6.3.2 Case of the Target Collection Ratio of 40-50-60%

(1) Planning Strategy

This option is alternatively proposed that the target collection ratio would be reduced from 60% to 40% in 1998, from 80% to 50% in 2004 and from 100% to 60% in the year of 2008.

(2) Design Basis

All the design basis, such as location of the transfer station, vehicle fleet composition and other necessary materials and facilities would be the same as the previous option. The only difference is the target collection ratio.

(3) Determination of the Basic Conditions

The following describes the basic conditions to determine the required number of the above vehicles.

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

The proportion of waste amount to be collected by direct and indirect transport system is exactly the same as the previous option; that is, between 1998 and 2003 direct transport would be applied since the transfer station will start to operate from the year 2004.

The waste amount collected by direct and indirect transport is estimated as shown in **Table E.6-24.**

Table E.6-24 Proportion of Waste Amount to be Collected by Direct and Indirect Transport (Collection Ratio 40-50-60%)

(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)*
1998	302	302	0	0
1999	311	311	0	0
2000	320	320	0	0
2001	330	330	0	0
2002	341	341	0	0
2003	352	352	0	0
2004	578	298	281	303
2005	601	308	293	315
2006	627	321	306	328
2007	654	334	321	343
2008	956	486	469	491

* The details are shown in *Section 5.5, Data Book (1).*

(b) Number of Collection/Transportation Trips

The number of trips for collection and transportation is also exactly the same as the previous option as follows:

(i) Direct Transport Area

Three (3) trips for container trucks and dump trucks, and two (2) trips for side loaders.

(ii) Indirect Transport Area (collection)

4.5 trips in a day is expected for container trucks and dump trucks. For the side loaders, it would be possibly made on 3.5 trips a day.

(iii) Indirect Transport Area (transportation)

Five (5) trips a day could be made between the transfer station and the final disposal site at Ruai.

(c) Container Capacity and Performance

Collection

Same as **Option B-2**: 2.4 t/each

Transport

Same as **Option B-2**: 7 t/each

(d) Proportion of Waste Amount Collected by Types of Vehicles

The proportion of waste amount to be collected by each type of truck does not depend on the location of final disposal sites so that the distribution is the same as **Option B-2,** as follows:

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

(e) Design Waste Amount to be Collected

Based on the above conditions, design waste amount collected by container trucks and dump trucks for each transport system is calculated as shown in **Tables E.6-25** and **E.6-26.**

Table E.6-25 Waste Amount Designed to be Collected by Direct Transport (Collection Ratio 40-50-60%)

(Unit: ton/day)

Year	Total amount collected by direct (1)	Total amount collected by compactors (2) = (1)×50%	Total amount collected by side loaders (3) = (1)×30%	Total amount collected by dump trucks (4) = (1)×20%
1998	302	151	91	60
1999	311	156	93	62
2000	320	160	96	64
2001	330	165	99	66
2002	341	171	102	68
2003	352	176	106	70
2004	298	149	89	60
2005	308	154	92	62
2006	321	161	96	64
2007	334	167	100	67
2008	486	243	146	97

Table E.6-26 Waste Amount Designed to be Collected by Indirect Transport (Collection Ratio 40-50-60%)

(Unit: ton/day)

Year	Total amount collected by indirect (1)	Total amount collected by compactors (2) = (1)×50%	Total amount collected by side loaders (3) = (1)×30%	Total amount collected by dump trucks (4) = (1)×20%
1998	0	0	0	0
1999	0	0	0	0
2000	0	0	0	0
2001	0	0	0	0
2002	0	0	0	0
2003	0	0	0	0
2004	281	141	84	56
2005	293	146	88	59
2006	306	153	92	61
2007	321	161	96	64
2008	469	234	141	94

(4) Calculation of the Required Quantities of Vehicles and Other Facilities

(a) Containers (collection)

From the preceding **Tables E.6-25** and **E.6-26**, as of 1998 and 2004 it will be necessary to provide the following container quantities.

- Total amount of waste collected by containers (as of 1998) :151 t/day
- Total amount of waste collected by containers (as of 2004) :289 t/day (149 + 140 = 289 t/day)

All the containers have to store the above total amount for a week since the waste collection is planned to be carried out once a week, i.e., 151 t/day in 1998 and 289 t/day in 2004. Thus,

151 × 7 ÷ 2.4 = 440 containers (as of 1998); and

289 × 7 ÷ 2.4 = 842 containers (as of 2004, direct transport; 149 × 7 ÷ 2.4 = 434, and indirect transport; 140 × 7 ÷ 2.4 = 408)

are to be installed. If an availability factor of 95% is assumed, the container number required will be 440 ÷ 0.95 = 463 (as of 1998), and 842 ÷ 0.95 ≅ 887 (as of 2004, direct transport; 458, and indirect transport; 429).

(b) Detachable Container Trucks

On average, it is assumed that the NCC has to pick up the containers once a week to provide a minimum level of services throughout the city. Thus,

463 × 1/7 (collected once a week) = 66.1 (as of 1998)

458 × 1/7 (collected once a week) = 65.4 (as of 2004, direct transport)

429 × 1/7 (collected once a week) = 61.3 (as of 2004, indirect transport)

To transport these on a route of 3 trips a day for the direct transport and 4.5 trips a day for the indirect transport, it will be necessary to have the following on the assumption of an availability factor of 90%.

Direct transport: 66.1 ÷ 3.0 ÷ 0.90 = 25 trucks (as of 1998)
Direct transport: 65.4 ÷ 3.0 ÷ 0.90 = 24 trucks (as of 2004)
Indirect transport: 61.3 ÷ 4.5 ÷ 0.90 = 15 trucks (as of 2004)

The total required number of trucks as is therefore:

25 (as of 1998)
24 + 15 = 39 (as of 2004)

On the other hand, for waste transport from the transfer station to the disposal site 20 m^3 capacity container trucks are adopted from the year of 2004. The waste amount for the secondary transport is estimated by the waste amount carried to the transfer station. The number of trips between the transfer station and the disposal site is five. This design waste amount is thus 303 t/day as of 2004, and the required number of trucks is:

303 ÷ (7 × 5) ÷ 0.90 = 9.6; thus, 10 trucks will be required (availability 90%).

(c) Side Loaders

Side loaders will be working 2 trips a day for direct transport and 3.5 trips a day for indirect to carry 4 tons per trip. For the handling of the

91 tons of waste generated in a day for direct transport as of 1998, and 89 tons per day for direct transport and 84 tons per day for indirect as of 2004, it will be necessary to have:

Direct transport : $91 \div (2 \times 4) \div 0.90 = 13$ loaders (as of 1998)
Direct transport : $89 \div (2 \times 4) \div 0.90 = 12$ loaders (as of 2004)
Indirect transport : $84 \div (3.5 \times 4) \div 0.90 = 7$ loaders (as of 2004)

The above considers an availability factor of 90%. The total required number of trucks as is therefore:

13 (as of 1998)
12 + 7 = 19 (as of 2004)

(d) Dump Trucks (Tippers)

For the handling of the 60 tons of waste generated in a day for direct transport as of 1998, and 60 tons per day for direct transport and 56 tons per day for indirect as of 2004, it will be necessary to have:

Direct Transport: $60 \div (3 \times 4) \div 0.90 = 5.6$; thus, 6 trucks will be required (availability 90%) (as of 1998 and 2004).

Indirect Transport: $56 \div (4.5 \times 4) \div 0.90 = 3.4$; thus, 3 trucks will be required (availability 90%) (as of 2004).

The total required number of trucks is therefore:

6 (as of 1998)
6 + 3 = 9 (as of 2004)

(e) Wheel Loaders

This equipment portion is assumed to be of the same number as the dump trucks because the combination of a truck and a loader will enhance to a great extent the efficiency of carrying the waste. Consequently, the number of wheel loaders is 6 as of 1998 and 9 as of 2004. This number already includes 90% availability.

(f) Water Sprinklers

The same proportion to the number of wheel loaders is assumed to be planned, i.e., in 1998 $6 \div 6 = 1.0$, and in 2004 $9 \div 6 = 1.5$. One water sprinklers are to be procured in both 1998 and 2004.

(g) Inspection Cars

The same number of vehicles as the preceding option is assumed to be planned, i.e., 22 inspection cars are to be prepared.

(h) Recovery Trucks

The same number of vehicles as the preceding option is assumed to be planned, i.e., one recovery truck is to be prepared from 1998 to 2003, and one will be added from 2004.

(i) Parking Lots

A parking space for the collection vehicles is required to be secured in one location for every district, i.e., 6 parking lots are to be prepared.

(5) Calculation of the Required Manpower

Basic conditions to estimate the required personnel for collection and transportation are the same as **Option B-2.**

For the other years, the same procedures above would result in required quantities as given in **Table E.6-27.**

Table E.6-27 Vehicle, Equipment and Manpower Required (Collection Ratio: 40-50-60%)

No	Items	Quantity										
		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	Detachable-container truck	25	25	26	27	28	29	39	41	43	44	65
2	Container	463	477	491	507	523	540	887	923	963	1004	1467
3	Trailer truck	0	0	0	0	0	0	10	10	10	11	16
4	Side loader	13	13	13	14	14	15	19	20	21	22	31
5	Dump truck	6	6	6	6	6	7	9	9	10	10	15
6	Wheel loader	6	6	6	6	6	7	9	9	10	10	15
7	Water sprinkler	1	1	1	1	1	1	1	2	2	2	2
8	Inspection car	22	22	22	22	22	22	22	22	22	22	22
9	Tow truck	1	1	1	1	1	1	2	2	2	2	2
10	Parking lots	6	6	6	6	6	6	6	6	6	6	6
11	Driver	83	85	86	88	90	92	116	119	123	127	173
12	Loader	74	77	79	81	84	87	198	206	215	225	328
13	Sweeper	223	230	237	244	252	260	594	618	645	674	984
14	Supervisor	56	58	60	61	63	65	88	91	95	99	144
15	Headman	15	15	16	16	17	17	40	41	43	45	66

6.3.3 Vehicle and Equipment Allocation

(1) Case of the Target Collection Ratio of 60-80-100%

Vehicles and equipment are allocated in accordance with the waste amount to be collected from each district. **Tables 6-2-28 and 6.2-29** show the number of vehicles and equipment required for each district with and without the transfer station from 1998 to 2008, respectively.

The proportion of waste amount to be collected from each district varies year by year because of different population growth rates by district, as presented later in **Table 6.2-36.**

Table 6.2-28 Number of Vehicles and Equipment Required for Each District (Collection Ratio: 60-80-100% - With Transfer Station)

Vehicles/Equipment Required	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Embakasi District											
Contrainer Truck	14	15	16	18	18	18	30	31	34	36	53
Side Loader	7	8	8	9	9	9	14	16	17	19	24
Tipper	3	4	4	4	4	5	7	8	8	9	12
Container	311	332	354	374	394	417	686	723	769	815	1184
Wheel Loader	3	4	4	4	4	5	7	8	8	9	12
Sprinkler	1	1	1	1	1	1	1	1	1	2	2
Inspection Car	5	5	5	5	5	5	5	5	5	5	5
Southern District											
Contrainer Truck	2	2	2	2	3	3	4	5	5	5	7
Side Loader	1	1	1	1	1	1	2	2	2	2	4
Tipper	1	1	1	1	1	1	1	1	1	1	2
Container	50	52	54	56	59	61	99	104	109	105	165
Wheel Loader	1	1	1	1	1	1	1	1	1	1	2
Sprinkler	0	0	0	0	0	0	0	0	0	0	0
Inspection Car	3	3	3	3	3	3	3	3	3	3	3
Northern District											
Contrainer Truck	8	8	9	9	9	10	16	17	14	15	22
Side Loader	4	4	4	4	5	5	8	8	7	7	11
Tipper	2	2	2	2	2	2	4	4	3	3	5
Container	186	189	194	203	212	221	360	378	320	335	494
Wheel Loader	2	2	2	2	2	2	4	4	3	3	5
Sprinkler	0	0	0	0	0	0	1	1	1	1	1
Inspection Car	3	3	3	3	3	3	3	3	3	3	3
Central District											
Contrainer Truck	1	1	1	0	0	0	1	1	1	1	1
Side Loader	0	0	0	0	0	0	0	0	0	0	0
Tipper	0	0	0	0	0	0	0	0	0	0	0
Container	14	14	14	9	9	9	14	14	14	15	21
Wheel Loader	0	0	0	0	0	0	0	0	0	0	0
Sprinkler	0	0	0	0	0	0	0	0	0	0	0
Inspection Car	2	2	2	2	2	2	2	2	2	2	2
Eastern District											
Contrainer Truck	6	6	6	6	6	6	10	10	10	10	14
Side Loader	3	3	3	3	3	3	5	5	5	5	7
Tipper	1	1	1	1	1	1	2	2	2	2	3
Container	135	136	138	138	140	142	221	224	228	232	322
Wheel Loader	1	1	1	1	1	1	2	2	2	2	3
Sprinkler	0	0	0	0	0	0	0	0	0	0	1
Inspection Car	4	4	4	4	4	4	4	4	4	4	4
Western District											
Contrainer Truck	10	11	11	12	13	14	22	23	28	30	42
Side Loader	5	5	6	6	6	7	11	11	14	14	21
Tipper	2	2	2	3	3	3	5	5	7	7	10
Container	235	244	254	275	290	306	493	525	634	674	957
Wheel Loader	2	2	2	3	3	3	5	5	7	7	10
Sprinkler	1	1	1	1	1	1	1	1	1	1	1
Inspection Car	5	5	5	5	5	5	5	5	5	5	5

Table 6.2-29 Number of Vehicles and Equipment Required for Each District (Collection Ratio: 60-80-100% - Without Transfer Station)

Vehicles/Equipment Required	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Embakasi District											
Contrainer Truck	16	18	19	20	22	23	30	31	34	36	53
Side Loader	9	9	10	10	10	11	14	16	17	19	24
Tipper	3	4	4	5	5	5	7	8	8	9	12
Container	311	332	354	374	394	417	686	723	769	815	1184
Wheel Loader	3	4	4	5	5	5	7	8	8	9	12
Sprinkler	1	1	1	1	1	1	1	1	1	2	2
Inspection Car	5	5	5	5	5	5	5	5	5	5	5
Southern District											
Contrainer Truck	3	3	3	3	3	3	4	5	5	5	7
Side Loader	1	1	1	2	2	2	2	2	2	2	4
Tipper	1	1	1	1	1	1	1	1	1	1	2
Container	50	52	54	56	59	61	99	104	109	105	165
Wheel Loader	1	1	1	1	1	1	1	1	1	1	2
Sprinkler	0	0	0	0	0	0	0	0	0	0	0
Inspection Car	3	3	3	3	3	3	3	3	3	3	3
Northern District											
Contrainer Truck	10	10	10	11	11	12	16	17	14	15	22
Side Loader	5	5	5	6	6	6	8	8	7	7	11
Tipper	2	2	2	2	2	2	4	4	3	3	5
Container	182	189	194	203	212	221	360	378	320	335	494
Wheel Loader	2	2	2	2	2	2	4	4	3	3	5
Sprinkler	0	0	0	0	0	0	1	1	1	1	1
Inspection Car	3	3	3	3	3	3	3	3	3	3	3
Central District											
Contrainer Truck	1	1	1	0	0	0	1	1	1	1	1
Side Loader	0	0	0	0	0	0	0	0	0	0	0
Tipper	0	0	0	0	0	0	0	0	0	0	0
Container	14	14	14	9	9	9	14	14	14	15	21
Wheel Loader	0	0	0	0	0	0	0	0	0	0	0
Sprinkler	0	0	0	0	0	0	0	0	0	0	0
Inspection Car	2	2	2	2	2	2	2	2	2	2	2
Eastern District											
Contrainer Truck	7	7	7	7	7	7	10	10	10	10	14
Side Loader	4	4	4	4	4	4	5	5	5	5	7
Tipper	2	2	2	2	2	2	2	2	2	2	3
Container	135	136	138	138	140	142	221	224	228	232	322
Wheel Loader	2	2	2	2	2	2	2	2	2	2	3
Sprinkler	0	0	0	0	0	0	0	0	0	0	1
Inspection Car	4	4	4	4	4	4	4	4	4	4	4
Western District											
Contrainer Truck	12	12	13	15	15	16	22	23	28	30	42
Side Loader	6	7	7	7	8	8	11	11	14	14	21
Tipper	3	3	3	3	3	4	5	5	7	7	10
Container	235	244	254	275	290	306	493	525	634	674	957
Wheel Loader	3	3	3	3	3	4	5	5	7	7	10
Sprinkler	1	1	1	1	1	1	1	1	1	1	1
Inspection Car	5	5	5	5	5	5	5	5	5	5	5

(2) Case of the Target Collection Ratio of 40-50-60%

Another case of vehicle and equipment allocation in accordance with the waste amount to be collected from each district is shown in Tables 6.2-30 and

6.2-31. These two tables show the number of vehicles and equipment required for each district with and without the transfer station from 1998 to 2008, respectively.

Table 6.2-30 Number of Vehicles and Equipment Required for Each District (Collection Ratio: 40-50-60% - With Transfer Station)

Vehicles/Equipment Required	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Embakasi District											
Contrainer Truck	8	8	8	9	9	9	14	15	16	17	25
Side Loader	3	3	4	4	4	5	7	8	9	9	11
Tipper	2	2	2	2	2	2	4	4	4	4	6
Container	155	163	173	180	187	196	324	339	356	374	553
Wheel Loader	2	2	2	2	2	2	4	4	4	4	6
Sprinkler	1	1	1	1	1	1	1	1	1	1	1
Inspection Car	5	5	5	5	5	5	5	5	5	5	5
Southern District											
Contrainer Truck	1	1	1	1	1	1	2	2	2	2	3
Side Loader	1	1	1	1	1	1	1	1	1	1	2
Tipper	0	0	0	0	0	0	0	0	1	1	1
Container	25	26	26	27	28	28	47	49	51	53	77
Wheel Loader	0	0	0	0	0	0	0	0	1	1	1
Sprinkler	0	0	0	0	0	0	0	0	0	0	0
Inspection Car	3	3	3	3	3	3	3	3	3	3	3
Northern District											
Contrainer Truck	4	4	4	4	4	5	8	8	7	7	10
Side Loader	2	2	2	2	2	2	4	4	3	3	5
Tipper	1	1	1	1	1	1	2	2	2	2	2
Container	91	93	94	98	101	103	170	77	149	154	231
Wheel Loader	1	1	1	1	1	1	2	2	2	2	2
Sprinkler	0	0	0	0	0	0	1	1	1	1	1
Inspection Car	3	3	3	3	3	3	3	3	3	3	3
Central District											
Contrainer Truck	0	0	0	0	0	0	0	0	0	0	0
Side Loader	0	0	0	0	0	0	0	0	0	0	0
Tipper	0	0	0	0	0	0	0	0	0	0	0
Container	7	7	7	4	4	4	7	7	7	7	10
Wheel Loader	0	0	0	0	0	0	0	0	0	0	0
Sprinkler	0	0	0	0	0	0	0	0	0	0	0
Inspection Car	2	2	2	2	2	2	2	2	2	2	2
Eastern District											
Contrainer Truck	3	3	3	3	3	3	5	5	5	5	7
Side Loader	1	1	1	1	1	1	2	2	2	2	3
Tipper	1	1	1	1	1	1	1	1	1	1	3
Container	67	67	67	66	66	66	105	105	106	107	150
Wheel Loader	1	1	1	1	1	1	1	1	1	1	2
Sprinkler	0	0	0	0	0	0	0	0	0	0	0
Inspection Car	4	4	4	4	4	4	4	4	4	4	4
Western District											
Contrainer Truck	5	5	6	6	6	6	10	11	13	14	20
Side Loader	3	3	3	3	3	3	5	5	6	7	10
Tipper	1	1	1	1	1	1	2	2	2	2	4
Container	118	11	124	132	137	143	234	246	294	309	446
Wheel Loader	1	1	1	1	1	1	2	2	2	2	4
Sprinkler	0	0	0	0	0	0	0	1	1	1	1
Inspection Car	5	5	5	5	5	5	5	5	5	5	5

Table 6.2-31 Number of Vehicles and Equipment Required for Each District (Collection Ratio: 40-50-60% - Without Transfer Station)

Vehicles/Equipment Required	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Embakasi District											
Contrainer Truck	9	9	9	10	11	11	14	15	16	17	25
Side Loader	4	4	4	5	5	5	7	8	9	9	11
Tipper	2	2	2	2	2	3	4	4	4	4	6
Container	155	163	173	180	187	196	324	339	356	374	553
Wheel Loader	2	2	2	2	2	3	4	4	4	4	6
Sprinkler	1	1	1	1	1	1	1	1	1	1	1
Inspection Car	5	5	5	5	5	5	5	5	5	5	5
Southern District											
Contrainer Truck	1	1	1	1	1	2	2	2	2	2	3
Side Loader	1	1	1	1	1	1	1	1	1	1	2
Tipper	0	0	0	0	0	0	0	0	1	1	1
Container	25	26	26	27	28	28	47	49	51	53	77
Wheel Loader	0	0	0	0	0	0	0	0	1	1	1
Sprinkler	0	0	0	0	0	0	0	0	0	0	0
Inspection Car	3	3	3	3	3	3	3	3	3	3	3
Northern District											
Contrainer Truck	5	5	5	5	5	5	8	8	7	7	10
Side Loader	3	3	3	3	3	3	4	4	3	3	5
Tipper	1	1	1	1	1	1	2	2	2	2	2
Container	91	93	94	98	101	103	170	77	149	154	231
Wheel Loader	1	1	1	1	1	1	2	2	2	2	2
Sprinkler	0	0	0	0	0	0	1	1	1	1	1
Inspection Car	3	3	3	3	3	3	3	3	3	3	3
Central District											
Contrainer Truck	0	0	0	0	0	0	0	0	0	0	0
Side Loader	0	0	0	0	0	0	0	0	0	0	0
Tipper	0	0	0	0	0	0	0	0	0	0	0
Container	7	7	7	4	4	4	7	7	7	7	10
Wheel Loader	0	0	0	0	0	0	0	0	0	0	0
Sprinkler	0	0	0	0	0	0	0	0	0	0	0
Inspection Car	2	2	2	2	2	2	2	2	2	2	2
Eastern District											
Contrainer Truck	4	4	4	4	4	3	5	5	5	5	7
Side Loader	2	2	2	2	2	2	2	2	2	2	3
Tipper	1	1	1	1	1	1	1	1	1	1	2
Container	67	67	67	66	66	66	105	105	106	107	150
Wheel Loader	1	1	1	1	1	1	1	1	1	1	2
Sprinkler	0	0	0	0	0	0	0	0	0	0	0
Inspection Car	4	4	4	4	4	4	4	4	4	4	4
Western District											
Contrainer Truck	6	6	7	7	7	8	10	11	13	14	20
Side Loader	3	3	3	3	3	3	5	5	6	7	10
Tipper	2	2	2	2	2	2	2	2	2	2	4
Container	118	11	124	132	137	143	234	246	294	309	446
Wheel Loader	2	2	2	2	2	2	2	2	2	2	4
Sprinkler	0	0	0	0	0	0	0	1	1	1	1
Inspection Car	5	5	5	5	5	5	5	5	5	5	5

6.3.4 Staff Allocation

(1) Target Collection Ratio: 60-80-100%

The number of staff is allocated in accordance with the waste amount to be collected from each district. **Tables 6.2-32** and **6.2-33** show the number of staff for each district with and without the transfer station from 1998 to 2008, respectively.

Table 6.2-32 Number of Staff Required for Each District
(Collection Ratio: 60-80-100% - With Transfer Station)

Staff Required	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Embakasi District											
Driver	41	43	45	47	50	52	79	82	86	91	128
Loader	70	74	78	84	88	93	154	162	172	182	264
Sweeper	208	222	236	249	264	279	459	483	515	546	795
Supervisor	32	34	36	37	39	41	67	71	76	79	116
Headman	14	15	16	18	18	19	31	32	35	37	54
Southern District											
Driver	7	7	7	7	7	8	11	12	12	13	18
Loader	11	12	12	12	13	14	22	23	24	26	37
Sweeper	34	35	36	37	39	41	66	70	73	77	111
Supervisor	5	5	5	6	6	6	10	10	11	11	16
Headman	2	2	2	2	3	3	4	5	5	5	7
Northern District											
Driver	23	24	25	26	26	27	41	43	36	37	53
Loader	40	42	43	45	47	49	80	84	71	75	111
Sweeper	121	126	129	136	142	148	241	253	214	225	332
Supervisor	18	19	19	20	21	22	35	37	31	33	48
Headman	8	8	9	9	9	10	16	17	14	15	22
Central District											
Driver	2	2	2	1	1	1	2	2	2	2	2
Loader	3	3	3	2	2	2	3	3	3	3	5
Sweeper	9	9	9	6	6	6	9	10	10	10	14
Supervisor	1	1	1	1	1	1	1	1	1	1	2
Headman	1	1	1	0	0	0	1	1	1	1	1
Eastern District											
Driver	17	17	17	17	17	17	25	25	26	26	35
Loader	30	30	31	31	31	32	49	50	51	52	72
Sweeper	90	91	92	92	93	95	148	150	153	156	216
Supervisor	13	13	14	14	14	14	22	22	22	23	31
Headman	6	6	6	6	6	6	10	10	10	10	14
Western District											
Driver	30	31	32	35	36	38	56	59	71	75	103
Loader	52	54	57	61	65	68	110	117	142	151	214
Sweeper	157	163	170	184	194	205	330	352	425	452	642
Supervisor	23	24	25	26	28	30	48	51	62	66	93
Headman	10	11	11	12	13	14	22	23	28	30	43

Table 6.2-33 Number of Staff Required for Each District
(Collection Ratio: 60-80-100% - Without Transfer Station)

Staff Required	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Embakasi District											
Driver	46	49	52	55	58	60	79	82	86	91	128
Loader	85	93	97	106	111	117	154	162	172	182	264
Sweeper	256	276	293	317	332	350	459	483	515	546	795
Supervisor	37	39	43	45	46	51	67	71	76	79	116
Headman	17	19	19	22	23	24	31	32	35	37	54
Southern District											
Driver	8	8	8	8	8	9	11	12	12	13	18
Loader	14	14	15	16	16	17	22	23	24	26	37
Sweeper	42	43	44	48	49	51	66	70	73	77	111
Supervisor	6	6	6	7	7	7	10	10	11	11	16
Headman	3	3	3	3	3	3	4	5	5	5	7
Northern District											
Driver	27	28	29	30	31	32	41	43	36	37	53
Loader	50	52	53	57	59	61	80	84	71	75	111
Sweeper	150	156	160	172	178	184	241	253	214	225	332
Supervisor	22	23	23	24	25	26	35	37	31	33	48
Headman	10	10	11	11	12	12	16	17	14	15	22
Central District											
Driver	2	2	2	1	1	1	2	2	2	2	2
Loader	4	4	4	2	2	2	3	3	3	3	5
Sweeper	12	11	11	7	7	7	9	10	10	10	14
Supervisor	2	2	2	1	1	1	1	1	1	1	2
Headman	1	1	1	0	0	0	1	1	1	1	1
Eastern District											
Driver	20	20	20	20	20	20	25	25	26	26	35
Loader	37	37	38	39	39	39	49	50	51	52	72
Sweeper	111	112	113	117	117	118	148	150	153	156	216
Supervisor	16	16	16	16	17	17	22	22	22	23	31
Headman	7	7	8	8	8	8	10	10	10	10	14
Western District											
Driver	35	36	37	40	42	44	56	59	71	75	103
Loader	65	67	70	78	82	86	110	117	142	151	214
Sweeper	194	203	210	233	244	256	330	352	425	452	642
Supervisor	28	29	30	33	35	36	48	51	62	66	93
Headman	13	13	13	16	16	17	22	23	28	30	43

(2) Target Collection Ratio: 40-50-60%

Another case of staff allocation in accordance with the waste amount to be collected from each district is shown in **Tables 6.2-34** and **6.2-35**. These two tables show the number of staff required for each district with and without the transfer station from 1998 to 2008, respectively.

Table 6.2-34 Number of Staff Required for Each District (Collection Ratio: 40-50-60% - With Transfer Station)

Staff Required	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Embakasi District											
Driver	25	25	28	28	29	29	43	44	46	48	65
Loader	34	36	38	40	41	43	73	76	80	84	123
Sweeper	103	110	115	120	124	130	218	227	239	252	370
Supervisor	15	16	16	18	19	20	32	33	35	36	53
Headman	8	8	8	9	9	9	15	15	16	17	26
Southern District											
Driver	4	4	4	4	4	4	6	6	6	7	9
Loader	6	6	6	6	6	6	10	11	11	12	17
Sweeper	17	17	17	18	19	19	31	33	34	35	52
Supervisor	3	3	3	3	3	3	5	5	5	5	8
Headman	1	1	1	1	1	1	2	2	2	2	3
Northern District											
Driver	14	15	15	15	15	16	22	23	19	19	27
Loader	20	21	21	22	22	23	38	40	33	34	52
Sweeper	61	62	63	65	67	69	114	119	100	103	155
Supervisor	9	9	10	10	10	10	17	18	15	15	23
Headman	4	4	4	4	4	5	8	8	7	7	10
Central District											
Driver	1	1	1	1	1	1	1	1	1	1	1
Loader	2	2	1	1	1	1	1	1	1	2	2
Sweeper	5	5	4	3	3	3	4	4	4	5	6
Supervisor	1	1	1	0	0	0	1	1	1	1	1
Headman	0	0	0	0	0	0	0	0	0	0	0
Eastern District											
Driver	11	11	10	10	10	10	14	14	14	13	18
Loader	15	15	15	15	15	15	23	23	34	34	34
Sweeper	45	45	45	44	44	44	70	70	71	71	101
Supervisor	7	7	7	7	7	7	10	10	10	11	15
Headman	3	3	3	3	3	3	5	5	5	5	7
Western District											
Driver	19	19	19	20	21	21	30	31	37	39	53
Loader	26	26	28	29	31	32	53	55	66	69	100
Sweeper	79	80	83	88	92	96	157	165	197	208	300
Supervisor	12	12	13	13	14	14	23	24	29	31	44
Headman	5	5	6	6	6	6	10	11	13	14	20

Table 6.2-35 Number of Staff Required for Each District (Collection Ratio: 40-50-60% - Without Transfer Station)

Staff Required	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Embakasi District											
Driver	28	29	29	31	32	33	43	44	46	48	65
Loader	43	45	48	50	53	54	73	76	80	84	123
Sweeper	129	136	143	152	158	163	218	227	239	252	370
Supervisor	19	20	22	22	23	25	32	33	35	36	53
Headman	9	9	10	10	10	11	15	15	16	17	26
Southern District											
Driver	5	5	5	5	5	5	6	6	6	7	9
Loader	7	7	7	8	8	8	10	11	11	12	17
Sweeper	21	21	22	23	23	24	31	33	34	35	52
Supervisor	3	3	3	3	3	3	5	5	5	5	8
Headman	1	1	1	2	2	2	2	2	2	2	3
Northern District											
Driver	16	17	17	17	17	18	22	23	19	19	27
Loader	25	26	26	28	28	29	38	40	33	34	52
Sweeper	75	77	78	83	84	86	114	119	100	103	155
Supervisor	11	11	11	12	12	12	17	18	15	15	23
Headman	5	5	5	6	6	6	8	8	7	7	10
Central District											
Driver	1	1	1	1	1	1	1	1	1	1	1
Loader	2	2	2	1	1	1	1	1	1	2	2
Sweeper	6	6	5	3	3	3	4	4	4	5	6
Supervisor	1	1	1	1	0	0	1	1	1	1	1
Headman	0	0	0	0	0	0	0	0	0	0	0
Eastern District											
Driver	12	12	12	12	11	11	14	14	14	13	18
Loader	19	19	18	19	18	18	23	23	24	24	34
Sweeper	56	56	55	56	55	55	70	70	71	71	101
Supervisor	8	8	8	8	8	8	10	10	10	11	15
Headman	4	4	4	4	4	4	5	5	5	5	7
Western District											
Driver	21	21	22	22	24	24	30	31	37	39	53
Loader	32	33	34	37	38	40	53	55	66	69	100
Sweeper	97	100	102	112	115	119	157	165	197	208	300
Supervisor	14	15	15	15	17	17	23	24	29	31	44
Headman	7	7	7	7	7	8	10	11	13	14	20

Table 6.2-36 Projected Proportion of Waste Amount to be Collected from Each District

District	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Embakasi	34%	34%	35%	35%	36%	36%	37%	37%	37%	37%	38%
Southern	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Northern	20%	20%	19%	19%	19%	19%	19%	19%	15%	15%	16%
Central	2%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Eastern	15%	14%	14%	13%	13%	12%	12%	11%	11%	11%	10%
Western	25%	25%	25%	26%	26%	27%	26%	27%	31%	31%	30%

Note: Total percentages may not be 100% due to rounding.

6.4 Cost Estimate of Each Collection and Transportation System Option

6.4.1 Unit Cost of Each System Component

The following table shows unit costs of each system component examined in the preceding subsections. Based on the unit costs, the total project cost is estimated accordingly and the detailed financial assessment is described in the **Supporting Report, Section J**.

Table E.6-37 Unit Cost of Each System Component

No.	Item	Specifications	Unit	Cost (Kshs.)	Remarks
1	Detachable container truck	8 m^3	Each	4,000,000	
2	Detachable container truck	20 m^3	Each	6,000,000	with the same size of a container
3	Container	8 m^3	Each	250,000	
4	Compactor truck	8 m^3	Each	4,500,000	
5	Side loader	8 m^3	Each	3,750,000	
6	Dump truck	8 m^3	Each	3,250,000	
7	Wheel loader	2 m^3 bucket	Each	10,000,000	
8	Water sprinkler	8,000 litre	Each	2,250,000	
9	Inspection car		Each	2,500,000	average of the three types: 4-wheel-drive, pick-up and sedan
10	Recovery truck		Each	20,000,000	
11	Parking lot		Each	9,000,000	land acquisition not included
12	Workshop		Each	30,000,000	land acquisition not included
13	Transfer station		LS	1,500,000,000	-ditto-

The construction cost for the transfer station including the required facility procurement of Item 13 in the table above is estimated based on the following cost of each work item.

Table E.6-38 Breakdown of Cost for the Construction of Transfer Station

Item	Unit	Quantity	Unit Cost (Kshs.)	Cost (×1,000Kshs.)
1. Civil Works				
Platform	m^2	1,900	200,000	380,000
Slope for Vehicle	m^2	250	150,000	37,500
Roof	m^2	500	50,000	25,000
Truck Scale Room	m^2	40	27,500	1,100
Workshop Room	m^2	160	27,500	4,400
Pavement	m^2	48,400	5,000	242,000
Fence and Gate	m	1,400	2,000	2,800
Sub-total				**692,800**
2. Facility				
Truck Scale	Each	4	6,250,000	25,000
Car Washing Machine	Each	2	3,500,000	7,000
Workshop	LS	1	50,000	50,000
Guide Chute	Each	8	40,000,000	320,000
Electric Work	LS	1	50,000,000	50,000
Wheel Loader	Each	2	2,500,000	5,000
Sub-total				**457,000**
Total				**1,149,800**
Overhead	**LS**	**1**	**Total × 30%**	**350,200**
Grand Total				**1,500,000**

6.4.2 Operation and Maintenance Cost

(1) Personnel Cost Associated with Collection/Transportation Services

The execution of the previous options will require appropriate number of operation and maintenance staff. The wages paid to NCC personnel who are involved in daily collection/transportation operation are decided on a uniform basis in accordance with the job grade. The job grade is determined by the type of job and years of continued service. Benefits, such as pension are actually paid to some extent for the job assignment in addition to the base salary decided by the grade. The monthly payments for the personnel including the benefits as of 1997 are calculated as given in **Table E.6-39**.

Table E.6-39 Monthly Personnel Cost for Collection/Transportation Services

Job type	Monthly Pay in 1997 (Kshs.)
Headman/headwoman	5,750
Driver	7,610
Loader	4,940
Sweeper	4,940
Administrative staff	11,055

(2) Cost for Fuel and Oil/Lubricant

Fuel and oil/lubricant cost is calculated based on daily diesel consumption of each vehicle and machine. Particularly, oil and lubricant cost is estimated as 20% of total fuel cost. **Table E.6-40** shows the annual fuel and oil/lubricant cost for each vehicle and equipment planned in the preceding options.

Table E.6-40 Annual Fuel and Oil/Lubricant Cost for Each Vehicle and Equipment

Equipment	Qty	Consumption (lit/day)	No. of Days	Fuel costs (Kshs.)*	Oil/Lubricant costs (Kshs.)	Total (Kshs.)
Detachable container truck (8 m^3)	1	50	360	612,000	122,400	734,400
Detachable container truck (20 m^3)	1	70	360	856,800	171,360	1,028,160
Compactor truck	1	40	360	489,600	97,920	587,520
Side loader	1	40	360	489,600	97,920	587,520
Dump truck	1	40	360	489,600	97,920	587,520
Wheel loader	1	120	360	1468,800	293,760	1,762,560
Water sprinkler	1	40	360	489,600	97,920	587,520
Inspection car	1	40	360	489,600	97,920	587,520
Recovery truck	1	70	120	285,600	57,120	342,720

* Fuel cost is calculated based on the assumption that the diesel cost is 34 Kshs. per litre (as of January 1998).

(3) Repair and Overhaul Cost

The cost required for servicing and repairing/overhauling the equipment is determined in terms of their proportion to the basic equipment cost. Starting from the premise that servicing facilities will be provided under the project which will be implemented by procurement of the equipment and allowing for the fact that some of the servicing tools and spare parts are included in the

standard accessories, it is fair to assume that the annual repair and overhaul cost would be about 3% of the equipment cost.

SECTION F

ENVIRONMENTAL CONSIDERATIONS

THE STUDY ON SOLID WASTE MANAGEMENT IN NAIROBI CITY IN THE REPUBLIC OF KENYA

FINAL REPORT

SECTION F

ENVIRONMENTAL CONSIDERATIONS

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SECTION F

ENVIRONMENTAL CONSIDERATIONS

1. PRESENT ENVIRONMENTAL CONDITIONS IN NAIROBI CITY

1.1 Environmental Quality of Nairobi City

1.1.1 Water

(1) Surface Water

Nairobi City is watered by small rivers, such as the Nairobi, Gitathuru, Mathare, Ngong and Kirichwa Kubwa Rivers. In this study, field measurements were conducted by the Study Team to know the quality of existing rivers in Nairobi City. Results of the measurement are summarised in **Table F.1-1** and locations of the measurement are shown in **Figure F.1-1**. According to the results, it was concluded that most of the rivers in Nairobi City are polluted, mainly by organic substances originating from uncollected solid wastes, industrial effluents and domestic wastewater. Besides, analyzing previous reports on the subject, it was confirmed that the pollutants of rivers crossing Nairobi City are not only organic substances but also heavy metals and chemicals.

Table F.1-1 Water Quality of Rivers in Nairobi City

Station No.		GPS*	River Name	Oxygen mg/l	pH	SS ppm	EC ms/cm	Temperature °C
1	S E	1,14,303 36,53,471	Gitathuru	1.00	8.80	85.00	0.39	23.70
2	S E	1,14,659 36,52,657	Gitathuru	1.10	7.40	121.90	0.63	23.00
3	S E	1,15,454 36,51,873	Gitathuru	2.00	7.20	83.30	0.52	24.20
4	S E	No accessible	Gitathuru					
5	S E	1,14,928 36,49,174	Mathare	4.30	7.50	70.50	0.42	20.60
6	S E	1,14,072 36,48,116	Mathare	5.00	7.50	32.40	0.42	20.50
7	S E	1,14,292 36,54,843	Nairobi	4.10	7.40	110.00	0.59	22.10
8	S E	no data	Nairobi	3.80	7.50	120.50	0.69	22.80
9	S E	1,16,273 36,52,474	Nairobi	2.80	7.50	149.30	0.66	21.50
10	S E	1,17,421 36,52,152	Nairobi	0.90	7.30	210.00	0.64	23.00
11	S E	1,17,421 36,52,152	Nairobi	4.30	7.40	310.00	0.59	21.00
12	S E	1,16,030 36,46,440	Nairobi	5.60	7.60	392.00	0.63	20.80
13	S E	1,16,459 26,48,060	Masonga Wai	4.50	7.60	294.00	0.53	20.00
14	S E	No accessible	Ngong					
15	S E	1,18,390 36,53,360	Ngong	1.70	7.40	72.40	0.65	21.80

Table F.1-1 Water Quality of Rivers in Nairobi City (Cont'd)

Station No.		GPS	River Name	Oxygen mg/l	pH	SS ppm	EC ms/cm	Temperature °C
16	S E	1,19,186 36,51,455	Ngong	1.00	7.60	70.10	0.65	22.10
17	S E	1,17,586 36,47,297	Ngong	4.30	7.80	62.10	0.77	25.50
18	S E	1,18,658 36,49,019	Ngong	4.30	7.90	62.20	0.88	22.20
19	S E	1,17,883 36,48,084	Ngong	2.70	7.50	26.30	0.44	21.30
20	S E	1,19,225 36,48,090	Nairobi dam	4.50	8.00	30.10	1.00	22.90
21	S E	1,18,583 36,46,314	Afl.Nairobi dam	3.30	7.20	26.10	1.40	19.90
22	S E	1,17,633 36,45,235	Kiriehwa Kubwa	2.90	7.50	118.30	0.79	21.30

* GPS indicates the latitude and longitude of the measurement points.

(2) Groundwater

According to *the National Environment Secretariat Report (1987),* "there is insufficient information at present concerning the extent of aquifers, their structure and volume of groundwater". **Table F.1-2** shows the quality of groundwater in Nairobi Province. The water quality is generally satisfactory for all domestic purposes from a chemical point of view, except the fluoride content that exceed the World Health Organisation (WHO) drinking water guidelines of 1.5 mg/l. The removal of fluoride is not technically easy and economically feasible representing one of the more intractable problems in relation to groundwater utilisation. The other element that slightly exceeds the guidelines in Nairobi groundwater is the iron that causes undesirable taste at levels of 0.3 mg/l. Although the Table gives valuable data, it shows only the physical-chemical characteristics of the water, lacking the portion that corresponds to bacteriological, bio-chemical, nitrogen, pesticides and heavy metal analysis to have a comprehensive water quality data.

Table F.1-2 Groundwater Quality in Nairobi Province

Parameter	Unit	Value	
		1983/84	1985
pH		7.9	7.7
Color	mg Pt/l	-	9.3
Turbidity	NTU	28.9	6.4
Oxygen	mg O2/l	-	6
Conductivity	µs/cm	859	506
Iron	mg Fe/l	1.48	1
Manganese	mg Mn/l	0.7	0.12
Calcium	mg Ca/l	43.3	20
Magnesium	mg Mg/l	8.16	2.2
Sodium	mg Na/l	164	148
Potassium	mg K/l	19.3	20
Total Hardness	mg/l	48.4	64
Total Alkalinity	mg/l	-	192
Chloride	mg Cl/l	72.4	40
Fluoride	mg F/l	6.59	3.5
Sulphate	mg SO4/l	32.3	15
TDS	mg/l	521	304

Source: Ministry of Water Development

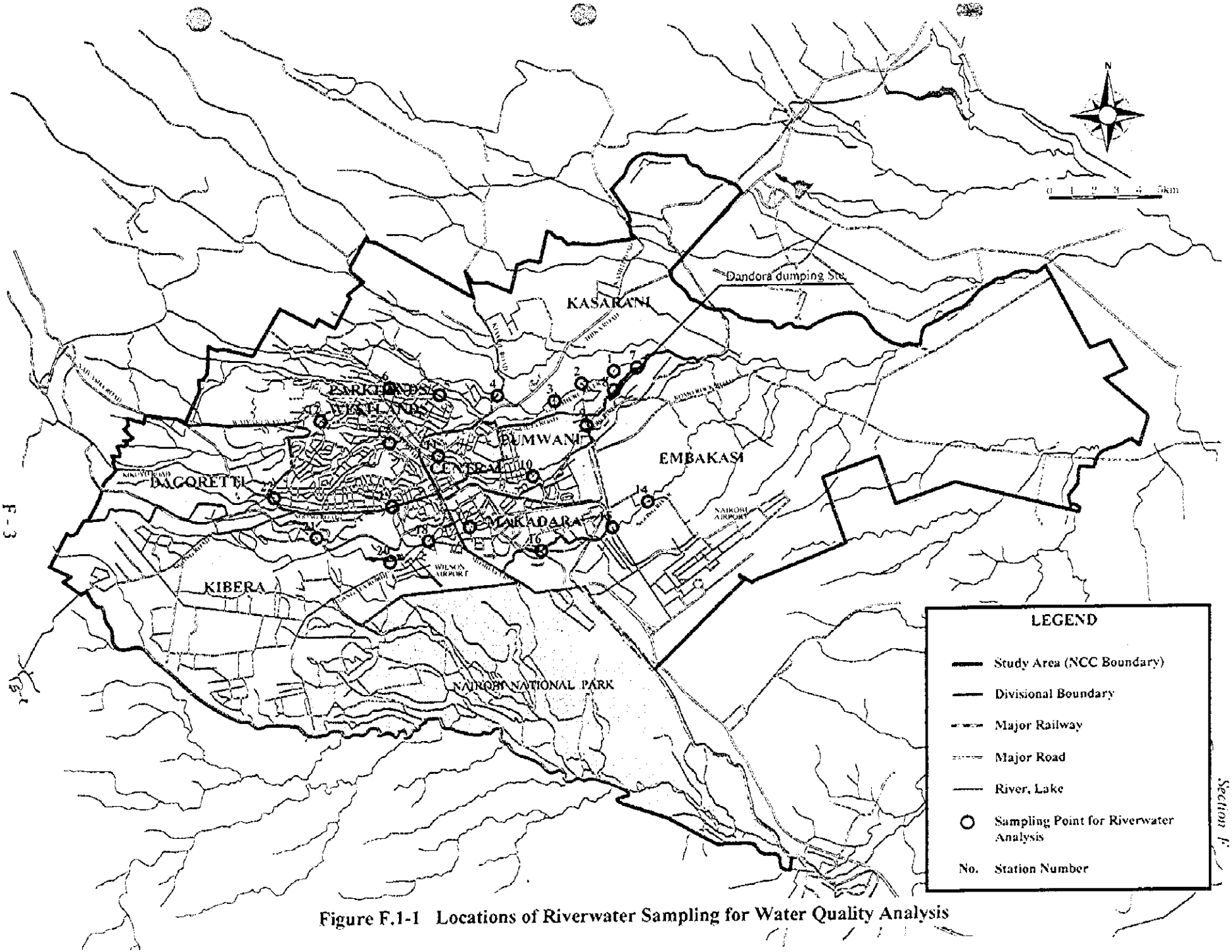


Figure F.1-1 Locations of Riverwater Sampling for Water Quality Analysis

(3) Water Supply

According to previous studies the percentage of total population served in 1984 was about of 89% being the average per capita water consumption of 72 littre/person/day. Currently the coverage of water supply is about of 95%. The Nairobi City Council (NCC) supplied water while some private service is provided, particularly in Runda. The water quality supplied to Nairobi City in 1984 is shown in **Table F.1-3**. Although the table gives valuable data, it is necessary to know the portion that corresponds to bacteriological quality to evaluate the portability of the water supplied to Nairobi's residents.

Table F.1-3 Water Quality of Nairobi Water Supply System

Parameter	Unit	Place				
		Kangemi	Dandora	Univ. of Nairobi	Pangani	Kibera
Color	Hazen	5	5	5	5	5
Taste & Odor	-	-	-	-	-	-
Turbidity	NTU	0.75	0.75	1	1	0.5
Total alkalinity	mg/l	30	25	24	27	28
pH	-	7.6	7.4	7.8	7.8	7.7
Total hardness	mg/l	30	280	40	39	38
Calcium hardness	mg/l	16	120	20	20	15
Residual chlorine	mg/l	0.3	0.3	0.3	0.3	0.1
Iron	mg/l	0.3	0.3	0.3	0.3	0.3
Chloride	mg/l	30	14	25	15	15
Bacteria (coliform)	MPN/100ml	-	-	-	-	-

Source: *Nairobi Master Plan for Sewer, Sanitation & Drainage, July 1996*

(4) Water Pollution Control in Nairobi City

The most important sources polluting watercourses are industrial wastewater, domestic wastewater and solid waste.

The Water Quality and Pollution Control Section of the Ministry of Water Development (MOWD) is responsible for implementation of the nationwide water quality monitoring program.

On the other hand, the Nairobi City Council (NCC) through the Water and Sewerage Department also has the responsibility of monitoring industrial effluents before discharging into the sewers. At present there is no systematic monitoring of different effluents resulting from various industries. Data from two industries in Nairobi shows BOD discharged levels of 1,913 mg/l and 884 mg/l. These values are considered extremely high to be discharged in the sewerage system or in watercourses.

(5) Standards

(a) Drinking Water

With respect to drinking-water quality, the internationally recognised and authoritative guidelines is published by the World Health Organisation (WHO, 1984) and these have been adopted by many countries worldwide including Kenya. Summaries of the WHO guidelines and criteria adopted by the Nairobi City Council (NCC) for drinking water quality are given in **Section 9.3, Table 9.3.1 and Table 9.3.2 of Data Book (1).**

(b) Industrial Effluents

NCC has developed the standard for industrial effluents to be discharged into natural water bodies as presented in the table below:

Table F.1-4 Discharge Standard for Industrial Effluents into Natural Water Bodies

Parameter	Unit	Level
BOD_5 at 20°C	mg/l	≤ 20
pH		6.0 - 9.0
Temperature	°C	≤ 25
Suspended Solids	mg/l	≤ 30
Nitrates	mg/l	≤ 45

Source: NCC

(c) Domestic Effluents

The effluent quality required for discharging is the same as those mentioned in the prior table, but no information is available regarding standards for bacteriological quality of treated effluents before discharging into natural receiving waters.

(d) Indicators of Pollution

The Nairobi City Council is applying as criteria the following indicators of pollution for water:

Table F.1-5 Indicators of Pollution Applied by NCC

Parameter	Unit	Max. Limit
Chemical Oxygen Demand (COD)	mg/l	10
Biochemical Oxygen Demand (BOD)	mg/l	6
Total nitrogen (NO_3)	mg/l	1
Ammonia (NH_3)	mg/l	0.5
Grease	mg/l	0.5

Source: NCC

1.1.2 Sewage

The Nairobi City Council (NCC) through the Sewerage Department has the responsibility of providing sewerage services in the City.

(1) Sewage Treatment Facilities

Sewage treatment facilities are composed of sewers and sewage treatment plants. In the field observation were confirmed that some parts of the sewers are blocked or damaged permitting the leakage of sewage directly into the rivers. With respect to sewage treatment plants the following are the plants owned and operated by NCC within the city boundary.

(a) Kariobangi
(b) Dandora
(c) Industrial Area
(d) General Service Unit Camp
(e) Kahawa West
(f) Karen

In order to know about the treatment system applied and its performance, the Study Team visited two facilities: Kariobangi and Dandora.

(2) Kariobangi Sewage Treatment Plant

The sewage treatment plant of Kariobangi was built in 1961/1963 and is composed by screen basin, sedimentation, bio-filtration and sludge basin (digesters and drying beds). Settled sludge is pumped to digesters after which it is dried on open beds. Treated effluent is discharged to the Nairobi River. Sludge produced in the plant is used by farmers so that disease transmission potential exists from the handling practices. Also heavy metals concentration in the sludge was reported but no available data exist in relation to its impact on the field crops.

(3) Dandora Estate Sewage Treatment Plant

This plant has been in operation since 1980 along the Nairobi River. Extensive area is available for the plant expansion. The sewage treatment plant of Dandora is composed of screen basin and grit channels, primary sedimentation and facultative and maturation lagoons. The treated effluents are discharged into the Nairobi River.

(4) Standard

The Nairobi City Council has developed the standard for industrial effluents to be discharged into the Sewerage System as presented in the table below.

Table F.1-6 Discharge Standard for Industrial Effluents into the Sewerage System

Parameter	Unit	Level
BOD_5 at 20°C	mg/l	≤ 450
pH		6.0 - 9.0
Temperature	°C	≤ 30
Suspended Solids	mg/l	≤ 300
Grease	mg/l	≤ 100

Source: NCC

1.1.3 Air Quality

The air quality may be influenced by moving or stationary sources. Moving sources are related mainly to the traffic of motor vehicles while stationary sources are related mainly to industries.

There is no systematic air quality monitoring system in Nairobi, therefore, trends in air quality cannot be established. Some measurements were done under the Global Environmental Monitoring System (GEMS) Project on Air Quality, 1977-1978 and results are shown in **Table F.1-7**. After that, in 1982, new measurements were conducted and results revealed higher concentration of suspended particular matter (SPM) in Nairobi as shown in **Table F.1-8**.

Acidity of the rain also was measured in Nairobi area, indicating a pH value of 5.52. This acidity is due to emissions of acidic gases (sulfur and nitrogen oxides) from industries.

Other parameters could not be compared due to the lack of information. The concentration of SPM found by that time exceeds the limits stated in the Japanese Standard.

Actually, by simple observation of the city centre, it can be said that air quality has deteriorated mainly due to moving sources.

Table F.1-7 Air Quality in Nairobi City (1977/78)

Parameter	Unit	Suburban area	Industrial area
SO_2	ug/m^3	36	57
SPM	ug/m^3	51	80

Source: *National State of Environment, 1987*

Table F.1-8 Air Quality in Nairobi City (1982)

Survey site	Unit	SPM	% increased
Industrial area	ug/m^3	252	157.5
Burubura	ug/m^3	80	78.4
South C	ug/m^3	103	101
Shauri Moyo	ug/m^3	92	90.2
Woodley	ug/m^3	83	81.4

Source: *National State of Environment, 1987*

1.1.4 Solid Waste

As scheduled, surveys were conducted at 31 garbage collection points of the city (first 5 located at high income area, next 11 located at medium income area, 10 located in low income area and the remaining 5 located in slums area) and at the existing final disposal site (Dandora). Locations of the selected collection points are presented in **Figure F.1-2**.

(1) Objective

The survey on the actual condition of the environment at selected garbage collection points of different income levels, slums and at the Dandora disposal site has the main objective of understanding the features and behavior of those components of the environment most related to the management of solid waste.

(2) Field Survey Procedure

Firstly, the identification of the points to be surveyed by means of initial observation of the areas concerned was conducted. Then, full surveys were made through field observation and interviews to residents as described hereinafter.

(3) Findings on Environmental Pollution by Solid Waste at Selected Garbage Collection Points

(a) High Income Area

In the identification process were chosen the following places:

(i) Langata
(ii) Runda
(iii) Spring Valley
(iv) Loresho
(v) Kitisuru

Table F.1-9 and concerned photographs inserted in **Subsection 6.1.3 of Data Book (1)** summarise the results of the survey. Major findings are summarised below:

(i) Mainly, there are single family houses with extensive grounds and gardens.

(ii) The waste produced is domestic although it is composed also of garden wastes and wastes resulting from the pruning of trees.

(iii) During the survey only in Langata could be seen an open dumping sites.

(iv) Presence of scavengers was also noted in Langata and Spring Valley.

(v) In some areas service is provided every Monday by NCC and in other areas by the private sector. Wastes are put in bins and stored in front of the houses from where they are collected.

(vi) In some areas where no services are provided, the waste is managed individually by residents.

(vii) Although collection services are provided regularly in most parts of the high income areas, the burning of garden waste resulting from pruning of trees is common.

(viii) Environmental Sanitation is quite satisfactory in high income areas due to the contribution of proper solid waste management.

Table F.1-9 Environmental Pollution at Garbage Collecting Points in High Income Areas

Collection point	Langata	Runda	Spring Valley	Loresho	Kitusuri	%
General Information						
Scattering of waste	a	c	c	c	c	20
Frequency of collection	I	r	r	r	n	40
Blockage of channel by waste	c	c	c	c	c	-
Air pollution						
Scattering of dust	b	c	c	c	c	-
Gas from waste	b	c	c	c	c	-
Smoke from combustion	a	c	c	c	c	20
Exhausting gas from collection veh.	d	d	d	d	-	-
Water pollution						
Leachate production	c	c	c	c	c	-
River pollution by leachate	c	c	c	c	c	-
Ground water pollution by leachate	c	c	c	c	c	-
Offensive odor						
Kitchen waste	b	c	c	c	c	-
Leachate	c	c	c	c	c	-
Gas from waste	c	c	c	c	c	-
Noise						
Collection vehicles	d	d	d	d	-	-
Collecting works	d	d	d	d	-	-
Health and Sanitation						
Insects	b	c	c	c	c	-
Sewage on the road	c	c	c	c	c	-
Presence of animals	c	c	c	c	c	-
Presence of scavenger	b	c	b	b	c	-
Landscape						
Degradation due to waste	a	c	c	c	c	20

Legend:
a: high significance, b: low significance, c: no significance, d: unknown
r: regular, I: irregular, n: no collection provided (residents manage their waste individually),
%: percentage of selected points with problems of high significance

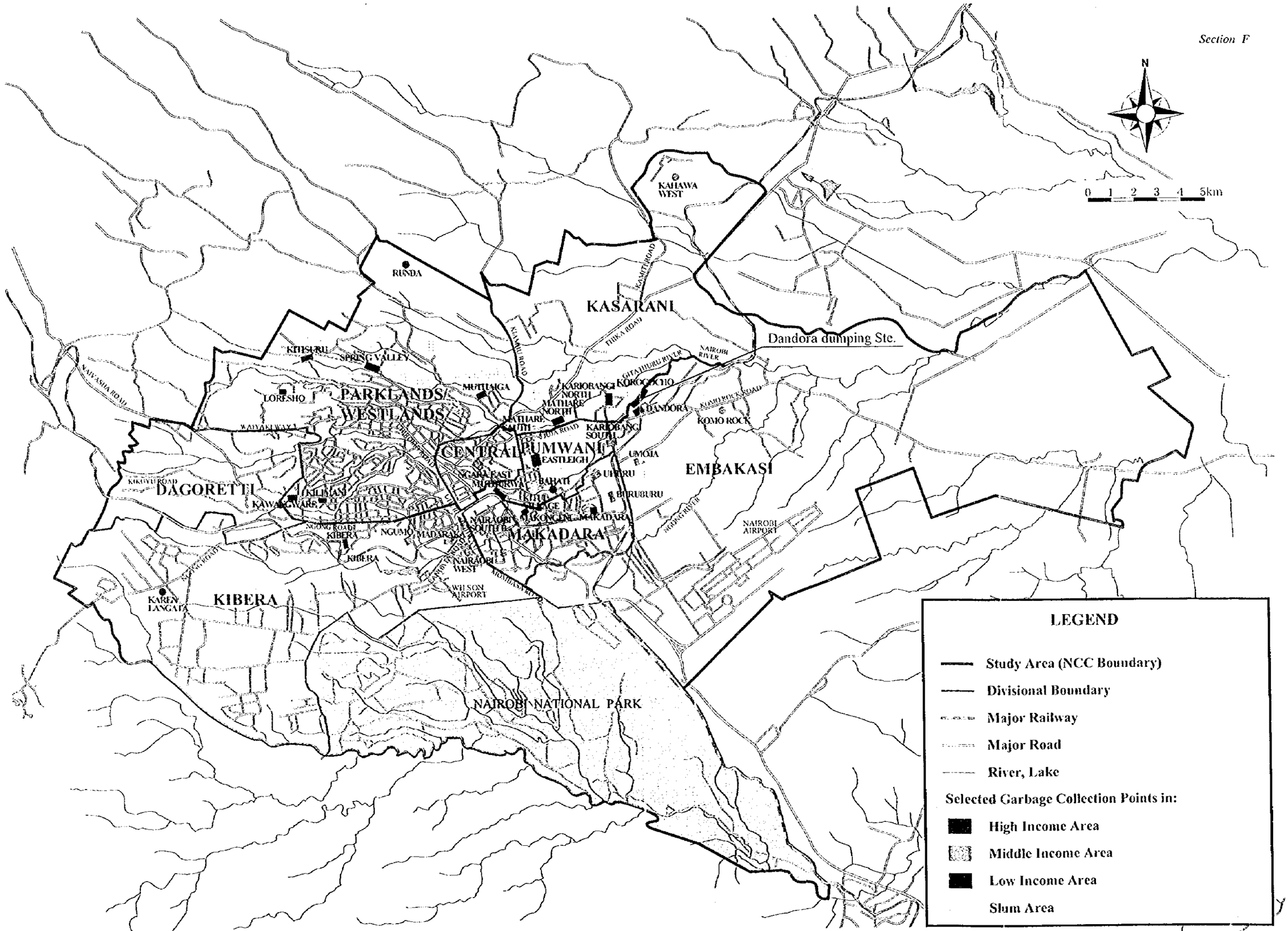


Figure F.1-2 Locations of Selected Garbage Collection Points for Environmental Pollution Survey

(b) Middle Income Area

In the identification process were chosen the following places:

(i) Buru-Buru
(ii) Umoja
(iii) Komarock
(iv) Kahawa West
(v) Nairobi West
(vi) Ngara East
(vii) South B
(viii) Madaraka
(ix) Ngumo
(x) Uhuru
(xi) Kariobangi South

Table F.1-10 and concerned photographs inserted in **Subsection 6.1.3 of Data Book (1)** summarise the results of the survey. Major findings are summarised below.

(i) Open dumping is the usual method of disposal along the roads, next to the buildings, open spaces and even in the places allocated for recreational purposes including school environments.

(ii) Burning of waste, presence of scavengers who deal with recycling and animals which feed on the waste, are the daily panorama of these areas.

(iii) In some areas collection is not provided and the quantity of waste is reduced at the dumping place through burning by NCC employees or the residents.

(iv) In some areas the collection is very irregular while in Nairobi West the collection is provided weekly by NCC and the private sector.

(v) Leachate generated from the waste and the waste in its solid form pollutes watercourses (mainly Nairobi River and partly Ngong River).

(vi) One communal container and various refuse cubicles for storage particularly in Madaraka could be seen. At the time of survey all of them are full of garbage with flies and bad odour because no regular collection is provided.

(vii) Near the Kariokor market could be seen an open dumping site with flies and smell coexisting with a high number of people.

(viii) Also were observed blockage of drainage channels in many parts of the area.

(ix) Generally, the waste management in the middle income areas is poorly managed.

Table F.1-10 Environmental Pollution at Garbage Collecting Points in Middle Income Areas

Collection point	Buru buru	Umoja	Komo rock	Kahawa	Nairobi West	Ngara East	South B	Mada raka	Ngumo	Kariobangi	%
General Information											
Scattering of waste	a	a	a	a	b	a	a	a	a	a	90.9
Frequency of collection	I	I	I	n	r	I	I	I	I	n	90.9
Blockage of channel by waste	a	a	a	a	c	a	c	c	a	a	63.6
Air Pollution											
Scattering of dust	a	a	b	b	b	a	b	b	a	a	54.5
Gas from waste	a	a	b	b	c	a	b	a	a	a	63.6
Smoke from combustion	a	a	a	a	a	a	a	a	a	a	100
Exhausting gas from collection veh.	d	d	d	-	d	d	d	d	d	-	-
Water Pollution											
Leachate production	a	a	b	b	c	a	c	a	b	a	45.4
River pollution by leachate	a	a	b	b	c	a	c	a	b	a	45.4
Ground water pollution by leachate	d	d	d	d	c	d	c	d	d	d	-
Offensive Odour											
Kitchen waste	a	a	a	b	c	a	b	a	a	a	72.7
Leachate	a	a	b	b	c	a	c	a	b	a	45.4
Gas from waste	a	a	b	b	c	a	b	a	a	a	63.6
Noise											
Collection vehicles	d	d	d	-	d	d	d	d	d	-	-
Collecting works	d	d	d	-	d	d	d	d	d	-	-
Health and Sanitation											
Insects	a	a	a	a	c	a	a	a	a	a	90.9
sewage on the road	c	a	b	a	c	a	c	a	c	c	36.4
Presence of animals	c	b	b	b	c	b	c	c	c	a	9.09
Presence of scavenger	a	a	a	a	a	a	a	a	a	a	100
Landscape											
Degradation due to waste	a	a	a	a	a	a	a	a	a	a	100

Legend:
a: high significance, b: low significance, c: no significance, d: unknown
r: regular, I: irregular, n: no collection provided , %: percentage of selected points with problems of high significance

(c) Low Income Area

In the identification process were chosen the following places:

(i) Makadara
(ii) Makongeni
(iii) Dandora
(iv) East Leigh
(v) Mathare North
(vi) Muthurwa
(vii) Kibera state
(viii) Kawangware
(ix) Bahati
(x) Kariobangi north

Table F.1-11 and concerned photographs inserted in **Subsection 6.1.3 of Data Book (1)** summarise the results of the survey. Major findings are summarised below.

(i) Open dumping of waste along the roads, burning of waste and presence of scavengers, domestic animals and birds, were common characteristics in these areas. Further, pedestrian crossing over open dumping site was noted.

(ii) In Makongeni (South) could be noted only one open dumping site with very small quantity of garbage. The place is relatively clean.

(iii) In most of the places surveyed, the waste is clogging the drainage channel.

(iv) No collection is provided in some areas while in other areas it is done occasionally. In some areas tractors and lorries are used in handling the waste.

(v) In the area of Kawangware one cubicle for storage of waste managed by a community organised group was observed.

(vi) Production of compost from market waste is conducted under the auspices of NCC, UNEP, NGOs and residents.

(vii) During the survey, a child trying to dispose of waste into the drainage channel was observed. This should be a consequence of lack of education.

(viii) In Kariobangi North area could be seen a medium scale waste recycling placed on the road. At the time of the survey, smell characteristic of fermentation could be noted.

(ix) Sewage flowing over the landscape was observed in some areas.

(x) Public health risk in these areas due to poor environmental sanitation mainly in the solid waste management sector.

Table F.1-11 Environmental Pollution at Garbage Collecting Points in Low Income Areas

Collection point	Maka dara	Makon geni	Dandora	East Leigh	Mathare	Muthur wa	Kibera	Kawang ware	Bahati	Kariobangi	%
General Information											
Scattering of waste	a	a	a	a	a	a	a	a	a	a	100.0
Frequency of collection	I	n	n	n	n	I	n	n	n	I	100.0
Blockage of channel by waste	a	c	a	a	a	a	a	a	a	a	90.0
Air Pollution											
Scattering of dust	a	b	a	a	a	a	a	a	b	a	80.0
Gas from waste	a	a	a	a	a	a	a	a	a	a	100.0
Smoke from combustion	a	a	a	a	a	a	a	a	a	a	100.0
Exhausting gas from collection veh.	d	-	-	-	-	d	-	-	-	d	-
Water Pollution											
Leachate production	a	b	a	a	a	b	a	a	a	a	80.0
River pollution by leachate	a	b	a	a	a	b	a	a	a	a	80.0
Ground water pollution by leachate	d	d	d	d	d	d	d	d	d	d	-
Offensive Odour											
Kitchen waste	a	a	a	a	a	a	a	a	a	b	90.0
Leachate	a	b	a	a	a	b	a	a	a	a	80.0
Gas from waste	a	a	a	a	a	a	a	a	a	a	100.0
Noise											
Collection vehicles	d	-	-	-	-	d	-	-	-	d	-
Collecting works	d	-	-	-	-	d	-	-	-	d	-
Health and Sanitation											
Insects	a	a	a	a	a	a	a	a	a	a	100.0
Sewage on the road	a	c	b	c	a	b	c	a	c	c	30.0
Presence of animals	a	c	a	c	a	a	c	a	c	a	60.0
Presence of scavenger	a	a	a	a	a	a	a	a	a	a	100.0
Landscape											
Degradation due to waste	a	a	a	a	a	a	a	a	a	a	100.0

Legend:
a: high significance, b: low significance, c: no significance, d: unknown, r: regular, I: irregular, n: no collection provided,
%:percentage of selected points with problems of high significance

(d) Slum Areas

In the identification process were chosen the following places:

(i) Kitui Village
(ii) Kibera
(iii) Mathare South
(iv) Korogocho
(v) Kayaba

Table F.1-12 and concerned photographs inserted in **Subsection 6.1.3 of Data Book (1)** summarise the results of the survey. Major findings are summarised below.

(i) Open dumping of waste along the road sides, burning of waste, presence of birds and domestic animals (chicken, sheep, goats, cattle), pedestrian crossing and sewage constitute the normal panorama of the places.

(ii) Generally, waste is brought by the residents from the slums to the open dumping site located along the road side. Kibera slum is an example of this practice. Service is not provided and at times tractors are provided to remove the garbage.

(iii) Blockage of drainage channel could be also observed

(iv) Untreated sewage is discharged into watercourses such as the Nairobi River and Nairobi Dam.

(v) Community based organisations participation in solid waste management was observed in some slums like Kayaba. This kind of involvement in waste management could facilitate environmental management and sustainability in the area.

(vi) Generally, the waste management in slum areas is unsatisfactory although residents are cooperative in taking the waste to the dumping sites along the roads and open spaces.

Table F.1-12 Environmental Pollution at Garbage Collection Points in Slum Areas

Collection point	Kitui Village	Kibera	Mathare South	Kogorocho	Kayaba	%
General Information						
Scattering of waste	a	a	a	a	a	100.0
Frecuency of collection	n	n	l	n	n	100.0
Blockage of channel by waste	a	a	a	a	a	100.0
Air Pollution						
Scattering of dust	a	a	a	a	a	100.0
Gas from waste	a	a	a	a	a	100.0
Smoke from combustion	a	a	a	a	a	100.0
Exhausting gas from collection vehicles	-	-	d	-	-	-

Table F.1-12 Environmental Pollution at Garbage Collection Points in Slum Areas (Cont'd)

Collection point	Kitui Village	Kibera	Mathare South	Kogorocho	Kayaba	%
Water Pollution						
Leachate production	a	a	a	a	a	100.0
River pollution by leachate	a	a	a	a	a	100.0
Groundwater pollution by leachate	d	d	d	d	d	-
Offensive Odour						
Kitchen waste	a	a	a	a	a	100.0
Leachate	a	a	a	a	a	100.0
Gas from waste	a	a	a	a	a	100.0
Noise						
Collection vehicles	-	-	d	-	-	-
Collecting works	-	-	d	-	-	-
Health and Sanitation						
Insects	a	a	a	a	a	100.0
sewage on the road	a	a	b	a	a	80.0
Presence of animals	b	a	a	a	b	60.0
Presence of scavenger	a	a	a	a	a	100.0
Landscape						
Degradation due to waste	a	a	a	a	a	100.0

Legend:
a: high significance, b: low significance, c: no significance, d: unknown
r: regular, I: irregular, n: no collection provided , %: percentage of selected points with problems of high significance

(e) Others

While surveying it was observed that illegal dumping into the forest is also practiced by residents and industrial sector. [Refer to the photograph in **Subsection 6.1.3 of Data Book (1)**].

(4) Environmental Pollution by Solid Waste at the Dandora Disposal Site

Major findings are as described below.

(a) General

The Dandora Disposal Site is the only one existing in Nairobi City and the place was a quarry site along the Nairobi River. The place is adjacent to a housing area.

Collected solid waste are disposed of by insufficient means permitting serious pollution.

(b) Air Pollution

The Dandora Disposal Site can be categorised as open dumping, where burning waste is usually practiced causing air pollution. There is no facility existing for gas elimination. No available data were found to study the actual condition, but by means of observation on the site it can be assumed that concentration of dust and offensive odour tends to worsen the air quality of the place. Offensive odour and smoke are the major complaints of people living around the place.

(c) Water Pollution

The only existing river, Nairobi River, near the actual solid waste disposal site, is polluted by leachates and solid waste from the disposal site.

(d) Offensive Odour

The generation of gases can be perceived even at long distance from the center of the disposal site. This is very particular during the fermentation process of the waste.

(e) Noise

Noise generates but insignificant. This is due to the absence of equipment and limited vehicles operating at the disposal site.

(f) Health and Sanitation

The Dandora Disposal Site is categorised as open dumping where solid wastes poses a risk from a sanitary point of view that can affect directly the operators of the landfill site, scavengers and residents living around the site. The site constitutes breeding grounds for different organisms that are carriers of diseases such as malaria, typhoid, dysentery, etc.

During the survey, the people in charge of one primary school located next to the disposal site were interviewed and according to them the major complaints are those related to smoke, smell and broken glasses which are deposited around the school. Cases of respiratory and stomach problems among children and teachers have been mentioned by the people interviewed. School children passing through the dumping site often pick objects which are dangerous to their health. This is also a similar risk to scavengers.

(g) Landscape

The disposal site is surrounded by households and schools (primary and secondary). Besides, some truck waste collectors discharge the waste before reaching the disposal site. All this contributes to the degradation of the environmental quality of the place.

(h) Soil Pollution

The Dandora Disposal Site receives domestic, industrial, commercial, hospital and institutional wastes. Domestic waste may pollute the soil with organic matter while industrial waste may introduce organic matter and toxic elements to the soil.

There is lack of information on the soil quality although it can be estimated that toxic elements are introduced at the disposal site by some industries. On the other hand, *the National Development Plan 1994-*

1996 recognises that tanneries and the leather industry need an urgent strengthening in the management of toxic chemicals including hazardous wastes.

During the field survey the dumping of tanneries wastes could be noted; that means that until now toxic wastes are entering the disposal site at Dandora. As reference presented in **Section 6.1, Table 6.1.1 of Data Book (1)** is a list of private disposal companies at the Dandora site according to previous studies (1985).

(5) Social Aspects at Dandora Disposal Site

(a) Scavengers

Since the disposal site is unfenced, and according to the people interviewed, more than 500 scavengers earn for their living by operating in the site. This is an important socio-economic activity with regard to scavengers and contributes to the conservation of natural resources.

Mainly, materials recycled by scavengers are the following:

(i) Waste paper
(ii) Cardboard (boxes)
(iii) Glass
(iv) Metals

(b) Housing

The Dandora disposal site is surrounded by a densely populated area, including various schools such as:

(i) Oxics Gospel Church (informal primary school): This is located between the disposal site and the Nairobi River and has about 250 children.

(ii) NCC Primary School: This is located at the entrance of the disposal site on the main road. The School has approximately 1,000 children.

(iii) NCC Primary School: This is located near the disposal site with approximately 1,000 children.

(iv) Dandora Secondary School: This is located near the disposal site with about of 400 students.

According to the interview, some scavengers are living in the disposal site while others live in the surrounding area.

1.1.5 Legal Aspects

Laws relevant to the environment in Kenya can be found in **Section 6.1, Table 6.1.2 of Data Book (1)** and those relevant to the Study are described below:

(1) Laws Related to Water

(a) The Water Act, Cap 372
(b) Local Government Act
(c) The Public Health Act

(2) Laws Related to Air

(a) The Traffic Act, Cap 403
(b) The Penal Code, Cap 63
(c) Local Government Act

(3) Laws Related to Soil

The Law on Chemical Substances deals with the use and disposal of chemical substances.

(4) Laws Related to Public Health

(a) The Public Health Act
(b) The Factories Act-Cap 514

(5) Laws Related to Environmental Impact Assessment (EIA)

The existing laws are sectoral and are not specific for conducting EIA. However, draft guidelines are being revised for approval by the Parliament, which will be useful.

1.2 Abstraction of Problems on Environmental and Sanitary Conditions

1.2.1 General Conditions

(1) Water Supply

Currently the total population served is about 95%. The NCC supplied water although some private service is provided, particularly in Runda. The water quality supplied to Nairobi City is generally satisfactory from the point of view of physical-chemical aspects. To assess the potability of water it is necessary to consider those related to bacteriological characteristics.

(2) Sewage

Sewage treatment facilities are composed of sewers and sewage treatment plants. During the field observation it was confirmed that some parts of the sewers were blocked or damaged, permitting the leakage of sewage directly into the rivers.

In both sewage treatment plants at Dandora and Kariobangi, poor maintenance of the facilities was observed. No data related to the effluent quality were available to assess the efficiency of the treatment. An adequate sewage treatment facility can bring about an improvement of the environmental sanitation of Nairobi City and can alleviate diseases such as cholera that can have big repercussion in the public health and the country's economy.

(3) Drainage Facilities

Drainage facilities are mainly composed of open channels constructed in both sides of the road. Actually most of these facilities are blocked by solid waste dumped by the residents.

1.2.2 Environmental Problems Due to Solid Waste

(1) Water Pollution

Delays in waste collection for a long time, generates a smell of black liquid called leachate which is considered as a high polluter when it reaches watercourses due to its high concentration in BOD, COD and chemicals. During the survey piling of uncollected wastes for a long time was observed to generate leachate which pollutes the existing water courses. The leachate can also penetrate into the soil and pollutes the groundwater. In this last respect, no data were available to analyse its impact to the groundwater.

Intensive rains often hit the Nairobi urban area, causing not only flooding along riverside areas of small rivers but also traffic interruption even at main roads. This fact brings as a consequence the transfer of uncollected wastes to rivers, drains, streams and lowland areas.

(2) Air Pollution

The physical reduction of the amount of waste produced by means of burning has been established as a common practice in Nairobi City. This habit mainly can be attributable to the poor collection service given to the residents. Actually the sources of air pollution in Nairobi City are vehicular emission, factory emission and the haphazard generalised burning of wastes.

Actually, there is limited refuse collection in the central business districts of the city, and in most residential areas there is no collection. This practice brings about the scattering of waste and dust into the air, thus worsening its quality.

Around the actual solid waste disposal site located at Dandora, the major complaints given by persons interviewed were those related to smoke and smell.

(3) Landscape

Indiscriminate dumping of waste has been noted during the survey along the road sides, open spaces, places designated for recreation, near bridges, in

forest or in rivers. Actually in the urban area of the city, solid waste can be found everywhere having a high negative impact on the environment quality.

(4) Noise

Lack of solid waste disposal equipment and inadequate collection vehicles have minimised the generation of noise. This means no impact of noise on the environment.

1.2.3 Public Health Problems Due to Solid Waste

Most of the solid waste collecting points in the city do not conform to the minimum sanitary practices which should be established to upgrade the level of the public health and the environmental condition.

The uncollected refuse has potential effect on the public health, since it allows the reproduction of vectors of diseases such as cockroaches, rats, flies and mosquitoes. It also generates offensive odours. During the survey, at the Dandora disposal site and in most parts of the selected solid waste collecting points, there could be noted offensive odour, smoke and the reproduction of insects which are major carriers of diseases. Smoke is a significant respiratory irritant and can increase respiratory illness that is prevalent in Nairobi Province. The uncollected solid waste causes, not only bad sanitary condition but also health risks to the residents. Most severely affected are those located in the low income areas and slums where uncollected solid waste contributes to the high rates of disease incidence.

Around the Dandora disposal site, persons interviewed have mentioned cases of respiratory and stomach problems among children and adults due to the smoke and smell coming from the site.

2. INITIAL ENVIRONMENTAL EXAMINATION (IEE)

2.1 Background Information

One of the priority projects selected under the Master Plan for the Feasibility Study is the construction of a new landfill site. Screening and scoping were conducted by the JICA Study Team for each candidate site, and it was concluded that the Initial Environmental Examination (IEE) and Environmental Impact Assessment (EIA) are necessary to be conducted since some components of the environment could be adversely affected by the implementation of the project.

2.2 Objectives of the IEE

Prior to the study on EIA, the Initial Environmental Examination was conducted for all candidates sites as part of the Master Plan to understand the present environmental condition of the project area and to describe potential impact resulting from its implementation.

2.3 Procedure of the Examination

The Initial Environmental Examination (IEE) is conducted as part of the Master Plan to analyse the candidate places for solid waste disposal site in Nairobi. The IEE includes the analysis of the following components:

(1) Natural conditions of each candidate site
(2) Project justification
(3) Project description
(4) Potential impacts to be generated by the project

2.4 Execution of the IEE

2.4.1 Natural Conditions

(1) Candidate A (Ruai Area)

(a) General Information

The place is located at about 30 km east of Nairobi City on flat land adjacent to the Nairobi River. The place available for the disposal site is a grassland of about 20 ha., next to the actual Dandora Estate Sewage Treatment Works. The place is fenced and is owned by NCC. There are no trees in the site except the riverine vegetation (forest) on the left bank of the Nairobi River and the place currently is used for pasture of livestock. Presence of many varieties of birds that feed on the insects and fishes from the ponds of the sewage works, has been observed.

(b) Socioeconomic Condition

There is no population living near the site although it is important to mention that the Ruai area corresponds mainly to the low income area of subsistence cultivators, pasture keepers and small-scale traders.

(c) Water

The Nairobi River is next to the site and at the moment presents characteristics of pollution. A population of about 5,000 inhabitants is being served by a water supply system owned by NCC before it enters the site. The system is composed of a deep well, a reservoir and pipelines for distribution. The people served from the system have complained of brown teeth and salty taste, assuming that it is due mainly to the presence of high concentration of fluoride and calcium carbonate in the water.

(d) Air and Noise

During the survey, no air pollution or generation of noise could be noted.

(e) Landscape

The place is located on flat land adjacent to the Nairobi River.

(f) Conclusion

The sewage treatment plant can coexist with the proposed solid waste dumping site because of the available large land for a long term demand expansion and some similar characteristic of treatment. In addition, there are no significant socioeconomic activities at the site.

(2) Candidate B (Industrial Area - Kayole)

(a) General Information

The place is located at about 19.5 km from Nairobi City on a slope area adjacent to the Ngong River. The place for the disposal site of about 20 ha is composed of grassland, agricultural land and four ponds currently used for industrial wastewater treatment. The place is unfenced and is owned by the Central Government. There are no trees in the site and some parts of the place is used currently for agriculture.

(b) Socioeconomic Condition

Population living near the site is composed of one slum (Kayole Matope) and a residential complex of high rise buildings. Most of the people living in the slum are using the place for grazing and agricultural purposes, and the main plantations are for sugarcane, maize, banana and green vegetables. On the other side of the river, there are many quarries that are currently working 24 hours/day.

(c) Water

The existing surface water near the candidate site is the Ngong River that at the moment of the observation was of black colour and smell as consequence of its high pollution. Regarding drinking water, the service is provided by NCC.

(d) Air and Noise

Production of hard dust and noise has been observed from the quarries, affecting the environment of the place.

(e) Landscape

The landscape consists of flat topography that is bordered by two rivers to the West and East. The area has been transformed to a cultural landscape. The area looks like an industrial area.

(f) Conclusion

The environmental condition of the area is quite unsatisfactory because of the agricultural fields irrigated with sewage, abandoned sewage treatment facilities, unauthorized dumping of solid wastes by private firms in the site and the hard production of noise and dust from the quarries. Consequently dust, noise and disease vectors such as mosquitoes, flies and rats are a threat.

The relatively small size of the proposed site limits its use in the long-term demand expansion for solid waste disposal. However, the proposed site can be developed for short-term solid waste disposal use. To do this, mitigation measures have to be considered for a number of issues.

(3) Candidate C (Athi River Area)

(a) General Information

The place is located at about 27 km from Nairobi City on a slope area with respect to the main road. The place for the disposal site of about 20 ha is composed of grassland. The soil composition varies from sandy clay to stony within a depth of about 1.5 m, based on the observation of excavations. The place is unfenced and is owned by the private sector. There are no trees in the site and some parts of the place currently are used for soil extraction and pasture for livestock. There are no perennial rivers nearby except dry valleys and the Athi River to the East.

(b) Socioeconomic Condition

Near the place can be found some industries such as a whisky factory that has about 90 employees. The site is in close proximity to the Athi River Town with several industries. Currently in some parts of the proposed site, extraction of soil for use in the cement industry and construction has been observed. There are also a number of settlements along the Nairobi-Mombasa Road to the South.

(c) Water

The nearest existing surface water to the candidate site is the Athi River that is far, about 2 km from the site. According to interviewed people, this river receives pollution from many industries around the site. Regarding ground water quality, the whisky factory near the site is using ground water for its production process and the water taste is quite salty.

(d) Air and Noise

Low level of dust and noise has been noted from the excavation place and factories.

(e) Landscape

Some parts of the place are surrounded by hills and has an excellent view from the main road.

(f) Conclusion

In view of the limited settlements and availability of land for long term use, the site could serve as dumping site and can also be shared by NCC and Athi River Town.

(4) Candidate D (Ruiru)

(a) General Information

The place is located in a flat area at about 22 km from Nairobi City and about 3 km from the Ruiru Urban Center. The place for the disposal site of about 16 ha is grassland. The soil is largely composed of clay underlain by murmur/laterite resting on relatively hard rock closer to the surface in some areas, according to the observation on the site. The place is fenced and is owned by the private sector. The site is located in an open grassland with short trees.

(b) Socioeconomic Condition

The area is used largely for cattle ranching. A milk production industry with 400 workers, a Nicol Club and Peponi Secondary School with 200 students and 80 staff, respectively, are located in the vicinity of the site. In front of the place there is the Kenya Clay Products Factory and about one kilometer away to the Southwest there is the Kenyatta University.

(c) Water

The nearest existing surface water to the candidate site is the Kamiti River that is about one kilometer from the site. Besides the Kamiti River, there is a dry valley to the North with several dams mainly for watering domestic livestock. Some of the dams are used for irrigation. Ground water is used for institutional, industrial and domestic consumption in the area. Regarding the quality, the water taste is quite salty, assuming that it is due mainly to calcium carbonate.

(d) Air and Noise

During the survey, no air pollution or generation of noise has been noted in the proposed site area.

(e) Landscape

The place is located on flat land closer to the Thika Road, but bordered by two valleys to the South and North.

(f) Conclusion

The site could be used for waste disposal taking into account mitigation measures for landscape, water pollution, noise and air pollution. The proximity of the site to Nairobi City and the Ruiru Urban Council means that the site could be used by both urban centres for the disposal of solid waste with a view to sharing the costs.

2.4.2 Project Justification

The Dandora Disposal Site categorised as an open dumping type has a detrimental effect on public health and the environment of the surrounding area due not only to the air and water pollution but also to the associated problem of insects and animal pest. For this reason the construction of a new landfill site in a sanitary manner is highly recommendable to improve the environmental quality of the city and the level of public health of the population.

2.4.3 Project Description

The proposed project is the construction of a new landfill site to serve all urban areas of Nairobi City. This project is selected as one of the priority projects to be analysed in the feasibility stage of the Study.

The landfill site mainly consists of the following components:

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

2.4.4 Potential Impacts to be Generated by the Project

(1) Potential Negative Environmental Impacts

(a) Impacts on Surface Water Quality

Contamination of surface water can occur as polluted groundwater is discharged into it, or by surface runoff directly from the disposal site.

(b) Impacts on Groundwater Quality

Contamination of groundwater by leachate can occur under favorable hydraulic conditions, in which the leachate generated from the solid waste pass through the soil to reach finally the acquifer. Among favorable hydraulic conditions for this phenomena are the low

permeability of the soil located under the wastes, the saturation of the waste and the presence of fractures in rocks.

(c) Impacts on Soil

The soil existing under the disposal site may be contaminated by pathogenic microorganism, heavy metal, salts and other pollutants contained in the leachate from the solid waste. The soil can attenuate some contaminants depending on its characteristic such as adsorption capacity, ion exchange capacity, and porosity. When the capacity of the soil for attenuation is saturated, then leachate can go to the groundwater. Soils with high concentration of clay and organic matter are more likely to attenuate contaminants than soils consisting of sand, silt and gravel.

(d) Impacts on Air Quality

(i) Dust

The dust originating from the unloading and spreading operation at the disposal site is of the most concern. Dust can irritate the eyes and may also carry pathogenic microorganisms that might be inhaled.

(ii) Odour

Generally, there is a smell from a disposal site created by the anaerobic biodegradation of waste that releases gases as hydrogen sulfide and ammonia. Besides, the decomposition process may include toxic volatile organic such as benzene and vinyl chloride.

(iii) Smoke

At the disposal site, smoke can be generated by burning waste and this can occur underground or in the surface. Underground burning mainly emerges due to the high temperature that manages the anaerobic biodegradation process of the waste. Smoke is a significant respiratory irritant and can increase respiratory illness in the population.

(iv) Noise

<u>During Construction of the Disposal Site</u>

Equipment and tools used during the construction period are likely to emit noise disturbing the environment of surrounding living people.

During the Operation of the Facility

Equipment, vehicles and tools used during the operation of the facility also may emit noise that could incommode the residents living around the place.

During Closure of the Disposal Site

When the disposal site has completed its span life, closure procedure shall be performed with the utilisation of equipment, vehicles and tools, which as the above may emit undesirable noise.

(v) Hygiene and Sanitation

A poor operation of the disposal site can adversely impact the environment such as the breeding of harmful insects that could affect the public health of the neighborhood of the landfill site.

(vi) Gas Migration

The gas produced during the anaerobic decomposition process of the garbage in the landfill disposal site can migrate underground and be accumulated in basements of buildings located in the migration way. Landfill gas has a high concentration of methane and for this it is potentially explosive.

(vii) Social Aspects

The resettlement of inhabitants living inside the candidate site or who are using the site for their economic activities should be considered carefully to minimize concerned impacts. On the other hand, similar attention should be paid to scavengers who are working at the existing disposal site.

(viii) Landscape

Depending on the location of the disposal site, visual changes on the landscape may be noted by residents living around the place.

(2) Potential Positive Environmental Impacts

The new disposal site for solid waste of Nairobi City is proposed to be constructed utilising the method of sanitary landfill where the components influencing public health and the environment are eliminated or minimized as follows:

(a) Elimination or decrease of disease vectors (e.g., flies, rats, cockroaches), which are popular when garbage is open dumped.

(b) Minimisation of water, soil and air pollution, permitting an increase in the public health level of the population and a better quality of the environment.

3. ADDITIONAL STUDIES

3.1 Hospital and Industrial Wastes

3.1.1 Study on the Present Hospital Waste Management

(1) Introduction

(a) Definition of Terms

In this study, Hospital Waste is defined as waste produced in conjunction with the activities at medical institutions.

(b) Categories of Waste Generated at Hospitals and Health Care Facilities

At hospitals and health care facilities can be generated three kinds of wastes: clinical waste, infectious waste and general waste. The composition of each type is described below.

(i) Clinical Waste

- Ash
- Sludge
- Waste oil
- Waste acid
- Waste alkali
- Waste plastics
- Waste pieces of glass and ceramics
- Waste pieces of metal
- Waste pieces of rubber

(ii) Infectious Waste

- Blood and other body fluids
- Pathogenic waste produced by operations: organ, tissue
- Sharps adhered bloods
- Waste in the laboratories which deals with pathogens
- Other waste adhered blood

(iii) General Waste

- Food remains
- Paper
- Other wastes categorised as domestic waste

(2) Objective

The survey on hospital waste was conducted during the first field work in Nairobi City in order to understand the existing management system and identify and recommend possible countermeasures to improve the handling of these wastes from the generation points to the disposal site.

(3) Survey Methodology

The survey based on a rapid diagnosis analysis was composed of the followwing:

(a) On site inspection of the facilities
(b) By means of questionnaire
(c) Direct interview to persons working at the facilities

(4) Selection of Hospitals to be Surveyed

According to the hospital size (large, medium and small), the following hospitals were selected for the survey:

(a) Kenyatta National Hospital
(b) Mathare Mental Hospital
(c) Pumwani Maternity Hospital
(d) Mbagathi District Hospital
(e) Mater Misericordiae Hospital
(f) M.P. Shah Hospital
(g) Gertrudes Hospital
(h) Westlands Cottage Hospital
(i) Alice Nursing Home
(j) Nairobi West Hospital
(k) Coptic N Home Hospital
(l) Masaba Hospital
(m) Aga Khan Hospital
(n) Jamaa Home & Maternity Hospital
(o) Guru Nanak Ramgarhina Sikh Hospital
(p) St. James Medical Centre Ltd.
(q) Nairobi Hospital

From this number, 10 hospitals as listed below had responded to the questionnaire and on these hospitals more detailed analysis was conducted. The list of these hospitals is as follows:

(a) Large Sized Hospitals

(i) Kenyatta National Hospital
(ii) Mathare Mental Hospital

(b) Medium Sized Hospitals

(i) Pumwani Maternity Hospital
(ii) Mbagathi District Hospital
(iii) Mater Misericordiae
(iv) M. P. Shah Hospital

(c) Small Sized Hospitals

(i) Gertrudes Hospital
(ii) Westlands Cottage Hospital
(iii) Alice Nursing Home
(iv) Nairobi West Hospital

The questionnaire results are summarised in the following **Table F.3-1**.

Table F.3-1 Summary of Questionnaire Results on Hospital Waste

Name of Hospital	No. of Staff	No. of Beds	Average No. of Visitors per Day	Hospital Wastes in Kg per Day						Total (kg)	Volume of Stockyard for waste (m^3)	Treatment System (Yes/No)	Waste Collected By	Cost of Waste Disposal per month (Kshs)
				Clinical	(%)	Infec-tious	(%)	General	(%)					
Kenyatta National Hospital	4285	2000	20000	900	11%	50	1%	7000	88%	7950	1300	Yes (Incinerator)	Hospital	816900
Mathare Mental Hospital	-	1100	550	80	29%	0	0%	200	71%	280	1800	No	NCC	-
Average (Large)	-	**1550**	**10275**	**490**	**12%**	**50**	**1%**	**3600**	**87%**	**4115**	**1550**	-	-	-
Pumwani Maternity Hospital	600	360	65	50	12%	200	46%	180	42%	430	17	Yes (Incinerator out of order)	NCC	400
Mbagathi District Hospital	450	200	250	-	-	-	-	-	-	-	-	No	NCC	-
Mater Misericordiae	489	160	500	10	26%	6	16%	22	58%	38	-	Yes (Incinerator)	Private	10000
M.P. Shah Hospital	-	106	300	5	6%	19	22%	63	72%	87	30	Yes (Incinerator)	NCC	-
Average (Midium)	-	**206.5**	**278.7**	-	-	-	-	-	-	-	-	-	-	-
Gertrudes Hospital	328	80	200	-	-	-	-	-	-	-	4	Yes (Incinerator)	Private/ NCC	5000
Westlands Cottage Hospital	48	90	60	-	-	-	-	-	-	-	-	Yes (not specified)	Hospital	-
Alice Nursing Home	30	9	10	-	-	3	-	5	-	-	-	No	Private/ NCC	5000
Nairobi West Hospital	110	70	55	30	48%	12	19%	21	33%	63	-	Yes (not specified)	NCC	-
Average (Small)	-	**62.25**	**81.25**	-	-	-	-	-	-	-	-	-	-	-

(5) Major Findings

Significant points are the following:

(a) Large Sized Hospitals

Regarding large hospitals, the Kenyatta National Hospital manages waste by itself utilising an incinerator for clinical waste and macerator for placentas. However, other infectious waste, paper waste and food remains are disposed of at the NCC disposal site.

On the other hand, the Mathare Mental Hospital has no facility for solid waste treatment and the waste produced is collected by NCC and disposed of directly without any treatment at the disposal site. Accumulation of waste awaiting collection was indicated as one of the major items that affect the environment of the place.

In each hospital there is a stockyard for waste with an average volume of about 1,550 m^3.

The number of beds in these hospitals ranges from 1,100 to 2,000. The charge paid by these hospitals for solid waste disposal is about of 3.4 Kshs/kg.

(b) Medium Sized Hospitals

Three out of the four hospitals selected for the survey have their own incinerators to treat clinical wastes, although one incinerator in one hospital is out of order due to the lack of maintenance. Incinerators are used to burn clinical and infectious waste to some extent, while the remaining waste or those completely untreated are collected and disposed of by NCC or a private company.

Inefficiency in the collection of hospital wastes have been expressed by some respondents to the questionnaire although one respondent had indicated that NCC even without working tools is very effective on the site but under supervision.

Two hospitals have their own stockyard for waste with a volume of about 17 and 30 m^3, respectively.

The number of beds in these hospitals ranges from 106 to 360. The charge paid by these hospitals for solid waste disposal ranges between 0.03 - 9 Kshs/kg.

(c) Small Sized Hospitals

The existence of only one incinerator has been confirmed by analyzing the questionnaire of four hospitals. The number of beds in these hospitals is ranging from 9 to 90.

NCC or private companies provide the services of collection and disposal although in one hospital the waste is managed by itself.

Some of the respondents to the questionnaire have indicated that NCC is not efficient in providing waste collection and disposal services.

According to the questionnaire, one hospital has its own stockyard for waste of about 4 m^3 while another hospital utilises drums to store the waste.

Not enough information was given on quantity of waste generated so that the charge paid for solid waste disposal could not be estimated.

3.1.2 Study on the Present Industrial Waste Management

(1) Introduction

The city economy is solidly based on an eastern industrial area. This medium/light industrial base includes car assembly, beer brewing, production of paints and rubber for cars, domestic sets manufacture, foodstuff industries, press, packing and pharmaceuticals.

(2) Objective

The survey on industrial waste was conducted during the first field work in Nairobi City to understand the existing management system and identify and recommend possible countermeasures to improve the handling of these wastes from the generation points to the disposal site.

(3) Survey Methodology

The survey based on a rapid diagnosis analysis was conducted by questionnaire and direct interview to people in charge of the industries.

(4) Selection of Industries to be Surveyed

The following 16 industries were randomly selected for the survey, considering their sizes which were estimated according to the number of employees in small, medium and large factories:

(a) Aziz Din Tannery Ltd.
(b) Mareba Enterprises Ltd.
(c) Plastic & Rubber Industries
(d) Polythene Industries
(e) Kenya Cold Storage
(f) Vacu-lug Rubber Industries Ltd.
(g) Galsheet (K) Ltd.
(h) Smith Kline Beecham
(i) Firestone East Africa Ltd.
(j) Sunflag Spinning Mills (EA) Ltd.
(k) House of Manji

(l) East African Industries
(m) BAT Ltd.
(n) Impala Glass Mart
(o) Kenya Cooperative Creameries Ltd.
(p) Timsales Ltd.

From this number, the following 10 industries had responded to the questionnaire and on these industries more detailed analysis were conducted:

(a) **Small Industries**

(i) Aziz Din Tannery Ltd.
(ii) Mareba Enterprises Ltd.
(iii) Plastic & Rubber Industries

(b) **Medium Industries**

(i) Polythene Industries
(ii) Kenya Cold Storage
(iii) Vacu-lug Rubber Industries Ltd.
(iv) Galsheet (K) Ltd.
(v) Smith Kline Beecham

(c) **Large Industries**

(i) Firestone East Africa Ltd.
(ii) Sunflag Spinning Mills (EA) Ltd.

The questionnaire results are summarised in **Table F.3-2** below.

Table F.3-2 Summary of Questionnaire Results on Industrial Waste

Name of Factory	No. of Staff	Product	Nature of Waste	Production in kg/day	Waste in kg/day	Treatment System	Waste Collected By	Cost of Waste Disposal per Month (Kshs)
Aziz Din Tannery	20	Vegetable tanned leather, vegetable lining leather, Upper finishing leather	-	1600	500	No	NCC	2000
Mareba Enterprises	42	Concrete roof tiles, concrete ridges, fencing posts	-	-	-	No	Factory	-
Plastic & Rubber Industries	80	Moulded & extruded rubber products	-	1200	60	No	NCC	-
Polythene Industries	110	Polythene sheeting, tubing, bags	Polythene	-	10	Open burning	Factory	-
Kenya Cold Storage	150	Meat, fish, poultry, seafoods, green grocery	Polythene, waste paper	-	-	Open burning	Factory	10000
Vaculug Rubber Industries	170	-	Rubber waste	-	500	No	Private	-

Table F.3-2 Summary of Questionnaire Results on Industrial Waste (Cont'd)

Name of Factory	No. of Staff	Product	Nature of Waste	Production in kg/day	Waste in kg/day	Treatment System	Waste Collected By	Cost of Waste Disposal per Month (Kshs)
Galsheet	250	Galvanised iron sheets	Paper, iron scrap, zinc skimming flux	120000	-	Open burning & recycling	Factory	5000
Smith Kline Beecham	300	Pharmaceutical products, nutritionals, powders	Polythene paper, grass, waste foodstuff	-	6100	No	Private	10000
Firestone	730	Tires, Tubes	Textile fabric, rubber, steel wire, Polythene paper, paper, dust, wooden crates, metals	-	5220	No	Private	-
Sunflag spinning	760	Yarn, fabric suiting, bed sheeting, shirting	-	4900	-	Recycling	NCC	2400

(5) Major Findings

Significant points are the following:

(a) Some industries make recycling of their wastes by themselves. Some of these recycled waste are used as raw materials for making products of lesser quality and others are sold to other companies.

(b) Most of the respondents to the questionnaire have indicated that NCC services are very poor.

(c) Categories of waste generated at the selected industries are both organic and inorganic and two of them are sources of chemical wastes that need special care in order to protect public health and the environment.

(d) Sixty percent (60%) of the factories surveyed have their own stockyard for waste.

(e) There is no factory having solid waste treatment system, while in some factories open burning of waste is very common.

(f) According to the respondents, the new landfill site should be located at a distance of 20-40 km from the city centre.

(g) The waste collection is provided by NCC (30%), private company (30%), themselves (40%).

(h) The charge paid by factories for solid waste disposal ranges from 0.05-0.13 Kshs/kg.

3.1.3 General Recommendation for the Improvement of Hospital and Industrial Waste Management

(1) Hospital Waste

(a) Laws and Regulations

Since there are no legislation or regulations on hospital waste in Kenya, they should be formulated and implemented as soon as possible for use as the first tool into the process of establishment of hospital waste management in Nairobi City.

(b) Policy on Hospital Waste Management

Policy should be given by concerned authorities for the establishment of a differential service for collection, transportation and disposal of hospital waste in Nairobi City.

(c) Treatment System at Hospitals

The obligatory use of incinerator for clinical and infectious waste treatment should be applied in all hospitals regardless of their size. This means that only the ash should be collected from hospitals and disposed of at a designated area for hospital waste.

(d) Education on Hospital Waste Handling

Education on how to deal with hospital waste should be given to all medical staff (doctors, nurses, cleaners, etc.) and to people engaged in the collection, transportation and disposal, because all of them potentially handle infectious or dangerous waste. The elaboration of a Hospital Waste Treatment Manual by the concerned authorities would be substantially beneficial.

(e) Segregation

The first thing that must be done for source reduction is to avoid mixing wastes. A mixture of a small amount of clinical or infectious waste with a larger amount of general waste creates a large amount of material that must be treated as a clinical and/or infectious waste. Another basic rule is not to make waste liquid if dry. Housekeeping operations as simple as sweeping prior to washing floors can substantially reduce waste volume and perhaps it is the simplest and most inexpensive method for reducing hospital waste at source.

In conclusion, segregation practice is highly recommendable to be applied in all hospitals of Nairobi City because it permits treating smaller quantities of waste.

(2) Industrial Waste

(a) Laws and Regulations

Since there are no laws or standards on the management or regulation of industrial waste in Kenya, they should be formulated and implemented for use in the improvement of industrial waste management in Nairobi City. The legislation should include some economic incentive system for the industries in order to minimise the production of industrial waste and to promote the use of pollution control equipment.

In the elaboration of laws, regulations and standards related to industrial waste management, the necessary coordination between NCC and the Government should be established by clearly defining the roles of each organisation concerned in order to avoid duplication of activities or conflicts at the time of enforcement of the legislation.

(b) Industrial Inventory

An inventory should be conducted to cover all industries located in Nairobi City to identify the real needs of treatment, collection and disposal of wastes. Each industry should submit to NCC information on the characteristics and amount of industrial waste that generates for use in the preparation of an appropriate industrial waste management system.

(c) Recycling

NCC should promote recycling activities at all industries, starting with those industries that are heavier producers of waste. All industries should be required to plan the utilisation of the recyclable materials and to increase the means for their use.

(d) Treatment System

The characteristics of solid industrial waste are so variable that it is necessary to find out the best treatment and final disposal alternatives from a technical and economic point of view. Basic treatment methods needed for industrial waste are:

(i) chemical treatment (such as neutralisation, oxidation and reduction);

(ii) thermal treatment (such as incineration); and

(iii) disposal.

Secure landfill is still the cheapest way of disposal and for this it is very important to control its use; besides, to extend its life span it is necessary to promote the minimisation of waste generated at the source.

The execution of an Environmental Impact Assessment is highly advisable prior to the construction of an industrial waste disposal site.

(e) Hazardous Industrial Waste

Some industrial wastes are of such hazardous nature that they are very likely to do harm to the living environment when used for land reclamation without any processing. Within this category are industrial wastes that contain mercury, cadmium, lead, hexavalent chromium, arsenic, etc., which should have a special treatment for disposal.

Disposal of these industrial wastes should be entrusted only to agents with a permit for disposal of hazardous industrial waste.

(f) Necessity of Cooperation from Enterprises

Enterprises such as manufacturers and distributors should make a self-assessment on product disposability and should develop processes that would enable the treatment of industrial waste at generation source. It is necessary that enterprises examine the raw materials they use and take the necessary steps that would mitigate environmental pollution caused by their waste.

Enterprises should make efforts to cooperate with the national government and NCC to ensure appropriate waste treatment.

3.2 Environmental Justification for the Closure of Dandora Dumpsite

3.2.1 Introduction

The Kenyan authorities concerned had requested the JICA Study Team a Justification Report to close down the existing garbage disposal site at Dandora. The Study Team had accepted this request and instructed the same local consultant for EIA to carry out the study.

3.2.2 Procedure of the Study to Justify the Closure

The study was carried out by the local consultant under the supervision of the JICA Study Team based on the prepared Terms of Reference and taking into account the existing laws and regulations related to environment in Kenya and the international standards.

The Terms of Reference has been prepared with respect to the findings during the First Field Work which was conducted during the Master Plan Phase. The Terms of Reference can be found in **Subsection 6.2.1 of the Data Book (1)**.

3.2.3 Execution of the Study

To know the components of the environment affected by the disposal site, surveys on the present condition of the natural and social environments were made by the consultant.

(1) General Information

The study to justify the closure of Dandora Disposal Site was carried out by Billtech Environmental Consultants Ltd. under the supervision of the JICA Study Team. The study was conducted to become aware of the present conditions and it consisted of the analysis of natural and social environment of the area. The analytical data and information obtained from the study is to be used to prepare the approach to the environmental management plan as well as the monitoring plan for the closing of the site.

There was a heavy rain during the field study attributed to the El Niño phenomenon currently being experienced in Kenya. However, the rain did not hamper the field operations.

As for the natural environment study, sampling points were selected taking into account existing resources, facilities and representative places of the site for environmental analysis, i.e., river, well, soil, etc. The laboratory owned by the Kenyatta University conducted the analysis of water while the laboratory owned by the University of Nairobi (Nuclear Science Institute) conducted the analysis of soil. Offensive odour survey was surveyed in-situ by the Consultant.

As for water analysis, immediately after the in-situ examination was carried out for specific items, the samples were taken to the laboratory in a sealed container. At the same time, the social environment study was conducted by means of questionnaire and direct interview to the people living around the site. Besides, public awareness survey was conducted on the people to evaluate their willingness to cooperate for a better management of solid waste and also to measure public concern about the improvement of sanitary environment.

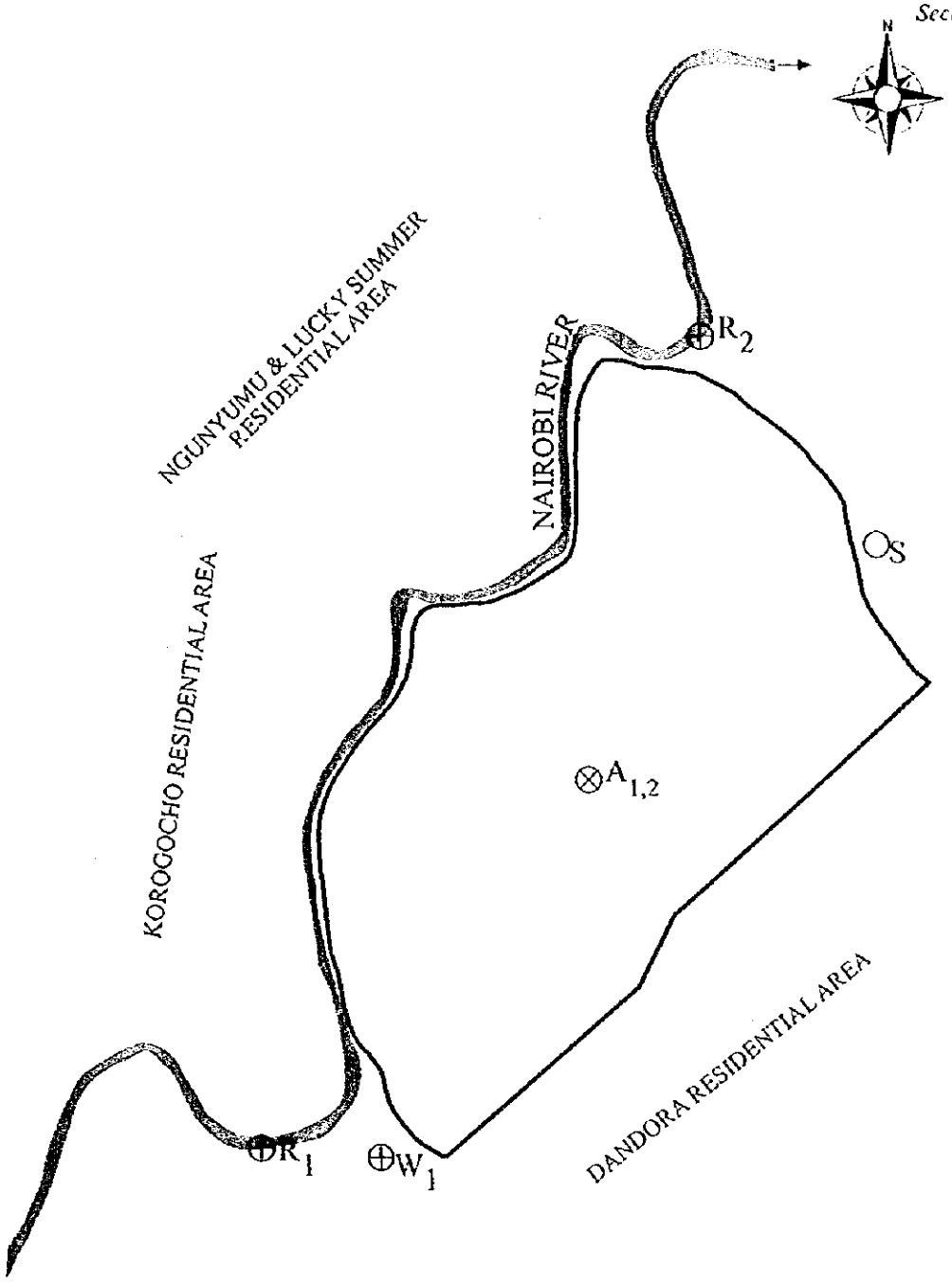
Based on the study on the present conditions, further study was carried out to know the impacts occasioned by the Dandora Disposal Site on the surrounding environment. Finally, the environmental management and environmental monitoring plans were prepared to implement the closure and post-closure activities at the site.

(2) Natural Environment of Dandora Disposal Site

Locations of sampling points for the survey are as shown in **Figure F.3-1**

(a) Surface Water

Samples were collected at the upstream and downstream of the dumpsite from Nairobi River. The results are presented in the **Table F.3-3**.



$\otimes A_{1,2}$	AIR QUALITY MEASUREMENTS
$\oplus R_1$	NAIROBI RIVER WATER QUALITY SAMPLING UPSTREAM
$\oplus R_2$	NAIROBI RIVER WATER QUALITY SAMPLING DOWNSTREAM
$\oplus W_1$	GROUND WATER QUALITY SAMPLING
$\bigcirc S$	SOIL SAMPLING
——	DANDORA DISPOSAL SITE BOUNDARY
	RIVER

Figure F.3-1 Locations of Sampling Points for Environmental Survey at Dandora Disposal Site Area

Table F.3-3 Water Quality Analysis of Nairobi River in Dandora Area

Parameter	Water Quality Standard (1)*	Unit	Sampling Point (2)*	
			R1	R2
pH	6.0-8.5		7.8	7.6
Temperature	-	°C	24.6	22.5
DO	>2	mg/l	1.9	5.8
BOD	<10	mg/l	67	55
COD	-	mg/l	474.8	262.8

Legend:
(1)* : Japanese Standard Category E applied for environmental conservation and industrial use of rivers
(2)* : Sampling conducted on Nov. 21, 1997
R1 : River sampling upstream of the disposal site
R2 : River sampling downstream of the disposal site
- : No fixed value

(b) Groundwater

The groundwater sample was taken from the already existing borehole near the dumpsite. This borehole had been abandoned many years ago and its depth is about of 100 m. The table below shows the results of the analysis.

Table F.3-4 Water Quality Analysis of Groundwater in Dandora Area

Parameter	Water Quality Criteria (1)*	Unit	Sampling Point (2)*
			W1
Pb	0.05	mg/l	<0.002
Cr	0.05	mg/l	<0.002
Cu	0.1	mg/l	<0.002
Fe	0.3	mg/l	0.25
Mn	0.1	mg/l	<0.05
Zn	5.0	mg/l	<0.02
Hg	0.001	mg/l	<0.02
As	0.05	mg/l	<0.01
Temperature		°C	-
pH	6.5-8.5		7.5
Permanganate	-	mg/l	6.5
Nitrate as NO_3	45	mg/l	0.75
Nitrite as NO_2	0.01	mg/l	0.014
NH_3	0.5	mg/l	0.1
TN exclusive (NO_3)	1.0	mg/l	9.1

Legend:
(1)* : Criteria developed by NCC for drinking water
(2)* Sampling conducted on Nov. 25, 1997
- : No fixed value
W1 : 150 m from Dandora Police Post

(c) Soil Pollution

The soil sample was taken from one meter below the surface at the disposal site and then was analysed to know the state of soil pollution by heavy metals. The results are presented in the table below.

Table F.3-5 Soil Pollution Analysis at Dandora Disposal Site

Parameter	Unit	Value
Cr	µg/g	328
Mn	µg/g	2.81
Fe	µg/g	13.3
Cu	µg/g	12.3
Zn	µg/g	87.8
Hg	µg/g	<10.0
Pb	µg/g	71.1

(d) Offensive Odour

As to the offensive odour survey, two parameters were checked in-situ in two opportunities. Results of the analysis are presented in the table below.

Table F.3-6 Offensive Odour Survey at Dandora Disposal Site

Parameter	Standard*	Unit	Value	
			Dec. 18 '97	Dec. 19 '97
H_2S	0.06-0.2 **	ppm	< 0.2	< 0.2
NH_3	1.0-2.0 ***	ppm	< 2	< 2

Legend:
* Japanese Offensive Odour Control Law
** Value applied for industrial area
*** Value applied on boundary line

(e) Landscape

The landscape mainly consists of heaps of garbage interspersed with vegetation such as grass and shrubs. Human scavengers as well as scavenger birds (mainly marabou storks) are common in the place.

(f) Fauna and Flora

This survey was undertaken by walking throughout the area to identify the major species. Species diversity and density was very low.

Most of the vegetation was found at the river valley bottom where dumping was not as much as the flat ground at the top of the valley. Most plant species were invaders or disturbance species, with herbs being the most common. Along the river, herbs and patches of farms of maize, beans, bananas and sugarcane were observed.

As regard animals in the site, only a few stray dogs and marabou storks were found. Flies and mosquitoes were also very common at the site.

(3) Social Environmental Aspects of Dandora Disposal Site

Questionnaire and direct interview to people living around the site was conducted this survey. The survey result is summarised as follows:

(a) Analysis of Population Affected by the Dump

Interviews were conducted on 56 households from Dandora, Kariobangi, Korogocho and Lucky Summer states. The households were selected using random sampling and the major findings are given below. The social and public awareness data is presented in **Subsection 6.2.2 of Data Book (1).**

(i) Manner of Subsistence

Self-employment ratio in Dandora Estate occupies 59.3% of a sample of 56 respondents and the major type of business of these self-employed people is shop-keeping. Employment ratio was analysed on a sample of 25 respondents and 81.8% of these are employed by private firms and 9.1% by public establishments.

(ii) Income Level

In Dandora Estate, 81.5% of the 56 respondents earn less than Kshs. 5,000 and 11.1% between Kshs. 5,000 and Kshs. 10,000.

(iii) Education

In Dandora Estate, 37% of the 56 respondents have primary level of education and the same figure have secondary level of education.

In terms of post-secondary level of education, the percentages are 7.5% for Dandora Estate and 44.4% for Lucky Summer. Thus, the population around the site is well educated and can comprehend the basic advantages of a proper solid waste management. This situation makes it easier to create awareness and participation among the people.

(iv) Age Structure of the Population and Composition

The age structure of the population around the Dandora Disposal Site is as follows:

Table F.3-7 Age Structure of the Population around Dandora Disposal Site

Site	Age					
	<20 years	20-29 years	30-39 years	40-49 years	50-59 years	>60 years
Dandora	3.7%	37%	33.3%	18.5%	7.5%	0%
Kariobangi	0%	33.3%	33.3%	33.4%	0%	0%
Korogocho	0%	9.1%	36.4%	27.3%	18.2%	9%
Lucky Summer	0%	44.4%	44.4%	11.2%	0%	0%

According to the sampling survey, the population around the dumpsite is mainly in the 20-49 age group which is considered as economically active age group and is composed by about 61% (Male) and 39% (Female). The population is largely married and Christians and the major ethnic group is Kikuyu.

(v) Housing

Housing ownership and permanent structure are as follows:

Table F.3-8 Housing Ownership and Permanent Structure

Site	Housing Condition	
	Ownership	Permanent Structure
Dandora Estate	18.5%	77%
Korogocho Area	18.2%	36.4%
Lucky Summer	0%	100%

(vi) Health Condition

According to the survey, the types of illness in the area range from malaria, cholera, dysentery and respiratory infections to typhoid. Most of the 56 respondents said they were aware of the health hazards due to poor disposal of solid waste (92.6% in Dandora, 100% in Kariobangi, 100% in Korogocho and 77.8% in Lucky Summer).

(vii) Sanitation

The percentage of respondents according to sanitation condition or practices in the area is summarised below:

Water Sources

The area surrounding the dumpsite is well covered by the NCC Water and Sewerage services as indicated in the table below.

Table F.3-9 Sources of Water Around Dandora Disposal Site

Water Sources	Dandora Estate	Kariobangi	Korogocho	Lucky Summer
Household Tap	70.4%	66.7%	27.3%	88.9%
Public Tap	18.5%	33.3%	63.6%	11.1%
River	3.7%	0.0%	0.0%	0.0%
Dam	0.0%	0.0%	9.1%	0.0%
Others	7.4%	0.0%	0.0%	0.0%

Sewage Disposal Method

Sewage disposal around the Dandora Disposal Site is as follows:

Table F.3-10 Sewage Disposal Method Around Dandora Disposal Site

Method	Dandora Estate	Kariobangi	Korogocho	Lucky Summer
NCC Sewer	70.4%	66.7%	27.3%	88.9
Septic Tank	18.5%	33.3%	63.6%	11.1
Pit Latrine	3.7%	0.0%	0.0%	0.0%
Open Ground	0.0%	0.0%	9.1%	0.0%

Garbage Disposal Method

Most respondents reported that they dump their waste. The area is very poorly served by the NCC collection service as shown in the table below.

Table F.3-11 Garbage Disposal Method Around Dandora Disposal Site

Method	Dandora Estate	Kariobangi	Korogocho	Lucky Summer
NCC Collection	7.4%	22.2%	0.0%	11.1%
Burning	11.1%	0.0%	18.2%	0.0%
Recycling	0.0%	0.0%	9.1%	0.0%
Composting	0.0%	0.0%	27.3%	33.3%
Dumping	77.8%	77.8%	45.4%	55.6%
Private Collector	3.7%	0.0%	0.0%	0.0%

Types of Pollution

According to the survey, air pollution was considered to be of most significance by respondents in the area as indicated in the table below.

Table F.3-12 Types of Pollution Around Dandora Disposal Site

Type of Pollution	Dandora Estate	Kariobangi	Korogocho	Lucky Summer
Air	85.2%	44.4%	90.9%	88.9%
Water	0.0%	22.2%	0.0%	0.0%
Noise	14.8%	33.4%	0.0%	0.0%
Others	0.0%	0.0%	9.1%	11.1%

(b) Public Awareness

The analysis was done through a questionnaire administered to heads of households in various areas of Nairobi. The major findings are summarised below.

(i) Necessity of New Disposal Site

According to the survey, a low percentage of respondents in Dandora, Korogocho and Lucky Summer said that a garbage disposal site is very important. This can be attributed to the lack of knowledge on the types of landfill currently practiced in the solid waste management (SWM) sector.

The highest percentage of respondents reporting "very important" came from Kariobangi (77.8%).

(ii) Environmental Degradation in Nairobi

The extent of environmental degradation in Nairobi was also asked and 89.2% said "very much" and only 1.8% said "very little".

(iii) Willingness to Participate in the SWM Improvement for Nairobi City

Nairobi residents are willing to participate in SWM improvement even to the extent of payment for an improved service. The majority of respondents in the survey are willing to pay; i.e., 74.1% in Dandora, 77.8% in Kariobangi, 63.6% in Kogorocho and 77.8% in Lucky Summer.

(4) Negative Impacts of Dandora Disposal Site on the Environment

(a) Negative Impacts on the Natural Environment

(i) Air Pollution

Presently refuse disposal is by the open dumping method. Strong winds and birds scatter the refuse and strong odour spreads in the neighborhood. From the field survey no offensive gases were detected but this fact does not mean that there is no generation of

gases whose concentration levels in the environment depend on climatic condition.

Burning of garbage at the dump is usually practiced causing air pollution that can increase respiratory illness in the area. During the first stage of the master plan study the major complaints given by people living around the dumpsite were offensive odour and smoke.

(ii) Water Pollution

During the survey period, there was too much rain due to El Niño phenomena resulting in a considerable dilution of the water of Nairobi River. The water quality data collected by the survey cannot be used for environmental assessment since it do not represent the existing condition of the river in the disposal site area. In this regard more extensive survey is necessary to be made. Definitely it is assumed that there is pollution of Nairobi River due to leachate.

As regard groundwater pollution, the current water quality of one borehole near the dump seemed to be not yet influenced by the dump and this can be attributed to the soil property underlying the site.

(iii) Soil pollution

From the analysis result it was demonstrated that the soil underlying the site is impacted mainly by chromium and lead.

(b) Negative Impacts on the Social Environment

(i) Housing

The disposal site is surrounded by a densely populated area including various schools. During the survey a high percentage of respondents in the area have houses of permanent structure and air pollution was considered as the most significant.

(ii) Public Health

According to the survey, the types of illness in the area range from malaria, cholera, dysentery, and respiratory infections to typhoid. The dump unsanitary condition constitutes breeding grounds for many vectors of diseases. According to the survey there is a high level of awareness of the people in relation to the health hazards occasioned by a poor solid waste disposal, therefore, they can accept and cooperate with the closure of the dump.

(5) Predictable Impacts, Assessment and Mitigation Measures for Closure of Dandora Disposal Site

Impact prediction is based on all activities relating to the closure implementation. Considering that the dumpsite will be closed, this fact will contribute in a positive way to the improvement of the environment and the public health of the surrounding population. Nevertheless some adverse impacts can also be predicted and proper mitigation measures should be taken to protect or minimise negative effects accordingly. In this study, potential impacts were predicted and their significance were also assessed during the closure and post-closure phases in three levels; namely, high impact, moderate impact and low impact.

The forecasting results were assessed by comparing them with values specified in standards used as assessment targets. The standards used in this study as presented in **Section 9.3 of the Data Book (1)** include the following:

(a) WHO Guidelines for Drinking Water Quality
(b) NCC Drinking Water Quality Criteria
(c) Japanese Water Quality Standards
(d) Japanese Offensive Odour Control Law
(e) WHO Noise Specification

The predictable negative impacts, assessment and mitigation measures are as described below.

(a) Negative Impacts on Natural Environment, Assessment and Mitigation Measures

The generation of offensive odour is a predictable impact of high significance at the site especially during construction of the ring drains and accommodation of the garbage at the disposal site. This impact shall be mitigated by proper management of the closure and provision of air masks to workers. The public should be informed about the implementation of the closure to get the cooperation and understanding.

The survey on water quality of Nairobi River was conducted during a heavy rainfall period associated with El Niño phenomena and, therefore, pollutant concentrations had been significantly diluted. Water pollution of Nairobi River is assessed as a negative impact although it is determined to be low in significance during the closure and after closure stages. The adverse impact shall be controllable with a proper management of the works and the provision of drains with sediment traps.

Dust and exhaust fumes from vehicles and equipment are predicted impacts of moderate significance on the workers and surrounding communities. Exhaust fumes from vehicles shall be controlled with the proper maintenance of trucks and equipment. For the dust control, watering may be required for access road and operational places during

the closure stage, especially in the dry season. During the closure stage, air masks and protective clothing to workers shall be provided. It is also important to cover soil materials transported to the disposal site.

Noise generation is expected during the closure. This impact assessed as impact of moderate significance is likely to affect the workers and people living near the site. In order to mitigate this impact, 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). In this last regard the provision of ear muffs is desirable.

Gas migration is predictable impact of moderate significance due to the proximity of the dumpsite to the residential area and it is unlikely to affect the surrounding area for a long time. To mitigate this impact it is necessary to install a gas control system and to avoid building construction near the site at least until gas generation has ceased.

(b) Impacts on Social Environment, Assessment and Mitigation Measures

(i) Negative Impacts

After closure of the dumpsite, many scavengers currently working at the site will be jobless. The Nairobi City Council or the government can accommodate these people to work at the new disposal site or in other business establishments.

The increase of vehicles due to closure work can be considered of low impact in the current traffic. The selection of the nearest source for necessary materials is recommended in order not to increase the current traffic jam of Nairobi City.

(ii) Positive Impacts

The following positive impacts may be also considered:

- The closure of Dandora Disposal Site will improve the health and environmental condition of the surrounding population.

Predictable negative impacts, assessment and mitigation measures for the closure of Dandora Disposal Site are summarised in **Table F.3-13** below.

Table F.3-13 Predictable Negative Impacts, Assessment and Mitigation Measures for the Closure of Dandora Disposal Site

Predictable Impacts	Impact Stage	Significance	Mitigation Measure
Offensive odour	CL	High	• Proper management of construction of drains and works for garbage accommodation. • Provision of air masks to workers.
Water Pollution of Nairobi River	CL	Low	• Provision of drains with sediment traps. • Proper management of construction.
	PCL	Low	• Maintenance of drains in operation after closure stage.
Dust, exhaust fumes from vehicles and equipment	CL	Moderate	• Watering of access road and operational places • Covering of soil materials with sheet. • Provision of mask and protective clothing to operators. • Proper maintenance of vehicle/equipment.
Noise	CL	Moderate (landfill site and surrounding area)	• Work schedule informed to the public and operation of heavy equipment limited to daytime only. • Adequate maintenance of equipment and trucks which must have exhaust mufflers. • Provision of ear muffs to workers.
Gas Migration	PCL	Moderate	• Avoidance of building construction near the site for a long time. • Installation of gas control system.
Traffic		Low	• Selection of nearest source for necessary materials.
Scavengers	PCL	High	• Accommodation by NCC or the Government of scavengers to work at the new disposal site or in other business establishments.

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

(6) Environmental Management Plan for Closure of Dandora Disposal Site

The preparation of an environmental management plan for the closure of Dandora Disposal Site is based on predictable impacts and mitigation measures. Managing item is specified for the closure and post-closure stages, describing impact sources, measuring standards, management approach and management location. The environmental management plan is shown in **Table F.3-14.**

(a) Closure Stage

Nairobi River can be protected from adverse effects by means of proper management of the construction of drains and landfiling works in an effort not to worsen its present condition. Noise, dust and traffic congestion are controllable to some extent by adjusting working hours and the number or speed of mobilised vehicles.

(b) Post-closure Stage

NCC should be responsible for controlling negative impacts appropriately using the environmental management plan.

Table F.3-14 Environmental Management Plan for the Closure of Dandora Disposal Site

Management Item	Source of Impact	Measuring Standard of Impact	Management Approach	Management Location
Closure Stage				
Offensive Odour	• All civil works of the closure	• People's complaints	• Proper management of the works • Provision of air masks to workers	• Area surrounding dumpsite • Dumpsite
Water Pollution of Nairobi River	• All civil works of the closure	• No surface runoff and soil erosion from the dumpsite	• Avoidance of spill of soil into river • Provision of ring drain around dumpsite	• Dumpsite
Dust, Exhaust Fumes from Vehicles and Equipment	• Mobilization of equipment and vehicles • Civil works	• People's complaints	• Covering soil materials with sheet • Road watering • Control of number or speed of vehicles/ equipment • Provision of masks and proper clothing to operators • Proper maintenance of vehicles and equipment	• Dumpsite • 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 • Provision of ear muffs to workers	• Access and main roads • Dumpsite
Traffic	• Mobilization of equipment	• Traffic congestion frequency/ duration	• Effort to minimize traffic jam by selection of nearest source for necessary materials • Adjustment of working time	• Dumpsite • Access and main roads
Post-Closure Stage				
Water Pollution of Nairobi River	• Soil erosion	• No surface runoff and soil erosion from the dumpsite	• Proper maintenance of drains around the dumpsite	• Dumpsite
Gas Migration	• Gas generated at dumpsite	• Field measurement	• Land use limitation in the surrounding area • Installation of a gas control system	• Area surrounding the dumpsite • Dumpsite
Scavengers	• Recycling activities	• Loss of income of scavengers	• NCC or the Government should accommodate these people to work at the new disposal site or in other businesses	• Dumpsite

(7) Environmental Monitoring Plan For Closure of Dandora Disposal Site

The main objective of the environmental monitoring plan is to evaluate the efficacy of the mitigation measures. Items that should be monitored are based on the identification of potential impacts involved during the closure of the dumpsite as well as after completion. The monitoring location, frequency and duration should be decided taking into account their significance and effectiveness on each monitoring item. The Matrix of the Environmental Monitoring Plan is shown in the table below:

Table F.3-15 Environmental Monitoring Plan for the Closure of Dandora Disposal Site

Monitoring Items	Location	Monitoring Method	Frequency	Duration
Offensive Odour	Dumpsite and surrounding residential area	People complaint	Everyday	Closure stage
Water Pollution of Nairobi River	Dumpsite area	Field Inspection	1/month	Closure and post-closure stage
Dust and Exhaust Fumes	Dumpsite and surrounding residential area	People complaint	1/week	Closure stage
Noise	Dumpsite, main and access roads	Field measurement of noise level	1/week	Closure stage
Traffic	Main and access roads	Field inspection	1/week	Closure stage
Gas Migration	Landfill site and surrounding area	Field measurement of gas and site inspection	1/week	Post-closure stage

(a) Natural Environmental Aspects

NCC should inspect and maintain the drain facilities to be constructed around the site in order to minimise soil erosion and more degradation of the Nairobi River. Monitoring duration for drain facilities is desirable to cover closure and post-closure stages.

In establishing the monitoring plan, it is also important to conduct an interview on the surrounding population to know about the generation of offensive odour, dust and exhaust fumes from vehicles/equipment.

Noise levels should be monitored once a week at the dumpsite and roads. During closure stage of the dumpsite the level of 90 dB(A)-8 hours should not be exceeded to protect the health of the workers.

Gas migration is considered to be of moderate significance and monitoring of the generated gas should be performed at the gas outlet pipe. Also it is important to check the surrounding area to avoid the construction of buildings.

As for dust, it should be monitored at the dumpsite and surrounding residential area by means of public interview.

(b) Social Environmental Aspects

NCC should monitor the traffic congestion and noise levels at the same time in access road and main roads.

(8) Conclusions and Recommendations

(a) Current Impacts of Dandora Disposal Site on the Environment

The survey period had coincided with heavy rains attributable to the El Niño phenomenon and some results of analysis cannot be used to reflect the current condition of the site. However, the social environmental is the most affected according to the survey. Offensive odour, high frequency of respiratory diseases which are related to smoke, and a lot of flies around the area which are vectors of many diseases were common responses given by many interviewed people.

Finally, from the analysis result it was demonstrated that the soil underlying the site is impacted mainly by chromium and lead.

(b) Closure of Dandora Disposal Site

Potential negative impacts to be generated during the closure and post-closure stages and mitigation measures are described below.

(i) Generation of offensive odour created by the construction of drains and landfilling works is highly predictable. Mitigation measures include the proper management of the construction works for garbage accommodation as well as the provision of air masks to workers.

(ii) The water quality of Nairobi River is already too degraded and for this reason the impact shall be of low significance during closure and after closure stages. Mitigation measures include the construction of drains with sediment traps and the proper management of the landfilling works.

(iii) Dust and exhaust fumes from equipment and vehicles during the closure stage will result. Dust mitigation includes the watering of access and operational places, the provision of air masks and protective clothing to operators and, finally, the soil materials should be covered with sheet. As for exhaust fumes, proper maintenance of equipment and vehicles shall be required. Frequent medical checkup and treatment of affected workers is recommendable.

(iv) Moderate increase in the noise levels during the closure stage is expected to affect the workers and the communities located around the site. In this regard, the work schedule should be informed to the public and operation of heavy equipment should be limited to

daytime only. Besides, adequate maintenance of equipment and trucks that must have exhaust mufflers is required to minimise this impact. On the other hand, the provision of ear muffs to workers is recommended.

(v) The gas produced during the anaerobic decomposition process of the garbage in the landfill disposal site can migrate underground and be accumulated in basements of buildings located in the migration way. Landfill gas has a high concentration of methane and for this it is potentially explosive. This impact is assessed of having moderate significance due to the proximity of the dump to the residential area. The installation of a gas control system and the enforcement of land use regulation to avoid building construction in the area surrounding the disposal site are proposed mitigation measures.

(vi) During the closure stage, the number of vehicles necessary for transportation of materials to the disposal site will generate low impact on the current traffic. To avoid more traffic congestion on Nairobi roads, it is important to select the nearest source for necessary materials.

(vii) Once Dandora is closed, scavengers will be jobless. In this regard, NCC or the government should assist these people and to accommodate them in the new landfill site or to make them work in other business establishments.

Potential positive impacts to be generated by the closure are as given below.

- Public Health and Environment: The closure of Dandora Disposal Site will improve the health and environmental condition of the surrounding population.