost for:

SRDC: (D) × (F) = 12 × 136 = US$1,632/truck/yr

PELICAN-C: (E) × (F) = 31 × 136 = US$4,216/truck/yr

5.4.2 Collection cost

Year	Municipal waste to be collected by the Municipality (ton/day)	(ton/year)	Estimated unit cost (US$/ton)	Depreciation cost borne by the Municipality (US$/ton)	Contract cost (US$/year) (2) × {(3) − (4)}
	(1)	(1)×365=(2)	(3)	(4)	(5)*
1995	1,181	431,065	15.3	3.9	4,914,000
96	1,227	447,855	14.1	3.0	4,971,000
97	1,278	466,470	12.9	2.0	5,085,000
98	1,341	489,465	11.7	1.0	5,237,000
99	1,406	513,190	10.5	0	5,388,000
2000	1,460	532,900	10.5	0	5,595,000
01	1,506	549,690	10.5	0	5,772,000
02	1,553	566,845	10.5	0	5,952,000
03	1,600	584,000	10.5	0	6,132,000
04	1,649	601,885	10.5	0	6,320,000
05	1,699	620,135	10.5	0	6,511,000
06	1,749	638,385	10.5	0	6,703,000
07	1,802	657,730	10.5	0	6,906,000
08	1,858	678,170	10.5	0	7,121,000
09	1,913	698,245	10.5	0	7,332,000
10	1,968	718,320	10.5	0	7,542,000

* Round up and down decimals above/equal or under 500

5.4.3 Cost of bin

The procurement cost of bin and cart are reportedly as follows,

[bin] 1. Plastic bin (110 ℓ, Austrian-made, brand-new): US$17.8 (incl.taxes)
2. Plastic bin (120 ℓ, Germany-made, brand-new): US$11.7 (incl.taxes)
3. Plastic bin (240 ℓ, Germany-made, used)*: US$ 1.0 (incl.taxes)
* RGR delivers used a plastic bin (240 l) by US$25.2 for full payment, US$28.3 for installment respectively.
4. Plastic bin (110 ℓ, Romanian-made, brand-new): US$22.2 (incl.taxes)

[cart] 1. Steel cart (200 ℓ, Romanian-made, brand-new): US$211 (incl.taxes)

[container]
1. Steel container(4m^3, Romanian-made, brand-new): US$417(incl.taxes)
* ADP expends US$14/year/one container for its maintenance.

Detailed specification of bins is shown in Table 5.1-2 in the Appendices Part.

5.5 Time and Motion Study (TMS)

Time and Motion Study (TMS) is one of the most significant method to obtain the basic data on actual conditions regarding collection and haulage and the related matters. By TMS what is measured are;

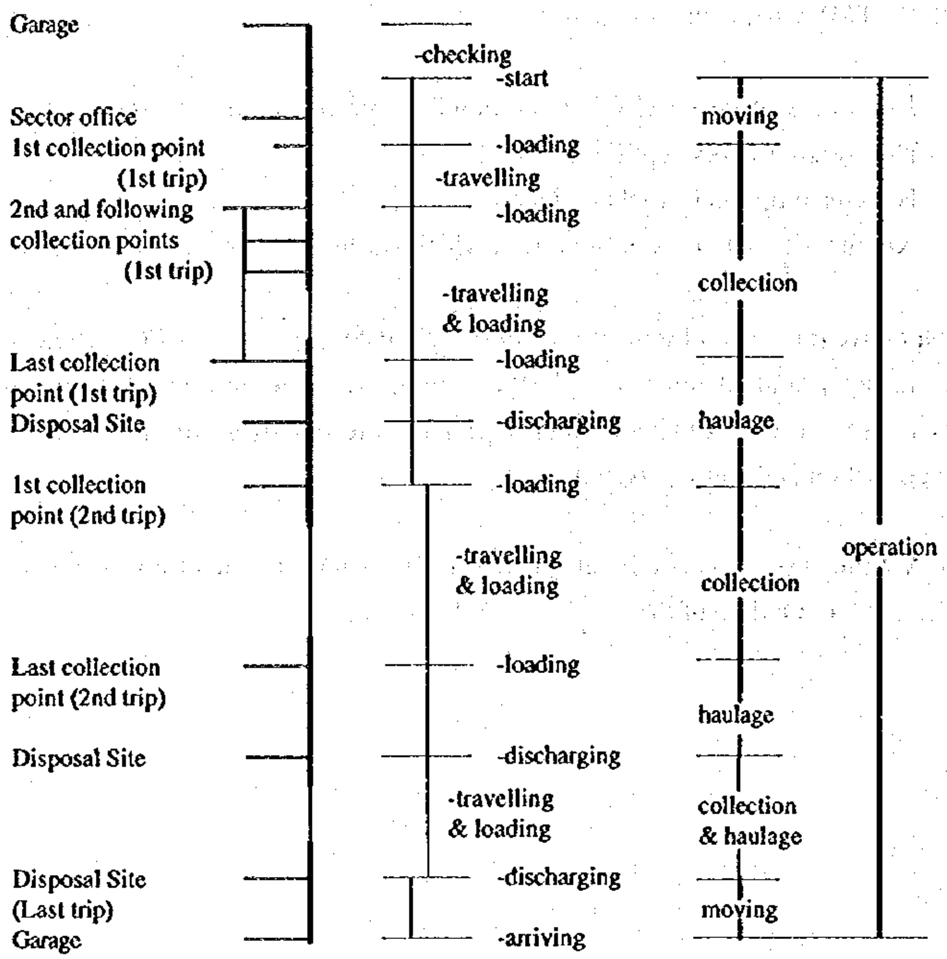
1. Net time on each activity of operation from starting upto finishing.
2. Net weight of collected (and hauled) waste.
3. Net consumption of fuel and its cost.
4. Number of containers or bins from which waste are collected.

Based on above data, useful indicators can be calculated, such as loading efficiency, hauling velocity and efficiency. Further more, by combining cost data, cost efficiency also can be estimated. Such indicators are indispensable for reviewing existing collection and hauling systems.

The JICA Study Team carried out TMS on six different collection systems in November, 1994. Outline of the TMS is as follows.

5.5.1 Difinition of the words for TMS

The followings are specified activities of collection and haulage in TMS.



5.5.2 Results

1) Compactor (MEDIAS) + 110 ℓ steel bins

Registered number: 32B4157, Capacity: 10 m^3, Crew: 3,
Collection area: Sector 1
Date of Study: November 8, 1994 (Start work 6:34, Finish work 15:59,
Work hours: 9:25)

Item	1st trip	2nd trip	3rd trip	Total
1) Loading time	1:54'	2:13'	–	4:07'
2) Traveling time and distance	18' 5.9 km	3' 1.6 km	– –	21' 7.5 km
3) Haulage time (to disposal site) and distance	47' 20.9 km	47' 19.7 km	– –	1:34' 40.6 km
4) Haulage time (to next trip) and distance	44' 16.7 km	– –	– –	44' 16.7 km
5) Collected waste	5.5 ton	5.5 ton	–	11.0 ton
6) Collection time efficiency { 1) + 2) } / 5) [min./ton]	24.0	24.7	–	24.4
7) Haulage velocity [km/h]	24.8	25.1	–	25.0
8) Moving time (to 1st trip) and distance	21' 11.7 km			
9) Moving time (to garage) and distance	32' 18.2 km			
10) Total operation distance	94.7 km			
11) Fuel Consumption	45 ℓ			
12) Fuel efficiency 10) / 11)	2.1 km/ℓ			

2) Container truck (SRDAC) + 4m³ containers

Registered number: 31B6088, Capacity: 4 m³, Crew: 1,
Collection area: Sector 6
Date of Study: November 9, 1994 (Start work 7:20, Finish work 14:37,
Work hours: 7:17)

Item	1st trip	2nd trip	3rd trip	Total
1) Loading time	14'	11'	19'	44'
2) Traveling time and distance	11' 4.5 km	0' 0 km	0' 0 km	11' 4.5 km
3) Haulage time (to disposal site) and distance	1:10' 23.9 km	1:06' 21.1 km	1:16' 19.0 km	3:32' 64.0 km
4) Haulage time (to next trip) and distance	46' 17.8 km	49' 18.6 km	– –	1:35' 36.4 km
5) Collected waste	1.3 ton	1.3 ton	1.2 ton	3.8 ton
6) Collection time efficiency { 1) + 2) } / 5) [min./ton]	19.2	8.5	15.8	14.5
7) Haulage velocity [km/h]	21.6	20.7	15.0	19.6
8) Moving time (to 1st trip) and distance	15' 5.6 km			
9) Moving time (to garage) and distance	46' 18.9 km			
10) Total operation distance	129.4 km			
11) Fuel Consumption	38 ℓ			
12) Fuel efficiency 10) / 11)	3.4 km/ℓ			

3) Rotative Compactor (PELICAN) + 110 ℓ bins

Registered number: B04BZR, Capacity: 12 m^3, Crew: 4,
Collection area: Sector 3
Date of Study: November 10, 1994 (Start work 6:28, Finish work 15:55, Work hours: 9:27)

Item	1st trip	2nd trip	3rd trip	Total
1) Loading time	2:00'	2:04'	–	4:04'
2) Traveling time and distance	19' 1.4 km	21' 4 km	– –	40' 5.4 km
3) Haulage time (to disposal site) and distance	57' 17.2 km	47' 15.7 km	– –	1:44' 32.9 km
4) Haulage time (to next trip) and distance	34' 17.1 km	– –	– –	34' 17.1 km
5) Collected waste	6.0 ton	5.6 ton	–	11.6 ton
6) Collection time efficiency { 1) + 2) } / 5) [min./ton]	23.2	25.9	–	24.5
7) Haulage velocity [km/h]	22.6	20.0	–	21.7
8) Moving time (to 1st trip) and distance	31' 11.6 km			
9) Moving time (to garage) and distance	23' 12.3 km			
10) Total operation distance	79.3 km			
11) Fuel Consumption	62 ℓ			
12) Fuel efficiency 10) / 11)	1.3 km/ℓ			

4) Rotative Container Compactor (PELICAN – Container) + 4m³ containers

Registered number: B04ULH, Capacity: 12 m³, Crew: 2,
Collection area: Sector 5
Date of Study: November 11, 1994 (Start work 6:27, Finish work 16:15,
Work hours: 9:48)

Item	1st trip	2nd trip	3rd trip	Total
1) Loading time	2:57'	1:36'	–	4:33'
2) Traveling time and distance	35' 9.4 km	15' 4.8 km	– –	50' 14.2 km
3) Haulage time (to disposal site) and distance	55' 15.6 km	57' 17.8 km	– –	1:52' 33.4 km
4) Haulage time (to next trip) and distance	23' 13.9 km	– –	– –	23' 13.9 km
5) Collected waste	10.5 ton	6.2 ton	–	16.7 ton
6) Collection time efficiency { 1) + 2) } / 5) [min./ton]	20.2	17.9	–	19.3
7) Haulage velocity [km/h]	22.7	18.7	–	21.0
8) Moving time (to 1st trip) and distance	24' 8.8 km			
9) Moving time (to garage) and distance	27' 13.5 km			
10) Total operation distance	83.8 km			
11) Fuel Consumption	73 ℓ			
12) Fuel efficiency 10) / 11)	1.1 km/ℓ			

5) Rotative Compactor (LIAZ) + 110 ℓ bins

Registered number: 31B7994, Capacity: 12 m^3, Crew: 3,
Collection area: Sector 2
Date of Study: November 15,1994 (Start work 6:31, Finish work 15:25,
Work hours: 8:54)

Item	1st trip	2nd trip	3rd trip	Total
1) Loading time	1:42'	2:28'	–	4:10'
2) Traveling time and distance	20' 7.0 km	4' 1.8 km	– –	24' 8.8 km
3) Haulage time (to disposal site) and distance	37' 7.8 km	45' 12.9 km	– –	1:22' 20.7 km
4) Haulage time (to next trip) and distance	22' 11.5 km	– –	– –	22' 11.5 km
5) Collected waste	4.1 ton	5.6 ton	–	9.7 ton
6) Collection time efficiency { 1) + 2) } / 5) [min./ton]	29.8	27.1	–	28.2
7) Haulage velocity [km/h]	19.6	17.2	–	18.6
8) Moving time (to 1st trip) and distance	15' 5.1 km			
9) Moving time (to garage) and distance	29' 15.0 km			
10) Total operation distance	61.0 km			
11) Fuel Consumption	40 ℓ			
12) Fuel efficiency 10) / 11)	1.5 km/ℓ			

6) Compactor (RGR-16) + 240 ℓ plastic bins

Registered number: B03FRM, Capacity: 16 m³, Crew: 3,
Collection area: Sector 6
Date of Study: November 24, 1994 (Start work 7:17, Finish work 15:10, Work hours: 7:53)

Item	1st trip	2nd trip	3rd trip	Total
1) Loading time	53'	44'	26'	2:03'
2) Traveling time and distance	4' 3.3 km	10' 1.6 km	5' 0.5 km	19' 5.4 km
3) Haulage time (to disposal site) and distance	44' 20.4 km	43' 19.0 km	44' 19.9 km	2:11' 59.3 km
4) Haulage time (to next trip) and distance	31' 18.5 km	34' 19.6 km	– –	1:05' 38.1 km
5) Collected waste: weighing base ( ): theoretical figure	5.6 ton (7.6)	4.2 ton (6.1)	2.5 ton (3.5)	12.3 ton (17.2)
6) Collection time efficiency { 1) + 2) } / 5) [min./ton] ( ): theoretical figure	10.2 (7.5)	12.9 (8.9)	12.4 (8.9)	11.5 (8.3)
7) Haulage velocity [km/h]	31.1	30.1	27.1	29.8
8) Moving time (to 1st trip) and distance	18' 8.4 km			
9) Moving time (to garage) and distance	31' 19.0 km			
10) Total operation distance	156.7 km			
11) Fuel Consumption	85 ℓ			
12) Fuel efficiency 10) / 11)	1.8 km/ℓ			

5.5.3 Comparison of systems

Item Collected Area No. of trip	MEDIAS (110 ℓ) Sec. 1 2	PELIC. (110 ℓ) Sec. 3 2	LIAZ (110 ℓ) Sec. 2 2	RGR-16 (240 ℓ) Sec. 6 3	SRDAC (4 m^3) Sec. 6 3	PELI-CON (4 m^3) Sec. 5 2
1) Loading time	4:07'	4:04'	4:10'	2:03'	44'	4:33'
2) Traveling time and distance [km]	21' 7.5	40' 5.4	24' 8.8	19' 5.4	11' 4.5	50' 14.2
3) Haulage time (to disposal site) and distance [km]	1:34' 40.6	1:44' 32.9	51' 20.7	2:11' 59.3	3:32' 64.0	1:52' 33.4
4) Haulage time (to next trip) and distance	44' 16.7	34' 17.1	22' 11.5	1:05' 38.1	1:35' 36.4	23' 13.9
5) Collected waste ( ): theoretical figure	6.6 (11.0)	8.8 (11.6)	8.1 (9.7)	12.3 (17.2)	3.5 (3.9)	8.9 (16.7)
6) Collection time efficiency { 1) + 2) } / 5) [min./ton] ( ): theoretical figure	40.6 (24.4)	32.3 (24.5)	33.8 (28.2)	11.5 (8.3)	15.7 (14.5)	36.3 (19.3)
7) Haulage velocity [km/h]	25.0	21.7	26.5	29.8	19.6	21.0
8) Moving time (to 1st trip) and distance [km]	21' 11.7	31' 11.6	15' 5.1	18' 8.4	15' 5.6	24' 8.8
9) Moving time (to garage) and distance [km]	32' 18.2	23' 12.3	29' 15.0	31' 19.0	46' 18.9	27 13.5
10) Total operation distance [km]	94.7	79.3	61.0	156.7	129.4	83.8
11) Fuel Consumption [ℓ]	45	62	40	85	38	73
12) Fuel efficiency 10) / 11) [km/ℓ]	2.1	1.3	1.5	1.8	3.4	1.1

6. STREET SWEEPING

6.1 Street Sweeping

1) Total expenses for SW of ADP in 1994:

US$2,260,000/year	- Salary	1,285,000/yr
	- O/M	975,000/yr

2) Gross unit cost $2,260,000/18,615 ton = $121/ton

6.2 Existing Mechanical Sweeping

1) Cost/year:	<u>$745,800</u>	- Ford	$479,500 (15 cars)
		- IFA	$107,500 (18 cars)
		- FAWN	$158,800 (7 cars)
2) Collection/year:	<u>1,908 ton</u>	- Ford	843 ton
		- IFA	687 ton
		- FAWN	378 ton

3) Gross unit cost per ton $745,800/3,820 ton = <u>$391/ton</u>

- 1,908	<u>$569/ton</u>
- IFA	<u>$156/ton</u> (beyond durability)
- FAWN	<u>$420/ton</u>

4) Gross Sweeping length/year: <u>44,238 km</u>

5) Gross Unit Cost per km: $745,800/44,238 km = <u>$16.9/km</u>

6) Working ratio: 65%

7) Rental cost of mechanical sweeper: US$48/shift (6 hours)

Annual cost for mechanical sweeper:

40 cars × 65% × 2 shift/day × US$48 × 303 days
= US$756,288/year (at maximum use)
40 cars × 65% × 1.5 shift/day × US$48 303 days
= US$ 567,216/year (at average use)

Table 6.2-1 Mechanical Sweeper's Comparison (cost in US$/year)

Type	Max Load (ton)	Average Load/shift (ton)	Depreciation	Duty	Salary	Maintenance cost	Fuel	Total collection (ton)	No. car	Cost /ton /car *	Total cost/ type
Ford	5.0	0.57	19,780	1,590	1,580	667	1,833	112.5	15	226	381,750
IFA	3.4	0.38	1,209	-	1,580	1,389	1,833	76.4	18	78	108,200
FAWN	4.8	0.55	18,949	-	1,580	333	1,833	108.1	7	210	158,900

	Total Cost
Ford	25,450 (remain 1.33 years)
IFA	6,011 (beyond durability)
FAWN	22,695 (remain 6 years)

* Actual base, not payload base.

6.3 Existing Manual Sweeping

1) Total cost/year: $1,738,008 (including rental cost for mechanical sweepers)
$1,490,760 (excluding rental cost for mechanical sweepers)

2) Collection/year: 31 compactors 75% × 4.4 ton/shift × 1.0 shift/day × 303 days
30,997 ton/year

3) Gross unit cost per ton: $1,490,760/30,997 ton = $48.1/ton

4) Gross Sweeping length/year:
12.8 km/2 (both sides)/shift × 100 shift/day × 70% × 303 days
= 135,744 km

5) Gross Unit Cost per km: $1,490,760/13,744 km = $11.0/km

6) Working ratio for workers: 70% (current condition)
compactors: 75% (current condition)

Table 6.3-1 Manual Sweeping Data per shift (cost in US$/year)

1 shift	Max collection (ton)	Average length swept (km)	Depreciation		Salary for 20 workers /shift	Maintenance & Fual cost	Total cost/ shift/year	Total length swept/ year/shift (km)	Total waste/ year/shift (ton)
			Compactor etc.	Container (2)					
20 workers	2.4	12.8 (gross)	2,635	87	12,332	2,187	17,214	3,878	727

6.4 Other Equipment

1) Street Container ($2m^3$)
- Distributed to all the streets to be swept
- 3 unit/km
- Price: $220/unit
- Durability: 4 years

2) Town trash box (120 litre)
- Distributed to all trunk streets
- 8 unit/km
- Price: $12/unit
- Durability: 4 years

6.5 Street Sweeping Cost

6.5.1 Composition of the Cost

Composition of the cost on street sweeping is classified as shown in the following table.

Table 6.5-1 Outline of Cost Separation

	Mechanical Sweeping		Manual Sweeping	Other Equipment
	Mecanical Sweeper(car lane)	Manual Sweeper (side walk)	Manual Sweeper	Installed
-Mechanical equipment (incl.interest) -Fuel -Maintenance	Mec.sweeper (depreciation per year)	Container truck/ Patrol Car (depreciation per year)		-Street container -Trash box (depreciation per year)
-Salary, OH -Cart,Sweeping tools	Drivers[1]	Workers[1] and drivers[1]		
Separation of Cost Estimation	A (per mec.sweeper)	B (per shift)		C

6.5.2 Formula

Total Annual Cost = A+B+C

Here: 1) A and C do not depend on waste amount, but depend on the length of streets to be swept.
2) A part of B depends on waste amount.

6.5.3 Cost of A

Year	Ford (US$25,450) (unit)	IFA (US$6,011) (unit)	FAWN (US$22,695) (unit)	Total (US$)
1996~1998	15	0	7	540,125
1999	15	0	0 (13 purchased)	381,750 (295,035)
2000~2010	0	0	13	295,035

Note: Cost composition in detail is shown in p.6-2 of *Appendices Interim Report(2)*.

6.5 Street Sweeping Cost

6.5.1 Composition of the Cost

Composition of the cost on street sweeping is classified as shown in the following table.

Table 6.5-1 Outline of Cost Separation

	Mechanical Sweeping		Manual Sweeping	Other Equipment
	Mecanical Sweeper(car lane)	Manual Sweeper (side walk)	Manual Sweeper	Installed
-Mechanical equipment (incl.interest) -Fuel -Maintenance	**Mec.sweeper** **(depreciation per year)**	**Container truck/ Patrol Car** **(depreciation per year)**		-Street container -Trash box (depreciation per year)
-Salary, OH -Cart,Sweeping tools	**Drivers'**	**Workers' and drivers'**		
Separation of Cost Estimation	**A** (per mec.sweeper)	**B** (per shift)		**C**

6.5.2 Formula

Total Annual Cost = A+B+C

Here: 1) A and C do not depend on waste amount, but depend on the length of streets to be swept.
2) <u>A part of B depends on waste amount.</u>

6.5.3 Cost of A

Year	Ford (US$25,450) (unit)	IFA (US$6,011) (unit)	FAWN (US$22,695) (unit)	Total (US$)
1996~1998	15	0	7	540,125
1999	15	0	0 (13 purchased)	381,750 (295,035)
2000~2010	0	0	13	295,035

Note: Cost composition in detail is shown in p.6-2 of *Appendices Interim Report(2)*.

6.5.4 Cost of C

Cost for street containers and trash boxes to be installed along all the streets that are served by street sweeping will be fixed since 1996 until 2010 at US$ 36,900 per year.

6.5.5 Cost of B

1 shift (8hours)	Collection at maximum (ton)	Average sweeping length (km)	Depreciation (US$)/year: Compactor truck (A)	Depreciation (US$)/year: Container, Tools (B)	Salary for 20 workers (US$)/ year (C)	Maintenance & Fuel (US$)/ year (D)	Total Cost per Shift (US$)/ year (A+ +D)	Total length swept/ year/shift (km)	No. of Shift (planned)	Total cost (10^3US$)
20 workers	2.4	12.8 (gross)						3,878		
Year										
1996			1,273	87	12,332	1,056	14,748		50	737
1997			1,336	87	12,332	1,109	14,864		43	639
1998			1,420	87	12,332	1,179	15,018		43	646
1999			1,526	87	12,332	1,266	15,211		42	639
2000			1,607	87	12,332	1,334	15,360		41	630
2001			1,731	87	12,332	1,437	15,587		40	623
2002			1,837	87	12,332	1,524	15,780		39	615
2003			1,929	87	12,332	1,601	15,949		38	606
2004			2,026	87	12,332	1,682	16,127		37	597
2005			2,148	87	12,332	1,782	16,349		36	589
2006			2,229	87	12,332	1,850	16,498		36	594
2007			2,364	87	12,332	1,962	16,745		34	569
2008			2,506	87	12,332	2,076	17,001		33	561
2009			2,627	87	12,332	2,180	17,226		32	551
2010			2,693	87	12,332	2,235	17,347		32	555
Total			29,252	1,305	184,980	24,273	239,810		-	9,151
(%)			(12.2)	(0.5)	(77.1)	(10.2)	(100.0)			

6.5.6 Street Waste to be Collected

	Waste to be collected (ton/OP-day)	Waste by Collector (ton/OP-day)				Compactor waste quantity base	Projected Shift	Compactor shift base
		Mec. Sweeper	Man.Swp with Mec.	Manual sweeper	Total manual collection			
	(1)=(2)+(3)	(2)	(Compactor truck)		(3)	motivation rate:80%		motivation rate:80%
1995	58.5	6.0	8.9	43.6	52.5	-	-	
96	58.5	6.3	9.4	42.8	52.2	7	50	14
97	60.8	7.0	10.5	43.3	53.8	7	43	12
98	63.1	7.9	11.8	43.4	55.2	7	43	12
99	66.6	8.9	13.4	44.3	57.7	8	42	12
2000	68.9	9.9	14.8	44.2	59.0	8	41	12
01	72.3	11.2	16.8	44.3	61.1	8	40	12
02	74.6	11.9	17.8	44.9	62.7	8	39	11
03	76.9	12.4	18.8	45.7	64.5	9	38	11
04	79.2	13.0	19.7	46.5	66.2	9	37	11
05	81.5	13.7	20.5	47.3	67.8	9	36	10
06	83.8	14.2	21.4	48.2	69.6	9	36	10
07	86.1	15.1	22.6	48.4	71.0	9	34	10
08	88.4	15.9	23.9	48.6	72.5	10	33	10
09	90.7	16.7	25.0	49.0	74.0	10	32	9
2010	93.0	17.1	25.5	50.4	75.9	10	32	9

Note: 1) OP(operation) days per week is **6.1 days**. Thus waste to be collected per an OP day(W-op) is assumed as **WG ^ 7 ÷ 6.1**.
Here: WG is waste generation per day

2) A mechanical sweeper has more than 4.8ton of loading capacity, for Ford 5.0ton, for **FAWN 4.8ton**. Accordingly, even in 2010, there only should be 4 FAWNs in terms of waste collection for the mechanical sweeping system.

In the Master Plan, 13 FAWN will be used since year 1999 in accordance with planned street length to be swept by mechanical sweepers. Thus, additional purchase of some mechanical sweepers needs no more.

3) Regarding compactor truck, it is proposed here that one having 4.4ton of capacity will be used. However, this doesn't always deny to use smaller(2~3ton) one in stead of.

4) It is assumed that new copmactor trucks made in Romania* will fully used since year 1996 as the street sweeping will statrt to be contracted out to private contractor(s). In this case the depreciation cost will be US$9,486/year^8years which covers 3.6 shifts per day (US$2,635/shift/year).

* Pelican Type equiped in line with ADP's specification, 5ton/trip

5ton^2trips^80% motivation rate = **8ton/OP-day**

5) Number of compactor trucks includes 6 ones for "patrol" (one per Sector, shift base).

6.5.7 Cost Projection

Year	Mechanical Sweeper related Cost (cost A) (10³ US$)	Manual Sweeping related Cost (cost B) (10³ US$)	Other equipment (Street Container, Trash box) Cost (cost C) (10³ US$)	Total Street Sweeping Cost (A+B+C) (10³ US$)
1996	540.1	737.4	36.9	**1,314.4**
1997	540.1	639.2	36.9	**1,216.2**
1998	540.1	645.8	36.9	**1,222.8**
1999	381.8	638.9	36.9	**1,057.6**
2000	295.0	629.8	36.9	**961.7**
2001	295.0	623.5	36.9	**955.4**
2002	295.0	615.4	36.9	**947.3**
2003	295.0	606.1	36.9	**938.0**
2004	295.0	596.7	36.9	**928.6**
2005	295.0	588.6	36.9	**920.5**
2006	295.0	593.9	36.9	**925.8**
2007	295.0	569.3	36.9	**901.2**
2008	295.0	561.0	36.9	**892.9**
2009	295.0	551.2	36.9	**883.1**
2010	295.0	555.1	36.9	**887.0**
Total				**14,952.5**

7. Final Disposal

7.1 Inventory of Former and Present Landfill Sites

The Study Team has identified 8 former dumpsites in Bucharest. The oldest one opened in 1968. Those landfill sites are located near the boundary of Bucharest. The locations are shown as Fig. 7.1-1. It seem that most of the former landfill sites were selected from topographic reason. They are located in low land mainly because of securing large landfill capacity.

Other conditions such as hydrological conditions and surface water conditions were not considered in the selection of the sites. It seems that former landfill sites were selected to satisfy short term needs of waste dumping without paying much attention to protection of public health and environment.

As a result of a field investigation of the former landfill sites which is summarized in Table 7.1-1, the following problems were identified:

a. Some of the former landfill sites are still used illegally as dump sites. Some trucks dumping industrial waste were observed at some former landfill sites.

b. There are some risks of polluting water as no measures were taken during the landfill operation and after completion of landfill.

c. Some landfill sites that were closed more than 20 years ago may be transformed into public parks or agricultural land or industrial sites. The present illegal dumping however reduces the possibility of transforming the sites into useful facilities. Illegal dumping at the former landfill sites can be prevented if the sites are properly managed by the municipality.

Table 7.1-1 Summary of the Former Landfill Sites

Location	Period of Use	Topographic Condition before Landfill	Types of Waste Brought in	Comments
1. Giulesti	1970 - 1987	Swampy land along a small river	Municipal and industrial waste	1. The site has been filled up with large amounts of demolition waste. 2. There is illegal dumping 3. Odor and leachate are generated. 4. There is an industrial waste landfill adjacent to the site.
2. Rudent	1988 - 1993	Low land	Municipal and industrial waste	1. Residents near the site use shallow well with depth of 13 - 15 m. 2. Residents complained that the waste contaminated ground water. However, a water quality analysis indicated the ground waste is suitable for drinking. 3. There are two sites. One has been filled up. Use of the other was suspended. 4. There are bad smell and leachate.
3. Bragadiru	1974 - 1988	Disused quarry for brick manufacturing	Municipal and industrial waste	1. There is net fence. But, there is still illegal dumping. 2. Neither odor nor leachate.
4. Jilava I	1983 - 1988	Natural hollow	Municipal and industrial waste	1. The hollow is about 20 m deep. 2. There is much industrial waste deposit. 3. There is illegal dumping, waste is burning in some area. 4. Neither odor nor leachate.
5. Jilava II	1972 - 1988	Disused quarry for brick manufacturing	Municipal and industrial waste	1. The hollow is about 10 - 12 m deep. 2. There is illegal dumping. 3. Neither bad nor leachate.
6. Catelu	1968 -1974	Natural hollow	Municipal and industrial waste	1. It is about 20 m deep. 2. The site was closed when Glina landfill site opened. 3. The site is stable. 4. Neither odor nor leachate.

7. Cernica	1988 - 1990	Swampy land near a river	Municipal and industrial waste	1. The site is covered with soil. 2. Neither odor nor leachate. 3. The site is small.
	1968 - 1980			1. There is much demolition waste of buildings collapsed by 1977 earthquake. 2. The site is covered with soil. 3. There is illegal dumping.
8. Fundeni	1970 - 1974	Low slope land near a river	Municipal and industrial waste	1. There is illegal dumping. 2. The site is stable. 3. Neither odor nor leachate.

7.2 Outline of Glina Landfill Site

1) Description of the Environment

The Glina waste disposal site occupies a natural depression within the upper terrace of the Dimbovita river, and belongs to the flooding area of this river. Topographical map of Glina site is shown as Fig. 7.2-1. Human settlements around the site are all located upon the terrace outside the influence of natural floodings. The Glina waste disposal site is located between Glina and Popesti Leordeni villages.

Popesti Leordeni village (about 12,900 habitants) occupies the river terrace in the south-west part of the Glina waste disposal site. The overall structure of the village from east to the west is as follows:

1. East area with a mixing of factories and residences just on the south border of the waste disposal site;
2. Middle area with agricultural fields and factories, and a low density of human settlements;
3. West area with residential individual houses;
4. West area with apartments complex.

Water supply is based on individual wells and fountains in the houses area, and on collective system in the apartments complex. Water resources are phreatic aquifer in the individual water supply system, and deep groundwater in the collective system. Urban environment is characterized by a severe degradation due to the presence of several sources of nuisances:

1. Important traffic (west area);
2. Electrical lines (middle area);
3. Industrial plants (east and middle areas);
4. Derelict apartment buildings (west area).

Glina village (about 6300 habitants) is established all along the river terrace escarpment on the eastern side of the municipal landfill, outside the influence of the Bucharest ring road. Compared with Popesti Leordeni, this village is characterized by quietness and cleanliness of the public domain. Water supply totally relies on individual wells and fountains.

2) Geographical Description of Impacts

The environmental impacts of the waste disposal site on the surrounding environment may be presented according to 3 kinds of geographical units:

1. Impacts on the natural site occupied by the waste disposal facility;
2. Impacts on the Popesti Leordeni village;
3. Impacts on the Glina village.

a. Impacts on the Natural Site

Impacts on the natural site are not known with quantitative data but are evident as regards to the natural environment and its landscape value. The natural site is a small wetland area belonging to the hydrology and ecology of the Dimbovita valley. The natural ecology of the site has been certainly highly perturbed, directly and indirectly. The discharge of leachate into superficial water is the major impact on natural conditions, after the direct destruction of the natural site because of discharge of waste materials. From the landscape point of view, the waste disposal site is a severe nuisance when seen from the Dimbovita river, and more particularly from the ring road of Bucharest, which provides a panoramic view on the natural site and its landfilling.

b. Impacts on the Popesti Leordeni Village

Popesti Leordeni village seems to be extremely affected by the proximity of the waste disposal site, directly as well as indirectly.
Direct effects are:

1. Bad smells, permanently in east area and periodically in west area;
2. Passage for waste collecting tracks, inducing noise and heavy traffic;
3. Loss of paper and plastic waste from tracks along the road, and spreading within the village;
4. Health impacts through consumption of drinking water or through omnipresence of waste; these effects are however uncertain.
5. Landscape effects; these effects are however limited by 2 factors. First, only the immediate border of the landfill site is affected. Second, landscape value is basically very low in the southern part of the disposal site, since various sources of degradation are already affecting the environment. Accordingly, the waste disposal site induces relatively low effects on landscape.

Indirect effects are only the illegal deposit of waste along the road, particularly in the middle area. These effects are however extremely severe. Land owners concerned by this problem have no means to manage the situation.

c. Impacts on the Glina Village

Impacts of the waste disposal site on Glina village is not as visible as in the case of Popesti Leordeni. Since high frequency wind is from the north-east, Glina seems to be generally outside of such nuisances like bad smells, smokes, dust. Due to its location and orientation, landscape effect is quite negligible. Finally, traffic area is outside the residential area of the village, so that the landfilling activity did not induce any negative effects on traffic and on cleanliness of the village. The impact could be on the social environment exclusively. Location of the waste disposal site has induced a growth of the initial population because of the resource value of the waste disposal site for scavengers.

3) Impacts on the Social Environment

Impacts of the waste disposal site on the social environment are certainly all major impacts. There is probably no moderate impact. Identifiable major impacts are described below.

a. Impacts on Urban Amenities

Main sources of disamenities are the following:

1. Direct view on the waste deposit;
2. Presence of smoke in the landscape;
3. Noise due to traffic of dump tracks;
4. Odors due to the official deposit site, illegal deposits of waste, and passage of dump tracks.

The topography of the site and the absence of any buffer zone between waste deposit and main roads are conditions that induce a severe negative effect on landscape on east and north sides of the landfill. The degree of perception of the landscape nuisance by local inhabitants is uncertain.

b. Impacts on Sanitary Conditions

Local sanitary conditions are affected by the spreading of dust, smoke and bad smell by wind, and by the spreading of waste materials lost on the way by dump tracks. The illegal dumping of waste around the waste disposal site is the fundamental problem of degradation of sanitary conditions around the waste disposal site.

c. Impacts on Health

The impact on health is uncertain. However, omnipresence of waste is an important source of health hazards. Possible vectors of disease are the following:

1. Direct contact with waste deposit;
2. Insects, rats, dogs, birds;
3. Drinking water.

Population exposed to such hazards are mainly local inhabitants (including scavengers), and workers employed in the waste disposal facility.

4) Impacts on the Natural Environment

Impacts of the waste disposal site on the natural environment are as much important as it was for the social environment. They are likely to be all major impacts, without any moderate rank of impact. Identifiable major impacts are described below.

a. Natural Ecosystem

The direct destruction of a small wetland unit is the more decisive impact on the natural environment, since it induces negative values on landscape, ecological functions, groundwater quality, and maybe wildlife. From the strict point of view of impacts on wildlife, the location of the waste disposal site has necessarily induced a change in populations of invertebrates and insects. The increase of populations of rodents, insects, abandoned dogs, and birds is also extremely important.

b. Groundwater Quality

Lithologic materials are a mixed composition of compacted sands and gravels, with a high degree of permeability. Given the morphology and ecology of the site selected for deposit of waste, water table of the phreatic aquifer appears in surface. Since wastes disposed of at the Glina site include various materials, of which hazardous materials, it is expected that groundwater could be severely contaminated by leachate. Impact on drinking water is then supposed to be important, more particularly in Glina village. However, no complaint has been registered about water quality.

c. **Air Quality**

Spontaneous fires are frequent and are an important source of smoke and dust. Movement of tracks and other vehicles are an important source of dust and pollutants emissions. Degradation of air quality is then important along roads giving access to the waste disposal site, and within the limits and immediate surroundings of the landfill.

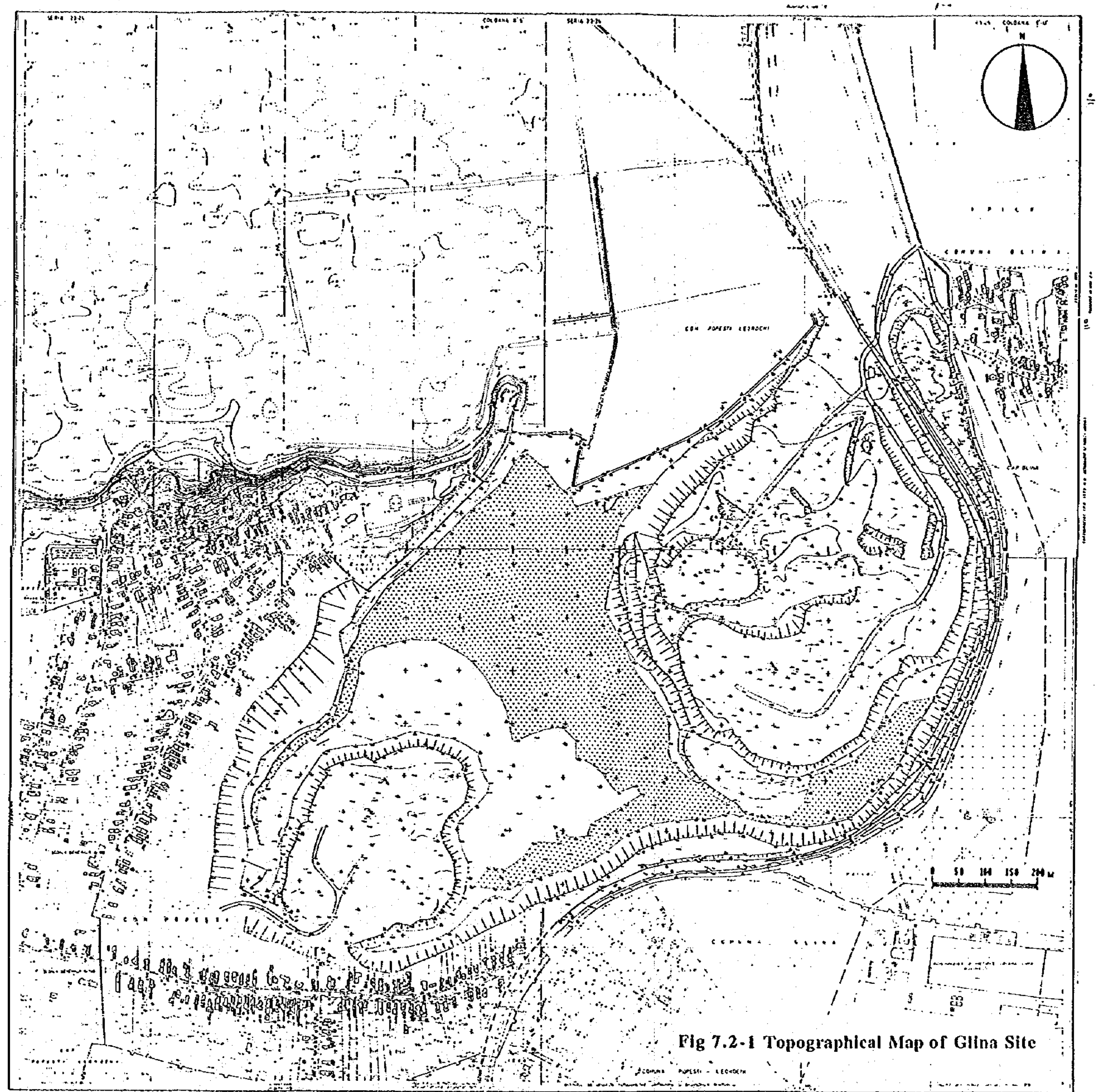


Fig 7.2-1 Topographical Map of Glina Site