CHAPTER 6

COLLECTION AND TRANSPORTATION PLAN

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6.1 General

The project proposed in the Master Plan has been divided into three (3) implementation stages; namely, the First Implementation Stage, the Second Implementation Stage and the Third Implementation Stage. This Chapter describes the Feasibility Study for the First Implementation Stage of the Collection and Transportation System Improvement Project which was selected as one of the priority projects in the Master Plan Study. The First Implementation Stage is scheduled to start in the year 1999 and completed in the year 2003.

In accordance with the Collection and Transportation Plan, the project in the First Implementation Stage is composed of four (4) component projects as discussed in the corresponding sections mentioned below.

(1) Procurement and operation plan for vehicles and equipment for the improvement of collection and transportation system, in **Section 6.2**;

(2) Construction of a new transfer station, in **Section 6.3**;

(3) Construction of a new small workshop and rehabilitation of the existing depots, in **Section 6.4**; and

(4) Introduction of community based waste management for informal settlements (Community Waste Management Project or CWMP), in **Section 6.5**.

Section 6.6 summarises the cost and schedule of the above four component projects, and the reduction of service level is considered in **Section 6.7.**

6.2 Procurement and Operation Plan for the Improvement of Collection and Transportation System

6.2.1 Objective of the Plan

The objective of this plan is to increase waste collection in the city through the procurement of collection vehicles and equipment and their proper operation.

6.2.2 Project Strategy

The quantities required are estimated according to the level of services planned. The target service level in the First Implementation Projects is set in such that collection ratio will be more than half of the waste generated, i.e., 60%, to realise the environmental improvement level.

As a result of analysis of technical options, the container system is adopted as the main collection system to be supplemented by side loaders, dump trucks (tippers) and wheel loaders. A new transfer station is also planned to be built to increase the effectiveness of collection and transportation operations. However, construction of

the transfer station requires a considerably large amount of funds. Besides, the transfer system has never been used in Kenya so far, although the system is not complicated. Therefore, two alternatives are considered for the First Implementation Stage; namely, with the construction of transfer station and without the construction of transfer station.

From the organisational and institutional points of view, a district-wise management is recommended since the existing collection and transportation system is being operated by each district which is managed by the Cleansing Section of the Department of Environment (DoE), NCC. Each district will operate and manage the collection vehicles and equipment on a daily basis, and preventive maintenance and minor repairs will be performed in a new workshop at Kaloleni. The plan for the new workshop is presented in **Section 6.4**.

6.2.3 Project Analysis

(1) Determination of the Basic Conditions

(a) Container Arrangement

The field surveys and analyses reveal that there are many locations in the city without any waste collection site so that wastes are thrown away on roads or in open derelict spaces. These scattered dumping points are to be basically replaced by containers. However, some of the dumping sites cannot be containerised because they either lack space for installing containers or are inaccessible to container vehicles.

In this plan, the number of required containers are determined on the assumption that daily generated amount of solid waste is firstly stored in containers installed throughout the city and then the containers are carried to the final disposal site once a week.

(b) Vehicle Fleet Composition

(i) Detachable Container Trucks

These trucks collect the containers installed in waste dumping locations on roads or on vacant derelict plots. Detachable container trucks can be classified into two based on the type of container release mechanism; i.e., the arm (or arm roll) type and the horizontally moving type. A comparison of the two types of container truck is shown in **Table 6.2-1**.

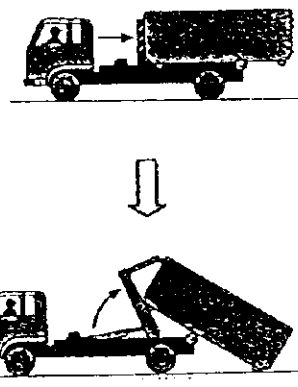
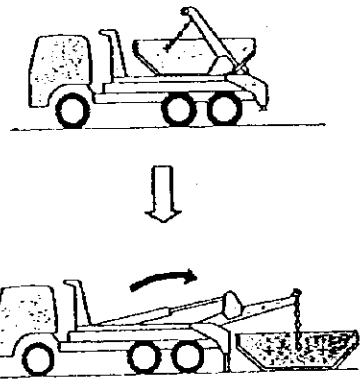
The comparison shows that the container truck with the arm type of release mechanism generally has a lower unit price than the truck with horizontally moving type. However, the container truck with a horizontally moving release mechanism is selected because it is difficult to load and position the container precisely onto the truck using the arm type.

Vehicle specification is for a 6-ton ($8\ m^3$) capacity type in consideration of local road width and the space available for container installation.

(ii) Side Loaders

Side loaders can negotiate a number of narrow roads that are accessible to the existing dump trucks or unsuitable for the installation of containers. Considering the existing dump trucks operated by NCC, medium-type (6-ton) side loaders are to be used.

Table 6.2-1 Comparison of Detachable Container Vehicle Types

Item	Arm (Arm Roll) Type	Horizontally Moving Type
General View		
Release Mechanism	• An hydraulically operated arm is placed on a hook provided in one location at the front of the container, and the arm pulls the container up onto the truck. The container is tilted at an angle when loaded on the vehicle.	• A chain is applied to two (or four) points on the sides of the container which is loaded onto the truck by an hydraulically operated arm. The container is maintained in the horizontal position when loaded onto the vehicle.
Advantages	• Given the same the truck chassis specification, the arm roll truck can take a container of larger capacity than the horizontal release type. • The shape of the container can be selected with a relatively great degree of freedom.	• The container can be loaded onto the truck regardless of the surface condition of the road on which the container is positioned. • It is not necessary to align the truck position accurately with the container hook position. • The container is maintained in the horizontal position while being loaded onto the truck. This means that the container can be loaded without waste spilling out from the container.
Disadvantages	• Since the edge of the container moves on the road surface while it is being loaded onto the truck, this type cannot be used on bumpy road surfaces. • During the loading operation, it is necessary to position the truck accurately with the container position.	• Given the same truck chassis specification, the container has a smaller capacity than the arm roll type. • There are certain limitations on the shape of the container.
Rough Cost Estimate*	0.7 each	1.0 each

* Rough cost estimate is based on standard specifications and shows the price of the arm roll type system as the proportion of the price of the horizontally moving container system which is taken as 1.

(iii) Dump Trucks (Tippers)

Dump trucks in combination with wheel loaders is recommended to cover areas where space is not enough for the installation of containers and to clear the heaps of waste along the roadsides or on open spaces. Considering the existing dump trucks operated by NCC, medium-type (6-ton) dump trucks are to be used for the same reason as the above side loaders.

(iv) Wheel Loaders

In combination with the above dump trucks, wheel loaders are to be employed for loading wastes from dumping points on roadsides or open spaces. In view of the existing road width and accessibility to the dumping points, medium-type wheel loaders with bucket capacity of 2 cubic meters are to be used.

(v) Water Sprinklers

Water sprinkler vehicles are to be used for cleaning the dumping points after waste collection and for sprinkling roads in dry condition when covered with large amounts of sand and soil. Considering the local road width and spaces as well as ease of procurement, an 8,000 litre capacity sprinkler vehicle is planned.

(vi) Inspection Cars

To monitor the daily operation and transportation information, as well as tools and equipment for the operation, inspection cars are necessary. In view of the present road condition in Nairobi, 4-wheel drive cars are required to go through the area to be inspected. Additionally, some pickups for carrying work staff and sedans for administration work are needed for the inspection.

(vii) Recovery Trucks

To remove damaged collection vehicles blocking the roads, recovery trucks are planned to tow the vehicles to the workshop for repair.

(c) Proportion of Waste Amount Collected by Type of Vehicle Used

The proportion of waste amount collected according to the three types of vehicles to be used for collection, and taking into consideration local road conditions, is as follows:

Container trucks	: 50%
Side loaders	: 30%
Dump trucks (tippers)	: 20%

(d) Proportion of Waste Amount Collected by Direct and Indirect Transport

With the Construction of Transfer Station

The proportion of waste amount to be collected depending on the transportation system is estimated on the following assumptions:

(i) Waste from locations 15 to 20 km close to the candidate disposal site at Ruai are hauled directly to the disposal site to minimise the required dimensions of the transfer station and to reduce the investment cost. These locations are Mathare, Kahara, Roysambu, Makadara, Kaloleni/Makongeni, Maringo/Mibotela, Bahati, Pumwani, Eastleigh, Kamukunji, Embakasi, Dandora, Kasarani, Kairobangi and Njiru.

(ii) Waste from locations in the western side of the city are hauled to the transfer station, increasing the number of trips and reducing the transportation cost. These locations are Viwanda, Mugumoini, Kibera/Woodley, Waithaka, Kangemi, Ruita, Kawangware, Mutuini, Ngara, Starehe, Kenyatta/Golf Course, Karen/Langata, Kilimani, and Parklands.

The waste amounts to be collected by direct and indirect transport are estimated as shown in **Table 6.2-2**, and the collection areas by direct and indirect transport are as illustrated in **Figure 6.2-1**. The waste to be collected by NCC is 60% of all the waste estimated to be generated. Details of the calculation are presented in **Chapter 6 of Supporting Report Section E.**

Table 6.2-2 Proportion of Waste Amount Collected by Direct and Indirect Transport

(Unit: ton/day)

Year	Total amount collected by NCC (1)	Total amount collected by direct transport (2)	Total amount collected by indirect transport (3)	Total amount transported from transfer station (4)
1999	630	326	304	326
2000	657	342	315	337
2001	687	357	330	352
2002	719	372	347	369
2003	753	388	366	388

Without the Construction of Transfer Station

All the waste amount to be collected goes directly to the disposal site, which is estimated in Column (1) of **Table 6.2-2.**

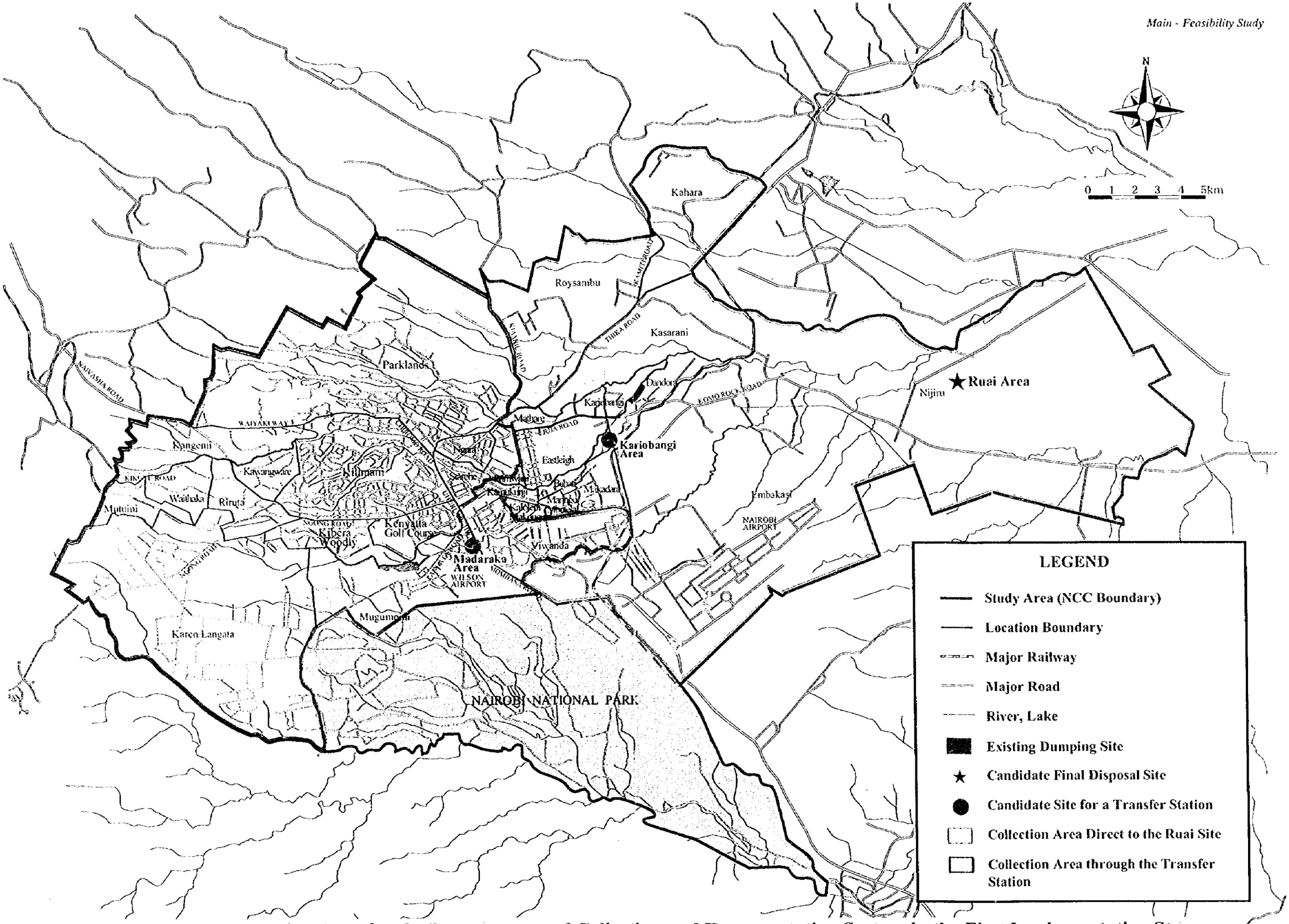


Figure 6.2-1 Collection Area for the Improvement of Collection and Transportation System in the First Implementation Stage (with Construction of the Transfer Station)

(c) Other Design Assumptions and Criteria

To roughly estimate the required number of the above vehicles, the other assumptions and criteria are fixed, as summarised in **Table 6.2-3.**

Table 6.2-3 Summary of the Design Assumptions and Criteria

Operating Time	8 hours a day
Vehicle Loading Capacity	
Container truck	6 t (maximum)
Side loader	4 t/trip
Dump truck (tipper)	4 t/trip
Tow truck	26 t (Gross Vehicle Weight)
Container Capacity and Performance	
Maximum container capacity	8 m^3
Apparent Specific Gravity	0.3
Ordinary loading condition	100% of the maximum
Ordinary container performance	2.4 t/trip
Number of Collection/Transportation Trips	
Container truck	3 trips/day (Direct transport) 4.5 trips/day (Indirect transport)
Side loader	2 trips/day (Direct transport) 3.5 trips/day (Indirect transport)
Dump truck (tipper)	3 trips/day (Direct transport) 4.5 trips/day (Indirect transport)
Availability	
Vehicles	90%
Containers	95%

(2) Calculation of the Required Quantities

Based on the above conditions, the required quantities of vehicles with and without the construction of transfer station are calculated, as shown in **Tables 6.2-4** and **6.2-5.**

Table 6.2-4 Vehicles Required for the Improvement of Collection and Transportation System in the First Implementation Stage (With the Construction of Transfer Station)

No	Items	Quantity				
		1999	2000	2001	2002	2003
1	Detachable-container truck	43	45	47	49	51
2	Container	967	1008	1055	1104	1156
3	Trailer truck	10	11	11	12	12
4	Side loader	21	22	23	24	25
5	Dump truck	10	11	11	12	12
6	Wheel loader	10	11	11	12	12
7	Water sprinkler	2	2	2	2	2
8	Inspection car	22	22	22	22	22
9	Recovery truck	1	1	1	1	1

Table 6.2-5 Vehicles Required for the Improvement of Collection and Transportation System in the First Implementation Stage (Without the Construction of Transfer Station)

No	Items	Quantity				
		1999	2000	2001	2002	2003
1	Detachable-container truck	51	53	56	58	61
2	Container	967	1008	1055	1104	1156
3	Trailer truck	0	0	0	0	0
4	Side loader	26	27	29	30	31
5	Dump truck	12	12	13	13	14
6	Wheel loader	12	12	13	13	14
7	Water sprinkler	2	2	2	2	2
8	Inspection car	22	22	22	22	22
9	Recovery truck	1	1	1	1	1

(3) Calculation of the Required Manpower

The required crew is as shown in **Table 6.2-6**. Based on the conditions, the required number is calculated, as shown in **Tables 6.2-7** and **6.2-8**.

Table 6.2-6 Crew Required for the Improvement of Collection and Transportation System in the First Implementation Stage

Crew Size	
Container truck	1 driver, 2 loaders, 6 sweepers, 1 supervisor and 1 headman for every 15 sweepers
Side loader	1 driver, 6 loaders, 18 sweepers, 1 supervisor and 1 headman for every 15 sweepers
Dump truck (tipper)	1 driver and 1 supervisor
Wheel loader	1 driver, 2 loaders, 6 sweepers, 1 supervisor and 1 headman for every 15 sweepers
Availability	80% for all designation

Table 6.2-7 Manpower Required for the Improvement of Collection and Transportation System in the First Implementation Stage (With the Construction of Transfer Station)

No	Manpower	Quantity				
		1999	2000	2001	2002	2003
1	Driver	124	128	133	137	143
2	Loader	215	224	235	246	258
3	Sweeper	646	672	704	738	774
4	Supervisor	96	100	104	109	114
5	Headman	43	45	47	49	52

Table 6.2-8 Manpower Required for the Improvement of Collection and Transportation System in the First Implementation Stage (Without the Construction of Transfer Station)

No	Manpower	Quantity				
		1999	2000	2001	2002	2003
1	Driver	143	148	154	160	166
2	Loader	267	277	298	309	322
3	Sweeper	801	831	894	927	966
4	Supervisor	115	120	126	131	138
5	Headman	53	55	60	62	64

(4) Vehicle and Equipment Allocation

Vehicles and equipment are allocated in accordance with the waste amount to be collected from each district. **Tables 6.2-9** and **6.2-10** show the number of vehicles and equipment required for each district.

Table 6.2-9 Number of Vehicles and Equipment Required for Each District (With the Construction of Transfer Station)

Vehicles/Equipment Required	1999	2000	2001	2002	2003
Embakashi District					
Container Truck	15	16	18	18	18
Side Loader	8	8	9	9	9
Tipper	4	4	4	4	5
Container	332	354	374	394	417
Wheel Loader	4	4	4	4	5
Sprinkler	1	1	1	1	1
Inspection Car	5	5	5	5	5
Southern District					
Container Truck	2	2	2	3	3
Side Loader	1	1	1	1	1
Tipper	1	1	1	1	1
Container	52	54	56	59	61
Wheel Loader	1	1	1	1	1
Sprinkler	0	0	0	0	0
Inspection Car	3	3	3	3	3
Northern District					
Container Truck	8	9	9	9	10
Side Loader	4	4	4	5	5
Tipper	2	2	2	2	2
Container	189	194	203	212	221
Wheel Loader	2	2	2	2	2
Sprinkler	0	0	0	0	0
Inspection Car	3	3	3	3	3
Central District					
Container Truck	1	1	0	0	0
Side Loader	0	0	0	0	0
Tipper	0	0	0	0	0
Container	14	14	9	9	9
Wheel Loader	0	0	0	0	0
Sprinkler	0	0	0	0	0
Inspection Car	2	2	2	2	2

Table 6.2-9 Number of Vehicles and Equipment Required for Each District (With the Construction of Transfer Station) (Cont'd.)

Vehicles/Equipment Required	1999	2000	2001	2002	2003
Eastern District					
Container Truck	6	6	6	6	6
Side Loader	3	3	3	3	3
Tipper	1	1	1	1	1
Container	136	138	138	140	142
Wheel Loader	1	1	1	1	1
Sprinkler	0	0	0	0	0
Inspection Car	4	4	4	4	4
Western District					
Container Truck	11	11	12	13	14
Side Loader	5	6	6	6	7
Tipper	2	2	3	3	3
Trailer Truck	2	3	3	3	3
Container	244	254	275	290	306
Wheel Loader	2	2	3	3	3
Sprinkler	1	1	1	1	1
Inspection Car	5	5	5	5	5

Table 6.2-10 Number of Vehicles and Equipment Required for Each District (Without the Construction of Transfer Station)

Vehicles/Equipment Required	1999	2000	2001	2002	2003
Embakashi District					
Container Truck	18	19	20	22	23
Side Loader	9	10	10	10	11
Tipper	4	4	5	5	5
Container	332	354	374	394	417
Wheel Loader	4	4	5	5	5
Sprinkler	1	1	1	1	1
Inspection Car	5	5	5	5	5
Southern District					
Container Truck	3	3	3	3	3
Side Loader	1	1	2	2	2
Tipper	1	1	1	1	1
Container	52	54	56	59	61
Wheel Loader	1	1	1	1	1
Sprinkler	0	0	0	0	0
Inspection Car	3	3	3	3	3
Northern District					
Container Truck	10	10	11	11	12
Side Loader	5	5	6	6	6
Tipper	2	2	2	2	2
Container	189	194	203	212	221
Wheel Loader	2	2	2	2	2
Sprinkler	0	0	0	0	0
Inspection Car	3	3	3	3	3

Table 6.2-10 Number of Vehicles and Equipment Required for Each District (Without the Construction of Transfer Station) (Cont'd.)

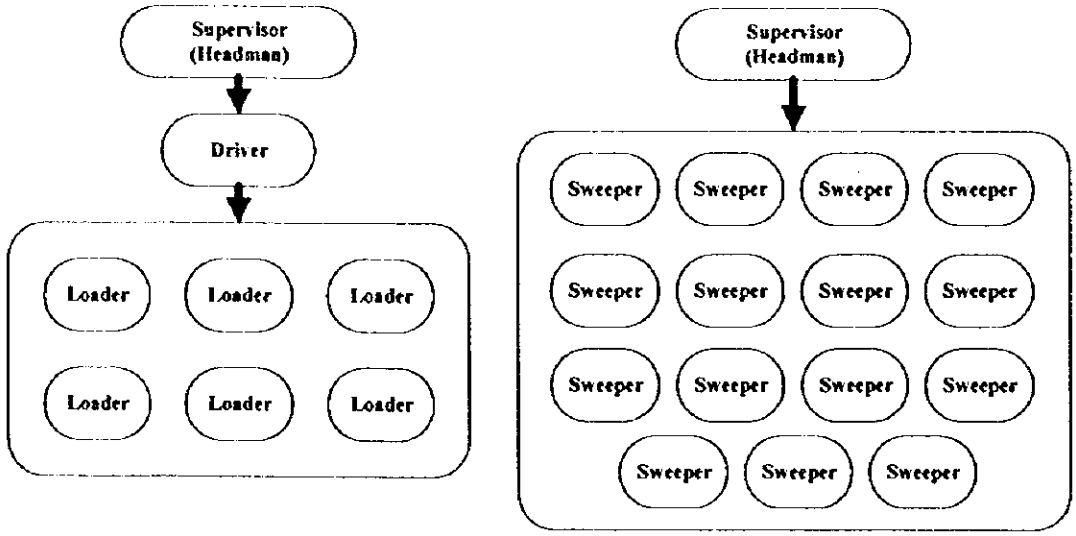
Vehicles/Equipment Required	1999	2000	2001	2002	2003
Central District					
Container Truck	1	1	0	0	0
Side Loader	0	0	0	0	0
Tipper	0	0	0	0	0
Container	14	14	9	9	9
Wheel Loader	0	0	0	0	0
Sprinkler	0	0	0	0	0
Inspection Car	2	2	2	2	2
Eastern District					
Container Truck	7	7	7	7	7
Side Loader	4	4	4	4	4
Tipper	2	2	2	2	2
Container	136	138	138	140	142
Wheel Loader	2	2	2	2	2
Sprinkler	0	0	0	0	0
Inspection Car	4	4	4	4	4
Western District					
Container Truck	12	13	15	15	16
Side Loader	7	7	7	8	8
Tipper	3	3	3	3	4
Container	244	254	275	290	306
Wheel Loader	3	3	3	3	4
Sprinkler	1	1	1	1	1
Inspection Car	5	5	5	5	5

(5) Vehicle Operation and Maintenance

To make the procurement procedure simpler and reduce the lead time of supply for spare parts, a small workshop which will be fully managed by the DoE should be constructed. The workshop will cover only preventive maintenance of the collection vehicles on a daily basis, minor repair of tire punctures, brakes, steering systems, etc., and procurement of spare parts for their repair. The new workshop should be located in the Kaloleni Cleansing Depot, which is one of the largest depots in the DoE and has enough space for the construction of a workshop.

Daily collection and transportation work should be operated based on the existing six (6) districts since management of the daily operation has been regularly done in each district. It seems to be very difficult to reorganise this district-wise system on a different type of location boundaries like boroughs.

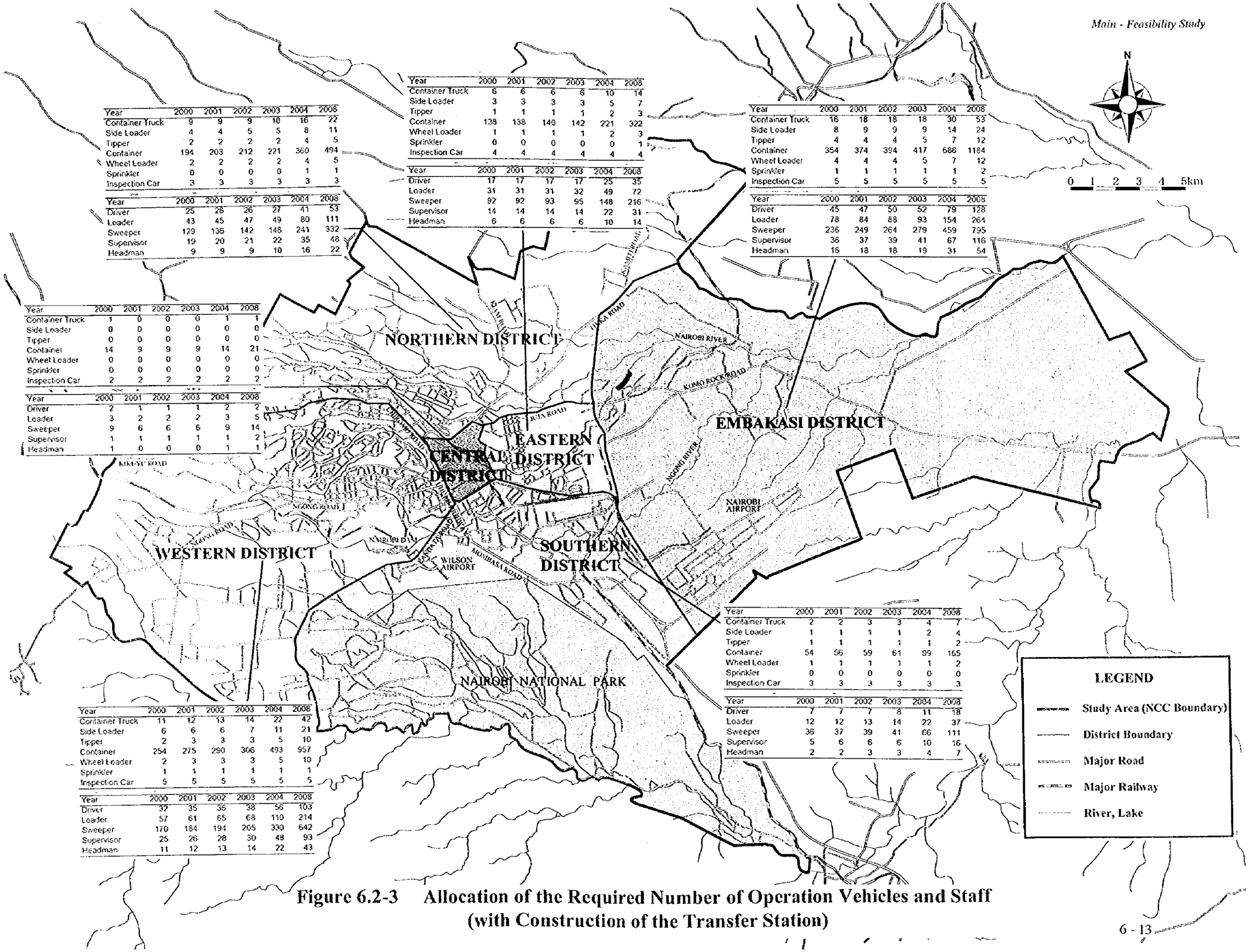
The organisation of the new collection and transportation system for each District, therefore, will be basically established under the District Inspector, and comprising senior foreman, senior headman, headman or supervisor, and drivers and loaders or sweepers. The staffing and composition of the organisational unit for the daily operation is illustrated as follows:



(Note: The number of loaders will depend on the collection type.)

Figure 6.2-2 Organisational Units for Daily Operation

Figures 6.2-3 and **6.2-4** illustrates the allocation of the required number of operation and management vehicles and staff in terms of the new collection and transportation system.



Year	2000	2001	2002	2003	2004	2008
Container Truck	9	9	9	10	16	22
Side Loader	4	4	5	5	8	11
Tipper	2	2	2	2	4	5
Container	194	203	212	221	360	494
Wheel Loader	2	2	2	2	4	5
Sprinkler	0	0	0	0	1	1
Inspection Car	3	3	3	3	3	3

Year	2000	2001	2002	2003	2004	2008
Driver	25	26	26	27	41	53
Loader	43	45	47	49	80	111
Sweeper	129	136	142	148	241	332
Supervisor	19	20	21	22	35	48
Headman	9	9	9	10	16	22

Year	2000	2001	2002	2003	2004	2008
Container Truck	6	6	6	6	10	14
Side Loader	3	3	3	3	5	7
Tipper	1	1	1	1	2	3
Container	138	138	140	142	221	322
Wheel Loader	1	1	1	1	2	3
Sprinkler	0	0	0	0	0	1
Inspection Car	4	4	4	4	4	4

Year	2000	2001	2002	2003	2004	2008
Driver	17	17	17	17	25	35
Loader	31	31	31	32	49	72
Sweeper	92	92	93	95	148	216
Supervisor	14	14	14	14	22	31
Headman	6	6	6	6	10	14

Year	2000	2001	2002	2003	2004	2008
Container Truck	16	18	18	18	30	53
Side Loader	8	9	9	9	14	24
Tipper	4	4	4	5	7	12
Container	354	374	394	417	686	1184
Wheel Loader	4	4	4	5	7	12
Sprinkler	1	1	1	1	1	2
Inspection Car	5	5	5	5	5	5

Year	2000	2001	2002	2003	2004	2008
Driver	45	47	50	52	79	128
Loader	78	84	88	93	154	264
Sweeper	236	249	264	279	459	795
Supervisor	36	37	39	41	67	116
Headman	16	18	18	19	31	54

Year	2000	2001	2002	2003	2004	2008
Container Truck	1	0	0	0	1	1
Side Loader	0	0	0	0	0	0
Tipper	0	0	0	0	0	0
Container	14	9	9	9	14	21
Wheel Loader	0	0	0	0	0	0
Sprinkler	0	0	0	0	0	0
Inspection Car	2	2	2	2	2	2

Year	2000	2001	2002	2003	2004	2008
Driver	2	1	1	1	2	2
Loader	3	2	2	2	3	5
Sweeper	9	6	6	6	9	14
Supervisor	1	1	1	1	1	2
Headman	1	0	0	0	1	1

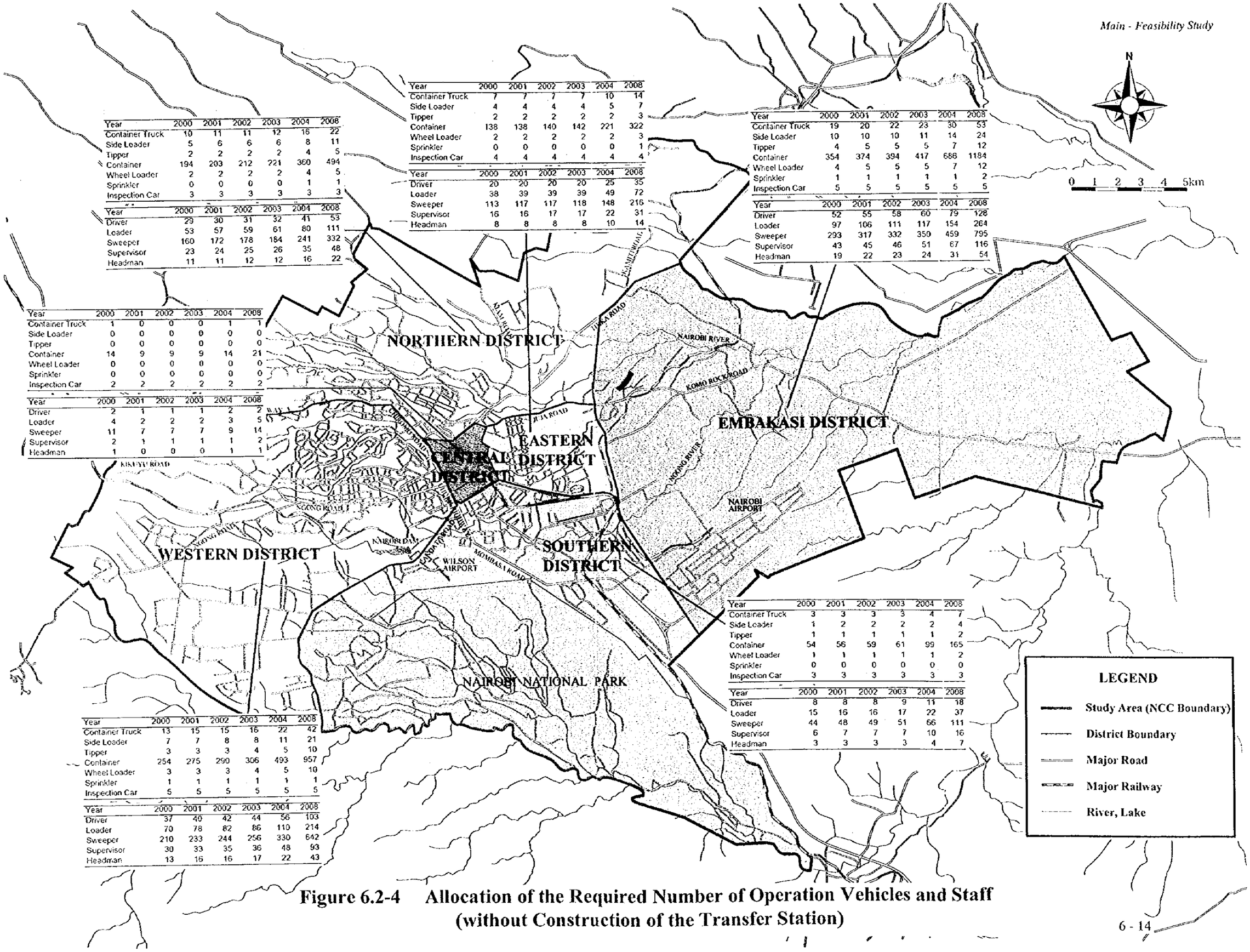
Year	2000	2001	2002	2003	2004	2008
Container Truck	11	12	13	14	22	42
Side Loader	6	6	6	7	11	21
Tipper	2	3	3	3	5	10
Container	254	275	290	306	493	957
Wheel Loader	2	3	3	3	5	10
Sprinkler	1	1	1	1	1	1
Inspection Car	5	5	5	5	5	5

Year	2000	2001	2002	2003	2004	2008
Driver	32	35	36	38	56	103
Loader	57	61	65	68	110	214
Sweeper	170	184	194	205	330	642
Supervisor	25	26	28	30	48	93
Headman	11	12	13	14	22	43

Year	2000	2001	2002	2003	2004	2008
Container Truck	2	2	3	3	4	7
Side Loader	1	1	1	1	2	4
Tipper	1	1	1	1	1	2
Container	54	56	59	61	99	165
Wheel Loader	1	1	1	1	1	2
Sprinkler	0	0	0	0	0	0
Inspection Car	3	3	3	3	3	3

Year	2000	2001	2002	2003	2004	2008
Driver	7	7	7	8	11	18
Loader	12	12	13	14	22	37
Sweeper	36	37	39	41	66	111
Supervisor	5	6	6	6	10	16
Headman	2	2	3	3	4	7

Figure 6.2-3 Allocation of the Required Number of Operation Vehicles and Staff (with Construction of the Transfer Station)



Year	2000	2001	2002	2003	2004	2008
Container Truck	10	11	11	12	16	22
Side Loader	5	6	6	6	8	11
Tipper	2	2	2	2	4	5
Container	194	203	212	221	360	494
Wheel Loader	2	2	2	2	4	5
Sprinkler	0	0	0	0	1	1
Inspection Car	3	3	3	3	3	3

Year	2000	2001	2002	2003	2004	2008
Driver	29	30	31	32	41	53
Loader	53	57	59	61	80	111
Sweeper	160	172	178	184	241	332
Supervisor	23	24	25	26	35	48
Headman	11	11	12	12	16	22

Year	2000	2001	2002	2003	2004	2008
Container Truck	7	7	7	7	10	14
Side Loader	4	4	4	4	5	7
Tipper	2	2	2	2	2	3
Container	138	138	140	142	221	322
Wheel Loader	2	2	2	2	2	3
Sprinkler	0	0	0	0	0	1
Inspection Car	4	4	4	4	4	4

Year	2000	2001	2002	2003	2004	2008
Driver	20	20	20	20	25	35
Loader	38	39	39	39	49	72
Sweeper	113	117	117	118	148	216
Supervisor	16	16	17	17	22	31
Headman	8	8	8	8	10	14

Year	2000	2001	2002	2003	2004	2008
Container Truck	19	20	22	23	30	53
Side Loader	10	10	10	11	14	24
Tipper	4	5	5	5	7	12
Container	354	374	394	417	686	1184
Wheel Loader	4	5	5	5	7	12
Sprinkler	1	1	1	1	1	2
Inspection Car	5	5	5	5	5	5

Year	2000	2001	2002	2003	2004	2008
Driver	52	55	58	60	79	128
Loader	97	106	111	117	154	264
Sweeper	293	317	332	350	459	795
Supervisor	43	45	46	51	67	116
Headman	19	22	23	24	31	54

Year	2000	2001	2002	2003	2004	2008
Container Truck	1	0	0	0	1	1
Side Loader	0	0	0	0	0	0
Tipper	0	0	0	0	0	0
Container	14	9	9	9	14	21
Wheel Loader	0	0	0	0	0	0
Sprinkler	0	0	0	0	0	0
Inspection Car	2	2	2	2	2	2

Year	2000	2001	2002	2003	2004	2008
Driver	2	1	1	1	2	2
Loader	4	2	2	2	3	5
Sweeper	11	7	7	7	9	14
Supervisor	2	1	1	1	1	2
Headman	1	0	0	0	1	1

Year	2000	2001	2002	2003	2004	2008
Container Truck	3	3	3	3	4	7
Side Loader	1	2	2	2	2	4
Tipper	1	1	1	1	1	2
Container	54	56	59	61	99	165
Wheel Loader	1	1	1	1	1	2
Sprinkler	0	0	0	0	0	0
Inspection Car	3	3	3	3	3	3

Year	2000	2001	2002	2003	2004	2008
Driver	8	8	8	9	11	18
Loader	15	16	16	17	22	37
Sweeper	44	48	49	51	66	111
Supervisor	6	7	7	7	10	16
Headman	3	3	3	3	4	7

Year	2000	2001	2002	2003	2004	2008
Container Truck	13	15	15	16	22	42
Side Loader	7	7	8	8	11	21
Tipper	3	3	3	4	5	10
Container	254	275	290	306	493	957
Wheel Loader	3	3	3	4	5	10
Sprinkler	1	1	1	1	1	1
Inspection Car	5	5	5	5	5	5

Year	2000	2001	2002	2003	2004	2008
Driver	37	40	42	44	56	103
Loader	70	78	82	86	110	214
Sweeper	210	233	244	256	330	642
Supervisor	30	33	35	36	48	93
Headman	13	16	16	17	22	43

Figure 6.2-4 Allocation of the Required Number of Operation Vehicles and Staff (without Construction of the Transfer Station)

6.2.4 Project Impacts

The procurement and operation of the new collection vehicles would have the following impacts:

(1) Improvement of efficiency and effectiveness of the collection and transportation operation;

(2) Increase of the amount of carried waste;

(3) Improvement of sanitation conditions of workers involved in loading of waste; and

(4) Promotion of people's awareness toward the importance of solid waste management and enhancement of people's collaboration to the new system.

Even if the collection rate, i.e., the proportion of amount of waste collected to the total amount of waste generated, will not be 100% but 40% or 60%, the City's environment and public health conditions would greatly improve. Since the containers are to be installed especially to cover mainly residential areas, instead of the existing uncollected waste dumping areas, the number of visible heaps of waste would be reduced.

6.2.5 Project Cost Estimate and Schedule

Project costs, such as initial investment costs and engineering costs, and their schedule in the First Implementation Stage are as presented **Tables 6.2-11 and 6.2-12** below. The project in the First Implementation Stage will start from the year of 1999 and end up in 2003. Firstly, design, engineering, bidding and contracting of the procured vehicles will be carried out. From the year of 2000, actual operation under the new collection and transportation system should be working smoothly.

Table 6.2-11 Project Cost and Schedule for the Improvement of Collection and Transportation System in the First Implementation Stage (With the Construction of Transfer Station)

Item	Year				
	1999	2000	2001	2002	2003
Required Number of Vehicles					
Detachable-container truck	-	47	2	2	-
Container	-	1008	47	49	-
Trailer truck	-	11	0	1	-
Side loader	-	22	1	1	-
Dump truck	-	10	1	0	-
Wheel loader	-	10	1	0	-
Water sprinkler	-	2	0	0	-
Inspection car	-	22	0	0	-
Recovery truck	-	1	0	0	-
Project Cost (1000 Kshs.)					
Initial Investment	-	823,500	30,000	40,800	-
Engineering	44,700	-	-	-	-
Total	**44,700**	**823,500**	**30,000**	**40,800**	**0**

Table 6.2-12 Project Cost and Schedule for the Improvement of Collection and Transportation System in the First Implementation Stage (Without the Construction of Transfer Station)

Item	Year				
	1999	2000	2001	2002	2003
Required Number of Vehicles					
Detachable-container truck	-	56	2	3	-
Container	-	1055	49	52	-
Trailer truck	-	-	-	-	-
Side loader	-	29	1	1	-
Dump truck	-	13	0	1	-
Wheel loader	-	13	0	1	-
Water sprinkler	-	2	0	0	-
Inspection car	-	22	0	0	-
Recovery truck	-	1	0	0	-
Project Cost (1000 Kshs.)					
Initial Investment	-	806,000	24,000	38,800	-
Engineering	43,400	-	-	-	-
Total	**43,400**	**806,000**	**24,000**	**38,800**	**0**

6.3 Construction of New Transfer Station

6.3.1 Objective of the Project

The objective of this project is to construct a new transfer station to improve the efficiency of collection and transportation operations by reducing the transportation time.

6.3.2 Project Strategy

The candidate site for the construction of transfer station is planned to be near the city centre area, as shown in **Figure 6.3-1**. The area to be covered by direct and indirect transport is also shown in the same figure. Private collectors in the area of indirect transport will bring the collected waste to the transfer station and will be charged with fees by NCC.

Many types of transfer station exist and the best option is selected by comparing all types in terms of ease of maintenance, efficiency of operation, flexibility for waste fluctuation, and investment and O&M (operation and maintenance) costs.

The project life of the transfer station is assumed at 30 years. The increase of waste amount to be collected is quite high and, accordingly, the waste amount to be treated in the transfer station will increase rapidly. Therefore, phased construction is recommended.

6.3.3 Project Analysis

(1) Location of the Transfer Station

It is preferred, in general, that transfer stations are located in the most convenient place to access from anywhere in the city and haul the waste to the

disposal site. The city centre is recommendable from this perspective; however, it might be extremely difficult to secure land for the transfer station in this area due to rapid urbanisation. In addition, much more careful consideration on the surrounding environment will be required if the station is near the city centre. Although Madaraka or the Kariobangi area which is one of the candidate disposal sites is also thought by NCC to be a candidate transfer station in the city, the specific site of the transfer station is yet to be decided.

For planning purposes, the site for the transfer station is considered to be an area as shown in **Figure 6.3-1**. The proposed site within the area is assumed to have the same conditions to construct the transfer station.

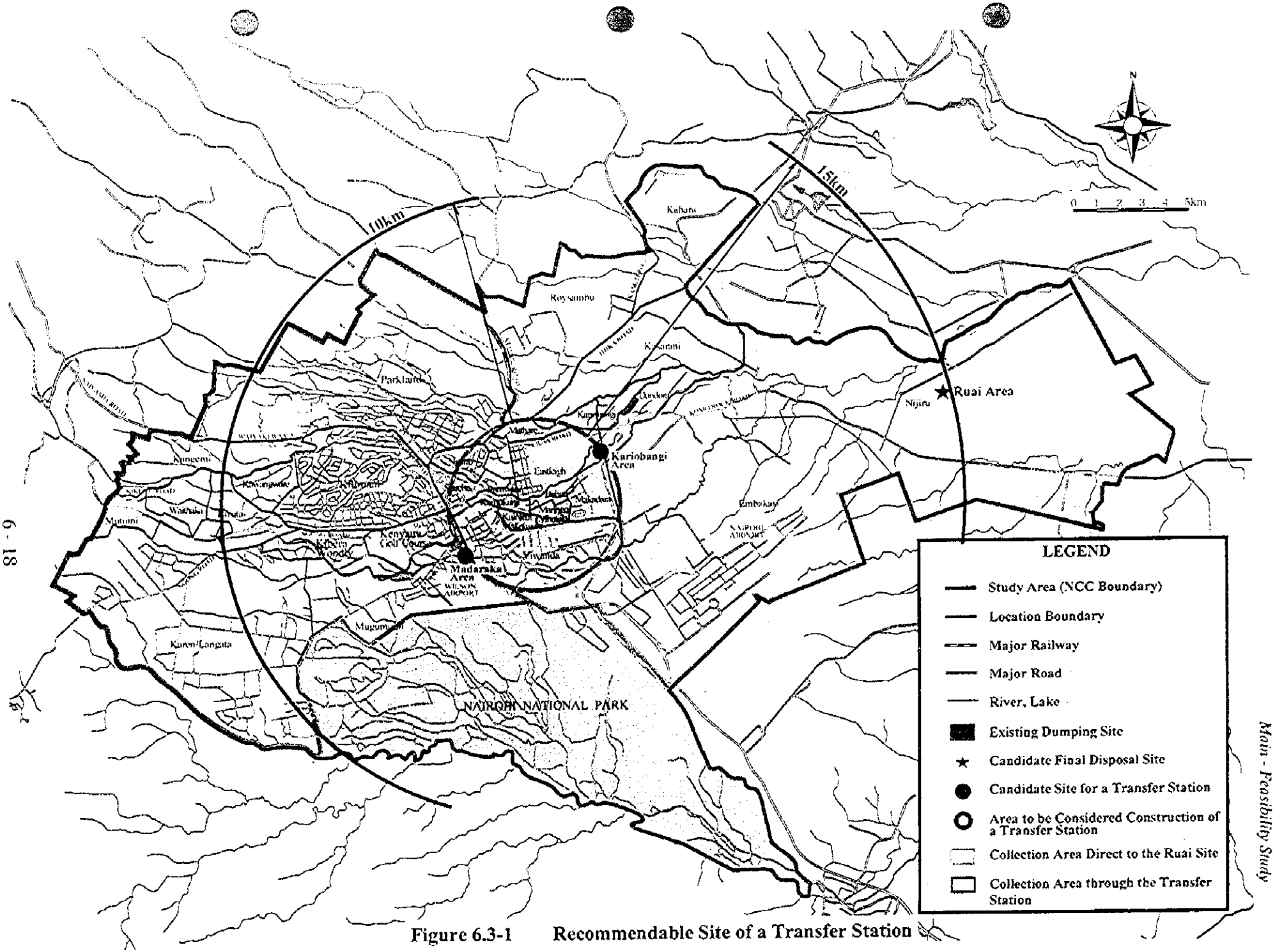


Figure 6.3-1 Recommendable Site of a Transfer Station

(2) Types of Transfer Station

There are five (5) types of transfer station as shown in **Table 6.3-1** below.

Table 6.3-1 Types of Transfer Station

Type	Outline
Common Type	Collected solid waste is transferred from each collection truck to hauled container or trailer type of vehicles by bucket loaders or crane buckets. There is no platform to be used for unloading waste in general.
Common Type with hoppers	By using discharge hoppers, the waste is transferred from collection vehicles to transportation vehicles. Considering transportability, the unloading platform is usually equipped inside the transfer station area.
Pit and Crane Type	The waste is dumped from each collection vehicle to a storage pit and then transferred to the transportation vehicles through hoppers by using crane buckets.
Compactor Container Type	The waste is packed in a closed container by compacting equipment.
Container Transfer Type	The waste is collected by container trucks, and the only container is hauled to the disposal site by larger tractors.

These five types of transfer station are compared to evaluate the required facilities, ease of maintenance, efficiency of operation, flexibility for waste fluctuation, and investment, operation and maintenance costs. The comparative evaluation is presented in **Table 6.3-2**.

The comparative evaluation shows that the optimum type is the common type with hoppers, considering efficiency and economical reasons. **Figure 6.3-2** below illustrates a general view of the common type of transfer station with hoppers.

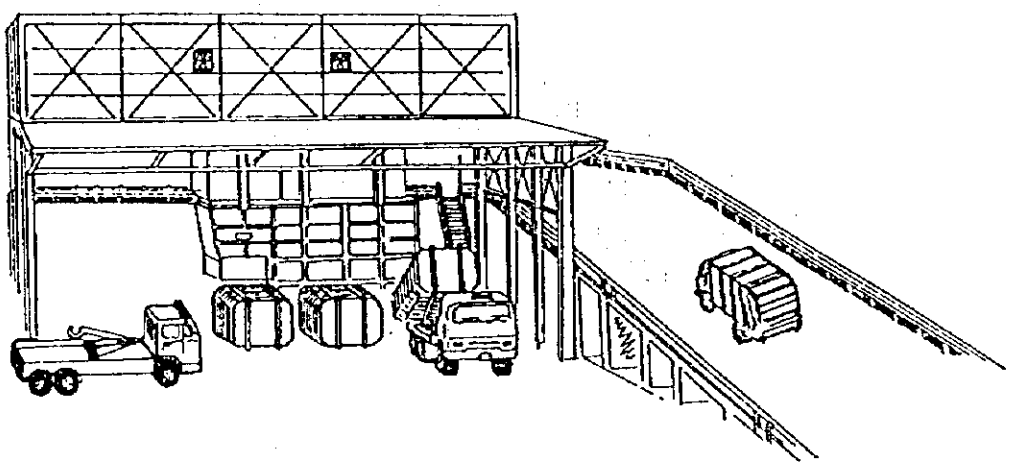


Figure 6.3-2 General View of the Common Type of Transfer Station with Hoppers

Table 6.3-2 Comparison of Types of Transfer Station

	Common method	Common method with hoppers	Pit and crane method	Compactor container method	Container transfer method
Required facility	-Bucket loader -Crane w/ bucket -Clamshell	-Guide hopper -Bucket loader	-Crane w/ bucket -Clamshell -Hopper	-Compactor -Hopper -Container	-Forklift -Container
Mechanism & stability	Simple & high A	Simple & high A	Simple & high A	Complex & a little low C	Simple & high A
Maintenance	Easy A	Easy (need to control the traffic route) A	Average (need a spare crane or clamshell) B	A little difficult (anxious about troubles with compactors) C	Easy A
Efficiency	Average B	High A	High A	High A	High A
Flexibility for waste fluctuation	Possible (need a storage space) A	Possible (need a storage space) A	Possible (need a large volume pit) A	A little low (depend on ability of compactors) B	Possible (need a large number of containers) A
Sanitary conditions	Need some prevention (odor and scattering) B	Need some prevention (odor and scattering) B	Need some prevention (odor, scattering and leachate) B	No problem (little concern about noise of) A	No problem A
Investment cost	Low A	Average B	A little high B	High C	Average B
Operation & maintenance cost	Low A	Low A	Low A	Average B	Average B
Evaluation	Acceptable A	Optimum A	Average B	Unacceptable (Expensive) C	Unacceptable (Need to change the collection system) C

Note: A: Excellent; B: Good; C: Fair

Figure 6.3-3 presents a general plan of the common type of transfer station with hoppers, and the major work items are as shown in **Table 6.3-3.**

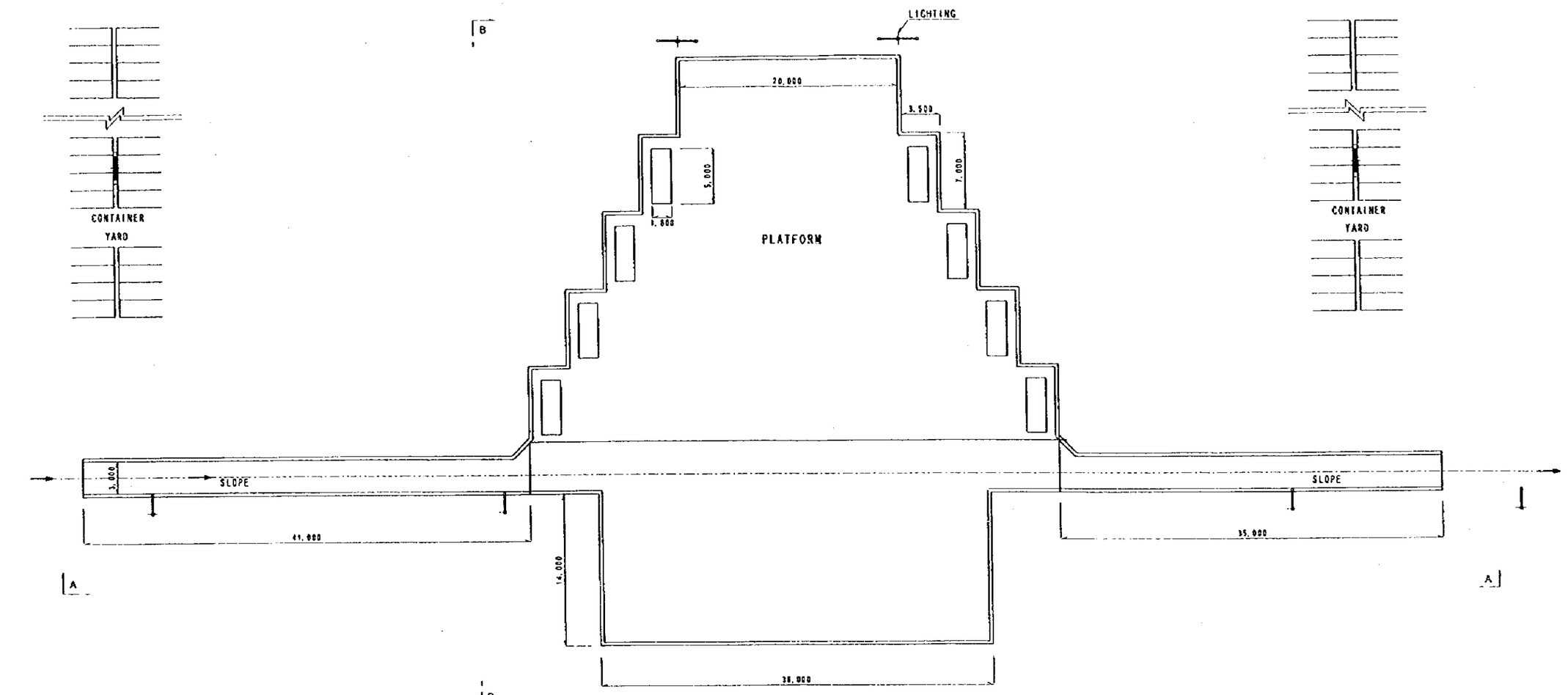


Figure 6.3-3 General Plan of Common Type of Transfer Station with Hoppers

Table 6.3-3 Major Work Items and Quantities for the Construction of Transfer Station

Item	Unit	Quantity
1. Civil Works		
Platform	m^2	1,900
Slope for Vehicle	m^2	250
Roof	m^2	500
Truck Scale Room	m^2	40
Workshop Room*	m^2	160
Pavement	m^2	48,400
Fence and Gate	m	1,400
2. Facility		
Truck Scale	Each	4
Car Washing Machine	Each	2
Workshop	LS	1
Guide Chute	Each	8
Electric Work	LS	1
Wheel Loader	Each	2

* The Workshop Room includes rooms for managerial staff and security personnel, as well as rest and changing rooms.

6.3.4 Project Impacts

The construction of a new transfer station would have the following impacts:

(1) Increase of the number of trips to collect the waste;
(2) Improvement of efficiency by centralising the system for waste treatment; and
(3) Possibility of introduction of a sorting system as a future improvement.

6.3.5 Project Cost Estimate and Schedule

The project cost and schedule in the First Implementation Stage are as presented in **Table 6.3-4** below. The project in the First Implementation Stage will start from the year 1999 and end up in 2003. Firstly, design, engineering, bidding and contracting of the construction will be carried out. In the year 2000, the actual construction work will be started and completed.

Table 6.3-4 Project Cost and Schedule for the Construction of Transfer Station in the First Implementation Stage

Item	Year				
	1999	2000	2001	2002	2003
Detailed Design and Engineering	▬				
Bidding and Contract	▬				
Construction		▬			
Start-up		◆			
Project Cost (1000 Kshs.)					
Initial Investment	-	900,000	-	-	-
Engineering	45,000	-	-	-	-
Total	**45,000**	**900,000**	-	-	-

6.4 Project for Construction of New Workshop and Rehabilitation of Depots

6.4.1 Objective of the Project

The objective of this project is to construct a new workshop and rehabilitate the existing depots to accelerate the procurement procedure and improve the vehicle maintenance and repair activities.

6.4.2 Project Strategy

A small-scale workshop which will be fully managed by the Department of Environment (DoE) should be constructed. The workshop will cover only preventive maintenance of the collection vehicles on a daily basis, minor repair of tire punctures, brakes, steering systems, etc., and procurement of spare parts for their repair. Major repair and overhaul of the vehicles will be carried out by the City Engineer's Workshop or a private repair shop in the city.

The new workshop should be located in the Kaloleni Cleansing Depot which is one of the largest depots in the DoE and has enough space for the construction of the workshop. In addition, there would be no need to secure the land for the construction.

The existing depots in six (6) districts should be rehabilitated to park the procured vehicles. Daily check-out and check-in will be recorded properly and daily maintenance as a minimum level, such as checking fuel, lubricants, lights and water, will be carried out in each depot before starting the operation every morning.

6.4.3 Project Analysis

(1) Proposed Work Items for the New Workshop

The new workshop could cover the following work items:

(a) Oil change
(b) Filter change
(c) Inspection and adjustment of each part
(d) Fixing of flat tyres
(e) Exchange of tyres
(f) Exchange of component assemblies
(g) Welding
(h) Painting
(i) Car washing
(j) Other minor repair, such as brake and clutch fixing

(2) Tools and Equipment Required for the New Workshop

Based on the above work items, the tools and equipment required for the new workshop is designed as shown in **Table 6.4-1**.

Table 6.4-1 Tools and Equipment Required for Construction of Workshop

Item	Unit	Quantity	Remarks
1. Service table	Each	1	
2. Vise	Each	1	
3. Safety locker	Each	1	
4. Supporting stand	Set	3	4 of each set
5. Trolley jack	Each	2	50 tons capacity each
6. Grease gun	Each	2	
7. Oil lifting pump	Each	2	
8. Bottle jack	Each	6	20 tons capacity each
9. Boosting jumper	Each	2	
10. Soldering iron	Each	2	
11. Battery tester	Each	1	
12. Battery charger	Each	1	
13. Hydrometer	Each	1	
14. Ohm meter	Each	2	
15. Crocodile clip	Each	6	
16. Welding machine	Each	1	3-phase
17. Wheel spanner cross	Each	9	5 for heavy vehicles and 4 for light vehicles
18. Compressor machine and pipes	Each	2	
19. Deflating machine	Each	1	
20. Inflating machine	Each	1	
21. Patches and glue	Set	10	
22. Manual tyre removing equipment	Each	1	
23. Machine to remove rim from tyre	Each	1	Hydraulic system
24. Tool kit	Set	5	
25. Fuel tanks and pumps	Set	1	Diesel/petrol
26. Radio communication equipment	Set	1	

(3) Main Facilities of the Workshop

The staff will use the existing office, and the major facilities required for the workshop, in addition to the existing facilities, are as follows:

(a) Inspection pits (Number of pits: 5)
(b) Sheds and storage facilities
(c) Washing bays (Number of bays: 2)

The workshop will require a total area of 500 m^2.

(4) Parking Lot Requirements

The Cleansing Section has been managing depots in each district to monitor the daily collection and transportation work and road sweeping. The increase in number of collection vehicles requires much more space for parking, and the following rehabilitation works are required for security:

(a) Construction of surrounding wall (10 feet in height) with a metal gate
(b) Construction of a metal gate
(c) Installation of an electric fence
(d) Construction of a guardhouse for security men

(e) Installation of a washing bay and an inspection pit
(f) Construction of drains
(g) Installation of security lighting all-round
(h) Installation of simple shed and a small storage
(i) Installation of manual tyre removing equipment, compressor and a vise
(j) Construction of security storage for all tools
(k) Installation of fuel tanks and pumps

The parking lot will require a total area of from 2,000 m^2 at Embakasi to 50 m^2 at Central District, depending on the number of vehicles. The area required for each parking lot is as follows:

Northern District	:	850 m^2
Southern District	:	350 m^2
Eastern District	:	600 m^2
Western District	:	1,600 m^2
Central District	:	50 m^2
Embakasi District	:	2,000 m^2

6.4.4 Project Impacts

The construction of a new workshop and rehabilitation of the existing depots would have the following impacts:

(1) Increase of vehicle availability rate
(2) Provision of regular waste collection services
(3) Extension of vehicle life
(4) Reduction of vehicle operation and maintenance cost

6.4.5 Project Cost Estimate and Schedule

The project cost and schedule in the First Implementation Stage are as presented in **Table 6.4-2** below. The project in the First Implementation Stage will start from the year 1999 and end up in 2003. Firstly, design, engineering, bidding and contracting of construction, and rehabilitation work will be carried out. In the year 2000, actual operations under the new workshop and parking lots is supposed to be working smoothly.

Table 6.4-2 Project Cost and Schedule for Construction of Workshop and Rehabilitation of Depots in the First Implementation Stage

Items	Year				
	1999	2000	2001	2002	2003
Detailed Design and Engineering	▬				
Bidding and Contract	▬				
Construction		▬			
Start-up		♦			
Project Cost (1000 Kshs.)					
Initial Investment	-	84,000	-	-	
Engineering	4,200	-	-	-	-
Total	**4,200**	**84,000**	-	-	-

6.5 Community Waste Management Project for Informal Settlements

6.5.1 Objective of the Project

The primary purpose of the Community Waste Management Project (CWMP) is to increase and improve the capacity of community based structures in slum areas in order to effectively carry out collection and transportation of waste.

6.5.2 Project Strategy

First of all, for smooth implementation of the project, responsibilities, functions and duties shall be clearly defined and the levels of communication are maintained as smoothly as possible. This will be achieved through the use of incentive based approaches that will encourage community participation.

At the village level, an assessment of the status of community organisation structures will be carried out to identify areas of weaknesses. The previous experimental collection work done in Kayaba will provide baseline information in which initial actions can be based as the project shifts from one slum to another.

The main strategy is the setting up of waste management community (WMC) groups whose composition, rules and procedures will empower them to involve all the slum residents. The constitution will also make a provision for financing their activities. It is strongly felt that the low group is the driving and decision-maker for the project. They will be able to resolve internal issues, for instance, allocation of funds through the local administration or the NCC. This means that the CWMP must address the need to strengthen the operation of WMC groups as a priority. One of the disadvantages of the existing groups is their weakness that sometimes renders them isolated from the rest of the community.

Education and awareness will be a central theme that will cross cut all the activities in the project. At least four (4) education and training seminars will be conducted in each of the selected slum areas. A "baraza" or public meeting will also be held. Communication equipment particularly for the presentation of video shows will be very important for educating the target groups. A close relationship with the new Community Development Section of NCC will be established to have access to the equipment.

Externally, the project will liaise with the interested parties who may wish to compliment activities such as community education and infrastructure support (toilets, water pipes and drainage) through the mediation of NGOs.

At the end of the 4 months period, however, it is anticipated that each WMC group will have the capacity to establish external contacts, prepare reports and make proposals.

6.5.3 Project Analysis

(1) Project Location

In terms of distribution of slum areas, Nairobi has around 40 to 50 informal settlements differing in relation to size and population as statistically indicated in **Table 6.5-1** below.

Table 6.5-1 List of Slum Areas in Nairobi

No.	Name of slum area	Area (ha)	Population
1	Fuata Nyayo	-	3,000
2	Mariguini	14.2	17,040
3	Lunga lunga	-	11,000
4	Kibera	225.6	248,160
5	Korogocho	49.2	56,580
6	Express	16.8	20,160
7	Kayaba	54.4	102,480
8	Mitumba	1.5	1,200
9	Bomas	2.1	1,680
10	Mathare	73.7	58,160
11	Thome	7.3	2,190
12	Njathini	8.75	2,625
13	Garba	13.75	4,125
14	Githurai	21.8	6,540
15	Kahawa	30.5	9,150
16	Kamai	9.95	2,985
17	Ngando	12.0	6,000
18	Riruta	15.0	7,500
19	Kiwandani	23.0	11,500
20	Kawangware muslim	111.0	55,000
21	Kawangware village	37.0	18,500
22	Kangemi	75.0	37,500
23	Dagoretti	14.5	7,250
24	Waithaka	41.0	20,500
25	Mutuini	45.0	22,500
26	Maili Saba	39.7	11,910
27	Soweto	10.0	6,000
28	Kalyole	23.3	13,980
29	Buruburu centre	4.5	1,890
30	Kitui	10.0	10,000
31	Pumwani	-	-
32	Runda	11.5	3,450
33	Kitisuru	11.25	3,375
34	Spring Valley	1.67	500
35	Kwa Ruebeni	-	-
36	Kuwinda	-	-
37	Kiambo	-	-

Source: Matrix, 1989

It should be noted that the above data is interim because area and population in slum areas normally vary within relatively short periods. However, at any given moment, all these slums are characterised by unique features that make living conditions very difficult. Some of the main features are the following:

(a) Very high population density per unit area, reaching 1,200 people per hectare in some areas;

(b) Sprawling mass of temporary shanty dwellings made of mud, iron sheets, plastics and paper;

(c) Inadequate sewage, water, health and drainage facilities; and

(d) Widespread poverty.

(2) Project Duration

To cover all informal settlements in Nairobi, the project would require a considerable amount of time and resources. For this reason, a proposal is made to implement the project in three (3) phases; that is, the first phase will cover 15 areas from the year 1999 to 2003, the second phase will cover 12 areas between 2004 and 2006, and the last phase will implement 10 areas from 2007 to 2008.

The first phase is composed of five (5) one-year terms beginning in 1999 and ending in the year 2003. After the first three (3) terms, the project will be reviewed and continued up to the year 2003 in selecting other three (3) areas in the remaining two terms. Each term will cover three separate slum areas, as shown in **Figure 6.5-1**.

From the informal settlements mentioned before, nine areas, namely Fuata Nyayo, Mariguini, Kuwinda, Lunga lunga, Soweto, Kwa Ruebeni, Kibera, Riruta and Mitumba have been identified to form the initial part of the project on the basis of proximity and sharing a common river named Ngong River.

The location of the nine (9) slum areas is as shown in **Figure 6.5-2**.

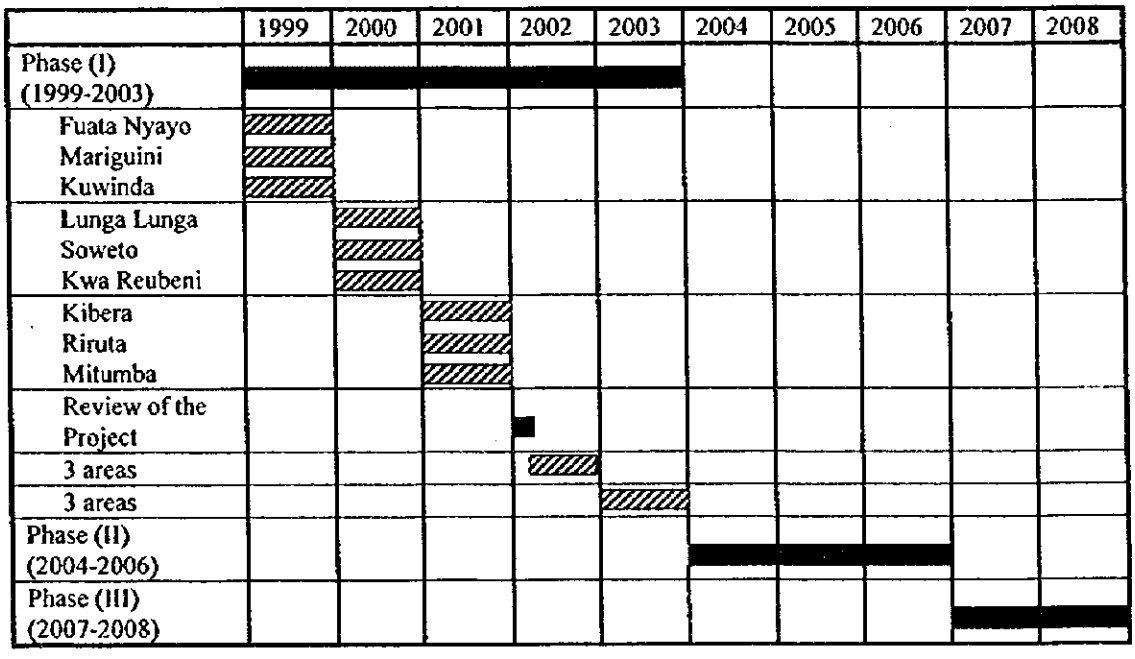


Figure 6.5-1 Schedule of the Community Waste Management Project

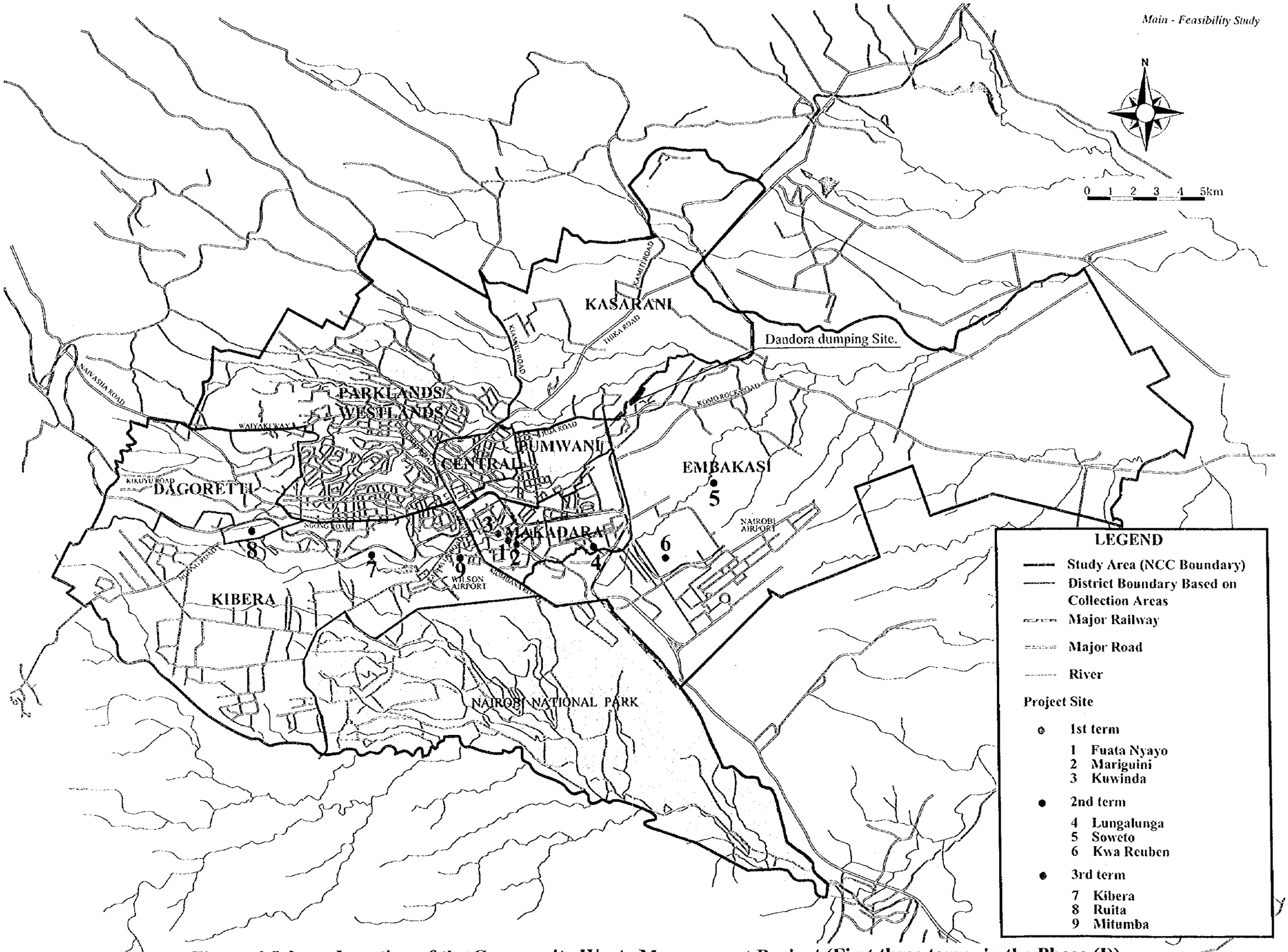


Figure 6.5-2 Location of the Community Waste Management Project (First three terms in the Phase (I))

(3) Target Population

The project, as a whole, aims at building partnership with the most disadvantaged population living in informal settlements of Nairobi City which is said to represent an estimated 55% of the total population (Nairobi Informal Settlements Coordination Committee, 1997). This Feasibility Study covers the first three (3) terms, i.e., nine (9) areas from the year 1999 to 2001 in Phase I. In each of the 9 slums, the project will try to reach the following targets. The target population is not necessarily covering the whole population, because this population should be subject to people who will be main workers in communities to be formed in the project and key helpers to tackle the solid waste management problems. The population is therefore decided based on the results of the experimental work and the assumed total population of the areas.

Table 6.5-2 Schedule of the Community Waste Management Project

Name of slums	Year	Target Population
Fuata Nyayo	1999	1,000
Mariguini		3,000
Kuwinda		1,000
Lunga Lunga	2000	2,000
Soweto		1,500
Kwa Reubeni		1,500
Kibera	2001	4,000
Riruta		500
Mitumba		500
Total		**15,000**

(4) Social and Economic Factors

The history of informal settlements in Nairobi started with the poor, displaced or urban emigrants who were drawn by the desire to eke a livelihood in the city. This is true today as it was several decades ago. Many of these migrants have their roots in the rural areas and due to the fact they lack basic skills and education, the lucky can only manage to secure manual or casual jobs. This means that the meagre incomes they receive can barely enable them to survive or support their families.

It is no coincidence therefore that the slum dwellers live in an environment with little or no social amenities. The dwellings are simply four walls and a roof over their heads.

It is difficult to move around because there is virtually no passageway. All available space is used to construct more dwellings to absorb the ever increasing demand of cheap accommodation.

The spontaneous and rapid growth of these slum areas has not been matched with adequate support by the central government or the local authorities, in developing proper plans or the provision of such social infrastructure as waste collection, water supply and sewerage disposal.

In response to these difficulties, the slum areas tend to grow strategically in areas close to rivers or streams. Often, they are also established within a short distance from the industrial activities, or high income areas that offer them employment opportunities.

In view of the large population in the slum areas, it would be sensible to expect them to impose considerable influence both politically and economically to improve their lot. On the contrary, most of the development activities and social investment usually occur outside these areas principally because of the low purchasing power of the slum residents. Secondly, their bargaining power is further weakened since the slums are temporary in nature. Furthermore, the residents or the plot owners have no ownership to the land. This state of affairs reduces their ability to influence the decision making process despite being represented by a local councilor and the area member of parliament. However, it is necessary to mention briefly another important factor associated with the problem of disempowerment of the slum dwellers i.e., the low organisational level of the slum residents which contributes greatly to the ineffectiveness of community action on issues like waste management.

Struggling to meet their basic needs is the major daily preoccupation of the slum population. It is noteworthy that the interests of other organisations or NGOs to assist the people is largely evident in formal education and health projects. Although small local community groups emerge from these project activities, it is recognised that in the absence of official assistance, these groups lack the capacity to ensure that their aims and objectives are sustained. This problem undermines their ability to create sufficient impact of their work in the whole slum area.

The approach adopted in this project shall put into account these constraints and seek innovative solutions, so that not only will the CWMP community groups become strong but also able to initiate the necessary impact needed to mobilise the whole slum population.

(5) Relevant Programmes and Policies

In general, the areas targeted in this project are supposed to be covered in the overall government programmes and policies regarding waste management in urban areas. However, as evidence shows, this is more in theory than in practice.

In Nairobi City, the NCC is the overall authority which is mandated to handle all types of waste collection and safe disposal through a form of taxation levied on the city residents referred to as "service charge". The extent to which this task is carried out over the years has been a subject of continuing debate in the recent past.

Recent proposals that call for the transfer of responsibility from the NCC to the private sector, and the increasing efforts of the NGOs, illustrate the new trends that are likely to shape the future of waste management in the city.

Whereas it appears that solid waste management is a viable business in the better planned central district of Nairobi, this is not the case in the slum areas. Therefore, it remains to be seen what role the residents of the slums can play in this regard.

In the Local Government Act, there are important provisions and by-laws that are meant to control and regulate the manner in which both domestic and industrial waste is disposed. Somehow today, these provisions do not seem to be in force. Consequently, on numerous occasions, this has led to situations where ad hoc directives are issued to clean up the accumulating garbage. Typical public slogans that are being used such as, 'restoring the city's lost glory', indicate the level of desperation and urgency of the problem. At international level, similar campaigns have been demonstrated by UNEP every year in what is called, 'Clean up the World Campaign'. In real terms however, these kind of initiatives have only served to sensitise the public.

(6) Interested Parties/Groups and Institutions

The Community Waste Management Project (CWMP) is of the prime interest to NCC, particularly because it targets the poor people living in conditions where there is no easy access for waste collection. Other sources of interest for the project have been shown by the local community leaders i.e., the chief and the District Officer in slum areas. Of special reference is the tremendous importance the project is given by the beneficiary local community groups and slum residents themselves.

Among the international organisations and sponsors, HABITAT is a United Nations (UN) body concerned with the improvement of the status of human settlements and gives special interest to uplifting housing standards. UNEP is primarily concerned with the improvement of environmental conditions despite the fact that it does not work directly with local communities.

A number of non-government organisations (NGOs) have launched small scale projects to teach local communities how to recycle and reuse waste materials such as paper and organics. Some private recycling companies are also involved in the purchasing of waste materials from individual collectors or retailers.

(7) Problem Statement

Three main types of solid waste are commonly produced in the project target areas (SPEK, 1997). They include food remains, plastic materials, human waste and wastepaper. They are disposed haphazardly on pathways, and on any empty space. With visible heaps of uncollected garbage, most of the wastes find their way into the nearby river where they are transported further downstream.

In the nine (9) selected project sites in Phase I, domestic waste is a major nuisance although there is a significant input of industrial waste emanating from the nearby factories which, if not removed, ends up in the river.

The main problem lies in safe collection and disposal, a fact well appreciated by the slum residents. The easy option for many is to get the waste out of their doorsteps without caring what happens next. It is a daily phenomena therefore to see a lot of waste littered practically everywhere on passageways, backyards, drainage channels, roadsides and in the river. This kind of behaviour is brought about by a combination of factors, and among them are:

(a) the acute shortage of labour and equipment;
(b) the lack of recognised central disposal sites;
(c) the poor organisation of the community to deal with waste management;
(d) the negative attitudes of the local residents; and
(e) the lack of adequate external assistance.

These conditions have aggravated the environment resulting in the following social impacts:

Health: Poor health is prevalent among both adults and children. Reports show that together with other factors, health cannot be improved without a thorough waste management programme. For instance, it is known that decomposing organic waste is a haven for pathogens to multiply with ease thus inflicting the people with diseases such as bilharzia, typhoid and dysentery.

Environment: Accumulation of organic and inorganic waste is harmful to the environment due to:

(a) loss of aesthetic value of the surroundings;
(b) bad odour - air pollution, pollution of rivers; and
(c) contamination of piped water supply through leakage.

Economy: Research shows that people living in a badly degraded environment have a lower level of economic output because of frequent attack by contagious diseases which keep them at home.

If this situation remains as it is, it is certain that the future of the people in the slums will continue to worsen. Diminished investments in social infrastructure coupled with the unabated growth of informal settlements are some of the key features which call for the exerted input of NGOs whose record of community mobilisation is widely acknowledged.

6.5.4 Project Impacts

The CWMP expects to produce five important results, as follows:

(1) Effectively managed waste management groups;

(2) Acquisition of relevant skills needed to collect and reduce the amount of waste before final disposal;

(3) Educated communities;

(4) Co-operation between community groups, NCC and other interested institutions; and

(5) Provision of equipment and materials.

6.5.5 Specific Objectives, Activities and Required Inputs

These results will be realised through main activities with the required inputs given in the following table.

Table 6.5-3 Specific Objectives, Activities and Inputs of the CWMP

Specific Objectives	Activities	Required Inputs
Cleaner Environment	• Organisation of waste management community (WMC) groups	• Personnel • Implements for collection / transportation work
	• Establish central disposal or collection area	• NCC cooperation • Labour
	• Reuse of waste	• Labour
	• Public education and awareness	• Materials • Personnel
Effectively managed WMC group	• Leadership training	• Personnel
	• Community participation	•
Co-operation enhancement	• Joint activities/cooperation agreements	• Personnel

6.5.6 Project Cost Estimate and Schedule

The project cost and schedule in the First Implementation Stage are as presented in **Table 6.5-4** below. The project in the First Implementation Stage will start from the year 1999 and end up in 2003.

Table 6.5-4 Project Cost and Schedule for the Community Waste Management Project

Items	Year				
	1999	2000	2001	2002	2003
1st Term*1	▬				
Cleaner Environment	♦ ♦ ♦				
Effectively Managed WMC group	♦ ♦ ♦				
Cooperation enhancement	♦ ♦ ♦				
2nd Term*2		▬			
Cleaner Environment		♦ ♦ ♦			
Effectively Managed WMC group		♦ ♦ ♦			
Cooperation enhancement		♦ ♦ ♦			
3rd Term*3			▬		
Cleaner Environment			♦ ♦ ♦		
Effectively Managed WMC group			♦ ♦ ♦		
Cooperation enhancement			♦ ♦ ♦		
Project Review				▬	
4th Term				▬	
5th Term					▬
Project Cost (1000 Kshs.)					
Total	2,400	2,400	2,400	2,400	2,400

*1 1st Term covers Fuata Nyayo, Mariguini and Kuwinda.
*2 2nd Term covers Lunga Lunga, Soweto and Kwa Reubeni.
*3 3rd Term covers Kibera, Riruta and Mitumba.

6.6 Summary of Project Cost and Schedule

The cost including operation/maintenance cost and depreciation, and the schedule of the above four (4) component projects mentioned before are as summarised below.

The total initial cost and engineering cost is Kshs. 1,984,200,000 (US$33,750,000), and the operation and maintenance (O&M) cost and depreciation amounts to Kshs. 2,219,200,000. The total project cost is Kshs. 4,203,400,000.

If the construction of transfer station is delayed to the next implementation stage, the total initial cost and engineering cost will amount to Kshs. 1,039,200 (US$17,674,000). The O&M cost and depreciation will be reduced to Kshs. 2,003,200,000, and the total project cost will be Kshs. 3,042,400,000.

Table 6.6-1 Project Cost and Schedule for the Improvement of Collection and Transportation System (1999-2003)

Year	1999	2000	2001	2002	2003
Schedule					
Procurement/Operation of Collection Vehicles					
Planning/Designing					
Bidding/Contracting					
Procurement					
Operation/Maintenance					
Construction of Transfer Station					
Planning/Designing					
Bidding/Contracting					
Construction					
Operation/Maintenance					
Construction of Workshop/Parking Lots					
Planning/Designing					
Bidding/Contracting					
Construction					
Operation/Maintenance					
Community Waste Management Project (CWMP)					
Initial Costs/Engineering Costs					
Collection/Transportation System	44,700	823,500	30,000	40,800	-
Transfer Station	45,000	900,000	-	-	-
Workshop/Parking Lots	4,200	84,000	-	-	-
CWMP	2,400	2,400	2,400	2,400	2,400
Sub-total	96,300	1,809,900	32,400	43,200	2,400
Operation/Maintenance Cost	-	250,200	492,700	489,500	490,200
Depreciation	-	66,800	138,900	142,700	148,200
Total Cost	**96,300**	**2,126,900**	**664,000**	**675,400**	**640,800**

Note: All costs are indicated in 1,000 Kshs.

6.7 Examination of Service Levels

This section examines reduced service level from the proposed 60% of waste collection rate in case that expected assumptions and conditions are not achieved. The reduced collection rate is assumed to be 40% in this study. The only difference between 60% collection and 40% collection is the number of vehicles to be required. The construction of a workshop and parking lots and the Community Waste

Management Project would be carried out in spite of reduction of the collection rate because these projects do not need a large amount of cost.

The required number of vehicles, equipment and manpower in the First Implementation Stage is therefore presented in **Tables 6.7-1 and 6.7-2** below, and the details are described in **Supporting Report Section E.**

Table 6.7-1 Vehicles and Manpower Required for the Improvement of Collection and Transportation System in the First Implementation Stage under the Reduced Level of Services (With the Construction of Transfer Station)

No	Items	Quantity				
		1999	2000	2001	2002	2003
1	Detachable-container truck	21	22	23	23	24
2	Container	477	491	507	523	540
3	Trailer truck	5	6	6	6	6
4	Side loader	10	11	11	11	12
5	Dump truck	5	5	5	5	5
6	Wheel loader	5	5	5	5	5
7	Water sprinkler	1	1	1	1	1
8	Inspection car	22	22	22	22	22
9	Recovery truck	1	1	1	1	1
10	Driver	75	77	78	80	81
11	Loader	106	109	113	116	120
12	Sweeper	319	327	338	349	361
13	Supervisor	48	50	51	53	54
14	Headman	21	22	23	23	24

Table 6.7-2 Vehicles and Manpower Required for the Improvement of Collection and Transportation System in the First Implementation Stage under the Reduced Level of Services (Without the Construction of Transfer Station)

No	Items	Quantity				
		1999	2000	2001	2002	2003
1	Detachable-container truck	25	26	27	28	29
2	Container	477	491	507	523	540
3	Trailer truck	0	0	0	0	0
4	Side loader	13	13	14	14	15
5	Dump truck	6	6	6	6	7
6	Wheel loader	6	6	6	6	7
7	Water sprinkler	1	1	1	1	1
8	Inspection car	22	22	22	22	22
9	Recovery truck	1	1	1	1	1
10	Driver	85	86	88	90	92
11	Loader	132	135	143	146	150
12	Sweeper	396	405	429	438	450
13	Supervisor	58	60	61	63	65
14	Headman	26	27	29	29	30

Project cost including initial investment, engineering, O&M and depreciation is summarised in **Table 6.7-3** below. The total initial cost and engineering cost is

Kshs. 1,506,500,000 (US$25,621,000), and the O&M and depreciation amounts to Kshs. 1,609,400,000. The total project cost is Kshs. 3,115,900,000.

In case that the transfer station is constructed in the second implementation stage, the total initial cost and engineering cost will be reduced to Kshs. 577,400,000 (US$9,820,000). The O&M cost and depreciation will also be reduced to Kshs. 1,360,100,000, and the total project cost will amount to Kshs. 1,937,500,000.

Table 6.7-3 Project Cost for the Improvement of Collection and Transportation System under the Reduced Level of Services (With Transfer Station)

Year	1999	2000	2001	2002	2003
Initial Costs/Engineering Costs					
Collection/Transportation System	22,000	423,300	4,000	12,000	-
Transfer Station	45,000	900,000	-	-	-
Workshop/Parking Lots	4,200	84,000	-	-	-
CWMP	2,400	2,400	2,400	2,400	2,400
Sub-total	73,600	1,409,700	6,400	14,400	2,400
Operation/Maintenance Cost	-	200,100	382,800	367,800	354,300
Depreciation	-	42,700	86,400	86,900	88,400
Total Cost	**73,600**	**1,652,500**	**475,600**	**469,100**	**445,100**

Note: All costs are indicated in 1,000 Kshs.

Table 6.7-4 Project Cost for the Improvement of Collection and Transportation System under the Reduced Level of Services (Without Transfer Station)

Year	1999	2000	2001	2002	2003
Initial Costs/Engineering Costs					
Collection/Transportation System	22,700	434,500	8,000	22,000	-
Workshop/Parking Lots	4,200	84,000	-	-	-
CWMP	2,400	2,400	2,400	2,400	2,400
Sub-total	29,300	510,900	10,400	24,400	2,400
Operation/Maintenance Cost	-	178,700	341,500	326,800	314,400
Depreciation	-	27,000	55,500	56,500	59,700
Total Cost	**29,300**	**716,600**	**407,400**	**407,700**	**376,500**

Note: All costs are indicated in 1,000 Kshs.

CHAPTER 7

FINANCIAL ANALYSIS OF PRIORITY PROJECTS

CHAPTER 7

FINANCIAL ANALYSIS OF PRIORITY PROJECTS

7.1 General

This financial analysis is carried out for the following priority projects of the First Implementation Stage (1998-2003):

(1) Institutional Restructuring and Financial Reform
(2) Promotion of Private Sector Involvement
(3) Construction of Final Disposal Site
(4) Improvement of Collection and Transportation System

7.2 Conditions and Assumptions

Basically, the conditions and assumptions in this financial analysis under the Feasibility Study are the same with those employed in the financial analysis in the Master Plan except:

(1) The new system starts to work in the second half of 2000.

(2) Investment cost for facilities/equipment which will start working in the next implementation stage are excluded in the analysis.

(3) Vehicles and equipment introduced in the Urgent Improvement Plan are continuously used only for the necessary operation in the First Implementation Stage, that is, they are excluded from the initial investment cost but counted in the operation and maintenance (O&M) cost and depreciation. In case that some of the vehicles and equipment are excessive for the operation, such items are assumed to be used for other projects other than SWM services.

7.3 Construction/Investment Schedule of Priority Projects

The construction/investment schedule of priority projects is shown in **Table 7.3-1.**

Table 7.3-1 Construction/Investment Schedule of Priority Projects

Unit: Kshs million

	1998	1999	2000	2001	2002	2003	Total
CBAP	0.0	23.9	23.9	0.0	0.0	0.0	47.8
PSI Contract	0.0	0.0	54.3	147.9	155.7	163.6	521.5
Final Disposal							
Initial Investment	0.0	0.0	786.4	565.0	405.1	0.0	1,756.5
Engineering	0.0	65.3	0.0	0.0	0.0	0.0	65.3
Total	0.0	65.3	786.4	565.0	405.1	0.0	1,821.8
Collection/Transportation							
Initial Investment	0.0	0.0	1,807.5	30.0	40.8	0.0	1,878.3
Engineering	0.0	93.9	0.0	0.0	0.0	0.0	93.9
Sub-Total	0.0	93.9	1,807.5	30.0	40.8	0.0	1,972.2
CWMP	0.0	2.4	2.4	2.4	2.4	2.4	12.0
Total	0.0	96.3	1,809.9	32.4	43.2	2.4	1,984.2
Grand Total*	0.0	185.5	2,620.1	597.4	448.3	2.4	3,853.7

* Grand Total excludes cost of PSI Contract.

7.4 Financing Source of Initial Investment

The financing source of initial investment (including engineering services) is assumed to be grant aid, because a loan is not advisable for the following reasons:

(1) Solid waste management closely affects the daily life activities of people, and the management condition in Nairobi is very serious requiring immediate improvement;

(2) A loan requires the additional financial burden of interest and redemption;

(3) Agreement between the lender and the borrower on the terms and conditions of a loan including interest rate and grace period takes time;

(4) The terms and conditions of the loan may be more severe in future than those presently expected due to future macro economic conditions of Kenya as well as the world economy;

(5) After terms and conditions are agreed, the financial burden may become severe because of the deterioration of currency exchange rates; and

(6) Even after the construction and procurement, the financial situation of NCC may be restrained for a long time.

It is assumed that the grant aid will cover the Capacity Building Assistance Program (CBAP), initial investment cost including engineering cost, and the Community Waste Management Project (CWMP).

The total initial investment from grant aid between 1999 and 2003 is therefore estimated at Kshs. 3,854 million (US$65.5 million).

7.5 Projection Results

7.5.1 Cost Schedule

The systems of the Master Plan are planned to achieve, firstly, 60% waste collection rate in 2000-2003. CBAP and the PSI contract will require Kshs. 48 million and Kshs. 522 million, respectively. The new final disposal site will require Kshs. 96.4 million for O&M, Kshs. 44 million for depreciation, and Kshs. 1,757 million for initial investment including the Dandora closure work. The new collection/transportation system will require Kshs. 1,723 million for O&M, Kshs. 497 million for depreciation, Kshs. 1,878 million for initial investment and Kshs. 12 million for CWMP.

On the other hand, to cover O&M cost, depreciation and the PSI contract, the average household charge should be 211 Kshs/month for all year average. In addition, 437 Kshs/month is necessary for commercial entities and 89 Kshs/ton for tipping in the period.

Details of the projection results and the average waste charges are shown in **Table 7.5-1** and **Table 7.5-2**, respectively.

Table 7.5-1 Cost Schedule

Unit: Kshs million

	1998	1999	2000	2001	2002	2003	Total
CBAP	0.0	23.9	23.9	0.0	0.0	0.0	47.8
PSI Contract	0.0	0.0	54.3	147.9	155.7	163.6	521.5
Final Disposal							
O&M	0.0	0.0	23.7	23.0	24.2	25.6	96.4
Depreciation	0.0	0.0	0.0	14.8	14.8	14.8	44.4
Initial Investment	0.0	0.0	786.4	565.0	405.1	0.0	1,756.5
Engineering	0.0	65.3	0.0	0.0	0.0	0.0	65.3
Total	0.0	65.3	810.0	602.8	444.1	40.4	1,962.6
Collection/Transportation							
O&M	0.0	0.0	250.2	492.7	489.5	490.2	1,722.6
Depreciation	0.0	0.0	66.8	138.9	142.7	148.2	496.5
Initial Investment	0.0	0.0	1,807.5	30.0	40.8	0.0	1,878.3
Engineering	0.0	93.9	0.0	0.0	0.0	0.0	93.9
Sub-Total	0.0	93.9	2,124.5	661.6	672.9	638.3	4,191.3
CWMP	0.0	2.4	2.4	2.4	2.4	2.4	12.0
Total	0.0	96.3	2,126.9	664.0	675.3	640.7	4,203.3
Grand Total	**0.0**	**185.5**	**3,015.1**	**1,414.7**	**1,275.2**	**844.7**	**6,735.1**

Table 7.5-2 Average Charges

	2000	2001	2002	2003	All Year Average
Household (Kshs/month)	196	221	213	207	211
Commercial (Kshs/month)	426	461	438	418	437
Tipping (Kshs/ton)	103	89	87	85	89

7.5.2 Setting Charge Rates

(1) Households

Household charges are to be differentiated in accordance with the income level or water consumption, as explained in **Chapter 3**. Each charge step is calculated from the results of the average household charge shown in **Table 7.5-2** above. Charge for each step is derived by applying the household income distribution. Results are shown in **Table 7.5-3**.

Table 7.5-3 Household Charge

Unit: Kshs/month

	2000	2001	2002	2003	All Year Average
Charge Step 1	151	170	164	159	162
Charge Step 2	196	221	213	207	211
Charge Step 3	242	272	262	254	260

If the all year average is employed in 2000 and continued to 2003, the total balance would just finance the O&M cost, depreciation and the PSI contract cost in 2003 or the final year of the First Implementation Stage.

(2) Commercial Establishments and Tipping Fees

As estimated in **Table 7.5-2**, charges to commercial establishments and tipping fees are set at 437 Kshs/month and 89 Kshs/ton, respectively.

7.6 Consideration of Service Level and Initial Investment

In case that the revenue necessary to achieve 60% waste collection ratio is not attained, reduction of service level and the initial investment may be taken into consideration.

Firstly, reduction of service level is considered not only from the viewpoint of revenue but on how the new system can be started without difficulty. Thus, the target level is decided as 40% in 2000-2003, as mentioned in the Master Plan Study.

Secondly, reduction of the initial investment is introduced as follows:

(a) the construction of transfer station is delayed to the Second Implementation Stage and direct transportation system is employed in the First Implementation Stage; and

(b) the sanitary level of landfill system for the new disposal site is reduced to Level 2+.

The Kshs. 48 million for CBAP, Kshs. 522 milliom for PSI contract and Kshs. 12 million for CWMP are not changed. The new final disposal site requires Kshs. 64 million for O&M, Kshs. 33 million for depreciation, and Kshs. 1,383 million for initial investment. The collection/transportation system requires Kshs. 1,161 million for O&M, Kshs. 199 million for depreciation, and Kshs. 539 million for initial investment.

On the other hand, to cover the O&M cost, depreciation and PSI contract cost, average household charge should be 135 Kshs/month, average charge for commercial establishments, 279 Kshs/month and average tipping fee, 88 Kshs/ton for the period. The total investment cost in this case is Kshs. 2,059 million (US$35.0 million).

The construction/investment schedule, total cost schedule and average waste charges are shown **in Table 7.6-1, Table 7.6-2** and **Table 7.6-3**, respectively.

Table 7.6-1 Construction/Investment Schedule (Service Level & Initial Investment Reduction)

Unit: Kshs million

	1998	1999	2000	2001	2002	2003	Total
CBAP	0.0	23.9	23.9	0.0	0.0	0.0	47.8
PSI Contract	0.0	0.0	54.3	147.9	155.7	163.6	521.5
Final Disposal							
Initial Investment	0.0	0.0	491.2	523.0	369.0	0.0	1,383.2
Engineering	0.0	51.0	0.0	0.0	0.0	0.0	51.0
Total	0.0	51.0	491.2	523.0	369.0	0.0	1,434.2
Collection/Transportation							
Initial Investment	0.0	0.0	508.5	8.0	22.0	0.0	538.5
Engineering	0.0	26.9	0.0	0.0	0.0	0.0	26.9
Sub-Total	0.0	26.9	508.5	8.0	22.0	0.0	565.4
CWMP	0.0	2.4	2.4	2.4	2.4	2.4	12.0
Total	0.0	29.3	510.9	10.4	24.4	2.4	577.4
Grand Total*	**0.0**	**104.2**	**1,026.0**	**533.4**	**393.4**	**2.4**	**2,059.4**

* Grand Total excludes cost of PSI Contract.

Table 7.6-2 Cost Schedule (Service Level & Initial Investment Reduction)

Unit: Kshs million

	1998	1999	2000	2001	2002	2003	Total
CBAP	0.0	23.9	23.9	0.0	0.0	0.0	47.8
PSI Contract	0.0	0.0	54.3	147.9	155.7	163.6	521.5
Final Disposal							
O&M	0.0	0.0	10.7	16.8	17.7	18.7	63.8
Depreciation	0.0	0.0	0.0	11.1	11.1	11.1	33.4
Initial Investment	0.0	0.0	491.2	523.0	369.0	0.0	1,383.2
Engineering	0.0	51.0	0.0	0.0	0.0	0.0	51.0
Total	0.0	51.0	501.9	550.9	397.8	29.8	1,531.4
Collection/Transportation							
O&M	0.0	0.0	178.7	341.5	326.8	314.4	1,161.4
Depreciation	0.0	0.0	27.0	55.5	56.5	59.7	198.7
Initial Investment	0.0	0.0	508.5	8.0	22.0	0.0	538.5
Engineering	0.0	26.9	0.0	0.0	0.0	0.0	26.9
Sub-Total	0.0	26.9	714.2	405.0	405.3	374.1	1,925.5
CWMP	0.0	2.4	2.4	2.4	2.4	2.4	12.0
Total	0.0	29.3	716.6	407.4	407.7	376.5	1,937.5
Grand Total	**0.0**	**104.2**	**1,296.7**	**1,106.1**	**961.2**	**569.9**	**4,038.1**

Table 7.6-3 Average Charges (Service Level & Initial Investment Reduction)

	2000	2001	2002	2003	All Year Average
Household (Kshs/month)	118	146	137	130	135
Commercial (Kshs/month)	128	305	282	263	279
Tipping (Kshs/ton)	31	94	92	90	88

7.7 Financial Statements

7.7.1 Assumptions/Definitions

In the financial projection, charge revenues, O&M cost, depreciation and initial investment are estimated. The projected financial statements only estimate simply cash account, initial investment account, charges account, grant aid account, O&M account and depreciation account. In addition, current assets include cash balance and non-current assets include initial investment balance in the balance sheet.

The following additional assumptions/conditions are made for the calculation:

(1) Calculation starts in 1998 without equity.

(2) CBAP and CWMP are assumed as initial investment. They are counted in the non-current asset account and are 100% amortised in the next year.

(3) Initial investment is financed by grant aid.

(4) PSI contract cost is assumed as operating cost in the collection/transportation system.

(5) Vehicles and equipment introduced in the Urgent Program and used in the new system are excluded from the investment account.

(6) Depreciated assets include vehicles/equipment and other works of the transfer station in accordance with the financial projection.

(7) Charges are set at 211 Kshs/month for households, 437 Kshs/month for commercial establishments and 89 Kshs/ton for tipping fees.

7.7.2 Calculation Results

Cash flow table, profit/loss statement and balance sheet are drafted based on the financial projection of the priority projects. (See **Tables 7.7-1 to 7.7-3.**)

Table 7.7-1 Cash Flow Table

Unit: Kshs million

	1998	1999	2000	2001	2002	2003
a. Sources						
Profit Post-Dep.	0.0	0.0	-5.1	-56.5	-8.4	12.6
Depreciation	0.0	0.0	93.1	180.0	159.9	165.4
Grant Aid	0.0	185.5	2,620.1	597.4	448.3	2.4
Sources Total	0.0	185.5	2,708.1	720.9	599.8	180.4
b. Uses						
1. Initial Investment						
Collection/Transportation	0.0	93.9	1,807.5	30.0	40.8	0.0
Disposal Site	0.0	65.3	786.4	565.0	405.1	0.0
CBAP	0.0	23.9	23.9	0.0	0.0	0.0
CWMP	0.0	2.4	2.4	2.4	2.4	2.4
Initial Investment Total	0.0	185.5	2,620.1	597.4	448.3	2.4
2. Replacement	0.0	0.0	0.0	0.0	0.0	0.0
3. Salvage Value	0.0	0.0	0.0	0.0	0.0	0.0
Uses Total	0.0	185.5	2,620.1	597.4	448.3	2.4
c. Net Cash Flow (a-b)	0.0	0.0	88.0	123.5	151.5	178.0
d. Accumulated Net Cash Flow	0.0	0.0	88.0	211.5	363.0	540.9

Note: Totals are not necessarily the same as sums of items due to rounding.

Table 7.7-2 Profit/Loss Statement

Unit: Kshs million

	1998	1999	2000	2001	2002	2003
a. Revenue						
Charges			416.1	787.1	820.9	857.3
Grant Aid		185.5	2,620.1	597.4	448.3	2.4
Revenue Total	0.0	185.5	3,036.3	1,384.5	1,269.2	859.7
b. Expense						
O&M			328.2	663.6	669.4	679.4
Depreciation			93.1	180.0	159.9	165.4
Expense Total	0.0	0.0	421.2	843.6	829.3	844.7
c. Net Profit (a-b)	0.0	185.5	2,615.0	540.9	439.9	15.0

Note: Totals are not necessarily the same as sums of items due to rounding.

Table 7.7-3 Balance Sheet

Unit: Kshs million

	1998	1999	2000	2001	2002	2003
a. Assets						
Current Assets			88.0	211.5	363.0	540.9
Non-Current Assets		185.5	2,712.6	3,130.0	3,418.3	3,255.4
Assets Total	0.0	185.5	2,800.5	3,341.4	3,781.3	3,796.3
b. Liabilities/Equity						
Liabilities		0.0	0.0	0.0	0.0	0.0
Equity		185.5	2,800.5	3,341.4	3,781.3	3,796.3
Liabilities/Equity Total	0.0	185.5	2,800.5	3,341.4	3,781.3	3,796.3

Note: Totals are not necessarily the same as sums of items due to rounding.

CHAPTER 8

ENVIRONMENTAL IMPACT ASSESSMENT

CHAPTER 8

ENVIRONMENTAL IMPACT ASSESSMENT

8.1 Introduction

8.1.1 Objectives of Environmental Impact Assessment (EIA)

An environmental impact assessment is required as a part of the feasibility study to delineate the characteristics of the project and to forecast potential impacts on the natural and social environments resulting from project implementation. The EIA will propose a suitable approach to identify significant impacts and impact sources, and proper measures are suggested to mitigate the adverse effects of the project.

8.1.2 Project Selected for EIA

One of the priority projects selected in the Master Plan is the construction of a new landfill site as a part of the solid waste management improvement program of Nairobi City. For this project, Initial Environmental Examination (IEE) was conducted on candidate sites and then a detailed EIA was executed on the two candidate sites (Ngong Forest Area and Ruai Area) chosen for the proposed project by the Kenyan authorities.

8.1.3 Procedure of EIA

The EIA on the two candidate sites was carried out by a local consultant under the supervision of the JICA Study Team based on the Terms of Reference. The technical specification of the Terms of Reference for EIA was prepared in accordance with the findings of the Initial Environmental Examination (IEE), while the administrative procedure was prepared taking the following guidelines into account:

(1) JICA Environmental Guidelines for Infrastructure Projects, VI Solid Waste Management, 1992.

(2) Guidelines of OECF, Waste Disposal Sector, 1996.

(3) Environmental Assessment Source Book, Sectoral Guidelines, World Bank.

(4) Guidelines for EIA in the Republic of Kenya, Draft Report, 1996.

The assessment of impacts was made, taking into account the existing regulations related to the environment in Kenya and international standards.

8.2 Execution of EIA

8.2.1 General

The environmental impact study was started on November 13, 1997 by Billtech Environmental Consultants Ltd., the selected local consulting firm, under the supervision of the JICA Study Team. The study was conducted to become aware of

the present condition of each candidate area, and it consisted of the analysis of the natural environment and the social environmental aspects.

Based on the study on current conditions, further study was carried out to forecast potential impacts and impact sources during construction, operation, closure and post-closure stages of the landfill site. Mitigation or preventive measures were proposed for each stage of the Project when negative impacts were predicted to appear. Finally, the environmental management plan and monitoring plan were prepared to implement and evaluate the efficiency of the mitigation measures.

8.2.2 Project Description

The proposed project is the construction of a new landfill site which will receive the urban domestic waste produced in Nairobi City. The new landfill site will consist mainly of the following components:

(1) Fence
(2) Building
(3) Truck scale
(4) Roads
(5) Ramps
(6) Drainage
(7) Gas and leachate treatment system
(8) Wells for ground water monitoring
(9) Structures for solid waste retention

8.2.3 Construction of Final Disposal Site at Ngong Road Forest Area

(1) Brief Description of the Site

The place is located on a flat land at about 10 km west of Nairobi City. The area available for the disposal site is approximately 33.2 ha and is composed of grassland (about 7 ha), indigenous forest (about 0.8 ha) and Eucalyptus plantation (about 25.4 ha). The area is unfenced and is owned by the central government.

(2) Predictable Negative Impacts, Assessment and Mitigation Measures

(a) Natural Environment

The most affected by project implementation is the flora and fauna of the site. The following negative impacts were identified:

(i) The major impacts during construction of the disposal site will be the destruction of approximately 0.8 ha of indigenous forest, 25.4 ha of Eucalyptus plantations and 7.0 ha of grassland. Besides, the physical removal of a section of the indigenous forest measuring approximately 0.5 km and 12 m for the access road construction is considered of high impact. This section contains about of 4,600 indigenous trees and shrubs in various ages and heights. These impacts are assessed as impact with high

significance and the mitigation measures include the plantation of 1.4 ha of mixed indigenous species with emplasis on the protected species; i.e., *Brachylaena huillensis* and *Warburgia ugandesis*.

(ii) Destruction of grassland and ecotone which have a total of 61 species of which 32 only occur there. These will be destroyed, and since there are no other glades and ecotones in the Ngong system they will be completely lost. Also animals and birds dependent on them will be disturbed. The impact is of high significance and can be mitigated with the plantation of a belt of mixed indigenous species around the candidate site reflective of the ecotone of approximately 15 ha.

(iii) The Bee-keeping Division of the Ministry of Agriculture, Livestock and Marketing is located in the Forest. The bee-keeping activities which are dependent on the flowering of the plants in the forest and the surrounding settled areas will be adversely affected. This impact is also of high significance and it can be mitigated by means of maintaining the diversity of plants in the indigenous forest.

(iv) Potential fire risks and squatting in the gazetted forest which are considered as high impact during operation of the project. The mitigation measures include intensified patrols of the forest and the prohibition of scavenging activities inside and outside of the landfill.

(v) Poaching of trees and tree parts for medicinal purposes and other uses will have a high impact on protected and over-exploited species. This will lower the biodiversity on both the indigenous forest and plantations. Fencing off the indigenous and riverine communities, inspection of vehicles entering and leaving the site, intensified patrols of the forest, expansion of the nursery to produce more seedlings and of a wider variety, plantation of a fuel wood buffer zone along the perimeter of the indigenous forest to cater for local requirements for wood and medicinal uses and the increase of areas with plantations of indigenous species are proposed mitigation measures. Regarding the plantation of indigenous species, the trees require over 50 years to mature; thus, a high rate of poaching cannot be solved in this way.

As for groundwater pollution, low impact is predicted on the existing wells (W1 and W2) allocated in adjacent areas considering the geological properties of the soils of the site. The implementation of a leachate collection and treatment system will mitigate this impact.

The generation of offensive odour and harmful insects are predictable impacts of high significance at the site especially when the disposal site is not well operated. These impacts shall be mitigated by daily soil covering of the disposed garbage, the installation of a gas control system and a regular medical checkup for workers.

Water pollution of Mutoine River which is used for irrigation of forest tree nurseries, watering livestock and alternative source of domestic water supply to the surrounding areas poor communities during drought is assessed as negative impact during the construction, operation, closure and post closure stages. A high significance of the impact is assessed taking into account the current water quality condition. The adverse impact shall be controllable with the proper management of construction, provision of drains with sediment traps, provision of water supply system for the surrounding communities as well as the proper operation of the proposed leachate collection/treatment.

As regard smoke, low impact is predicted when sanitary landfill method is implemented in which daily soil covering of the disposed garbage is practiced and the installation of gas control system is provided. However, dust and exhaust fumes from vehicles and equipment are predicted impacts of moderate significance on the workers at the site and the community. Exhaust fumes from vehicles shall be controlled with the proper maintenance of trucks and equipment. For the dust control, a control on the number or speed of vehicles/equipment shall be implemented and watering may be required for access road and operational places during the construction, operation and closure stages, especially in the dry season. During operation a medical checkup program shall be established. During the construction, operation and closure stages it is also important to cover soil materials transported to the disposal site.

Soil pollution is considered to be of low significance, due to the nature of solid waste to be disposed of at the landfill site. The pollution shall be minimised by the prohibition of dumping of toxic waste to the disposal site.

Noise generation is expected during construction, operation and closure stages of the project. During operation, assuming that only 45 % of the vehicles will be deployed to the Ngong site, the resulting increase in noise on the Ngong road and access road will not have a significant influence on the current noise levels and no community complaints are expected. On the other hand, during construction of the landfill, impact of moderate significance is likely to affect the workers. In order to mitigate these impacts, a control on the number or speed of vehicles/ equipment shall be implemented and the work schedule should be informed to the public and operation of heavy equipment limited to the day time only. Also, adequate maintenance of equipment and trucks which must have exhaust mufflers shall be implemented and the occupational exposures to noise should be kept to below 90 dB(A) during construction of roads and landfill.

Gas migration has low impact due to absence of buildings in the surrounding area and this condition should be kept to minimise this impact.

Due to the location of the disposal site, visual changes on the landscape may not be noted by residents living around the place.

Regarding land use, the long term plan as stipulated in the Kenya Forestry Master Plan, 1994, which has been adopted by the Government is to introduce ecotourism in the Ngong Road Forest and to enhance the use of the forest for forestry research and education. Therefore, construction and operation of a sanitary landfill on the site will adversely affect the current and planned uses of the Ngong Road Forest. For this impact, no mitigation measures can be proposed.

On the other hand the petroleum pipeline passing through the landfill site at Ngong Road Forest Site is likely to be affected by the project. Mitigation measures include the proper management of construction and operation of the landfill.

(b) Social Environment

(i) Negative Impacts

Migration of scavengers to the new disposal site is highly predictable and the destruction of the forest by them is also highly predictable because they will build their houses inside the forest and, probably, they will cut the trees for selling as a secondary activity to the recycling. For these reasons no scavengers should be permitted at the site but this decision is not practicable in Nairobi City unless NCC or the Government can accommodate these people to work in other businesses.

As the current level of the traffic on Ngong Road is about 2.5 times of the road capacity design, it is sensible for any increasing in the number of vehicles, therefore, impact of high significance is predicted on this road. To ensure smooth flow of the traffic on this road it should be upgraded to a dual carriage way.

On the other hand, a new access road of Class C should be constructed to take the heavy trucks from Ngong Road to the site.

(ii) Positive Impacts

The positive impacts may be as follows:

- The project will improve the health condition in the city.
- The project will create several jobs directly in various aspects of construction, transportation and operation of the SWM system.

Predictable negative impacts, assessment and mitigation measures for Ngong Forest Area are summarised in the **Table 8.2-1** below.

Table 8.2-1 Predictable Negative Impacts, Assessment and Mitigation Measures for Ngong Area

Predictable Impacts	Impact Stage	Significance	Mitigation Measures
Flora & Fauna	C	High	• Plantation of 1.4 ha of indigenous species • Expansion of the nursery to produce more tree seedlings • Plantation of 15 ha of mixed indigenous species around the candidate site
	O	High	• Plantation of a fuelwood buffering zone • Inspection of vehicles and patrols of the forest • Expansion of the nursery • Increase of areas with plantation of indigenous forest of various species to maintain the diversity of plants. However a high rate poaching can not be solved in this way. • Fencing off the indigenous and riverine communities • Activities of scavengers should be eliminated. However, this measure is not practicable in Nairobi City
	CL	Moderate	• Inspection of vehicles and patrols of the forest
Groundwater	O, PCL	Low	• Collection and Leachate treatment
Offensive odour	O	High	• Daily soil covering of the disposed garbage • Implement medical check-up program • Installation of a gas control system
Harmful insect generation	O	High	• Daily soil covering of the disposed garbage • Implement medical check-up program
Water Pollution of Mutoine River	C, CL	Moderate	• Provision of drains with sediment traps • Proper management of the construction
	O	High	• Maintain a ring-drain outside the landfill site enclosing dike • Provision of leachate treatment facilities • Water supply system for the surrounding communities
	PCL	High	• Maintain the ring-drain in operation after the closure stage • Continue using the leachate treatment facilities for long time depending on the production/quality of the leachate
Smoke from garbage	O	Low	• Daily soil covering of the disposed garbage, install gas control system
Dust, exhaust fumes from vehicles and equipment	C, O, CL	Moderate	• Control on the number or speed of vehicles/ equipment • Watering of access road and operational places. Soil materials should be covered with sheet • Proper maintenance of vehicle
Soil pollution	O, PCL	Low	• The landfill site should receive solid domestic waste only
Noise	C, O, CL	Low	• Trucks shall use exhaust mufflers to maintain the current noise levels • Work schedule should be informed to the public and operation of heavy equipment should be limited to the day time only • Control of number or speed of vehicles/ equipment • Adequate maintenance of equipment and trucks which must have exhaust mufflers
Gas Migration	O, PCL	Low	• Land use regulation should be enforced for surrounding area avoiding building construction
Traffic	C, O, CL	High (Access road)	• Construction of access road of Class C
		High (Main road)	• The road should be upgraded to dual carriage way
Landscape	C	Low	• The project should be implemented in an aesthetic development scene with landscape harmonisation
Interference with petroleum pipeline	C,O,CL,PCL	High	• Proper management of the construction and operation of the landfill site
Interference with Kenya Forestry Master Plan	C,O,CL,PCL	High	• No mitigation measures can be proposed
Scavengers	O	High	• NCC or the Government should provide alternative sources of jobs

Legend: C: Construction Phase; O: Operation Phase; CL: Closure Phase; PCL: Post-closure Phase

(c) Conclusion

In consideration of the result of the EIA, the JICA Study Team had considered that the construction of the disposal site in the Ngong Road Forest Area is not suitable because it is not compatible with the Kenya Forestry Master Plan which will introduce ecotourism in the area and will use the forest for forestry research and education.

The current level of traffic of Ngong Road is about 2.5 times of the road design capacity and this condition make it sensible for any increasing in the number of vehicles and to take the extra volume of vehicles of the project upgrading of the road become necessary which is beyond of the scope of this project.

On the other hand, scavengers are likely to move to the new landfill site after closing of the existing one at Dandora. This fact will contribute to the total destruction of the forest around the candidate site.

8.2.4 Construction of Final Disposal Site at the Ruai Area

Since the Ngong Road Forest Candidate Site is not suitable for the construction of landfill site, it is assumed that all the garbage of Nairobi City shall be taken to the Ruai Candidate Site using a transfer station whose location is still to be decided by the Kenyan authorities concerned. Based on this assumption, the study on predictable impacts as well as the identification of mitigation measures and assessment was conducted and the results are finally reflected in the environmental management and environmental monitoring plans.

(1) Brief Description of the Site

The site is located on the flat land adjacent to the Nairobi River at about 30 km east of Nairobi City. The area available for the disposal site is composed mainly of grassland of about 20 ha, next to the actual Dandora Estate Sewage Treatment Works. The area is owned by NCC and its main entrance is fenced.

(2) Predictable Negative Impacts, Assessment and Mitigation Measures

(a) Natural Environment

No impact is predicted on existing wells in the area and low impacts are predicted on the groundwater quality of adjacent areas especially downstream of the candidate site considering the geological properties of the soils of the site. The implementation of leachate collection and treatment system will be applied as a mitigation measure.

A poor operation of the disposal site can adversely impact the environment such as the breeding of harmful insects and the generation of offensive odour which could affect the health of workers and the neighborhood of the landfill site. These impacts considered to be of high significance shall be minimised by means of daily soil covering of the

disposed garbage, the installation of a gas control system and a regular medical checkup for workers.

The survey on water quality of Nairobi River was conducted during a heavy rainfall period associated with El Niño phenomena and, therefore, the pollutant concentrations had been significantly diluted. Water pollution of Nairobi River is assessed as negative impact although it is determined to be low in significance during the operation stage, because according to secondary data the water quality is already too degraded. The adverse impact shall be controllable with a proper management of the construction and the provision of drains with sediments traps as well as the proper operation of the proposed leachate collection/treatment.

As regard smoke, dust, exhaust fumes, soil pollution, gas migration and landscape, these are impacts of similar significance when compared to the Ngong site; therefore, the same conditions of mitigation measures are applicable.

Noise will be generated in the construction, operational and closure stages of the disposal site. On the main road the current levels are already above the recommended 55 dB(A) by WHO for communities exposures and the additional number of vehicles will generate an impact of low significance; however, proper measure should be taken to avoid any inconvenience to the residents. Public consensus is absolutely necessary about the project prior to the construction, and for the noise control, work schedule should be prepared in such a way that the operation of heavy equipment is limited to the daytime only. On the other hand for the workers involved in the construction and operation the impact will be of moderate significance due to the high noise levels emitted by the equipment. In this last regard, the level of 90 dB(A)-8 hr should not be exceeded in the working place.

(b) Social Environment

(i) Negative Impacts

Migration of scavengers to the new disposal site is highly predictable. If NCC decides to allow them to work into the facility, the provision of specific working rules should be enacted to control their activities without disturbing the smooth operation of the site.

During the construction, operation and closure phases of the landfill site, traffic congestion should be avoided. Mitigation measures for Kangundo road include the proper maintenance of the road, adequate routing and collection hours as well as the selection of the nearest source for necessary materials. During the operation phase, impact of high significance is predicted on the existing access road and to mitigate this impact upgrading of the

access road to Class C is recommended to meet the additional number of collection vehicles.

(ii) Positive Impacts

The following are the positive impacts:

- The project will improve the health condition in the city.
- The project will create several jobs directly in various aspects of construction, transportation and operation of the SWM system.

Predictable negative impacts, assessment and mitigation measures for Ruai Area are summarised in **Table 8.2-2** below.

Table 8.2-2 Predictable Negative Impacts, Assessment and Mitigation Measures for Ruai Area

Predictable Impacts	Impact Stage	Significance	Mitigation Measures
Groundwater	O, PCL	Low	• Collection and leachate treatment
Offensive Odour	O	High	• Daily soil covering of disposed garbage • Implementation of medical checkup program • Installation of gas control system
Harmful Insects Generation	O	High	• Daily soil covering of disposed garbage • Implementation of medical checkup program
Water Pollution of Nairobi River	C, CL	Low	• Provision of drains with sediment traps • Proper management of the construction
	O	Low	• Maintainance of ring-drain outside the landfill site enclosing dike • Provision of leachate treatment facilities
	PCL	Low	• Maintainance of ring-drain operation after closure stage • Continued use of leachate treatment facilities for a long time depending on production/quality of leachate
Smoke from Garbage	O	Low	• Daily soil covering of disposed garbage • Installation of gas control system
Dust, Exhaust Fumes from Vehicles and Equipment	C, O, CL	Moderate	• Watering of access road and operational places. Soil materials should be covered with sheet • Proper maintenance of vehicles • Control on the number or speed of vehicles/equipment
Soil Pollution	O, PCL	Low	• Landfill site should receive solid domestic waste only
Noise	C, O, CL	Low	• Public Information on work schedule • Limitation of operation of heavy equipment to daytime only • Adequate maintenance of equipment and trucks which must have exhaust mufflers
Gas Migration	O, PCL	Low	• Land use regulation to surrounding area, avoiding building construction
Traffic	C, CL	Low	• Adequate working hours to minimise traffic congestion • Selection of nearest source for necessary materials
	O	High (in access road)	• Upgrading of access road to Class C to accept the additional number of vehicles
		Low (Kangundo road)	• Adequate routing and collection hours to minimise traffic congestion • Selection of the nearest source for necessary materials • Proper maintenance of the road
Landscape	C	Low	• Project implementation in an aesthetic development scene with landscape harmonisation
Scavengers	O	High	• Enactment of specific working rules for scavengers if allowed to work in the landfill site

Legend: C: Construction Phase; O : Operation Phase; CL: Closure Phase; PCL: Post-Closure Phase

8.2.5 Environmental Management Plan for the Ruai Area

Predictable impacts and mitigation measures must be considered in the preparation of the environmental management plan. Management items are specified in each phase of project implementation, describing impact sources, measuring standard, management approach and management location. The post construction phase is composed of operation, closure and post-closure stages. The environmental management plan is shown in **Table 8.2-3**.

Table 8.2-3 Environmental Management Plan for the Establishment of Landfill Site at Ruai Area

Management Item	Source of Impact	Measuring Standard of Impact	Management Approach	Management Location
Construction Phase				
Water pollution of Nairobi River	• All civil works of project	• No surface runoff and soil erosion from the landfill	• Avoid spill soil into river • Provide ring drain around landfill	• Construction site
Dust, Exhaust fumes from equipment	• Mobilisation of equipment and vehicles • Civil works	• People's complaints	• Cover soil materials with sheet • Road watering • Proper maintenance of vehicles and equipment • Control of number or speed of vehicles/ equipment	• Construction site • Access road
Noise	• Operation of heavy equipment and vehicles	• WHO's Noise Standard	• Working hour of heavy equipment limited to daytime only • Control of number or speed of vehicles/ equipment • Proper maintenance of vehicles and equipment which must have exhaust mufflers	• Access & main road • Construction site
Traffic	• Mobilisation of vehicles and equipment	• Traffic congestion frequency/ duration	• Effort to avoid traffic jam by selection of nearest source for necessary materials • Adjustment of working time	• Construction site • Access & main road
Landscape	• All civil works of project	• People's perception	• Design of landfill should integrate aesthetic development of area	• Construction site
Post Construction Phase				
Groundwater Pollution	• Leachate	• NCC's criteria and WHO's guidelines for drinking water	• Control of leachate treatment system	• Landfill site
Offensive Odour	• Decomposition of garbage at landfill site	• Public complaint and reaction	• Daily covering of garbage • Installation of gas control system • Implementation of medical checkup program	• Landfill site
Harmful Insects	• Uncovered garbage	• Public complaint and reaction	• Daily covering of the garbage • Implementation of medical checkup program	• Landfill site
Water pollution of Nairobi River	• Leachate	• Japanese Standard for discharge into Public Water Courses	• Control of leachate treatment plant • Proper maintenance of drains around the landfill	• Landfill site

Table 8.2-3 Environmental Management Plan for the Establishment of Landfill Site at Ruai Area (Cont'd.)

Management Item	Source of Impact	Measuring Standard of Impact	Management Approach	Management Location
Smoke from garbage	• Burning of garbage at landfill site	• Public complaint and reaction	• Daily covering of garbage • Installation of gas control system	• Landfill site
Dust, Exhaust fumes from vehicles	• Mobilisation of equipment and vehicles	• Public complaint and reaction	• Cover soil materials with sheet • Road watering • Proper maintenance of vehicles and equipment • Implementation of medical checkup program	• Access & internal roads • Landfill site
Soil Pollution	• Toxic elements in the landfill site	• No toxic waste entering the site	• Control of type of waste introduced at landfill site	• Main gate
Noise	• Operation of heavy equipment and vehicles	• WHO's Noise Standard	• Working hour of heavy equipment limited to daytime only • Proper maintenance of equipment/vehicles which must have exhaust mufflers	• Access & main roads • Landfill site
Gas Migration	• Gas generated at landfill site	• Field inspection	• Land use limitation in the surrounding area • Installation of gas control system	• Area surrounding landfill site • Landfill site
Traffic	• Mobilisation of equipment/ vehicles	• Traffic congestion frequency/ duration	• Selection of adequate routing and time for waste transportation • Selection of nearest source for necessary materials • Build access road to main road specification (Class C) • Proper maintenance of road	• Landfill site • Access & main road
Scavengers	• Recycling activities	• Interference with the smooth operation of the landfill	• Provision of rules to control scavengers	• Landfill site

8.2.6 Environmental Monitoring Plan for the Ruai Area

Items that should be monitored during the construction and post-construction phases of the landfill site are based on the identification of natural and social environmental impacts. The main objective of the environmental monitoring plan is to evaluate the efficacy of the mitigation measures. NCC should establish a monitoring system at an early stage possible and be engaged in regular site inspection, field measurement and sample analysis. The monitoring location, frequency and duration should be decided taking into account its significance and effectiveness on each monitoring item. The Matrix of the Environmental Monitoring Plan for Ruai Area is shown in **Table 8.2-4** below.

Table 8.2-4 Environmental Monitoring Plan for the Ruai Area

Monitoring Items	Location	Monitoring Method	Frequency	Duration
Groundwater	• Groundwater monitoring well	• Water analysis for physical-chemical properties and bacteriological quality	• 1/year	Operation and post-closure stages
Offensive Odor	• Landfill site • Surrounding residential area	• Public opinion • Medical checkup	• Monthly	Operation stage
Harmful Insects	• Landfill site • Surrounding residential area	• Public opinion • Field inspection • Medical checkup	• Monthly	Operation stage
Water Pollution of Nairobi River	• Upstream and downstream of disposal site for water sampling • Inlet and outlet of leachate treatment plant	• Water analysis for leachate, physical-chemical properties and bacteriological quality	• 1/year	Operation and post-closure stages
Smoke	• Landfill site • Surrounding residential area	• Field inspection • Public opinion	• Everyday • Quarterly	Operation stage
Dust and exhaust fumes	• Landfill site • Surrounding residential area	• Public opinion • Field inspection • Medical checkup	• Quarterly	Construction, Operation and closure stages
Soil Pollution	• Main gate	• Inspection of types of waste	• Everyday	Operation stage
Noise	• Landfill site • Main and access roads	• Field measurement of noise level	• 1/year	Construction, Operation and closure stages
Gas Migration	• Landfill site • Surrounding area	• Field inspection	• 1/year	Operation and post-closure stages
Traffic	• Main and access roads	• Field inspection	• 1/year	Construction, Operation and closure stages
Scavengers	• Landfill site	• Field inspection	• Monthly	Operation stage

8.3 Conclusion

Although mitigation measures are workable to minimise the negative impacts on the environment, it is considered from the EIA that the construction of a final disposal site in the Ngong Road Forest Area is not suitable because it is not compatible with the Kenya Forestry Master Plan which will introduce ecotourism in the area and will use the forest for forestry research and education.

The other constraint is related to the current level of traffic of Ngong Road which is about 2.5 times of the road design capacity and this condition make it sensible for any increasing in the number of vehicles and to take the extra volume of vehicles of the project upgrading of the road become necessary which is beyond of the scope of this project.

On the other hand, scavengers will likely move to the new landfill site after closing of the existing one at Dandora. This fact will contribute to the total destruction of the forest around the candidate site.

Therefore, the final disposal site is recommendable to be constructed in the Ruai Area. The new final disposal site is proposed to be constructed utilising the method of sanitary landfill which could eliminate or decrease the factors influencing public health and the environment.