

## B. Collection and Transportation:

### B1 Current Condition

## B1. CURRENT CONDITIONS

### 1. Type of Collected Waste

The total area of Havana City, the target of the Study, is divided into 15 municipalities and 105 districts. The Population of the city is 2.24 million. The total amount of generated waste is unknown because weigh bridges are not installed in existing landfill sites. Therefore, a field study was carried out to determine the total amount of generated waste in the City.

Based on the consecutive 8-day field study, the total collected waste was 2,313 tons or 7,173 m<sup>3</sup>. About 45 - 50% of that was MSW while 25 - 30% was bulky waste and 10 – 15% industrial waste. Some kinds of waste were collected and carried to disposal sites by the city-collection service and some generators (Institutions).

Household waste (and non-hazardous hospital waste as MSW) was shown to be the largest source of solid waste. Household waste as a proportion of the daily total waste varied between 35% and 70% during the field survey.

Site observations showed that most MSW from residential areas that had been collected using a C/T vehicle (Compactor Truck (Camion)) was mixed with domestic waste and bulky waste such as construction waste and trees, market waste, etc. and that the MSW from industrial areas included organic industrial waste.

On the other hand, MSW collected using T/Cs (Tractor driven carts) and D/Ts (Dump Trucks) was mixed with large trees and plants from streets and gardens.

A summary of the type of collected waste is presented in Table 1.

**Table 1 Type of Collected Waste (kg/day)**

Type of Waste		M.S.W.		B.W.		Industrial	Others	TOTAL	Total ratio	Ratio of MSW of House/ Others	Fluctuant of Ave. MSW
		Mix W/Houses & Others	Medical	Mix w/Const & Trees	Trees , Market						
Tue	Mar.9	1,384,183	22,400	599,070	197,710	253,180	291,655	2,748,198	14.9%	50%	1.3
Wed	Mar.10	972,894	5,060	688,640	135,316	459,190	392,448	2,653,548	14.3%	37%	0.9
Thu	Mar.11	1,110,990	-	505,690	151,000	297,330	191,655	2,256,665	12.2%	49%	1.0
Fri	Mar.12	1,116,015	2,770	686,620	253,770	285,030	331,680	2,675,885	14.5%	42%	1.0
Sat	Mar.13	1,150,430	-	448,415	155,010	284,360	113,703	2,151,918	11.6%	53%	1.1
Sun	Mar.14	761,065	-	111,170	2,250	254,160	8,640	1,137,285	6.1%	67%	0.7
Mon	Mar.15	1,154,724	-	554,690	133,320	226,550	148,413	2,217,697	12.0%	52%	1.1
Tue	Mar.16	947,016	-	898,959	77,020	208,810	526,840	2,658,645	14.4%	36%	0.9
TOTAL		8,597,317	30,230	4,493,254	1,105,396	2,268,610	2,005,034	18,499,841	100.0%	46%	
Ratio		46.5%	0.2%	24.3%	6.0%	12.3%	10.8%	100.0%			
Ave.		1,074,665	10,077	561,657	138,175	283,576	250,629	2,312,480			

The total amount of MSW collected from the city by UPPH and DMSC was estimated at about 940 tons/day in 2004 as shown in Table 2. The Study will be carried out for city service collection, so current conditions and the future collection plan are based on the amount of 940 tons/day of MSW.

**Table 2 Summary of Quantity Survey of Waste Collected by UPPH and DMSC**

Unit: tons/day

Type of Waste	UPPH	DMSC			Total
		H/C	D/T	T/C	
Domestic and commercial waste* (%)	703 (75%)	75 (8%)	81 (9%)	81 (9%)	940 (100%)
Bulky waste and others	0	0	567**		567
Total	703	75	729		1,507

Source: Eight day field survey by the Study Team and UPPH in March 2004.

Note: \* These values for domestic and commercial waste were based on the actual measurement at the surveyed landfill sites as mixed and the estimation for SPLs.

\*\* The bulky waste and others consist of construction waste, yard waste, trees, and branches. This amount fluctuates by season, and 567 tons is assumed to be rather high because branches are more commonly cut before the hurricane season comes in summer.

## 2. City Service Collection Area and Population

### 2.1 City Service Executive Agencies

The collection and transportation of the generated waste from the city is managed by three (3) agencies, i.e. UPPH, DMSC and Aurora. The detailed organizational structure of UPPH and DMSC are described in B3, maintenance workshop.

UPPH collects MSW mainly from urban areas, particularly those with high population density, such as tourist, commercial and industrial areas where a large amount of waste is generated. The collection vehicles should work continuously whenever required. Collection and transportation of MSW in 7 municipalities close to urban areas use UPPH's C/T vehicles while suburban areas used D/T, T/C and H/C vehicles.

DMSC covers the remaining areas not served by UPPH. These are suburban and remote where there are larger areas of natural land and wildlife sanctuaries with lower population density. Collection vehicles used in this area are T/C, D/T, shovel loader-driven carts (S/C) and loaders, and horse driven carts (H/C).

Regarding collection and transportation of bulky waste, D/T, T/C and Ampliroll vehicles are used, the latter being able to carry UPPH's large steel containers, which have been installed in Havana City. Handling of bulky waste and construction waste was mainly conducted by Aurora enterprise and UPPH, which charges a collection fee for institutions requesting a special steel container. The bulky waste and construction waste are brought to the dumping sites. Institutions collect and transport their own waste by D/T and trucks to dumping sites.

The UPPH's and DMSC collect waste 365 days a year using their own collection vehicles to clean up all system areas. The collection systems are classified into three categories, the horse cart system, the specialized system, and the conventional collection system.

- Specialized Collection System (local name): C/T
- Conventional Collection System (local name): D/T, T/C

- Horse Driven Cart Collection System: H/C

The specialized collection system covers the high population areas where 20% of the total population lives such as Playa, Plaza, Centro Havana, etc, while the remainder is covered by conventional collection and horse carts such as in suburban and remote areas. The service area of each system is shown in Figure 1.

The summary of responsibility of the agencies for municipal solid waste collection work i.e. collection area, type of bins or containers, and type of vehicles is given in Table 3. The proportion of vehicles adopted in each municipality is shown in Table 4.

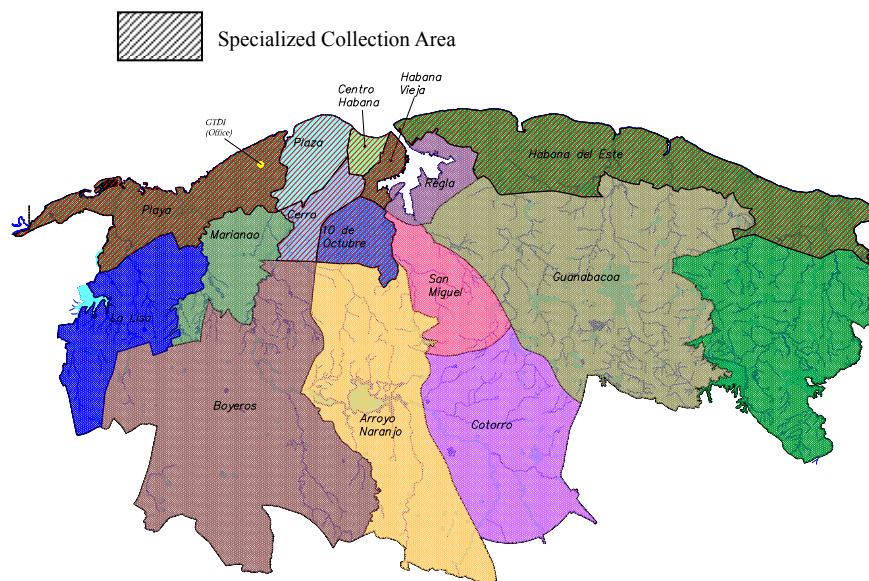


Figure 1 Specialized Collection Area

**Table 3 Operation Agencies and Collection System**

	UPPH	DMSC	DMSC (Contract Basis)	Aurora
Street Cleaning	By machines and manual work	By manual work	By manual work	By manual work
Collection/Transportation Equipment	C/T	T/C and D/T	H/C	T/C and D/T
Method of waste discharge and type of containers used	Bins, or waste piled up on streets	Bins, street containers, plastic bags, piled up on street	Plastic bags, other small bags, pile up on street	Street containers, pile up on street
Collection responsibility area	Habana Vieja, C. Habana, Plaza, Playa, and other 3 urban municipalitis	All other semi-urban areas not covered by UPPH	Rural areas	Habana Vieja and H.Del Este mainly, and 2 other districts for minor activity
Frequency of Collection	Daily	Daily	Daily	Daily

**Table 4 Collection Vehicles**

Municipalities	Type of Vehicles				Covered Area by Vehicles Type (km <sup>2</sup> )					Ratio
	C/T	D/T	T/C	H/C	C/T	D/T	T/C	H/C	Total	
Playa	Yes				36.2	0.0	0.0	0.0	36.2	4.97%
Plaza de la Revolucion	Yes				13.2	0.0	0.0	0.0	13.2	1.81%
Centro Habana	Yes				3.4	0.0	0.0	0.0	3.4	0.47%
Habana Vieja	Yes				4.3	0.0	0.0	0.0	4.3	0.59%
Regla		Yes	Yes		0.0	10.1	0	0	10.1	1.39%
Habana del Este	Yes			Yes	62.8	0.0	0.0	79.5	142.3	19.55%
Guanabacoa		Yes	Yes		0	16	113.5	0	129.5	17.79%
San Miguel del Padron		Yes	Yes		0	11.266	11.167	3.267	25.7	3.53%
Diez de Octubre	Yes				12.6	0	0	0	12.6	1.73%
Cerro	Yes				10.3	0	0	0	10.3	1.42%
Marianao	Yes*		Yes	Yes	0	0	21.5	0	21.5	2.95%
La Lisa	Yes*	Yes	Yes	Yes	2.5	6.8	23.85	3.55	36.7	5.04%
Boyeros	Yes*		Yes	Yes	0	0	67.1	67.1	134.2	18.44%
Arroyo Naranjo	Yes*	Yes	Yes	Yes	0	6.748	36.376	38.976	82.1	11.28%
Cotorro			Yes	Yes	0	0	35.6	30.1	65.7	9.03%
Total	7	5	8	5	145.3	50.9	309.1	222.5	727.8	100.00%
Only MainRoad	4									
Ratio					19.96%	7.00%	42.47%	30.57%	100.00%	

\*For main streets

## 2.2 Estimation of Population Covered and Population Density

The estimated collection service population is shown in Table 5.

A population of 1.2 million (55% of the total Havana City population) inhabiting 7 municipalities with an area of 145.3 km<sup>2</sup> is serviced with a C/T collection system by UPPH. Four municipalities out of the seven municipalities also use the C/T to clean main roads.

The D/T and T/C collection areas cover five municipalities with a population of 0.22 million (10% of the total population) over an area of 51 km<sup>2</sup>. A further 8 municipalities covering 309 km<sup>2</sup> and with a population of 0.5 million (22% of the total population) are served by T/C vehicle collection, while 5 municipalities with an area of 222.5 km<sup>2</sup> and

population of 0.3 million (13%) use H/C collection. The rest of the 7 municipalities use more than 2 different types of collection vehicles.

**Table 5 Covered Population**

Municipalities	Population Density	Estimated Covered Population					Ratio
	Cap/km <sup>2</sup>	C/T	D/T	T/C	H/C	Total	
Playa	5,011	181,256	0	0	0	181,256	8.33%
Plaza de la Revolucion	14,511	171,528	0	0	0	171,528	7.88%
Centro Habana	43,047	149,476	0	0	0	149,476	6.87%
Habana Vieja	21,046	94,635	0	0	0	94,635	4.35%
Regla	4,624	0	42,391	0	0	42,391	1.95%
Habana del Este	1,280	174,532	0	0	11,011	185,543	8.53%
Guanabacoa	834	0	42,517	63,775	0	106,292	4.88%
San Miguel del Padron	5,999	38,843	14,734	60,597	39,782	153,956	7.08%
Diez de Octubre	18,734	227,501	0	0	0	227,501	10.46%
Cerro	13,149	134,778	0	0	0	134,778	6.19%
Marianao	6,464	0	0	137,838	0	137,838	6.33%
La Lisa	3,408	32,242	12,222	50,319	33,060	127,843	5.88%
Boyeros	1,407	0	0	94,441	94,441	188,881	8.68%
Arroyo Naranjo	2,402	0	55,453	55,872	88,218	199,542	9.17%
Cotorro	1,134	0	0	13,402	61,051	74,453	3.42%
Total	2,992	1,204,791	167,316	476,243	327,563	2,175,913	100.00%
Ratio	-	55.37%	7.69%	21.89%	15.05%	100.00%	

### 2.3 Street Sweeping

There are two ways to clean streets and roads. These include cleaning with water and mechanical sweeping. Sweeping streets and roads in Havana City is executed manually except on special occasions such as a citizens' rally, celebration of May 1st and Labor Day, and mass meetings.

The sweepers from DMSC/Aurora are supervised by UPPH and work performance is periodically inspected by UPPH officers and other related agencies. The collected waste from sweeping streets is gathered and dumped into UPPH's bins. However, waste from main roads is collected and transferred by DMSC's D/T to the Calle 100 dumping site.

The estimated number of street sweepers is about 2,200, considering part of the sweeping is done 1 to 3 times a day and assuming that streets are cleaned daily according to the work schedule.

There are 1,726 units for the use of the sweepers, which have been prepared by Aurora and UPPH (one cart per person). The tools for sweeping usually consist of 2 PVC containers and several brooms. However, only 65% of these are in good condition and there is a shortfall of around 20 to 30%. The collected waste is dumped into waste bins used exclusively for this purpose on the streets.

Mechanical sweepers equipped with water sprinklers from UPPH are mobilized with water tank vehicles on a request basis and the collected waste is dumped in the Calle 100 dumping site.

A summary of total staff numbers is shown in Table 6. Photographs of street sweeping staff are also shown in Figure 2.

**Table 6 Number of Street Cleaning Staff Members**

Municipality	No. of Street Sweepers		No. of Frequency in Street Cleaning				No. of Hand-Carts by Condition				Street Sweeping Team Leaders (inspectors)	
	Approved	Currently	1- time/day	2- times/day	3- times/day	Total	Good	Not Bad	Bad	Total (In use)	Approved	Currently
Playa	316	377	315	56	8	379	377	0	0	377	29	29
Plaza de la Revolucion	280	284	167	39	11	217	105	31	77	213	14	13
Centro Habana	139	138	111	25	0	136	63	0	0	63	9	9
Habana Vieja	201	196	0	54	7	61	25	30	6	61	17	17
Regla	44	44	29	9	0	38	0	31	0	31	0	0
Habana del Este	114	114	96	0	0	96	0	109	0	109	6	6
Guanabacoa	104	109	86	10	0	96	0	73	0	73	17	17
San Miguel del Padron	98	93	96	2	0	98	35	34	4	73	17	12
Diez de Octubre	193	165	193	0	0	193	72	0	0	72	0	0
Cerro	126	111	89	19	0	108	96	10	1	107	10	9
Marianao	134	105	99	9	0	108	90	11	3	104	11	4
La Lisa	147	140	135	6	0	141	100	32	2	134	30	26
Boyerros	95	83	93	3	0	96	14	35	28	77	0	0
Arroyo Naranjo	246	223	134	22	16	172	34	92	16	142	28	28
Cotorro	86	90	82	4	0	86	50	38	2	90	8	12
Total	2,323	2,272	1,725	258	42	2,025	1,061	526	139	1,726	196	182
Ratio		97.8%	85.2%	12.7%	2.1%	100.0%	61.5%	30.5%	8.1%	100.0%		92.9%

Note: currently: Actually allocated among approved units



Typical Street Sweeper with a Pushcart



On duty Cleaning up Streets



A Mechanical Sweeper on May 1<sup>st</sup>, 2004



On duty on May 1<sup>st</sup>, 2004

**Figure 2 Sweeping manually and mechanically**

### **3. Detailed City-Service Collection System**

The City's MSW collection system covers 15 municipalities, comprising 105 districts. There are 3 types of collection systems. The first is operated by UPPH and uses HDPE bins and this is named the specialized collection system. The second is a conventional collection system operated by DMSC using ordinary bags with various sizes of buckets being provided by each house owner if there are no HDPE containers available. The third system is based on horse driven carts.

#### **3.1 Specialized Collection System**

##### **(1) Collection Method**

The waste generated by residents is deposited into waste bins situated along the curb and in front of the houses.

##### **(2) Collection Routes**

UPPH's C/T collection vehicles collect the waste along 51 routes every day and are equipped with equipment to lift HDPE bins.

The moving speed is estimated at 8 km/hr during waste collection and 55 to 60 km/hr depending on the traffic conditions when transporting waste.

##### **(3) Bins**

Bins for MSW are installed in seven municipalities and on main streets only. The bins are made from HDPE, and there are two different capacities; one is 770 liters and other is 1,100 liters. They are estimated to potentially carry up to 200 to 500 kg per bin.

About 13,000 bins are located at distances between 50 m and 200 m along the 51 collection routes, which is equal to one bin per 50 people in high population areas and one bin per 150 people for suburban areas. However, based on the time and motion study, about 55% of the bins are broken (no covers, no wheels, broken lifting portion and body, and so on). Therefore, the total number currently requiring replacement due to poor condition plus additional bins to cover shortages is calculated to be about 13,000 bins, which is equal to the existing number.

At present, an average of 260 bins per route are installed and one street sweeper is stationed at every 5 to 6 bins along the route.

There are also a total of 5 to 6 steel containers still in operation.

A summary of total bin numbers is given in Table 7. Photographs of their condition are shown in Figure 3.



**Table 7 Bins for MSW Collection by Specialized Collection System**

Municipality	Population (Cap.)	No. of Collection Routes (CC)	Bins in use (Incl. Broken)			No. of Bins per Route		No. of Street Sweepers	No. of Hand - Carts
			Total	Per population x 100	Per Route	Very bad (Broken)	Shortage		
Playa	181,256	11	3,256	1.7	296	331	296	377	377
Plaza (Aurora)	171,528	5	2,220	1.3	444	444	510	284	213
Centro Habana	149,476	5	728	0.4	146	145	204	138	63
Habana Vieja	94,635	3	793	0.8	264	267	322	196	61
Regla	42,391	-	-	-	-	-	-	44	31
Habana del Este	185,543	4	1,607	0.9	402	402	500	114	109
Guanabacoa	106,292	-	-	-	-	-	-	109	73
San Miguel	153,956	-	-	-	-	-	-	93	73
10 de Octubre	227,501	9	1,436	0.6	160	159	192	165	72
Cerro	134,778	5	1,413	1.0	283	283	322	111	107
Marianao	137,838	1	262	0.2	262	262	368	105	104
La Lisa	127,843	2	458	0.3	229	229	425	140	134
Boyerros	188,881	2	360	0.2	180	180	280	83	77
Arroyo Naranjo	199,542	1	147	0.1	147	147	242	223	142
Cotorro	74,453	-	-	-	-	-	-	90	90
Hospitales	0	3	588	-	196	0	0	0	0
	2,175,913	51	13,268	0.6	260	2,849	3,661	2,272	1,726



Typical Door to Door Collection



Typical Curbside Collection

**Figure 3 Typical Collection by Specialized System**

#### (4) Collection Equipment

As of 2004, UPPH used a total of 65 C/T collection vehicles, whose original capacities range between 14 m<sup>3</sup> and 22 m<sup>3</sup> (average of 18 m<sup>3</sup>). These collect MSW from the entire area in seven municipalities and from only main roads in four municipalities.

There are 65 collection vehicles in UPPH, but 24 vehicles are not working, because of aging equipment and no reserve parts. A list of collection vehicles is shown in Table 8.

There are also 23 special vehicles including mechanical street sweepers, bulldozers, tow trucks and others for special purposes. Only 10 are in reasonable working condition while the remaining 13 are under repair or have been scrapped as shown in Table 9.

The existing condition of special equipment is estimated as variously bad/good/no good. UPPH has more than 96 D/T units, 14 trucks, 14 other types of equipment and 60 steel

containers for environmental sanitation works. However, about 30% of them are not in service, as shown in Table 10.

All mechanical equipment is located at the motor pool in UPPH's maintenance workshop near the Calle 100 dump site in Marianao municipality.

**Table 8 List of C/T Vehicles**

Manufacture	Units	Date of Manufacture	Capacity (m <sup>3</sup> )	Maintenance Condition		Type of Fuel
				In operation	Out of Operation	
DAF: German	3	1988	72(18)	1	2	Diesel
OAF: Austria	2	1984	72(17)	0	2	Diesel
IVECO: Italy	4	1999	76(16)	2	2	Diesel
MERCEDES BENZ: Ge	1	1990	84(16)	0	1	Diesel
EBRO: French	2	1985	64(14)	2	0	Diesel
VOLVO: Sweden	2	1995	72(18)	1	1	Diesel
RENAULT: French	10	1990	72(17)	7	3	Diesel
PEGASO: Spain	16	1988	84(18)	9	7	Diesel
KAMAZ: Russia	15	2002/1998	76(18)	12	3	Diesel
MAN: German	9	1997	120(22)	5	4	Diesel
NISSAN: Japan	1	1990	48(10)	1	0	Diesel
Total	65	-	-	40	25	

Source: UPPH 2004

( ) Expected Volume After compression by C/T

**Table 9 List of Special Equipment**

Type of Vehicle	Total	In Operation	Frequency	Year of Manufacture	Name of Manufacturer	Purpose	Condition
Mechanical Street Sweepers	2	0	-	1982	Germany	Street	Bad
	2	1	on requested basis	1990	France	Street	Not bad
	1	1		2003	Russia	Street	Good
Bulldozers (large sized)	12	4	Daily	2002	Italy	Dumping Sites	Not bad
Bulldozers (small sized)	2	0	Daily	1980	Japan	Dumping Sites	Bad
					Komatsu		
High Pressure Washer	2	2	Daily	1989	Spain	Cleaning	Not bad
Tow Truck	1	1	Daily	1978	Russia	Driving Force	Bad
Tow Truck with Crane	1	1	Daily	1978	Russia	Pick up broken	Not bad
Total	23	10	-	-	-	-	-

**Table 10 List of Vehicles for Environmental Sanitation**

Type of Vehicle	Bulk Waste		Construction Waste		Total		Date of Manufac.	Manufact.
	Total	In Operation	Total	In Operation	Total	In Operation		
Dump Truck								
8m3	0	0	27	24	27	24	1982	
10 m3	52	43	3	2	55	45	2000	Russia
12m3	12	12	2	1	14	13	-	Russia
Sub-Total	64	55	32	27	96	82		
Bed Trucks								
6 m3	2	2	8	8	10	10	1984-1999	Russia
12 m3	0	0	4	4	4	4		
Sub-Total	2	2	12	12	14	14		
Shovel Loader	10	4	4	4	14	8	2000 1985	Russia
Mowing Vehicle	9	4	0	0	9	4	2002	Russia
Shovel Loader	14	6	3	1	17	7	2001	Russia
Truck w/Crane	0	0	7	3	7	3	1996	Spain
Total	99	71	58	47	157	118		
Steel Containers								
10m3	-	-	40	25				
20m3	20	13	-	-				
Sub-Total	20	15	40	25	60	40		

Source: UPPH 2004

(5) Collection Condition

Based on the results of the time and motion study and an interview survey, the overall operation speed was estimated to be 15 to 20 km/hr. The average crew size was two to four excluding the driver, depending on routes and size of collection vehicles. The operation distance was also estimated to be 100 to 150 km/route/vehicle. Table 11 presents a summary of the collection conditions.

**Table 11 Summary of C/T Vehicles Working Conditions**

Municipalities	Pick-up Time	No. of Crew/unit (Excluding Driver)	Operation distance (km/route/unit)
Playa	4am-11am	2-3	150
Plaza	4am-11am	2-4	-
Centro Havana	5am-12	2-3	100-120
Havana Vieja	7pm-4am	2-4	100
Regla	-	-	-
Havana del Este	6am-3pm	2-3	120-100
Guanabacoa	-	-	-
San Miguel del Padrón	-	-	-
Diez de Octubre	7am-3pm	2-3	-
Cerro	5am-2pm	2	120
Marianao	6am-5pm	2-3	42
La Lisa	7am-5pm	2-3	102
Boyeros	7am-2pm	2-3	118
Arroyo Naranjo	1pm-7pm	2-4	120

## 3.2 Conventional Collection System

### (1) Collection Method

Residents deposit waste in bags or buckets and bring it to designated places every day. Collection staff must often pick up waste from the backyard or from a particular place where bins are parked in factories, hotels and restaurants.

The conditions of collection points are much better than urban areas, because waste is located far from the front of houses. Residents watch each other regarding handling waste and are also more careful in its location and time of deposition. In some areas bags are hung on trees or elevated places where animals cannot reach them.

Some areas in Regla municipality, which has a high population density, do not have space for a storage area on the streets. Therefore, the local committee prepared several oil drums as containers for waste. These have been located in an open space where waste is deposited by the residents (approximately 500 persons) and picked up by a T/C every day.

### (2) Collection Routes

DMSC's T/C collection vehicles and D/T collection vehicles collect MSW along 89 routes every day, as shown in Table 12.

The speed is estimated to vary between 6 km/hr under operational conditions and 30 km/hr during transportation, depending on the collection route condition.

### (3) Bins

Residents use plastic shopping bags, small containers, oil drums and paper bags instead of HDPE bins. The garbage bags are put in front of the houses. The garbage bags are collected manually in 8 municipalities by T/C or D/T collection vehicles.

Based on the results of the time and motion study, the total pick up points per route was estimated to be 176 on average and the estimated number of times waste was picked up was 404.

Domestic category waste and market waste from industries, factories, offices, public markets, hotels and restaurants are dumped in their own waste bins or sometimes in containers located along streets or curbside.

Photographs of collection work are shown in Figure 4.



(1) Typical Curbside Collection



(2) Typical Station Collection



(3) Station Point for 500 Residents



(4) Typical Station collection

**Figure 4 Typical Collection by T/C in Remote Areas**

#### (4) Collection Vehicles

There are 15 DMSC offices in Havana City for MSW collection and bulky waste collection. They have a total of 87 traditional vehicles for MSW collection, 62 vehicles (71%) are allocated for T/C collection (average 15 m<sup>3</sup>/unit) and 25 vehicles (29%) for D/T (average 10 m<sup>3</sup>/unit) as shown in Table 12. These numbers are more than enough for daily collection, because it is a short distance to go to landfill sites, except for the D/T. However, most vehicles are beyond their normal expected life span, so new units are required.

There are a total of 269 collection vehicles for bulky waste collection including D/T, T/C and loaders. 22% of the vehicles are useless.

There is only one vehicle per route for MSW collection although two to three vehicles per route are available for bulky waste.

All mechanical equipment is located at the motor pool in each local district maintenance workshop.

**Table 12 Number of existing D/T, T/C Vehicles for MSW Collection**

Municipality	B.W										M.S.W			No. of Routes
	D/T		T/C		Loader		T/P		Sub-Total		D/T	T/C	S-Total	D/T, T/C
	Total	Out of Order	Total	Out of Order	Total	Out of Order	Total	Out of Order	Total	Out of Order	Total	Total	Total	MSW
Playa	11	3	8	4	0	0	3	2	22	9	0	0	0	0
Plaza	13	0	2	1	1	1	1	1	17	3	0	0	0	0
Centro Habana	8	3	1	0	1	0	0	0	10	3	0	0	0	0
Havana Vieja	4	1	1	0	1	0	0	0	6	1	0	0	0	0
Regla	5	0	0	0	0	0	1	0	6	0	0	6	6	6
Havana del Este	9	0	11	0	0	0	2	1	22	1	0	0	0	0
Guanabacoa	2	0	0	0	0	0	1	0	3	0	5	8	13	13
San Miguel	0	0	0	0	1	0	0	0	1	0	6	14	20	22
10 de Octubre	3	0	11	0	0	0	1	0	15	0	0	0	0	0
Cerro	11	0	9	1	0	0	1	0	21	1	0	0	0	0
Marianao	0	0	0	0	0	0	0	0	0	0	0	11	11	11
La Lisa	1	1	2	0	0	0	1	0	4	1	3	5	8	11
Boyeros	4	1	5	3	0	0	1	0	10	4	0	7	7	4
Arroyo Naranjo	0	0	0	0	0	0	0	0	0	0	11	9	20	20
Cotorro	3	0	4	0	0	0	1	1	8	1	0	2	2	2
UPPH	93	13	0	0	17	10	14	10	124	33	0	0	0	0
TOTAL	167	22	54	9	21	11	27	16	269	58	25	62	87	89

The operation distance is estimated to be 50 to 100 km/route/unit, and the expected number of trips is twice a day.

Table 13 shows a list of DMSC's waste collection vehicles.

**Table 13 Summary of T/C and D/T Vehicles Working Conditions**

Municipalities	Pick-up Time	No. of Crew members /unit (excluding driver)	Operation distance (km/route/unit)
Playa	6am-4pm	4	150
Plaza	6am-4pm	4	-
Centro Habana	7am-4am	4	100-120
Havana Vieja	7am-5pm	5	120
Regla	6am-2pm	2	-
Havana del Este	6am-3pm	4	40-50
Guanabacoa	6am-2pm	6	-
San Miguel del Padrón	6am-3pm	6	-
Diez de Octubre	7am-3pm	4	-
Cerro	7am-3pm	8	80
Marianao	6am-6pm	4	42
La Lisa	7am-6pm	4	102
Boyeros	7am-2pm	4	30-40
Arroyo Naranjo	7am-6pm	4-5	100

### 3.3 Horse-Driven Cart Collection System

#### (1) Collection Method

Residents use their own bags or buckets for garbage discharging. The garbage is put on the curbside and/or in front of the houses. The collection system is the same as the conventional collection system.

#### (2) Collection Routes

There are officially 304 routes in 6 municipalities. DMSC's local office arranges the working route daily depending on the condition of the horse's health and horse's operator. The list of routes is shown in Table 14.

The unit speed is estimated to vary between 1.5 km/hr while operating and 5.0km/hr during transportation, depending on the conditions of the collection route, horse's health, weather, and so on.

#### (3) Bins

Residents use plastic shopping bags, small containers, and paper bags for garbage discharging. The waste is collected as a mixed waste, which includes domestic waste, yard waste and trees. The distance between collection points is 5 m to 20 m.

#### (4) Collection Conditions

The horse is controlled by the coachman's signal but the collection speed is low and volume to be collected is limited. Also, working hours are 4 to 5 hours maximum per day and working is only allowed in the daytime.

The estimated average number of collection points, based on the time and motion study was 114 with 221 units of waste per route collected by a single coachman with one horse.

Based on the results of the time and motion study and interview survey, the operation speed was estimated to be 1.5 to 2.0 km/hr and the average crew members, including the coachman, was 1 or 2, depending on routes and size of collection vehicles. The operation distance was also estimated to be 5 to 15 km/route/unit.

The capacity of horse-driven carts ranges between 1.0 and 2.5 m<sup>3</sup>/unit depending on the number of horses per cart. Table 14 shows a list of H/C routes. Photographs of collection work are shown in Figure 5.



(1) Typical Curbside Collection



(2) Typical Collection

**Figure 5 Typical Collections with H/Cs in Remote Areas**

**Table 14 List of Routes and H/C vehicles for MSW Collection**

Municipalities	Number of H/C Routes and Units		
	In Service	Out of Order	Total Registered
Playa	0	0	0
Plaza de la Revolución	0	0	0
Centro Havana	0	0	0
Havana Vieja	0	0	0
Havana del Este	7	0	7
Guanabacoa	0	0	0
San Miguel del Padrón	0	0	0
Diez de Octubre	0	0	0
Cerro	0	0	0
Marianao	1	0	1
La Lisa	25	0	25
Boyeros	109	0	109
Arroyo Naranjo	122	0	122
Cotorro	40	0	40
Regla	0	0	0
Total	304	0	304

This collection system was introduced for the special period landfill sites. The sites are used as an urgent countermeasure for solid waste management. The activities of H/C are summarized in Table 15 and Table 16 shows collection conditions.



**Table 15 Number of H/C Delivering to Landfill**

Name of Collection Area	Municipality	Total number of H/C vehicles	Collected MSW (t/d)
Eléctrico D.S.	Arroyo Naranjo	17	2.8
Fraternidad D.S.	Arroyo Naranjo	27	4.5
Managua D.S.	Arroyo Naranjo	16	2.1
Lugardita D.S.	Boyeros	17	4.2
*P. Latina D.S.	Boyeros	43	13.4
Rincón D.S.	Boyeros	18	4.0
Las Cañas D.S.	Boyeros	19	2.5
El Vidrio D.S.	La Lisa	30	13.6
Los Perros D.S.	Cotorro	15	24.0
C. Florido	Havana del Este	5	0.9
S-Total		207	72.0
Calle 100	Marianao	21	3.6
G.Total		228	75.6

Note: Estimated collection vehicles for P. Latina area was calculated as follows

For H/C units (2m<sup>3</sup>/unit): 13.5 (t/d)/0.3(t/unit) = 43 units

For T/C units (15m<sup>3</sup>/unit): 13 (t/d)/2.7(t/unit) = 5 units

**Table 16 H/C Vehicle Working Conditions**

Municipalities	Pick-up Time	No. of Crew members/unit (including operator)	Operation distance (km/route/unit)
Playa	-	-	-
Plaza	-	-	-
Centro Havana	-	-	-
Havana Vieja	-	-	-
Regla	-	-	-
Havana del Este	5am-11am	3	4-5
Guanabacoa	-	-	-
San Miguel del Padrón	-	-	-
Diez de Octubre	-	-	-
Cerro	-	-	-
Marianao	-	-	-
La Lisa	7am-5pm	2	12
Boyeros	7am-2pm	2	18-20
Arroyo Naranjo	5am-2pm	1	12-32

#### 4. Transfer Station

There is no transfer station in the city, because in every instance, the landfill site is located about 4 to 6 km in a direct line from the collection area.

The landfill site location map is shown in Figure 6.

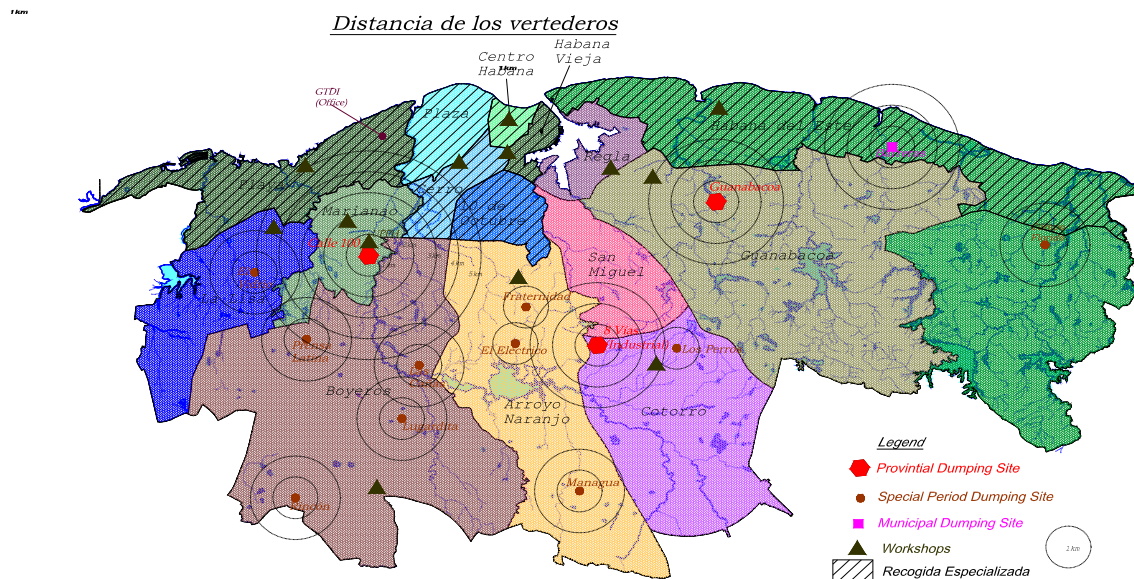


Figure 6 Direct Distances to Landfill Sites

## 5. Disposal

The city is currently using 14 open dumpsites located in 7 municipalities. The largest is the Calle 100 that has more than 100 ha for MSW and bulky waste disposal, and the second largest is Guanabacoa, which has about 28 ha for MSW disposal. There are 10 small-sized disposal sites called “special period landfills”. Also Ocho Vías is for industrial waste and Tarará (Barreras) is for bulky waste.

The sites are controlled by UPPH’s arrangement and instructions. Some of the landfill sites are expected to close very soon because of hygien issues.

There are no truck scales at any landfill site except Calle 100. However, even that scale has been out of order since February, 2004.

A list of disposal sites is shown in Table 17.

**Table 17 List of Disposal Sites by Waste and Collection Method**

Municipalities		Name of Dumping Sites			
		MSW	Bulky waste	MSW	MSW/Bulky waste
		C/T	D/T, T/C	D/T, T/C	H/C
1	Playa	Calle 100	Calle 100	-	-
2	Plaza (AURORA)	Calle 100	Calle 100	Calle 100	-
3	Centro Havana	Calle 100	Calle 100	Calle 100	-
4	Havana Vieja	Calle 100	Calle 100	Calle 100	-
5	Regla	-	Guanabacoa	Guanabacoa	-
6	Havana del Este	Guanabacoa	Barreras	Barreras	Campo Florido
7	Guanabacoa	-	Guanabacoa	Guanabacoa	-
8	San Miguel del Padrón	-	Ocho Vías	Guanabacoa	-
9	Diez de Octubre	Calle 100	Calle 100	-	-
10	Cerro	Calle 100	Calle 100	Calle 100	-
11	Marianao	Calle 100	Calle 100	-	-
12	La Lisa	Calle 100	Calle 100	-	El Vidrio
13	Boyeros	Calle 100	Calle 100	-	Las Cañas Latina, Lugardita, Rincón
14	Arroyo Naranjo	Calle 100	Ocho Vías	Calle 100	Fraternidad, El Eléctrico
15	Cotorro	-	Ocho Vías	Guanabacoa	Los Perros

## 6. Detailed Analysis of 8-day Field Study

### 6.1 Estimation of the Daily Collected Waste Amount

Based on the consecutive 8-day field study, the total amount of waste by weight, including MSW, bulky waste and industrial waste was 18,500 tons, an average of about 2,313 tons per day. City-service and generators collect those amounts of waste. Generators are government institutions. The daily fluctuation value was calculated between 0.5 on Sunday and 1.20 on Tuesday as shown in Table 18.

**Table 18 Total Weight Collected by City-Service and Generators (Institutions) (kg/day)**

Landfill	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Monday	Tuesday	TOTAL	Ave.	Ratio
	Mar. 9	Mar. 10	Mar. 11	Mar. 12	Mar. 13	Mar. 14	Mar. 15	Mar. 16			
Calle 100	1,963,203	1,873,988	1,431,095	1,690,680	1,441,818	748,650	1,307,727	1,628,645	12,085,806	1,510,726	65.33%
Guanabacoa	280,960	282,900	352,320	380,150	290,340	118,050	450,390	640,230	2,795,340	349,418	15.11%
8 Vías	369,040	355,600	361,540	429,100	310,400	205,250	340,380	253,600	2,624,910	328,114	14.19%
Barreras	47,650	52,430	55,520	104,100	24,300	2,250	15,750	72,000	374,000	46,750	2.02%
Eléctrico	2,575	2,275	2,350	2,275	5,925	1,900	2,925	2,500	22,725	2,841	0.12%
Fraternidad	5,350	3,400	3,475	4,000	6,575	4,125	4,475	4,625	36,025	4,503	0.19%
Guasimas	2,400	2,125	2,225	1,700	2,100	1,700	2,900	1,975	17,125	2,141	0.09%
Lugardita	2,500	5,250	5,250	5,250	5,250	5,250	5,250	250	34,250	4,281	0.19%
P. Latina	9,000	12,740	14,440	13,820	14,100	14,440	16,820	12,060	107,420	13,428	0.58%
Rincon	5,000	5,000	4,750	4,750	5,000	5,000	5,000	5,000	39,500	4,938	0.21%
Las Canas	2,250	2,250	2,250	2,750	4,500	2,250	2,250	2,250	20,750	2,594	0.11%
El Vidrio	13,800	13,800	13,800	13,800	13,800	0	12,600	13,800	95,400	11,925	0.59%
Los Perros	43,570	40,890	6,750	22,510	26,910	27,520	50,330	20,810	239,290	29,911	1.29%
C. Florido	900	900	900	1,000	900	900	900	900	7,300	913	0.04%
TOTAL	2,748,198	2,653,548	2,256,665	2,675,885	2,151,918	1,137,285	2,217,697	2,658,645	18,499,841	2,312,480	100.00%
Ratio to Average	196,299.86	189,539.14	161,190.36	191,134.64	153,708.43	87,483.46	158,406.93	189,903.21			
Fluctuation	1.19	1.15	0.98	1.16	0.93	0.49	0.96	1.15			

As shown in Table 19, the total collected volume in 8 days was 57,387 m<sup>3</sup> at an average of about 7,173 m<sup>3</sup> per day. Volume is estimated from original vehicle specifications. The deviation from average was calculated as between 0.5 on Sunday and 1.20 on Tuesday.

**Table 19 Total Volume Amount Collected by City-Service and Institutions (m<sup>3</sup>/day)**

Landfill	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Monday	Tuesday	TOTAL	Ave.	Ratio
	Mar.9	Mar.10	Mar.11	Mar.12	Mar.13	Mar.14	Mar.15	Mar.16			
Calle 100	5,183	5,195.00	3,893.00	4,433.50	3,455.00	1,943.00	3,275.50	3,478.50	30,856	3,857	53.77%
Guanabacoa	985	1,070.00	1,204.00	1,298.00	1,128.00	299.00	1,215.00	1,958.00	9,157	1,145	15.96%
8 Vías	1,328	1,620.00	1,532.00	1,845.00	1,359.00	833.00	1,386.00	998.00	10,901	1,363	19.00%
Barreras	267	301.00	280.00	459.00	54.00	15.00	35.00	160.00	1,571	196	2.74%
Eléctrico	26	22.75	23.50	22.75	31.25	19.00	29.25	25.00	199	25	0.35%
Fraternidad	54	34.00	34.75	40.00	65.75	41.25	44.75	46.25	360	45	0.63%
Guasimas	24	21.25	22.25	17.00	21.00	17.00	29.00	19.75	171	21	0.30%
Lugardita	25	52.50	52.50	52.50	52.50	52.50	52.50	2.50	343	43	0.60%
P. Latina	90	136.00	82.00	80.00	80.00	82.00	96.00	80.00	726	91	1.27%
Rincon	50	50.00	47.50	47.50	50.00	50.00	50.00	50.00	395	49	0.69%
Las Canoas	23	22.50	22.50	27.50	45.00	22.50	22.50	22.50	208	26	0.36%
El Vidrio	138	138.00	138.00	138.00	138.00	-	126.00	138.00	954	136	1.90%
Los Perros	242	227.50	67.50	155.50	175.50	186.00	269.50	150.50	1,474	184	2.57%
C. Florido	9	9.00	9.00	10.00	9.00	9.00	9.00	9.00	73	9	0.13%
TOTAL	8,442	8,900	7,409	8,626	6,664	3,569	6,640	7,138	57,387	7,173	100.00%
Ratio to Average	1.18	1.24	1.03	1.20	0.93	0.50	0.93	1.00			

The average unit weight generation per capita is estimated to be about 1.06 kg/cap/day (2,312,480/2,175,913).

The average loading specific gravities for MSW and bulky waste were roughly estimated to be 0.34 kg/liter (2,312,480/7,173,000) and 3.30 liters/cap/day (7,173,000/2,175,913) as shown in Tables 20 and 21.

Family income (10 US\$ in suburban areas, 20 US\$ in urban areas) has a heavy impact on collection values as shown in Table 20.

Collected waste is not expected to increase within the next 15 - 20 years since no significant improvement of the country's economy is envisaged during the period.

**Table 20 Average Unit Weight per Capita**

Municipality	Area Km <sup>2</sup>	Population 2002 Cap	Daily Generation								
			Per Area kg/km <sup>2</sup> /d	Average Total Waste		M.S.W.		B.W.		Others	
				kg/d	kg/Cap/d	kg/d	kg/Cap/d	kg/d	kg/Cap/d	kg/d	kg/Cap/d
Playa	36.20	181,256	9,039	327,200	1.81	152,976	0.84	96,977	0.54	77,246	0.43
Plaza	13.20	171,528	20,111	265,469	1.55	124,003	0.72	81,458	0.47	60,008	0.35
Centro Habana	3.40	149,476	48,048	163,363	1.09	76,255	0.51	48,787	0.33	38,321	0.26
Habana Vieja	4.30	94,635	37,458	161,071	1.70	72,696	0.77	50,102	0.53	38,273	0.40
Habana del Este	142.30	185,543	777	110,581	0.60	52,211	0.28	32,925	0.18	25,445	0.14
Guanabacoa	129.50	106,292	683	88,413	0.83	40,628	0.38	27,562	0.26	20,223	0.19
San Miguel	25.70	153,956	3,057	78,560	0.51	36,486	0.24	23,837	0.15	18,240	0.12
10 de Octubre	12.60	227,501	13,540	170,599	0.75	80,265	0.35	51,175	0.22	39,159	0.17
Cerro	10.30	134,778	17,203	177,186	1.31	82,249	0.61	54,454	0.40	40,483	0.30
Marianao	21.50	137,838	6,464	138,971	1.01	65,638	0.48	41,732	0.30	31,601	0.23
La Lisa	36.70	127,843	2,823	103,613	0.81	48,926	0.38	30,814	0.24	23,872	0.19
Boyeros	134.20	188,881	711	95,400	0.51	43,163	0.23	29,082	0.15	23,155	0.12
Arroyo Naranjo	82.10	199,542	1,257	103,166	0.52	48,972	0.25	30,095	0.15	24,098	0.12
Cotorro	65.70	74,453	455	29,911	0.40	14,566	0.20	8,593	0.12	6,752	0.09
Regla	10.10	42,391	5,693	57,496	1.36	26,553	0.63	17,962	0.42	12,982	0.31
Others	-	-	-	241,481	-	112,858	-	74,275	-	54,348	-
Total	727.80	2,175,913	3,177	2,312,480	1.06	1,078,445	0.50	699,830	0.32	534,206	0.25

**Table 21 Average Unit Volume per Capita**

Municipality (M <sup>3</sup> )	Area Km <sup>2</sup>	Population 2002 Cap	Daily Generation								
			Per Area m <sup>3</sup> /km <sup>2</sup> /d	Total Waste		M.S.W.		B.W.		Others	
	m <sup>3</sup> /d	liter/Cap/d	m <sup>3</sup> /d	lit/Cap/d	m <sup>3</sup> /d	lit/Cap/d	m <sup>3</sup> /d	lit/Cap/d	m <sup>3</sup> /d	lit/Cap/d	
Playa	36.20	181,256	22	805	4.44	375	2.069	239	1.3186	191	1.054
Plaza	13.20	171,528	53	699	4.07	324	1.889	216	1.2593	159	0.927
Centro Habana	3.40	149,476	101	344	2.30	161	1.077	103	0.6891	80	0.535
Habana Vieja	4.30	94,635	78	337	3.56	152	1.606	105	1.1095	80	0.845
Habana del Este	142.30	185,543	3	384	2.07	178	0.959	116	0.6252	90	0.485
Guanabacoa	129.50	106,292	2	305	2.87	138	1.298	95	0.8938	72	0.677
San Miguel	25.70	153,956	14	361	2.34	168	1.091	109	0.7080	84	0.546
10 de Octubre	12.60	227,501	31	385	1.69	182	0.800	115	0.5055	88	0.387
Cerro	10.30	134,778	42	428	3.17	199	1.477	131	0.9720	97	0.720
Marianao	21.50	137,838	24	507	3.68	244	1.770	147	1.0665	115	0.834
La Lisa	36.70	127,843	12	442	3.45	206	1.611	133	1.0403	103	0.806
Boyeros	134.20	188,881	3	435	2.30	201	1.064	130	0.6883	104	0.551
Arroyo Naranjo	82.10	199,542	6	466	2.33	223	1.118	135	0.6765	108	0.541
Cotorro	65.70	74,453	3	184	2.47	90	1.209	53	0.7119	42	0.564
Regla	10.10	42,391	24	239	5.65	111	2.618	74	1.7457	54	1.274
Others	-	-	-	855	-	399	-	262	-	194	-
Total	727.80	2,175,913	10	7,173	3.30	3,351	1.5400	2,163	0.9941	1,661	0.763

## 6.2 Performance of Collection Vehicles

Average daily number of collection vehicle trips to landfill sites is 769 to collect 2,313 tons per day.

Table 22 shows C/T traveled into the disposal sites only 78 times and for H/C it was 204 times. However, the average loading capacity with 18 m<sup>3</sup> C/T was 7.2 ton per unit and for 2.2 m<sup>3</sup> H/C was only 0.22 tons per unit.

**Table 22 Performances of Collection Vehicles**

Amount per Vehicles		Tuesday Mar. 9	Wednesday Mar. 10	Thursday Mar. 11	Friday Mar. 12	Saturday Mar. 13	Sunday Mar. 14	Monday Mar. 15	Tuesday Mar. 16	AVE.
Type of Vehicles (units)	C/T	95	71	82	78	81	64	70	84	78
	D/T	442	443	349	423	308	111	336	396	351
	T/C	144	186	131	149	125	58	113	111	127
	H/C	209	208	212	204	216	160	226	195	204
	Other	4	7	33	16	7	2	-	8	10
	Total	894	915	807	870	737	395	745	794	769.6
Total Weight (Kg)		2,748,198	2,653,548	2,256,665	2,675,885	2,151,918	1,137,285	2,217,697	2,658,645	2,312,480
Ratio		14.9%	14.3%	12.2%	14.5%	11.6%	6.1%	12.0%	14.4%	
Total Volume(m <sup>3</sup> )		8,442	8,900	7,409	8,626	6,664	3,569	6,640	7,138	7,173
Ave. Weight (kg/vehicle)	C/T	9,132	8,610	8,044	8,603	9,160	9,406	9,362	9,748	9,008
	D/T	3,339	3,549	3,388	3,655	3,427	2,954	3,558	3,894	3,471
	T/C	2,487	2,273	2,574	2,625	2,296	2,830	2,815	2,233	2,517
	H/C	216	225	222	232	223	207	216	224	221
	Other	420	60	920	1,275	2,731	5,040	0	760	1,601
	Total	3,074	2,900	2,796	3,076	2,920	2,879	2,977	3,348	3,005
Ave. Volume (m <sup>3</sup> /vehicle)	C/T	18.5	18.1	18.3	18.4	17.7	18.8	18.6	18.4	18.3
	D/T	9.5	9.7	9.8	10.1	9.3	10.0	9.5	9.2	9.6
	T/C	14.0	14.0	14.1	14.1	14.5	15.1	14.6	12.8	14.2
	H/C	2.2	2.2	2.2	2.3	2.2	2.1	2.2	2.2	2.2
	Other	1.8	34.1	5.3	22.6	7.7	24.0	-	11.1	15.2
	Total	9.4	9.7	9.2	9.9	9.0	9.0	8.9	9.0	9.3
Ave. Loading S.G.(kg/m <sup>3</sup> /v ehicle)	C/T	497.9	487.9	440.6	487.6	459.3	500.0	500.9	511.7	485.7
	D/T	303.1	285.8	302.9	289.3	339.7	252.0	336.6	342.9	306.5
	T/C	166.3	161.1	178.2	182.8	166.6	181.4	185.2	169.7	173.9
	H/C	96.3	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.5
	Other	240.0	60.0	339.5	115.2	304.2	210.0	-	225.2	186.8
	Total	325.5	298.2	304.6	310.2	322.9	318.6	334.0	372.5	323.3

### 6.3 Waste Amount Allocation of Disposal Sites

The main landfill site is the Calle 100 landfill site. The deposited waste amount in this site is about 1,661 tons/day or 65% by weight of the total collected waste. Guanabacoa landfill site receives about 350 tons/day or 15% of the total collected waste, and Ocho Vías landfill site receives about 350 tons/day amounting to 14%. The 10 special period landfill sites receive the rest at 190 tons/day.

UPPH and DMSC collect 65% of the waste while institutions collect about 35% as shown in Table 23 and Table 24.

**Table 23 Ratio of Collected Weight of City-service and Institutions**

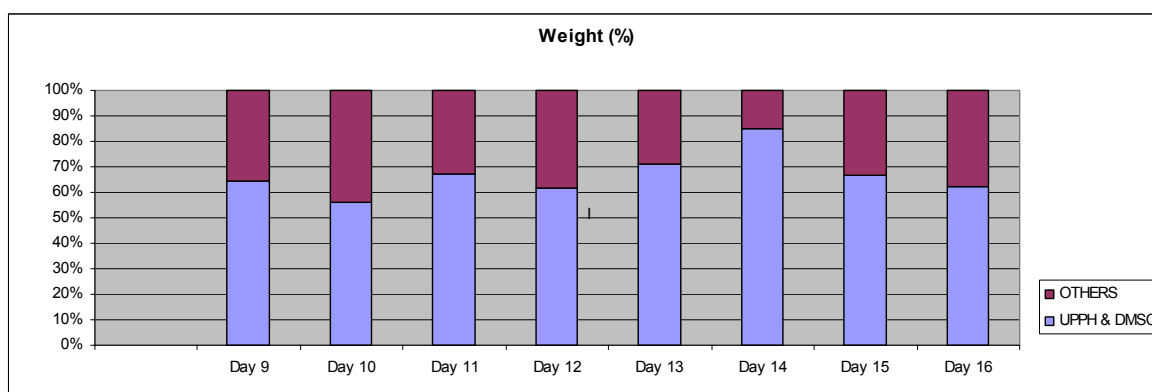
Unit: kg

Items	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Monday	Tuesday	Ave.	Ratio
	Mar.9	Mar.10	Mar.11	Mar.12	Mar.13	Mar.14	Mar.15	Mar.16		
UPPH & DMSC	1,770,378	1,491,908	1,518,025	1,646,725	1,532,598	969,215	1,472,697	1,657,585	1,507,391	0.65
Institutions	977,820	1,161,640	738,640	1,029,160	619,320	168,070	745,000	1,001,060	805,089	0.35
Total	2,748,198	2,653,548	2,256,665	2,675,885	2,151,918	1,137,285	2,217,697	2,658,645	2,312,480	

**Table 24 Detail Rate of Collected Weight of City-service and Institutions**

Unit: % Of Total Weight

Items	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Monday	Tuesday
	Mar.9	Mar.10	Mar.11	Mar.12	Mar.13	Mar.14	Mar.15	Mar.16
UPPH & DMSC	64.4%	56.2%	67.3%	61.5%	71.2%	85.2%	66.4%	62.3%
Institutions	35.6%	43.8%	32.7%	38.5%	28.8%	14.8%	33.6%	37.7%



### 6.4 Total Volume Transported to Dumping Sites

Calle 100 is the main landfill site among all the sites, and receives 3,860 m<sup>3</sup>/day or 54% by volume of the total waste which is collected by City-service and institutions. The Guanabacoa landfill site receives around 1,145 m<sup>3</sup>/day or 16% of the total waste. Ocho Vías landfill site receives industrial waste amounting to 1,360 m<sup>3</sup>/day or 19% of the total, as shown in Table 19. The average proportion of waste volume collected by City-service is calculated to be about 70-75%, while 25-30% is collected by institutions, as shown in Table 25. The ratio is almost consistent throughout the week except on Sunday when most

factories are closed, as shown in Table 26. The tendency in daily collected waste in terms of collection between weight and volume is almost the same.

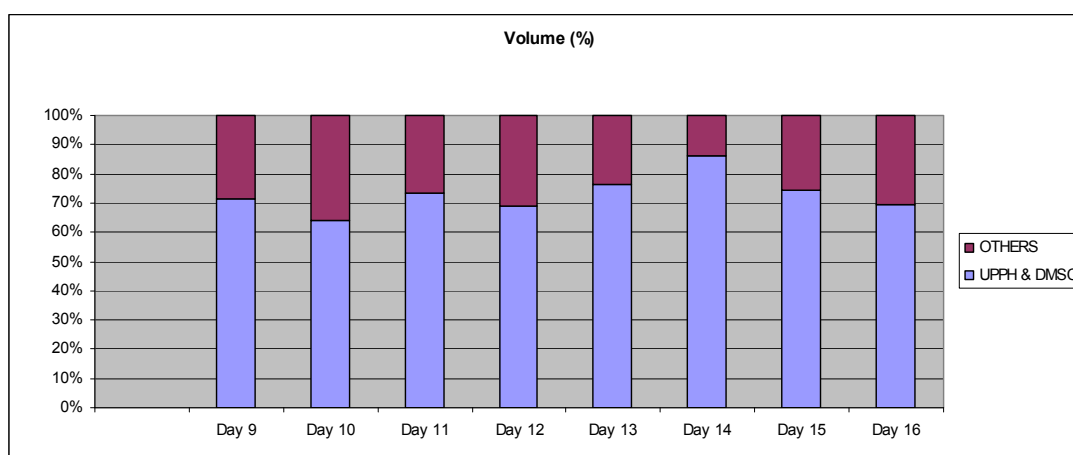
**Table 25 Ratio of Collected Volume of City-service and Institutions**

Unit: m<sup>3</sup>

Items	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Monday	Tuesday	Ave.	Ratio
	Mar.9	Mar.10	Mar.11	Mar.12	Mar.13	Mar.14	Mar.15	Mar.16		
UPPH & DMSC	6,028	5,696	5,431	5,955	5,092	3,078	4,949	4,963	5,149	0.72
Others	2,414	3,204	1,978	2,672	1,572	491	1,691	2,175	2,025	0.28
Total	8,442	8,900	7,409	8,626	6,664	3,569	6,640	7,138	7,173	

**Table 26 Daily Rate of Collected Waste on Volume Basis**

Items	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Monday	Tuesday
	Mar.9	Mar.10	Mar.11	Mar.12	Mar.13	Mar.14	Mar.15	Mar.16
UPPH & DMSC	71.41%	64.00%	73.30%	69.03%	76.41%	86.24%	74.53%	69.53%
Others	28.59%	36.00%	26.70%	30.97%	23.59%	13.76%	25.47%	30.47%



### 6.5 Total Number of Collection Vehicles to Landfill Sites

The total number of vehicles entering landfill sites was 6,157 units in 8 days, amounting to an average of 769 units per day. The 769 collection vehicles collect 2,313 tons or 7,173 m<sup>3</sup> of waste every day.

A total of 347 vehicles, that being 46% of the total number (769), enter the Calle 100 disposal site.

A total of 104 units (13%) enter Guanabacoa landfill site, and 102 units (13%) enter Ocho Vías disposal site. 18 units (3%) enter Barreras landfill site where bulky waste is disposed of.

Table 27 shows the total number of collection vehicles.

Table 28 shows the types of vehicles that were counted in landfill sites.

The highest ratio of 45.6% (351 units) was for D/Ts, while C/Ts made up 10.2% (78 units).

Table 29 shows the types of vehicles for MSW collection.

**Table 27 Total Number of Collection Vehicles**

Landfill	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Monday	Tuesday	TOTAL	Ave.	Ratio
	Mar.9	Mar.10	Mar.11	Mar.12	Mar.13	Mar.14	Mar.15	Mar.16			
Calle 100	462	473	357	400	293	153	301	332	2,771	346.38	45.0%
Guanabacoa	100	100	112	120	96	16	106	184	834	104.25	13.5%
Ocho Vías	102	113	125	113	111	71	111	73	819	102.38	13.3%
Barreras	23	27	23	42	6	1	4	20	146	18.25	2.4%
Elctrico	19	17	18	17	19	14	22	19	145	18.13	2.4%
Fraternidad	31	21	22	20	41	26	29	29	219	27.38	3.6%
Guasimas	18	16	17	13	16	13	22	15	130	16.25	2.1%
Lugardita	10	21	21	21	21	21	21	1	137	17.13	2.2%
P. Latina	6	9	6	6	6	6	7	6	52	6.50	0.8%
Rincon	20	20	19	19	20	20	20	20	158	19.75	2.6%
Las Canas	9	9	9	11	18	9	9	9	83	10.38	1.3%
El Vidrio	46	46	46	46	46	0	42	46	318	45.43	5.9%
Los Perros	43	38	27	37	39	40	46	35	305	38.13	5.0%
C. Florido	5	5	5	5	5	5	5	5	40	5.00	0.6%
<b>TOTAL</b>	894	915	807	870	737	395	745	794	6,157	769.63	100.0%
Ratio to Average	1.16	1.19	1.05	1.13	0.96	0.51	0.97	1.03			

**Table 28 Types of Vehicles**

No. of Vehicles		C/T	D/T	T/C	H/C	Other	Total	Ratio to average
Tue	Mar.09	95	442	144	209	4	894	14.5%
Wed	Mar.10	71	443	186	208	7	915	14.9%
Thu	Mar.11	82	349	131	212	33	807	13.1%
Fri	Mar.12	78	423	149	204	16	870	14.1%
Sat	Mar.13	81	308	125	216	7	737	12.0%
Sun	Mar.14	64	111	58	160	2	395	6.4%
Mon	Mar.15	70	336	113	226	-	745	12.1%
Tue	Mar.16	84	396	111	195	8	794	12.9%
<b>TOTAL</b>		625	2,808	1,017	1,630	77	6,157	100.0%
<b>AVE.</b>		78	351	127	204	11	769.6	
Ratio to average		10.2%	45.6%	16.5%	26.5%	1.3%	100.0%	

**Table 29 Types of Vehicles for MSW Collection**

Date		C/T	D/T	T/C	H/C	Total	Ratio to average
Tue	Mar.09	95	60	37	209	401	14.2%
Wed	Mar.10	71	31	32	208	342	12.1%
Thu	Mar.11	82	47	41	212	382	13.6%
Fri	Mar.12	78	35	33	204	350	12.4%
Sat	Mar.13	81	38	50	216	385	13.7%
Sun	Mar.14	64	5	18	160	247	8.8%
Mon	Mar.15	70	60	45	226	401	14.2%
Tue	Mar.16	84	10	18	195	307	10.9%
<b>TOTAL</b>		625	286	274	1,630	2,815	100.0%
<b>AVE.</b>		78	36	34	204	352	
Ratio to average		22.2%	10.2%	9.7%	57.9%	100.0%	

## 6.6 Relation between Type of Collection Vehicle and Capacity

The weight capacity of a C/T is about 40 times that of an H/C and 4 times that of a T/C based on the results of the time and motion study. Therefore, the specialized collection system is evaluated as the most efficient collection system. However, T/C or D/T collection is also required to collect bulky waste from the streets.

Most of the industrial waste collection is carried out using D/T or T/C, because it does not have to be an efficient collection. Institutions (generators) carry their own waste from the places where it is generated to the disposal site. The Ocho Vías landfill site is mainly



used for industrial waste disposal, but the site is also used for MSW disposal during an emergency.

**Table 30 Collection Waste by Vehicle (kg/day)**

Kgs. Per type of Truck		C/T	D/T	T/C	H/C	OTHERS	TOTAL	Ratio
Tue	Mar.9	867,498	1,475,795	358,100	45,125	1,680	2,748,198	14.9%
Wed	Mar.10	611,304	1,572,384	422,690	46,750	420	2,653,548	14.3%
Thu	Mar.11	659,570	1,182,445	337,240	47,050	30,360	2,256,665	12.2%
Fri	Mar.12	671,020	1,546,090	391,100	47,275	20,400	2,675,885	14.5%
Sat	Mar.13	741,935	1,055,663	287,000	48,200	19,120	2,151,918	11.6%
Sun	Mar.14	602,000	327,930	164,150	33,125	10,080	1,137,285	6.1%
Mon	Mar.15	655,358	1,195,370	318,069	48,900	0	2,217,697	12.0%
Tue	Mar.16	818,866	1,542,129	247,870	43,700	6,080	2,658,645	14.4%
TOTAL		5,627,551	9,897,806	2,526,219	360,125	88,140	18,499,841	100.0%
Ave		703,444	1,237,226	315,777	45,016	11,018	2,312,480	
Ratio		30.4%	53.5%	13.7%	1.9%	0.5%	100.0%	

**Table 31 Collection Waste by Vehicle (m<sup>3</sup>/day)**

m <sup>3</sup> Per type of Truck		C/T	D/T	T/C	H/C	OTHERS	TOTAL	Ratio
Tue	Mar.9	1,755	4,195	2,019	466	7	8,442	14.7%
Wed	Mar.10	1,284	4,296	2,613	468	239	8,900	15.5%
Thu	Mar.11	1,497	3,416	1,851	471	174	7,409	12.9%
Fri	Mar.12	1,433	4,253	2,107	473	361	8,626	15.0%
Sat	Mar.13	1,437	2,873	1,818	482	54	6,664	11.6%
Sun	Mar.14	1,204	1,109	877	331	48	3,569	6.2%
Mon	Mar.15	1,303	3,197	1,651	489	0	6,640	11.6%
Tue	Mar.16	1,549	3,638	1,425	437	89	7,138	12.4%
TOTAL		11,462	26,976	14,361	3,616	972	57,387	100.0%
Ave.		1,433	3,372	1,795	452	122	7,173	
Ratio		20.0%	47.0%	25.0%	6.3%	1.7%	100.0%	

## 6.7 Total Amount of Waste

There are 15 municipalities in Havana City. The total collected waste is estimated to be about 2,313 tons per day.

The waste from urban areas is collected by the C/T collection system. For example, in Playa municipality, about 327 tons/day of waste is collected by the C/T system. 14% of the amount dumped is to the Calle 100 landfill site.

Municipalities such as Cotorro, San Miguel, Guanabacoa and so on, which have applied the conventional collection system, generate from 1.3% to 4.5% of the total amount, including a small amount of waste from suburban or remote areas.

The source of about 10% of the total collected waste could not be identified and was classified as "others". A summary of collected waste amount by municipality is shown in Table 32 and Table 33.

The average bulk density at loading (or loaded) is estimated to be around 300 to 350 kg/m<sup>3</sup>. In urban areas, the maximum value is 480 kg/m<sup>3</sup> (Central Havana is more densely populated than suburban areas, so loads tend to be more fully compacted) as shown in Table 34.

**Table 32 Collected Waste Amount of Each Municipality (kg/day)**

Municipality	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Monday	Tuesday	TOTAL	Ratio	Ave
	Mar.9	Mar.10	Mar.11	Mar.12	Mar.13	Mar.14	Mar.15	Day 16			
Playa	354,340	528,242	283,195	343,870	324,960	213,940	273,510	295,540	2,617,597	14.1%	327,200
Plaza	408,068	258,656	230,440	350,740	328,340	66,400	221,360	259,749	2,123,753	11.5%	265,469
Centro Habana	182,020	179,580	194,810	193,420	124,995	114,200	106,040	211,838	1,306,903	7.1%	163,363
Habana Vieja	124,490	167,000	177,240	85,380	138,051	63,330	165,860	367,220	1,288,571	7.0%	161,071
Habana del Este	65,370	86,850	92,940	212,600	83,890	102,050	113,150	127,800	884,650	4.8%	110,581
Guanabacoa	103,140	87,420	89,940	64,320	57,820	20,200	140,400	144,060	707,300	3.8%	88,413
San Miguel	78,840	103,780	93,980	103,300	70,060	33,600	74,480	70,440	628,480	3.4%	78,560
10 de Octubre	226,190	176,480	164,530	178,500	146,510	98,960	170,510	203,110	1,364,790	7.4%	170,599
Cerro	217,500	180,012	169,510	209,590	157,683	60,560	205,973	216,660	1,417,488	7.7%	177,186
Marianao	196,775	121,760	119,140	137,490	126,479	80,660	148,508	180,959	1,111,771	6.0%	138,971
La Lisa	181,860	161,058	135,930	87,080	83,420	39,730	89,106	50,719	828,903	4.5%	103,613
Boyeros	78,160	177,890	122,000	120,500	75,800	39,190	56,150	93,510	763,200	4.1%	95,400
Arroyo Naranjo	90,315	140,210	121,900	97,385	93,480	85,695	96,620	99,720	825,325	4.5%	103,166
Cotoor	43,570	40,890	6,750	22,510	26,910	27,520	50,330	20,810	239,290	1.3%	29,911
Regla	47,500	50,540	38,540	104,540	74,260	14,040	68,140	62,410	459,970	2.5%	57,496
Others	350,060	193,180	215,820	364,660	239,260	77,210	237,560	254,100	1,931,850	10.4%	241,481
Total	2,748,198	2,653,548	2,256,665	2,675,885	2,151,918	1,137,285	2,217,697	2,658,645	18,499,841	100.0%	2,312,480
Ave	343,525	331,694	282,083	334,486	268,990	142,161	277,212	332,331	2,312,480		

**Table 33 Collected Waste Amount of Each Municipality (m<sup>3</sup>/day)**

Municipality	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Monday	Tuesday	TOTAL	Ratio	Ave
	Mar.9	Mar.10	Mar.11	Mar.12	Mar.13	Mar.14	Mar.15	Mar.16			
Playa	916	1,395	813	823	706	489	657	644	6,443	11.2%	805
Plaza	1,071	742	713	1,067	709	144	554	591	5,590	9.7%	699
Centro Habana	383	329	452	405	249	244	218	468	2,748	4.8%	344
Habana Vieja	294	327	295	229	333	147	291	777	2,693	4.7%	337
Habana del Este	319	460	455	762	290	235	259	294	3,074	5.4%	384
Guanabacoa	360	338	314	236	222	91	322	554	2,437	4.2%	305
San Miguel	364	470	426	431	334	150	360	350	2,885	5.0%	361
10 de Octubre	460	449	399	369	363	226	418	394	3,078	5.4%	385
Cerro	574	428	377	482	382	146	515	518	3,422	6.0%	428
Marianao	720	562	406	511	535	402	489	428	4,053	7.1%	507
La Lisa	724	707	515	406	401	126	362	291	3,532	6.2%	442
Boyeros	414	747	526	577	343	240	310	322	3,477	6.1%	435
Arroyo Naranjo	403	596	545	455	439	409	465	413	3,724	6.5%	466
Cotoor	242	228	68	156	176	186	270	151	1,474	2.6%	184
Regla	184	234	209	267,885	342	62	253	194	1,915	3.3%	239
Others	1,015	889	896	1,282	841	273	897	750	6,843	11.9%	855
Total	8,442	8,900	7,409	8,626	6,664	3,569	6,639	7,138	57,386	100.0%	7,173
Daily Ave	1,055	1,112	926	1,078	833	446	830	892	7,173	0	0

**Table 34 Load Specific Gravity of Each Municipality**

Specific Gravity	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Monday	Tuesday	Ave.	Ratio
	Mar.9	Mar.10	Mar.11	Mar.12	Mar.13	Mar.14	Mar.15	Mar.16		
Playa	387	379	348	418	460	438	416	459	413	130.6%
Plaza	381	349	323	329	463	461	400	440	393	124.3%
Centro Habana	475	546	431	478	502	468	486	453	480	151.7%
Habana Vieja	423	511	601	373	415	431	570	473	474	150.0%
Habana del Este	205	189	204	279	289	434	437	435	309	97.7%
Guanabacoa	287	259	286	273	260	222	436	260	285	90.2%
San Miguel	217	221	221	240	210	224	207	201	217	68.7%
10 de Octubre	492	393	412	484	404	438	408	516	443	140.1%
Cerro	379	421	450	435	413	415	400	418	416	131.6%
Marianao	273	217	293	269	236	201	304	423	277	87.6%
La Lisa	251	228	264	214	208	315	246	174	238	75.1%
Boyeros	189	238	232	209	221	164	181	291	216	68.2%
Arroyo Naranjo	224	235	224	214	213	210	208	241	221	69.9%
Cotoor	180	180	100	145	153	148	187	138	154	48.7%
Regla	258	216	184	239	217	226	269	322	242	76.4%
Others	345	217	241	284	284	283	265	339	282	89.2%
Ave.	310	300	301	305	309	317	339	349	316	100.0%

## 6.8 Collected MSW Amount by City-service

The collected amount of MSW by City-service (UPPH and DMSC) is shown in Table 35. The average waste amount was about 940 tons per day. The C/Ts collected 703 tons per day, D/Ts and T/Cs collected 162 tons per day and H/Cs collected 75.4 tons per day.

**Table 35 Collected MSW Amount by City-Service**

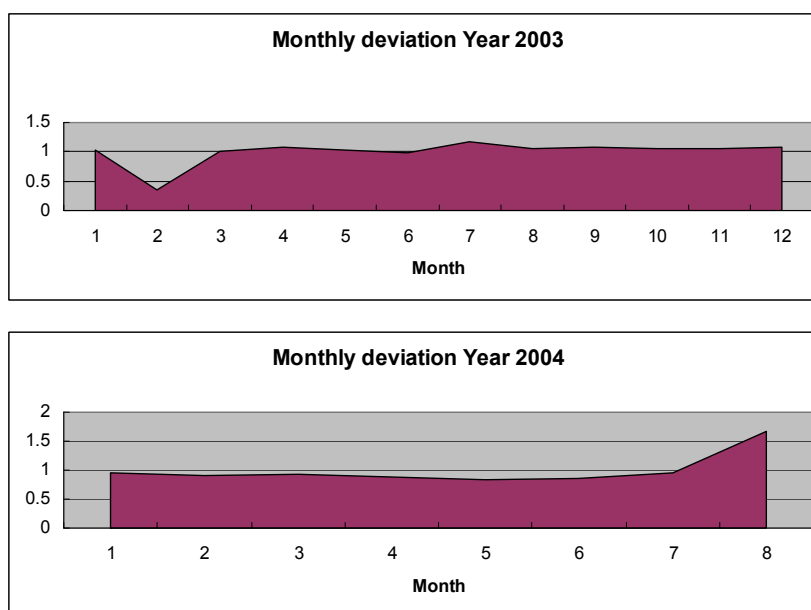
Name of Collection Areas	Municipality	Amount of MSW (t/d)					
		UPPH	DMSC			H/C	Total Weight (t/d)
		C/T	D/T	T/C	S-total		
1 Calle 100	Playa, Plaza de la Revolucion, Cetro Habana, Habana Vieja, Diez de Octubre, Cerro, Marianao, La lisa, Byeros, Arroyo Naranjo	588	-	-	0	0.0	587.7
	Plaza de la Revolucion, Cetro Habana, Habana Vieja, Cerro, Arroyo Naranjo	0	30.0	54.0	84.0	0.0	84.0
	Marianao	0	-	-	0	3.6	3.6
	Sub-Total	588	30.0	54.0	84.0	3.6	675.3
2 Guanabacoa	Habana del Este	110	-	-	0	0.0	109.9
	Regla, Guanabacoa, Cotorro, San Miguel del Padron	0	51.0	27.0	78.0	0.0	78.0
	-	0	0	0	0	0.0	0.0
	Sub-Total	110	51.0	27.0	78.0	0.0	187.9
3	8-vias (Industrial Waste)	4	0	0	0	0.0	3.8
4	Barreras (Bulk Waste)	0	0	0	0	0.0	0.0
5	Electrico D.S. Arroyo Naranjo	0	0	0	0	2.8	2.8
6	Fratemid D.S. Arroyo Naranjo	0	0	0	0	4.5	4.5
7	Managua D.S. Arroyo Naranjo	0	0	0	0	2.0	2.0
8	Lugardita D.S. Boyeros	0	0	0	0	4.0	4.0
9	**Prensa Lalina D.S. Boyeros	0	0	0	0	13.4	13.4
10	Rincon D.S. Boyeros	0	0	0	0	4.0	4.0
11	Las Canas D.S. Boyeros	0	0	0	0	2.5	2.5
12	El Vidrio D.S. La Lisa	0	0	0	0	13.6	13.6
13	Los Perros D.S. Cotorro	2	0	0	0	24.0	26.0
14	Canpo Florido D.S. Habana del Este	0	0	0	0	1.0	1.0
S-Total		703	81	81	162	75.4	940.8
Ratio		75%	9%	9%	17%	8%	100%

Note: P. Latina is assumed the vehicles are H/C(13/0.3=43 units)

### 6.9 Coefficient of Monthly Fluctuation

According to the available data from the three main landfills, Calle 100, Guanabacoa and Ocho Vías, the coefficient of monthly fluctuations is around  $\pm 5\%$  to  $\pm 10\%$  on average, except in February. The monthly deviations are shown in Figure 7.

Havana City was hit by hurricane Charley on August 13, 2004 and as a result the amount of bulky waste was increased at that time.



**Figure 7 Coefficient of Monthly Fluctuation**

## 7. Unlawful Dumping

There are many unlawful dumping spots in open spaces in the urban area. The city looks clean because each spot is small. The main causes of unlawful dumping are a shortage of waste bins and an inadequate collection system. There are some points in the city where construction waste remains uncollected. The reason for this is a lack of awareness by the citizens.

Along the Quibú River and coastal area, waste has been thrown into the sea and has been washed ashore creating other environmental issues.

UPPH cleans up the waste once every 3 to 4 months, including those sites visibly affected and the locations requested by the citizens.

Figure 8 shows unlawful dumping spots.



Floating waste causes environmental contamination



Unlawful dumping in an open space



Construction waste on the street



Littered household waste on the street

**Figure 8 Unlawful Dumping Spots**

## **8. Waste Pickers**

Waste pickers called “buzos” pick up recyclable materials such as aluminum cans and bottles from the waste bins. Cuban Decree # 272 prohibits that kind of activity. These activities in the landfills are also strictly prohibited because the activities are not good for health and their actions interfere with the dumping work.

However, there are some people who collect and segregate valuable materials in the landfill sites or on the streets. They can exchange these materials for cash or soft drinks at the market.

Generally, residents collect recyclable materials from household waste. They bring valuable materials to exchange them for daily necessities at the Association of Enterprises for the Recovery of Raw materials (UERMP), small offices that are located in more than 50 places in the city. The organization is under the Ministry of Metal-Merchants Industry (MOMMI). Such a recycling plan is an appropriate method for waste reduction and material recycling in Havana City.