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Management Information for Solid Waste Collection

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NATIONAL ENVIRONMENTAL RESEARCH CENTER
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FOREWORD

To find, through research, the means to protect, preserve, and improve our environment, we need a focus that accents the interplay among the components of our physical environment--the air, water, and land. The missions of the National Environmental Research Centers--in Cincinnati, Ohio; Research Triangle Park, North Carolina; and Corvallis, Oregon--provide this focus. The research and monitoring activities at these Centers reflect multidisciplinary approaches to environmental problems; they provide for the study of the effects of environmental contamination on man and the ecological cycle and the search for systems that prevent contamination and recover valuable resources.

Man and his surrounding air, water, and land must be protected from the multiple adverse effects of pesticides, radiation, noise, and other forms of pollution as well as poor management of solid waste. These separate pollution problems can receive interrelated solutions through the framework of our research programs--programs directed to one goal, a clean livable environment.

This publication, published by the National Environmental Research Center, Cincinnati, reports on the development of a management information system for solid waste collection. The evolution of this system from a pilot study on the collection of basic data for solid waste management to an operational management tool is discussed.

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ABSTRACT

The delivery of solid wastes services involves a complex interaction of men, machinery, and politics. Despite these complexities, very little reliable information on solid waste management systems is available to decision makers.

In recognition of this problem of data scarcity, a study was initiated on a pilot scale to collect reliable, uniform and continuous data from solid waste collection routes. The purpose of this study was to provide insight and experience into the collection of solid waste data which would be useful for national comparisons.

In this paper, the pilot study is discussed, and a case study illustrating the evolution of the pilot study into a management information system for solid waste collection is presented.

MANAGEMENT INFORMATION FOR SOLID WASTE COLLECTION

Solid Waste Management Systems consist of (a) personnel--engineers, planners, department managers, consultants, foremen, machine operators, laborers, etc.; (b) equipment--trucks, tractors, sweepers, railroad cars, barges, bulldozers, etc.; and (c) facilities--transfer stations, incinerators, open dumps, sanitary landfills, vehicle garages, etc. These systems may be operated in whole or in part by cities, counties, franchises, private collectors, and unlicensed collectors. Obviously, the delivery of solid waste management services involves a complex interaction of men, machinery, and politics. Despite these complexities, very little reliable information on solid waste management systems is available to decision makers. Today's needs must be met using resources and resource levels allocated in past years so that future plans are based on incomplete data from today's inadequate system.

Recognizing this fundamental problem of data scarcity, a study to determine the feasibility of establishing a basic data network for solid waste management was initiated. A pilot network was established in the metropolitan areas of Cleveland, Ohio; Wichita Falls, Texas; and Orlando, Florida. This network, which was designed to monitor solid waste collection routes on a continuous basis, proved to be inexpensive, reliable, and simple to implement. It provided data which could be useful for national comparisons or as a tool for managers of municipal solid waste systems. This paper discusses the pilot system and illustrates the evolution of the pilot system into a local management information system for solid waste collection with a case study based on the experience of Cleveland, Ohio. Data collection from specific routes for the pilot system proved such a useful local management tool that the City in cooperation with the Environmental Protection Agency (EPA) expanded the system to an on-line, city-wide Management Information System (MIS).

Management Information Systems

Management Information Systems (MIS) have been talked about with great enthusiasm and yet have failed to realize their apparent potential. Much has been promised regarding the kinds of decisions that can be made with MIS, but few examples are available in which this technique proved useful for on-line decision making. Perhaps part of the problem is that MIS has not been realistically defined. If this lack is, in fact, a real obstacle to the use and understanding of MIS, here is a working definition.

MIS may be defined as a system of people, equipment, procedures, documents, and communications that collects, validates, operates on, transforms, stores, retrieves, and presents data for use in planning, budgeting, accounting, controlling, and other management processes for various management purposes.

These data concern people, money, physical assets (materials, equipment, and plant) and other resources that are employed to fulfill an organization's objectives. The operations and transformations include recording, comparing, reconciling, tabulating, summarizing, and mathematically analyzing.

In fact, MIS can exist in one of three stages. The first stage is a system designed to answer questions about performance based on data that may be routinely collected from daily operations. Such systems are often called report generators and use a data base created by an agency's normal data processing capabilities. Since the information is already there or may be gathered easily, the MIS merely gives the manager an opportunity to access that information. A second-stage MIS is designed to project situations from data already collected: sometimes by simple trend analysis, sometimes by simulation models. A more sophisticated simulation system that may actually look outside the agency and its operation to analyze certain external effects is the third stage (2).

The system described in this paper is in the first stage; however, it might easily evolve into a second-stage system.

Development of the National System

Working with the Division of Waste Collection and Disposal, which has the primary responsibility for collecting and disposing of household solid waste in the City of Cleveland, the EPA initiated the development of a data system in October 1970. Two routes were selected for continuous evaluation, and data were obtained from the collection vehicle operator on each route in the form of daily reports. The reports pertained to such activities as the weight of the solid waste collected, number of miles driven, time required for collection, weather encountered, and extenuating circumstances including unusual traffic conditions (1).

Selected input data elements were collected on two forms (Figures 1 and 2). The first form, filled out annually, was based on the assumption that certain information regarding the system remained essentially constant. The truck driver on the selected solid waste collection routes daily filled out the second form. Data from these two forms were utilized as input to a standardized computer program.

Outputs from this program included such information as the Collection Route Summary Report and the Detailed Route Cost Report (Figure 3); the Detailed Route Operations Report and the Route Characteristics Report (Figure 4); and, the Detailed Vehicle-Crew Report (Figure 5). Most values in these reports are self-explanatory and reflect daily averages which were calculated for a given month; in the example, the averages are for November 1970. In the Detailed Route Cost Report (Figure 3), the values reported in columns 2 through 8 do not equal the total cost to operate per day as given by column 10. The values for manpower costs in these columns are based on actual hours worked although the crews are paid on the basis of an eight-hour day. Column 9 contains a ratio

Region				
SMSA				
City				
Route number				
Number residences served				
Number people served				
Economic level				
Length of route				
Crew size				
Land required for motor pool				
Number vehicles serviced by motor pool				
Land required for storing and servicing vehicles				
Crew classifications	No. on shift 1	2	Salary range	Time between steps
1				
2				
3				
4				
Cost of crew, actual				
Type vehicle used				
Size vehicle				
Crew size				
Cost of vehicle				
Vehicle age				
Life expectancy of vehicle				
Distance, vehicle storage to beginning of route				
Pick-up point				
Discharge point				
Distance to discharge				
Collection schedule				
Collection pattern				
Operating cost				
Maintenance cost				
Area served				
Is separation required?				
Regulations				

Figure 1. Solid waste collection route annual information form.

CITY ______________ ROUTE ______________ DATE ______________

VEHICLE NO. ______________ GAS ______________ OIL ______________

	Time	Mileage	Weight
Leave motor pool			
Start collection			
Leave route for discharge point			
Weight			
Arrive back on route			
Leave route for discharge point			
Weight			
Arrive back on route			
Leave route for discharge point			
Weight			
Return to motor pool			

Maintenance	Time Started	Time Finished	Mileage
Wash			
Repair			

Crew identification

Name	Classification
a.	
b.	
c.	
d.	
e.	

Figure 2. Daily collection route form.

COLLECTION ROUTE SUMMARY REPORT

Identification number	People served per week	Length of route (miles) per week	Weight/day pounds	Cost/day (dollars)	Pounds generated per capita per day	Cost/ton (dollars)	Cost/capita served per week (dollars)	Cost/residence served per week (dollars)
511002001	5,864	21.00	14,036	212	1.71	30.15	0.18	0.49
511002002	5,214	34.80	17,015	224	2.33	26.34	0.21	1.05
511005003	1,570	6.00	23,474	105	2.14	8.93	0.07	0.29

DETAILED ROUTE COST REPORT

(All values in dollars)

Identification number	Cost to travel to route per day	Equipment cost to collect per day	Manpower cost to collect per day	Total cost to collect per day	Equipment cost to transport per day	Manpower cost to transport per day	Total cost to transport per day	Ratio of productive cost per day to actual cost per day	Total cost to operate per day	Cost per square mile per week
511002001	5.67	9.30	50.71	60.01	6.56	35.77	42.33	0.51	211.62	4,809.47
511002002	11.04	17.50	84.00	101.50	9.82	47.14	56.95	0.75	224.10	4,030.55
511005003	2.29	14.90	39.54	54.44	9.41	24.97	34.39	0.87	104.86	243.29

Figure 3. Examples of reports (Collection Route Summary Report and Detailed Route Cost Report).

DETAILED ROUTE OPERATIONS REPORT

Identification number	From motor pool to start of route		Collection operation		Transportation operation		Time for collection per residence served	Qty Generated per residence per day (pounds)	Qty Generated per person per day (pounds)
	Distance (miles)	Time (min.)	Distance (miles)	Time (min.)	Distance (miles)	Time (min.)			
511002001	3.60	11.80	6.90	124.90	21.40	88.10	0.29	4.68	1.71
511002002	2.34	22.50	6.96	206.90	6.18	116.10	0.97	11.36	2.33
511002003	1.80	10.00	6.00	237.50	49.00	150.00	0.65	9.19	2.14

ROUTE CHARACTERISTICS REPORT

Identification number	Length of route per day (miles)	Type of service	Route Characteristics			Separation requirements	Avg. Weight collected per day
			Discharge point	Schedule	Area served (sq. miles)		
511002001	4	yard	incinerator	1/wk	0.220	No	14,036
511002002	7	yard	incinerator	1/wk	0.278	No	17,015
511002003	6	curb	landfill	1/wk	0.431	Yes	23,474

Figure 4. Examples of reports (Detailed Route Operations Report and Route Characteristics Report).

DETAILED VEHICLE-CREW REPORT

Identification number	Vehicle Characteristics						Crew		
	Type of vehicle	Size of vehicle (cu.yd)	Age of vehicle (years)	Life expectancy of vehicle	Maintenance cost per operating hr. (dollars)	Consumable cost per operating hr. (dollars)	Size	Hourly rate (dollars)	Work hours per week
511002001	Rear loader	20	4	5	2.880	0.641	6	4.06	40.0
511002002	Rear loader	16	4	5	2.880	0.463	6	4.06	40.0
511002003	Rear loader	25	1	5	0.960	0.497	3	3.33	8.0

Figure 5. Example of report (Detailed Vehicle-Crew Report).

obtained by dividing the sum of the values in columns 2 through 8 by the total daily cost in column 10. This ratio indicates the relationship between total daily cost and productive costs.

Shortly after the data system was initiated, a tax levy designed to provide funds for city services was defeated and the Commissioner of the Waste Collection and Disposal Division was faced with a number of difficult decisions regarding possible reductions in service levels. Having several months worth of data available from the routes being monitored within the city, the Cleveland managers were able to compare their six-man crews giving back-yard, once-per-week service with other routes being evaluated within the pilot data network. After careful consideration, back-yard service was eliminated and the collection crew was reduced by two men, leaving one driver and three laborers. Several months later, the collection crew was reduced from three to two laborers. Data collected from both routes from October 1970 through May 1971 are shown in Table 1. The cost per ton for waste collected for an average day dropped from a value close to $30.00 per ton to approximately $13.00 per ton with an estimated annual savings of over $4 million per year. With the results obtained from the pilot data network, the Cleveland Solid Waste manager, working with an EPA local and regional planning grant, initiated the development of a management information system for solid waste collection.

TABLE 1. MONTHLY COST DATA FOR THE TWO PILOT COLLECTION ROUTES

Equipment cost per day ($)	Manpower cost per day ($)	Total cost per day ($)	Cost per ton ($)	Cost per residence served per week ($)	Month (1970-71)	Crew size
ROUTE NO. 1						
18.64	194.88	213.52	30.30	.499	Oct.	6
16.69	194.88	211.57	36.50	.494	Nov.	6
20.72	194.88	215.60	34.81	.501	Dec.	6
19.72	130.56	150.28	22.50	.351	Jan.	4
22.16	130.56	152.72	22.40	.356	Feb.	4
19.13	130.56	149.69	20.19	.350	Mar.	4
24.85	98.48	115.33	14.50	.270	Apr.	3
23.85	98.88	123.73	14.14	.289	May	3
ROUTE NO. 2						
27.32	194.88	222.20	26.10	1.011	Oct.	6
25.15	194.88	220.03	26.19	1.005	Nov.	6
34.07	194.88	228.95	27.00	1.041	Dec.	6
37.57	130.56	168.13	16.60	.765	Jan.	4
37.42	130.56	167.98	17.00	.763	Feb.	4
39.12	130.56	169.68	15.21	.771	Mar.	4
37.62	98.48	128.10	11.28	.583	Apr.	3
29.12	98.88	128.00	12.64	.581	May	3

The Cleveland Management Information System

The Cleveland MIS was developed by using the basic approach utilized for the pilot data network. A daily form, similar to the one shown in Figure 2, is filled out by the truck driver on all of the routes.

The city is divided into six service areas, each with its own station and superintendent (Figure 6). Each service area is then subdivided into an average of six collection districts, with responsibility for collection in these districts assigned to a district foreman. Each collection district is then finally divided into collection routes, with one crew assigned to each of the 183 collection routes in the city.

Data are collected for an entire week on a given route and reported as a daily average. The data are then reaggregated, and a daily average is reported for the route supervisor. Output from these data are given in three reports: the route information report, the collection information report, and the cost information report (Figure 7). Manpower costs in the cost information report are based on the number of hours for which the crews are paid rather than on the basis of hours worked.

A set of weekly, district reports is computed containing the daily average performance. These values are given for each route in the district, for each route supervisor, and for the entire district. A summary report showing city-wide performance according to district is sent to the commissioner.

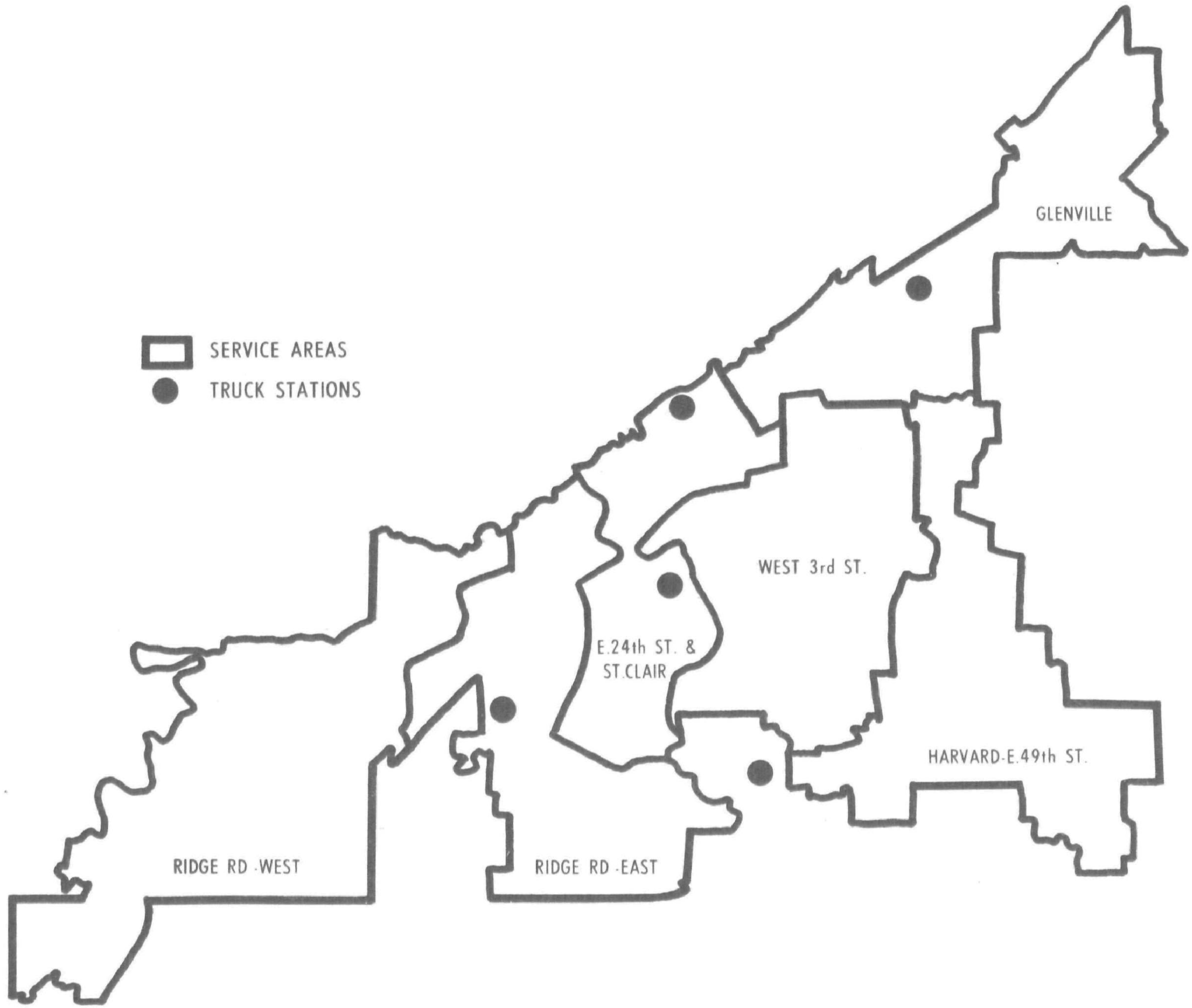

Figure 6. Cleveland solid waste collection districts and truck stations.

CLEVELAND
DIVISION OF COLLECTION AND DISPOSAL

ROUTE INFORMATION

ROUTE NUMBER	DAYS OF DATA USED	AVERAGE VEHICLE SIZE (CU YD)	VEHICLE TYPE			MOTOR POOL TO ROUTE (PER DAY)		COLLECTION OPERATION (PER DAY)		TRANSPORT OPERATION (PER DAY)		WEIGHT PER DAY (POUNDS)
						(MILES)	(MIN)	(MILES)	(MIN)	(MILES)	(MIN)	
611.	3.	20.	RL			4.5	20.7	4.0	226.7	15.5	96.0	20660.
612.	5.	19.	RL			2.7	21.0	5.7	198.4	15.0	122.0	21460.

CLEVELAND
DIVISION OF COLLECTION AND DISPOSAL

COLLECTION INFORMATION

ROUTE NUMBER	HOMES SERVED PER COLLECT	WEIGHT PER HOME PER COLLECT (POUNDS)	PERSONS SERVED PER COLLECT	GENERATE PER PERSON PER DAY (POUNDS)	COLLECT TIME PER HOME (MIN)	COLLECT TIME PER 100LB (MIN)	COLLECT TIME TO TOTAL TIME (MIN)	ACTUAL TIME TO PAID TIME (MIN)	LOADS PER WEEK			WEIGHT PER CU YD 1ST LOAD (POUNDS)
									INCIN	LAND FILL	XFER STA	
611.	439.	47.0	1410.	2.1	0.52	1.10	0.66	0.72	0.	5.	0.	621.
612.	286.	74.9	919.	3.3	0.69	0.92	0.58	0.71	6.	3.	0.	664.

CLEVELAND
DIVISION OF COLLECTION AND DISPOSAL

COST INFORMATION
(DOLLARS)

ROUTE NUMBER	COST TO ROUTE PER DAY	COST TO COLLECT PER DAY	COST TO XPORT PER DAY	TOTAL EQUIP COST PER DAY	TOTAL MANPWR COST PER DAY	TOTAL COST PER DAY	INCENT COST PER DAY	COST PER LOAD	COST PER TON	COST PER HOME PER WEEK	COST PER PERSON PER WEEK
611.	8.04	88.16	37.34	35.85	97.68	133.53	27.81	80.12	12.93	0.30	0.09
612.	8.17	77.23	47.49	35.22	97.68	132.90	28.21	73.83	12.39	0.46	0.14
613.	8.36	87.90	43.03	41.61	97.68	139.29	12.87	55.72	10.06	0.43	0.13

Figure 7. MIS computer listings.

Several categories have special significance for the commissioner, and to highlight their importance, a series of exception reports has been developed that permits the commissioner to determine the high and low crews in each of the following categories: average weight collected per day; average time collecting per day; houses served per day; collection time per home; collection time per 100 pounds lifted; ratio of actual time worked to paid time; incentive cost per day; cost per ton; and cost per home per week. Except for incentive cost, these items are self-explanatory. Incentive cost for a crew is determined by multiplying the average number of hours worked per day by their average wage rate and subtracting the product from the total paid cost for the crew per day. In the initial outputs from the system, it was determined that some crews worked a full eight hours per day whereas others worked as few as two hours per day.

Uses of the System

In most large American cities, the population refuses to vote for additional taxes and yet demands more service or refuses to relinquish the services they already have. Cities are faced with higher wages demanded by workers as well as increases in the purchase price of equipment, facilities, and other nonlabor related items. Not only are higher taxes being refused at the polls, but the tax base itself is erroding as middle and upper-income families move to the suburbs and take with them needed tax dollars. As these families leave, lower-income families who require just as many services from the city take their place. Property being condemned for highways and other non-taxable uses and being removed from tax rolls for public use does not reduce the demand for over-all services.

In Cleveland, this situation, coupled with the defeat of a much-needed tax levy, created a financial impact felt in all city departments, but nowhere more acutely than in the department responsible for the collection and disposal of solid waste. The City of Cleveland Division of Waste Collection and Disposal literally removed the waste from the point of generation, transported it to the disposal point, and disposed of it with no effort required by the general citizenry. Because of rising costs and limited revenues, some of these services were sharply curtailed.

The Cleveland solid waste managers were able to use this on-line system as a tool to assess their operational problems and to make some needed decisions. It is important to note that this assessment should be a continuous process. The usefulness of this system lies in its ability to pinpoint problem areas and to provide timely data for decisions to solve these problems. The critical nature of solid waste management and the short and long-range cost of implementating management decisions require that the latest management tools and techniques be applied. It is in this spirit that the management information system for solid waste collection discussed in this report has been presented.

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A C K N O W L E D G E M E N T S

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