PROPOSED SOLID WASTE MANAGEMENT SYSTEM
FOR GEORGE COMPLEX
AND
ENVIRONMENTAL IMPACT ASSESSMENTS OF
TRANSFER STATIONS AND ILLEGAL DUMPSITE

FINAL REPORT

CLIENT: CARE PROSPECT

APRIL 1999

L. HANDIA

P J DUINDAM

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Abbreviations

CSO	Central Statistical Offices
ECZ	Environmental Council of Zambia
EIA	Environmental Impact Assessment
JICA	Japan International Co-operation Agency
LCC	Lusaka City Council
RDC	Residents Development Committee

Executive summary

Residents of George compound, in close collaboration with CARE Zambia, the Lusaka City Council (LCC) and the Environmental Council of Zambia (ECZ) have embarked on a solid waste management project in George Complex. The project aim is to establish a system whereby garbage in the compound will be discharged into midden boxes and later transported to Transfer station (s) by the residents. The Lusaka City Council would then finally dispose the garbage to the Libala Dump Site.

CARE contracted Mr Handia to carry out an environmental impact assessment for the transfer stations to be located within George Complex. Mr Duindam assisted Mr Handia to carry out the work.

George Complex is located 17 km from the Lusaka City Center and occupies an area of 4.772 km^2. It is a high density area with an estimated population of 136,890 in the year 2000.The total amount of solid waste expected to be generated in 2000 is 568.4 tons per week with a volume of 1624 m^3. Inert and bidegradable materials make up about 90 % of this waste. Eliminating the two categories by composting and educating residents on soil waste will result in lower transport costs for transfer from the George Complex area to the final tipping site. The maximum reduction would be 90 %, so a minimum amount of 57 tons (or 162 m^3) per week would remain for transport to the final destination site. The waste can further be reduced by separating some materials for recycling/reuse.

It is proposed that 191 midden boxes can be used to cover the whole complex in such a way that any midden box is not further than 200 m away from a house. The required storage capacity for the transfer stations has been designed to cover a period of 8 days. The required floor space (with a maximum height of waste of 1 meter) is 232 m^2.The possible sites for transfer stations were selected based on whether the place was vacant or the land use could be compromised through negotiating for the land. It could not be verified whether all the sites were private property or not because the Lusaka City Council office in George Complex can only confirm if they went out physically on site.

The introduction of a solid waste collection system probably is within the reach of the residents and stall/shop owners of George Complex. The costs for transfer stations and midden boxes are estimated at K 214,160,000 and K 116,892,000, respectively. Wheel barrows will cost about K 2,000,000. Operations and maintenance will require each household to contribute K500 per month.Construction cost of the transfer stations and midden boxes will put a major burden on households in the initial costs. As the transfer stations are indispensable for a definite solution to the collection problem, ways have to be found to construct them and get them financed.

There is no expected significant environmental impact resulting from the illegal dump site across Mungwi Road. There is no expected contamination of groundwater and surface water as the leachate flow rate into the aquifer is estimated at 69 mm per year and it does not contain hazardous material. Although the dump promotes the breeding of disease vectors, its effect will not affect the people due to distance and existing waste dumps near the houses. Odours and dust are blown in a direction which is away from the complex.

Significant environmental impacts for the transfer stations are the breeding of disease vectors and a strong public objection to locating the stations within the complex. Hazardous waste will have to be separated at the place of generation and handled according to ECZ guidelines. Public objection has to be looked into by CARE PROSPECT and find a solution before going ahead with the project. It is recommended that the Lusaka City Council be approached so that land can be acquired for transfer station across Mungwi Road or in the vicinity of the complex.

Reclaiming disused quarries would be legal when the following conditions are fulfilled:
- The Lusaka City Council allocates the land to the owner (residents) for such purposes
- The Lusaka City Council authorises the land to be used for reclamation considering the manner of waste disposal

- The Environmental Council of Zambia has to be satisfied that there will be no significant damage to the environment
- A licence has to be obtained from the Environmental Council of Zambia to operate the waste disposal site.

The proposed project will provide healthy living environment, as the solid waste will be removed from the Complex. This will only be possible if the waste is transported frequently and regularly to the Libala Dump site and the midden boxes and station are properly operated and maintained

1. Introduction

Residents of George compound, in close collaboration with CARE Zambia, the Lusaka City Council (LCC) and the Environmental Council of Zambia (ECZ) have embarked on a solid waste management project in George Compound. The project aim is to establish a system whereby garbage in the compound will be discharged into midden boxes and later transported to a Transfer station by the residents. The Lusaka City Council would then finally dispose the garbage to the Libala Dump Site.

Since the environmental impact assessment is limited to 15 days of consultancy work, it is restricted to desk work and field visits to George Complex. There is no generation of new field data. The required time to do a serious determination of quantity and composition of generated solid waste in George Complex (including the correct statistically reliable sample size, participation of residents (' organizations), a team of operators, etc.) would take up to three months.

Therefore, information for generation of solid waste in high density areas, including the George Complex area, has been taken from the LCC/ECZ survey on the Solid Waste management Master Plan for Lusaka, which was done in 1995 - 1996.

In this study the term "solid waste" will be used to mean all kind of solid wastes that people or institutions want to get rid of. It refers to "solid" waste as opposed to "wet" waste which means waste water. It includes other types of wastes which popularly are referred to as garbage, refuse and litter.

All costs are given in Kwacha for March 1999. The exchange rate that has to be applied between Kwacha and US dollar is 2,300 Kwacha to 1 US dollar.

The first section of the report contains the executive summary which gives a short overview of the most important conclusions. Section 2 gives the Terms of Reference for this study. Sections 3 and 4 try to give a better insight of the population of the George Complex area. It forms the basis of this study in terms of natural environment and social infrastructure on which the calculations on waste generation and possible solutions for a better management of the waste are based. Section 5 tries to come to solutions for waste collection from the George Complex to the final destination. It not only gives possibilities but also indicates costs. Sections 6 and 7 give the environmental impact assessments of the illegal dump site and transfer stations, respectively. Finally, section 8 gives conclusions and recommendations.

2. Terms of Reference as given by CARE PROSPECT

The tender document [1], dated 26th November 1998, gives the Terms of Reference (TOR) for the general aim of this environmental impact assessment study:
"The aim of the consultancy is to identify suitable sites for the Transfer Station on the peripheral of George Compound" and as TOR the following (appendix to Invitation for an Environmental Impact Assessment Consultancy to identify transfer stations for Garbage disposal, George Compound):

The following are the TOR:

1. *Assess the following:*
   - *Impact of the waste currently being disposed across Mungwi Road to the environment.*
   - *Legal implications of reclaiming disused quarries.*
2. *Characterise and quantify the garbage generated in the compound per day and recommend the size and retention capacity of an appropriate transfer station.*
3. *Identify possible Transfer stations in the area and determine the cost of:*
   - *Transferring garbage from the midden boxes to the transfer station.*
   - *Managing and maintaining the transfer stations by the Lusaka City Council in order to meet the minimum requirements stipulated in the Environmental Act of Zambia.*

After the tender had been awarded to our consultancy team, in a specially arranged meeting some questions concerning the terms of reference were discussed. The conclusions of this meeting were summarized in the letter from CARE Prospect, dated 10 February 1999, indicating the "revised Terms of Reference":

Activity	*Description*	*Time*	
		# days	*%*
A	*Preliminaries*	*1*	*7*
B	*Assess the impact of waste being disposed of in Zone 21. Comment on the legal implications of disposal of waste in borrow pits.*	*2*	*13*
C	*Characterisation of solid waste. (Optimise use of any existing data)*	*3*	*19*
D	*Transfer station sites - technical considerations of location and physical size with respect to LCC collecting technology. Provide outline costs*	*5*	*35*
E	*EIA of transfer stations*	*2*	*13*
F	*Report writing*	*2*	*13*

Expected output:

The expected output of this consultancy is a *<u>report</u>* *containing, but not limited to, the following elements:*

- *Qualitative assessment of the impact of waste on the environment (including health implications). Some outline quantitative estimate of garbage production will be required as well.*
- *Commentary on the environmental and legal implications of using borrow pits as disposal sites.*
- *Commentary on the characteristics of the waste produced.*
- *Technical analysis of the location of transfer site(s) bearing in mind the technologies currently*

employed by Lusaka City Council.

- *Outline costs of any proposed physical structures or technologies.*
- *Environmental impact of any physical infrastructure to include possible risks to any aquifer in the vicinity.*
- *Recommendations.*

In addition to this letter, a note dated 12th February 1999 indicated that the Environmental Impact Assessment of the transfer site should be the focus of attention. The risks of transfer stations to the aquifer, if possible with estimations of flow rates. Another note on the same day, indicated that the transfer site must be within the boundary of George Complex for legal reasons. It further stated that there are private landowners outside.

3 Environmental Setting of George Complex and the surrounding area

3.1 Natural setting

Location and topography

George Complex is located about 17 km from the Lusaka City Centre and occupies an area of 4.772 km^2. See Appendix 1. East of the Complex is Matero township and the industrial area is in the South. Farms are located in the North and West of the complex. The Complex lies between 1220 and 1260 m above sea level with a downward slope from South to North.

The dump site is located South of the complex in an area which is open and unoccupied. The site is surrounded by an undeveloped area. The nearest development are new houses and JICA Field office, and George Complex lying about 50 m and 500 m North across Mungwi Road, respectively. The road is located about 20 m North. The dump is scattered over an approximate area of 10,000 m^2.

Geology and hydrology

The geology and hydro-geological features of George Complex area are presented in Figure 3.1. The ground surface is mostly covered by a laterite layer with depths of a few meters to tens of meters, but outcrops of schists and dolomite are found on the surface in some places. Most of the area is covered by the Cheta formation consisting of quartzite and gneiss and the outer area is surrounded by the Lusaka Dolomite formation consisting of dolomite and limestone. Groundwater storage in the area can be divided into two zones: unconfined aquifers found in the laterite formations and weathered zones in the surface layers; and confined aquifers which flow through the cracks in the deep hard rock or in fault fracture zones. Deeper confined aquifers can be further divided into groundwater in the Lusaka Dolomite formation and groundwater in the Cheta formation. The water flow rate is very high in the Lusaka Dolomite. The level of the static water table obtained from the pumping test data was 2m below the ground surface for LWSC no. 55 borehole.

There are many quarries resulting from small scale quarrying at the illegal dump site and are estimated to cover almost 70 % of the area. These borrow pits/quarries are usually not very wide (about 6 m diameter) but seem to be deep (some exceed 5 m). They are usually connected one to another. The quarries are filled with water in the rainy season. Some quarries do not dry up in the dry season and could have water up to 3 m deep. This water level is about 3.5 m below ground level. In March 1999, the water in some of the quarries was about 1.5 m below ground level.

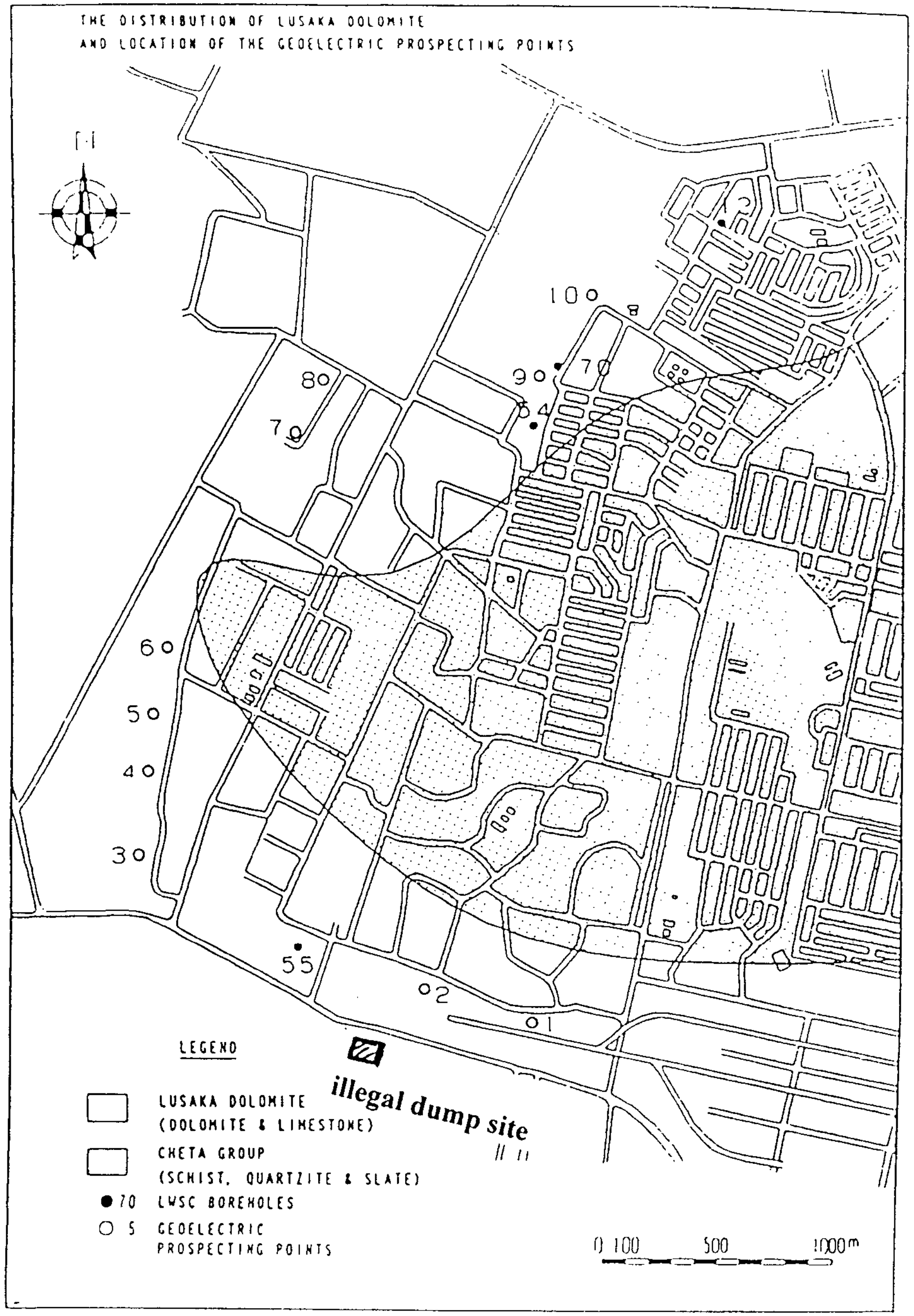
There are no streams or rivers except for a few natural and storm drains in the area.

Groundwater Quality

Results from samples done by Japan Techno revealed a major problem in indices of man-made contamination: NH_4-N, NO_2-N, and coliform group, which showed high concentrations in every hand-dug well sample. Samples from boreholes confirmed that aquifers were not contaminated [2].

Pollution problems

According to the Japan Techno report, the area has experienced outbreaks of cholera in the recent past. This was due to the contamination of the hand-dug wells by seepage from nearby pit latrines in the rainy season. The wells are dug in the laterite formation which is a shallow layer aquifer. The contamination is limited to shallow layer aquifers so far, and does not affect the deeper aquifers (confined).



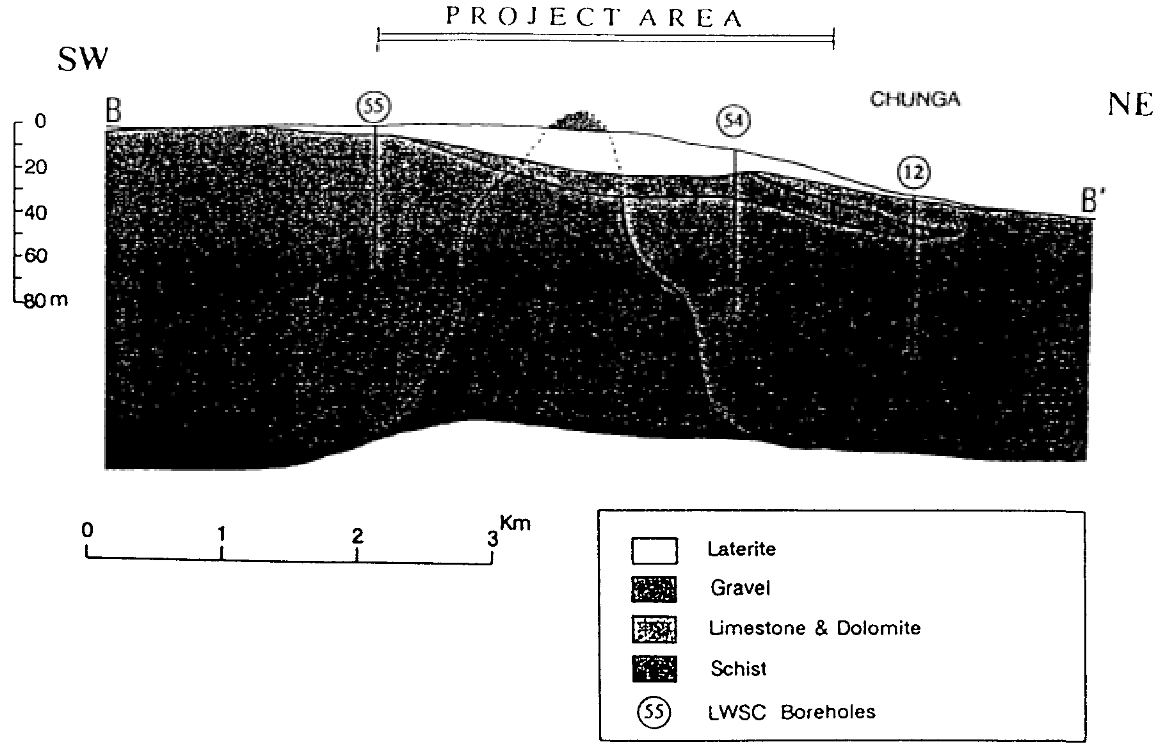


Figure 3.1 (a) Geology of the George Complex - left,
(b) Hydrogeological features of the complex - top

Meteorology

The area is situated in the Lusaka area at an average elevation above sea level of about 1240 m. The climate is characterised by four seasons, namely winter (June to August), pre-rainy season (September to October), rainy season (November to March) and post rainy season (April to May). The average annual rainfall is about 857 mm. The average annual value for actual evapotranspiration is 734 mm obtained using an empirical formula. The annual mean maximum and minimum temperatures are about 21.5 and 19.8 °C, respectively. Average monthly mean relative humidity values are in the region of 45 - 60 % and 60 - 86 % during the dry and wet seasons, respectively. Monthly wind speed is weak from December to May at 1.3 - 1.6 m/s and is strong from August to October at 2.3 - 2.4 m/s. The general wind direction is from NorthEast to SouthWest.

Ecology

The land is free from significant flora and fauna because the area is a high density residential area. The ecology at the illegal dump site has also been disturbed due to quarrying activities and the growing of maize. Most of the area is covered by quarries.

3.2 Social Infrastructure

Socio-economic Activities

George Complex is a high density and low income residential area [2]. The LCC study distinguished in the area the following townships: Lilanda, Paradise, Desai, Soweto, George which are located in the George Complex area and Chunga, Balaston, Matero and an Industrial area in Matero outside the Complex. The number of residents was estimated at 139,000 residents (CSO, 1990 census) with a yearly growth rate of 6.9 %. Applying the same growth rate, this will lead, for the year 2000, to a population of about 270,900 people. This number should be seen as a maximum as the adopted yearly growth rate of 6.9 % is a very high rate and more than twice as high as the growth rate for the whole country. A more realistic growth rate is lower is probably around 3 % per year. The number of households, indicated for 1990 is almost 12,900 with an average of 11 (!) persons per household.

The JICA field office estimated the population of George Complex alone at 120,000 for the year 1996.

The population is estimated at 111,303 for the year 1993 [2]. The yearly growth rates for high density areas are in the range of 5 to 6 % per year. These values are higher than the population growth of Zambia of about 3.2 % per year. The actual value for the population growth depends mainly on the age of the area. As George Complex is relatively old and well settled, there is not much room left for new plots; the growth rate will stabilize and be lower than those of new areas. In this study we assume a growth rate from 1993 onwards of 3 % per year. This leads to a population size for the year 2000 of $(1.03)^7 * 111{,}303 = 136{,}890$ residents. There are 23,000 households if an average household has 6 persons (estimate by JICA field officers and George Complex community representatives).

The level of education is low and so is the knowledge about health and sanitation [2]. The Complex has 6 schools, 12 markets and 2 hospitals. According to the Japan Techno report, approximately 81% of the households received some sort of income in 1993 estimated at US$ 99 (equivalent to K 227,700 at present) per household per month. Some residents engage in small scale quarrying of laterite and rocks, which are later crushed, near the illegal dump site.

3.3 Solid waste collection and disposal

George Complex, except for Lilanda, used to be an illegal squatter compound until recently when it was given the status of peri-urban settlement. Prior to this, the Lusaka City Council was not obliged to provide services, which include solid waste collection.

At the moment, almost all the waste generated in the Complex is dumped anywhere especially on the sides of roads. This clandestine dumping of waste has led to serious negative impacts; aesthetic degradation, breeding of flies, blockage of stormwater drains, pollution of stormwater, odours and possible pollution of groundwater in the shallow aquifer.

Nevertheless, there is a different and positive picture in Zone 21 where there is a pilot project. Solid waste is collected by residents and disposed of in midden boxes. Mr Isaac Mooleta, a member of the RDC, informed us that there were 8 midden boxes (capacity of 5 m^3 each) in Zone 21 serving a population of about 4000. The zone has an area of 0.2 km^2 and has some 825 households. Therefore, each midden box serves about 100 households (average of 6.5 persons per household). We were informed that some residents complain that the distance (100 m) they walk to midden boxes is too long . As a result, some residents dump waste elsewhere and not in the midden boxes. Residents from bordering zones also use the midden boxes which are located near zone boundaries.

Three midden boxes we visited were about a third full. However, we were informed that the midden boxes sometimes get full. The frequency of emptying the midden boxes is supposed to be once a month. When we visited the area we were informed that sometimes the boxes are emptied after more than a month.

The waste in all the 3 midden boxes was mainly soil and organic matter (about 60 - 80 %). There were more plastic containers than tins. However, both of these were very few compared to the other types. Refer to Section 4 for further details on solid waste.

Once the midden boxes are emptied, the waste is transported by a CARE PROSPECT tractor to an illegal dump site. See Figure 3.1 for the location of the illegal dump site. It is estimated that about 192 m^3 of waste is generated per month and only 24 m^3 (12 %) is transported per month from Zone 21 to the dump site.

The waste is dumped in quarries in the dry season and on flat ground surface in the rainy season due to inaccessibility of places where quarries are located. There is clandestine dumping and the dumps are scattered over an approximate area of 10,000 m^2. The waste we saw on 5 March 1999 had similar characteristics as the waste in midden boxes. One of the dumps located 15 m South of Mungwi Road was 0.7 m high and looked old. Some quarries have been filled up by the waste and vegetation has grown on top. We were informed by the driver who transports the waste that vegetation grows on dumps in less than 2 years after it is dumped. We saw and were also informed that some industries do dump waste in the same locality.

4. Solid waste characterization and generation in George Complex

As mentioned earlier, the data on quantity and composition of generated solid waste have been taken from a study carried out by a joint survey team made up of officers from Lusaka City Council (LCC) and the Environmental Council of Zambia (ECZ). This team worked on the first phase of a Solid Waste Management Master Plan for the City of Lusaka from 1995 to 1996. This first phase concentrated on the identification of problems related to solid wastes and the determination of quantities and the composition of solid waste generated in Lusaka. One of the high density areas that was included in the study was the George-Matero area. Information found for this area in the LCC/ECZ survey is used in this study.

Types of solid waste

The LCC study identified the following 7 main types of wastes.

a. Domestic waste;
b. Trade and commercial waste;
c. Institutional waste;
d. Non-hazardous industrial waste;
e. Hazardous waste:
   - Solvents, acids, heavy metals, cyanides
   - Hospital and clinic waste (bandages, blood)
f. Street and park wastes;
g. Special waste: demolition rubble, sewage sludge, tyres and car wrecks

As the George area is mainly a residential area, with some trade and commercial activity and two health institutions, the types of waste that are generated are basically of domestic, trade and commercial and hazardous medical origin. This study is therefore limited to these types of waste.

Composition and quantity of solid waste

According to the LCC study, there are 12 markets, consisting of some 1400 stalls and shops. In addition there are two health institutes with some 40 beds and cots. The population is estimated at 137,000.The residents can be seen as the main source for the production of solid wastes. These numbers are used in estimates and calculations in the study.

An overview of the components that make up domestic solid wastes is given in Table 4.1. These were the components used in the characterization study of the solid waste collected in the LCC survey. Table 4.2 gives the same components as they were found in solid waste collected in the George-Matero area. In the table calculations have been made for production per resident per day, production per household per day, production per household per week and finally the production for the whole George Complex area per week. Apart from indicating the total production of waste, the break down of the individual components is also given.

The market stalls produce an average of 1.67 kg of waste per stall per day mainly consisting of paper and organic material. The 1400 stalls are then responsible for 2,340 kg of waste per day or 16,400 kg per week. In addition it was found that the health institutes produce some 15,000 kg per week of which about 80 kg per week should be considered hazardous (medical) waste.

The densities of collected wastes were also established in the ECZ/LCC study, but the value depends strongly on the way this density was determined. For this study an average value of 350 kg/m^3 of waste will be used.

Table 4.1 General description of different components making up domestic waste

Component	Examples
paper & cardboard	Newspapers, cardboard, tetra pack, office paper, tissues, coated paper, soap packets
ferrous	cans, containers
Non-ferrous	aluminium foil, beverage cans, bags
Plastics	food containers, plastic foil, bottles, plastic bags
Glass	bottles, pots
Rags	textiles, clothes
Putrescibles	fruit skins, vegetable peelings, food refuse, bones, leaves
Others	wood, rubber, soil, leather, ashes, ceramics

Table 4.2 Composition of domestic solid waste as generated in the George-Complex area

Component	Composition %	Per resident in grams per day	Per household in kg per day	Per household in kg per week	George Complex area in tons per week
weight		560	3.36	23.52	537
paper & cardboard	2.7	15.1	0.09	0.64	14.5
ferrous	1	5.6	0.03	0.24	5.4
Non-ferrous	0.6	3.4	0.02	0.14	3.2
Plastics	3	16.8	0.1	0.71	16.1
Glass	0.8	4.5	0.03	0.19	4.3
Rags	1.7	9.5	0.06	0.4	9.1
Putrescibles	24.8	138.9	0.83	5.83	133.2
Others	65.6	367.4	2.2	15.43	352.3

The total weekly amount of generated waste of domestic origin is 537 tons, of commercial origin 16.4 tons and from the health institutes some 15 tons (partly infectious). The calculated respective volumes are: domestic: 1,534 m^3/week, commercial: 47 m^3/week and hospital: 43 m^3/week
These figures result in the following totals: **568.4 tons of waste per week**, with a **volume of about 1,624 m^3 per week**. Table 4.3 gives an overview of the amounts of waste generated.

Table 4.3 Overview of amounts of waste generated in George Complex

Type of waste	Total weight per week (tons)	Total volume per week (m^3)
Domestic	537	1534
Trade and commercial	16.4	47
Hospital	15	43
Totals:	**568.4**	**1624**

Conclusion

It can be expected that the residents of George Complex generate some **568.4 tons** of solid waste per week, with a **volume of 1,624 m^3**. Putrescent and inert materials, like fruit and vegetable rests and soil, ashes and organic material make up about 90 % of the generated waste. Putrescent materials can be reduced by using it as natural compost and animal food. The category of "others" which is mainly composed of soil can be reduced by educating residents on how to sweep their yards without generating soil waste. This category does not directly pose a threat to communal health or the quality of groundwater. The waste can further be reduced by separating some materials for recycling/reuse.

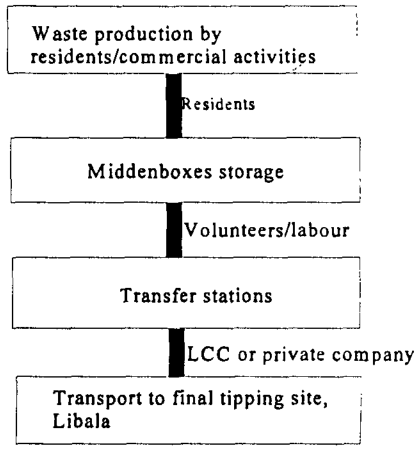
By reducing the two mentioned categories of waste as much as possible, the total volume of collected waste will decrease. This will result in lower transport costs for transfer from the George Complex area to the final tipping site. The maximum reduction would be 90 %, so a **minimum amount of 57 tons (or 162 m^3) per week** would remain for transport to the final destination site.

5. Waste collection in George Complex

5.1 Systems for waste collection

Different collection systems exist for collection of solid waste from a residential area to the final disposal site. The collection varies from very simple dumping of waste by the residents in a dug pit in a garden or at a communal site (= no collection) to house-to-house collection in those areas where residents are able and willing to pay for this kind of service. If waste is collected in Zambia, usually the final solution is dumping it at a tipping site, in Lusaka e.g. Libala tipping site.

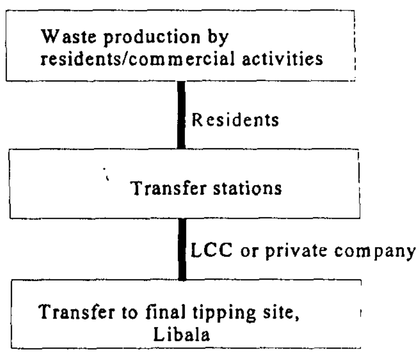
Figure 5.1 Collection system alternative A



In the TOR of CARE-PROSPECT the following possible structure for solid waste collection was given and in this study will be called **Alternative A**. See Figure 5.1. Waste generated by residents and commercial activities is dumped by the residents or by the marketeers and shop owners into so-called midden boxes. Regularly, volunteering residents or, if financially possible, paid workers take the collected waste from the midden boxes to so-called transfer stations. The frequency of emptying the midden boxes should be once or twice a week to avoid unhealthy spots of accumulated wastes. The waste at the transfer stations is collected with rolling material (trucks, tractor, trailer) and transferred to the tipping site. The frequency of emptying the transfer stations can vary from every day to twice a week. This frequency depends on the number of transfer stations, the transport capacity of the rolling material and the capacity of the transfer stations. For hygienic reasons a minimum frequency of twice a week is advisable.

For the sake of this study a second alternative, **Alternative B**, is introduced. The difference with Alternative A is that the midden boxes are skipped and residents take their waste directly to the transfer stations. Alternative B intends to reduce the number of sites where waste is to be collected by combining the function of the midden boxes with that of the transfer stations. In this way it reduces on the costs for construction of midden boxes. It will be used in those zones that are located close to roads that are accessible for rolling material. As the distance is reduced, residents are expected to take their waste directly to the transfer stations.

Figure 5.2 Collection system alternative B



Both alternatives can be used simultaneously within the George Complex area. Based on the study of maximum distances between the possible sites for midden boxes and transfer stations, as described in the following paragraph, it can be determined where alternative A is necessary (distance from residential plots to transfer stations is too long) or where alternative B is possible (distance to accessible road is acceptable).

5.2 Size, capacity and possible sites of midden boxes

Volume of waste to be collected

The total amount of solid waste which is generated by the residents of George Complex is estimated at **568.4 tons per week**, as explained in section 4. As the generation of waste was determined by an extensive study, and also confirmed by generation figures all over the world, we can safely assume that this figure is a reliable estimate. Generation of waste will be 100 % of the 568.4 tons, but, with any kind of collection system it will be impossible to collect this 100 % ! It is important to note that there will always be "losses" between generation of waste and its collection.

Waste gets lost because the organic fraction is used for feeding animals (chickens, pigs, dogs); not all waste is "given" to the collectors or taken to the midden boxes; there is re-use of waste (plastic bags, newspapers); and waste collectors do not take all the waste to the transfer stations. So, collection of waste always deals with a fraction of the waste generated, which depending on the collection efficiency, might vary between 40 and 95 % of the amount of waste generated.

On the other hand, there is the phenomenon that if one area is serviced with a collection system, residents from the neighbouring areas will also try to use that system, if possible without paying or any additional trouble. This might lead to amounts that have to be collected from the serviced area to actually exceed the generation of waste in the area ! Depending on the specific situation, the amount of collected waste might be 20 to 50 % more than the collected amount from the serviced area.

The real percentages can only be determined after the introduction of a collection system by measuring the amounts of waste collected and comparing these amounts with generation figures. Of course it can also be estimated beforehand. A safe assumption is: **50 % of the generated waste is eventually collected**. After the introduction of the collection system, the frequency of emptying the midden boxes and transfer stations can be adjusted to match the actual amounts of waste collected. With the assumption that 50 % of the generated waste will be collected from the whole area this means we have to take into account of **284 tons per week, or 41 tons per day**, with a total **volume of 116 m^3** of waste to be collected daily.

Sites for midden boxes and transfer stations

For the determination of possible sites for the location of midden boxes and transfer stations we have to consider the most accessible roads in the area presented in Figure 5.3 (adapted from Reference 2). Figure 5.4 presents the earlier mentioned Zone 21 where midden boxes have been introduced.

It can be seen from Figure 5.4 that the maximum distance zone 21 residents have to walk from their plots to the midden box is about 150 meters. Almost 90 % of the plots lie within a distance of 100 meters i.e. within a circle drawn around the location of the midden boxes with a radius of 100 meters. The remaining plots lie between 100 and 150 meters from the nearest midden box. The 8 midden boxes cover in a satisfactory way an area of about 0.2 km^2, or for every 0.025 km^2 (2.5 hectares) one midden box is required in zone 21.

Figure 5.3 Road conditions in George Complex (adapted from Reference 2)

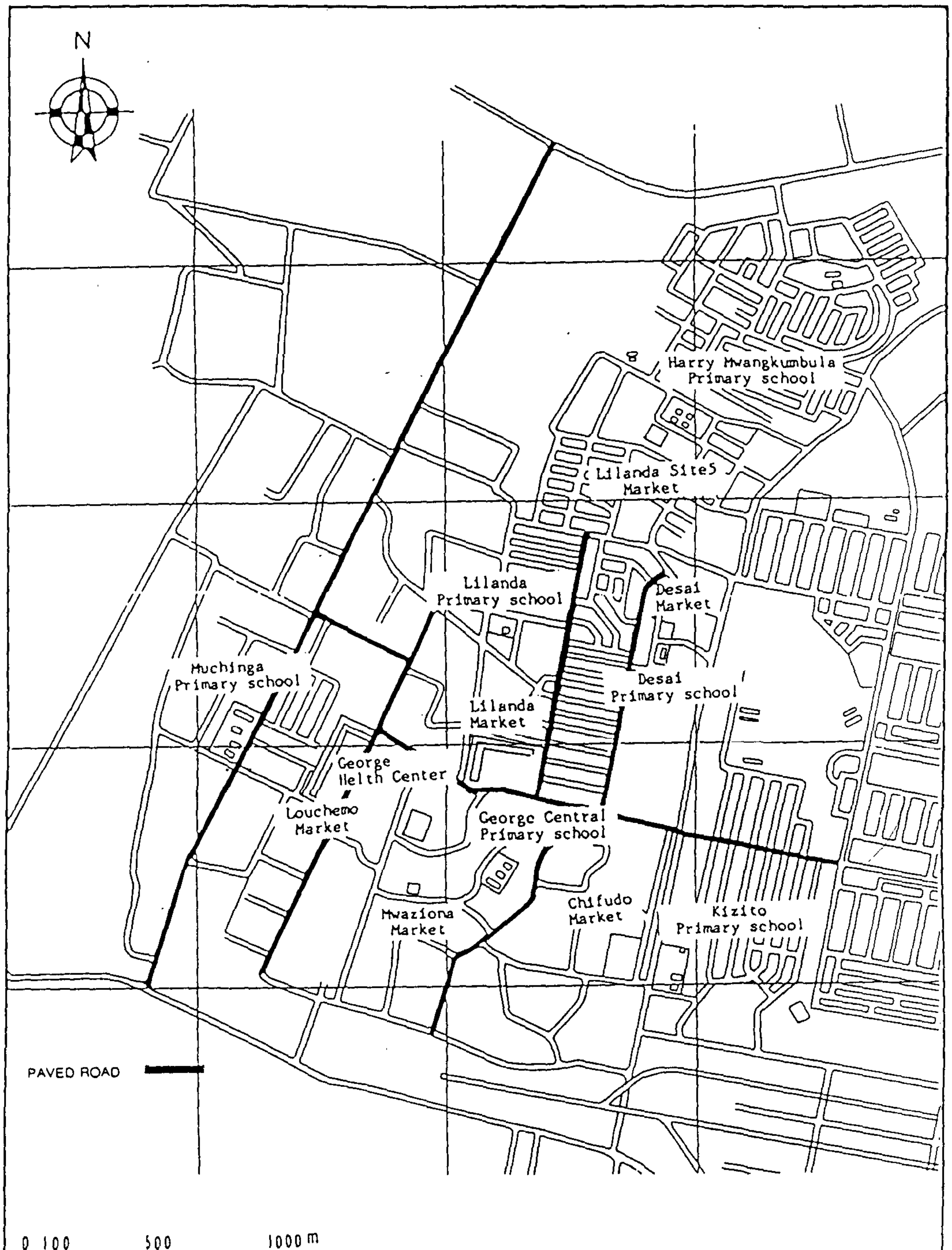
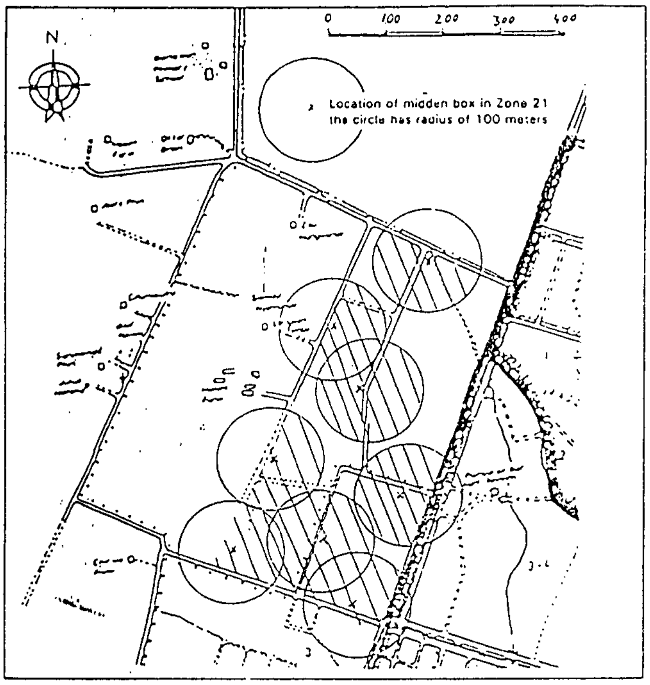


Figure 5.4 Zone 21 in detail, indicating the sites of the midden boxes



A survey conducted in the high density areas of the Peruvian capital Lima indicated the relationship between the "willingness" of using a midden box and the distance from their plots to the midden box presented in Figure 5.5 (adapted Reference 4). It is clear that a distance up to 200 meter is acceptable for more than 80 % of the residents in the Peruvian high density area.

The same trend has been confirmed by information from the representatives of Zone 21. Although some residents complain about the distance, which in any case is less than 150 meters, one of the results of the introduction of midden boxes in zone 21 is obviously cleaner streets and open places. Residents in other zones surrounding zone 21, have noticed the improvement and are actually trying to get the same system introduced in their zones.

Figure 5.5 Users of midden boxes distributed according to the distance between their plots and the boxes

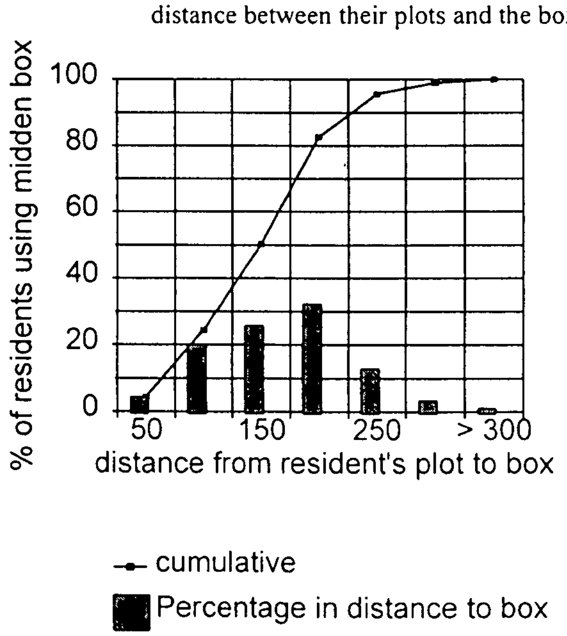
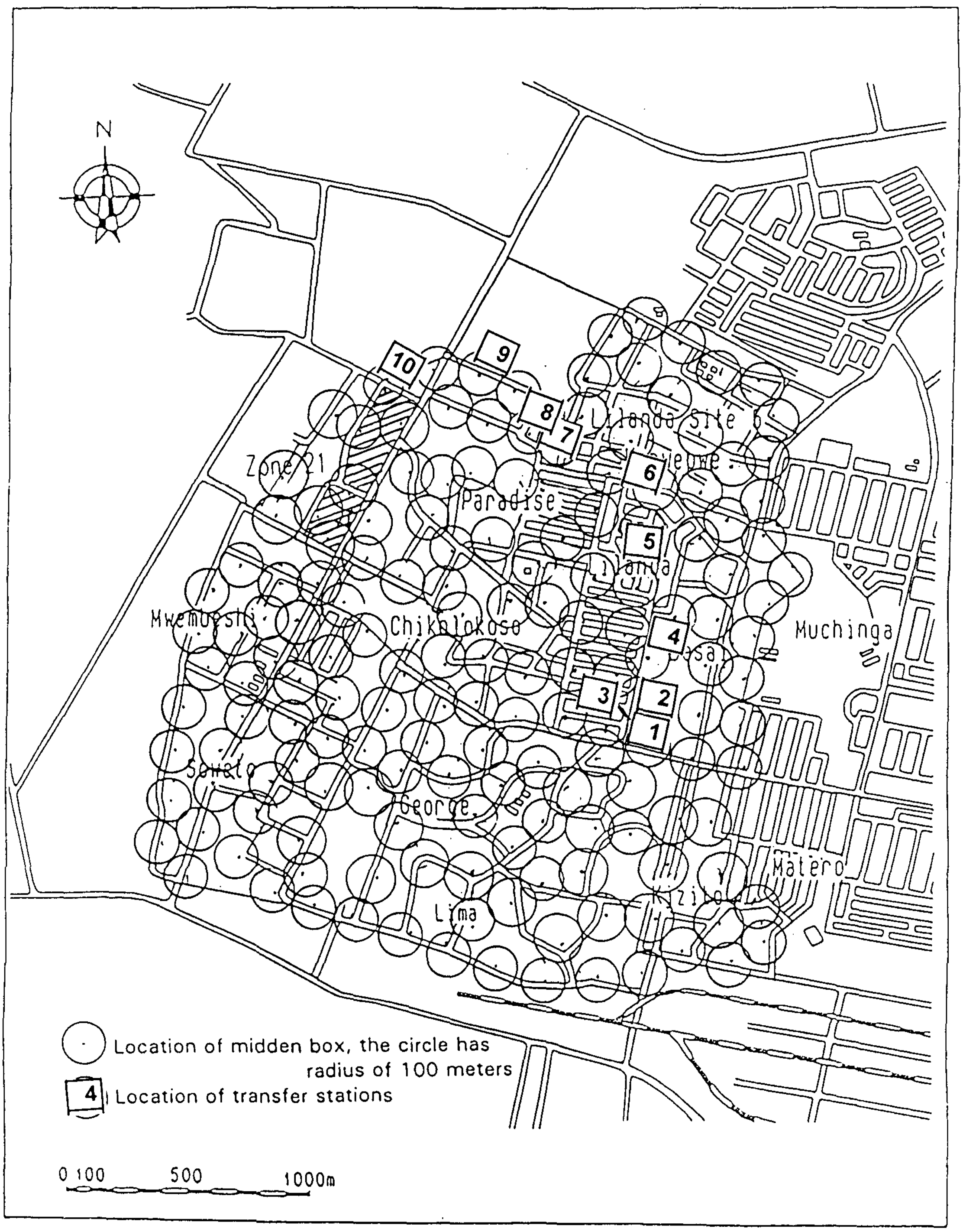


Figure 5.6 is a map of George Complex with circles indicating how many midden boxes cover the whole area with a maximum distance between plots and midden boxes of 200 meters. The whole area is covered with about 190 midden boxes, in such a way that the midden boxes are not further than 200 meters away from a plot. The midden boxes positioned at the accessible roads can be replaced by a transfer station (alternative B). The accumulated waste from the midden boxes has to be transferred to the transfer stations and then to the tipping site.

Figure 5.6 Map of George Complex with a distribution of midden boxes and transfer stations covering about 90 % of the plots within a distance of 100 meter to the nearest box (adapted from Reference 2)



An overview of the distributed midden boxes over the whole area of George Complex is given in Table 5.1. It relates the number of boxes as distributed per 0.025 km^2 of area to the number of residents served by one midden box. A re-distribution of the midden boxes over the compounds might be necessary to make up for those areas with a higher population density (e.g. Soweto and George).

Table 5.1 Numbers of midden boxes related to the areas of the compounds and their residents

Name of compound	Area (km^2)	Population year 2000 (persons)	Population density (persons/km^2)	Number of midden boxes required	# residents per box
George	1.821	68013	37349	73	932
Soweto	0.609	23186	38072	24	966
Chikolokoso	0.571	6103	10688	23	265
Desai	0.541	9936	18366	22	452
Paradise	0.539	10460	19406	22	475
Lilanda Site 5	0.471	12607	26766	19	664
Kizito	0.22	6587	29941	9	732
Total	**4.772**	**136892**	**28687**	**191**	**717**

Relation between number of midden boxes, distance and frequency of emptying

There is a relationship between the size of the midden boxes (the bigger, the more waste can be stored), the number of midden boxes (the higher their number, less waste per box will be collected) and the frequency of emptying the boxes.

In this section a choice has been made on the maximum distance we assumed residents are willing to walk when taking their waste to a midden box. It is assumed that a coverage of midden boxes where residents have to walk up to 150 meters, seems to be appropriate solution for George Complex. This results in 191 midden boxes. If 50 % of the generated waste actually gets to the midden boxes they will receive an amount of 41 tons per day, with a total volume of 116 m^3 of waste. If the midden boxes are well distributed, every box will receive as an average 215 kg or 0.6 m^3 per day.

With an effective volume of 3 m^3 it will be necessary to empty the boxes every 5 days, which is an acceptable frequency. These figures are averages and will only be achieved if the distribution of the midden boxes is done properly and the amount of co-operation from the residents is equal all over the Complex. The total capacity of the midden box should be larger and we use the current size of 9 m^3.

5.3 Size, capacity and possible sites of transfer stations

The size of the transfer stations depends directly on the capacity of the transport which will take the accumulated waste from the transfer stations to the tipping site. As 116 m^3 of waste is expected to be collected and transferred to the transfer stations per day, and the minimum frequency of twice per week is acceptable for hygienic reasons, the total storage volume of the transfer stations should be 464 m^3 (4 days between two collections times 116 m^3 per day). In this study it is advised to plan for 4 transfer stations, so each station should have storage capacity of at least 116 m^3. For aesthetic reasons a maximum height for storing waste is assumed to be 1 meter (see also section 5.4 on design of transfer stations).

As services are not always reliable, a safety factor of 2 is used. This means the required storage capacity should be able to cover a period of 8 days. The required floor space (with a maximum height of waste of 1 meter) will then be **about 232 m^2**.

The required floor space depending on the number of transfer stations chosen is given in Table 5.2. It should be noted that the weight and volume of waste to be collected in one day will be independent of the number of transfer stations and the conditions of service are the same.

Table 5.2 Relation between the chosen number of transfer stations and the required floor space

# of transfer stations	floor space each station (m^2)	possible dimensions (m * m)
1	928	40 * 25
2	464	24 * 20
3	308	15 * 20
4	232	20 * 12
6	152	16 * 10
8	116	16 * 8
10	100	12 * 8

The Terms of Reference spell out that sites for transfer stations must lie within George Complex for legal reasons. The possible sites given in Table 5.3 include some sites which are on the periphery of the complex. These were included because the complex is almost built up and it might be possible to acquire land on the periphery.

Whenever possible, transfer stations should be located:

a. as near as possible to the weighted center of the individual waste production areas to be served,
b. within easy access of major highway routes as well as near secondary or supplemental means of transportation,
c. where there will be a minimum of public and environmental objection to the transfer operations, and
d. where construction and operation will be most economical.

Additionally, if the transfer station site is to be used for processing operations involving materials recovery, the requirements for those operations must also be assessed.

For the situation in George Complex factors (a) and (d) are not considered because the area is almost built up, the complex area is small and the environmental setting for the possible sites is almost the same.

The possible sites in the table were selected based on whether the place was vacant or the land use could be compromised through negotiating for the land. We could not verify whether all sites were private property because the Lusaka City Council office in George Complex could only confirm if they went out physically on site. The ones we strongly recommend are sites 1, 3 and 5 because of their size and good accessibility. We also recommend that sites 9 and 10 be pursued in case it is possible to acquire them since we suspect they are already private property.

Table 5.3 Proposed sites for transfer stations

site #	surrounding areas	estimated size (m^2)	road accessibility	land use	comments
1	North: flats South: road East: houses West: houses	40 * 80	very good	maize	along main road to market
2	North: shops South: road East: pubs West: houses	30 * 30	very good	none	
3	North: houses South: houses East: houses West: houses	200 * 50	very good	football pitch	
4	North: church South: church East: churches West: houses	20 * 10	very good	none	Might be belonging to the churches
5	North: houses South: houses East: houses West: houses	50 * 70	very good	maize, children playground	
6	North: school South: houses East: school West: houses	20 * 10	good	none	might belong to school
7	North: houses South: houses East: houses West: houses	40 * 30	quite good	site for water tank and machinery house	This is a site for water tank and machinery house Need to negotiate with owners of plot. Also located outside complex boundary
8	North: houses South: houses East: houses West: houses	30 * 30	quite good	maize	located outside complex boundary
9	North: farm South: houses East: empty West: empty	100 * 100	qiute good	football pitch	located outside complex boundary. Could be owned by the farmer
10	North: farm South: houses East: shops West: farm	100 * 100	good	maize	located outside complex boundary

5.4 Costs of collection systems

The two alternative collection systems proposed for George Complex consist of the following elements: midden boxes, transfer stations, transport from midden boxes to transfer stations, transport from transfer stations to tipping site, dumping on tipping site and, organization and management. For each of these elements a short analysis has been made for the possible design and the related costs. A division has been made between initial costs and fixed costs. Also an indication has been made on the form of contribution by volunteers in every element. The cost of the project can be distributed to the household as well as the owners of market stalls, shops and other commercial ventures. The latter category can be charged the same rate as households. The use of the term "household" in this subsection includes the stall, shop and commercial venture owners and is estimated at 24,400.

Midden boxes

The costs involved in the midden boxes are only limited to the construction costs and are to be seen as initial costs only. The design of the midden box consists of a concrete slab (3.5 m * 2.5 m, 0.2 cm thick) and three walls 1.5 m high. The cost for construction of one box is estimated at K612,000. The cost for constructing 191 boxes is K116,892,000. Each household would be required to contribute K4800.

Volunteer input is limited to assistance of the residents in the construction of the midden boxes. The responsibility for maintenance and repair will fall under the overall costs of management.

Transfer stations

The costs for the transfer stations are to be seen as initial costs for the preparation of the sites and as fixed costs for maintenance and cleaning of the sites. The initial costs depend directly on the layout of the design. Minimum design consists of a concrete slab, strong enough to resist the load of the collected waste and possibly the weight of the truck that will be used for transport of the waste to the tipping site. The slab should have a slope to the outside so rain water will run to the outside drains. The drains should be connected to a soak-away or to existing sewer.

Around the concrete slab a wall could be constructed. This wall will keep waste inside the transfer station and if this wall is high enough, it will also keep playing children and animals away. On top of the wall a fence could be raised, high enough to completely keep people and animals away. If the front side of the station has a gate, the station is relatively protected from waste being blown around the site and people and animals scavenging through the stored waste. The walls should not be much higher than approximately 1 meter, the fence reaching up to about 3 meters. This will provide a clear view from the outside on the site and thus provides control on misuse and will keep most of the waste out of sight.

Further upgrading of the transfer station could be a small office for the attendants and for storing maintenance materials. The better the transfer station begins to function the more facilities could be provided, such as a latrine, drinking water and electricity connection, lighting etc.

In the beginning phase there is room for volunteers to clean and maintain the transfer station. As the site is dealing with more waste and the system gets more professional, attendants should be contracted at least during day time.

Some estimates on costs of the transfer stations are presented in Appendix 2. Costs for the basic design (concrete slab, walls, fence and gate) are estimated at K 53,540,000 for each transfer station. For 4 transfer stations it amounts to K214,160,000. This would require each resident to contribute about K9,000. If 4 attendants would be contracted, the regular costs are some K 1,000,000 per month, or K 41 per household per month.

Transport from midden boxes to transfer stations

The costs for the transport form the midden boxes to the transfer stations consist of the purchase of wheel barrows or small hand carts. These costs are to be considered primarily initial costs. The work itself can be done by volunteering residents or by paid workers. Initial costs for wheel barrows can be estimated at K 150,000 per wheel barrow (capacity: 75 kg) and for hand carts at K 500,000 (capacity: 250 kg).

Labour costs can be estimated as follows: one man should be able to empty and clean the surrounding s of 5 midden boxes per day (total average weight of waste: 1,075 kg). With labour costs per day estimated at K 10,000 per person, the labour costs would be K 50,000 per week to empty 20 to 25 boxes. These midden boxes would serve an average number of 14,000 to 18,000 people (frequency of emptying: twice a week) from 2,300 to 3,000 households. Labour costs would then be K 27 per household per week. A total number of about 13 workers is needed to empty and clean all midden boxes. The number of necessary wheel barrows is also 13, at a cost of K 2,000,000 or K 90 per household. Alternatively, the transport from the midden boxes to the transfer stations can be done by volunteering residents. This does require a better stimulation and organization of the residents.

Transport from transfer stations to tipping site

The transport from the transfer stations to the tipping site of Libala can only be done by motorized transport. The average distance from George Complex to Libala is about 18 km and this is too far to be covered by non-motorized vehicles. There are basically two options: the Lusaka City Council through the Public Health Service Department or a commercial company.

Cost estimate is as follows: daily rent for a 10 tonnes truck is between K 200,000 and K 300,000. Fuel costs can be estimated at K 10,000 per trip to Libala. With the estimated amount of 284 tonnes per week 28 trips to Libala are necessary. With 4 trips per day and 6 days per week collection this would lead to a total cost for transport (excluding labour for transport) of about K 2,000,000 per week. Calculated as an average per household for the whole George Complex area: K 90 per household per week. The actual costs for transport offered by LCC or by a private entrepreneur might be slightly higher but depend on the contract between George Complex and the transporter.

Dumping at tipping site

The costs for dumping at the Libala tipping site have to be arranged with the transporter. In case LCC would collect and transport the waste, the fee for tipping would be low. If a private entrepreneur would be contracted, a higher fee might be charged.

Organization and management

The introduction of a collection system of solid waste will require a team of representatives of the community. Its tasks will mainly lie in educating the community (why waste has to be collected, how much it will cost), getting the system introduced (collection of money and volunteer labour, determination of sites for midden boxes and transfer stations, etc.), getting the collection system organized (introduction of system in which compound first, collect money for initial and fixed costs, motivate volunteers, etc.) and starting and maintaining business contacts with the transporter. It is beyond the scope of this study to give detailed proposals on how the management should be organized, but it seems logical to follow the same lines as were followed with the introduction of the public drinking water system in George Complex. In this system residents pay for a fixed amount of drinking water. Maybe it will be possible to raise the costs for drinking water slightly so fixed costs for the collection system would be covered with the drinking water fees.

No estimates are given here for the costs involved in organization and management. This depends completely on the defined tasks to be performed by the management team and the dependance on paid officers or volunteers.

Another task for the management team would be the responsibility for maintenance and repair of the structures of the midden boxes and the transfer stations and other tools (wheel barrows, shovels). It is estimated that a 5 % of the initial investment costs should cover for these expenditures. As the initial (basic) investment is estimated to be K 53,5400,000, 5 % per year would be K 2,677,000, or K 3 per household per week.

Table 5.4 below indicates for each element if costs (✔) and what kind of costs are involved and if it seems feasible to have the work done by volunteers. The costs per household are computed based on the assumption that all households contribute. However, in practice it is not expected that everyone does so as is the case with the current water project within the same complex. Therefore, costs are presented in Appendix 3 based on varying percentage of contributors.

Table 5.4 Initial and regular costs per household and possibilities for volunteers

Element	Initial costs		Monthly costs		Volunteers
		per household initially		per household **per month**	
Midden boxes	✔ *1	4,800			
Transfer stations	✔ *1	9,000	✔ *2	41	✔ *4
Transport from midden boxes to station	✔ *1	100	✔ *3	107	✔ *4
Transport from station to tipping site		-	✔ *5	328	
Dumping		-	✔ *5	?	
Organization and management	?	?	✔ *2	9	✔
Total:		13,900		485	

*1 Includes costs for construction of site and possibly wheel barrows or handcarts.
*2 Includes costs for cleaning and maintenance of the transfer station.
*3 Includes costs for labour if operators are contracted
*4 It is possible to transport the collected waste from the midden boxes to the transfer stations and to maintain of the transfer stations by volunteers, but this requires organization.
*5 These costs are included in the contract that has to be defined between George Complex and the transporting company (private or LCC).

Conclusion

It can be seen that introduction of a solid waste collection system probably is within the reach of the residents of George Complex. If all residents are willing to pay for the service, the system can be further investigated.

The construction of the transfer stations and midden boxes will put a major burden on households within the initial costs. As the transfer stations are indispensable for a definite solution to the collection problem, ways have to be found to construct them and get them financed.

Monthly costs of about K500 per week per household can be considered financially within reach of the residents. The long distance transport costs make up the major part of the total costs. But together with the transfer stations they make up a very important element of the whole collection system. In the management team considerable attention must be given to a fee collection system. Linking the waste collection system to the drinking water system is one option. Maybe direct payment by the residents to the contracted workers , would be another.

6. Environmental impact assessments

6.1 Environmental impact assessment for illegal dump site

The environmental impact assessment is based on the environmental settings presented in Section 3. The significant environmental impacts for the illegal dump site are presented below.

Contamination of groundwater and/or surface water by leachate

When rain falls, some of it will be intercepted by roofs and vegetation and will evaporate back to the atmosphere. The part of the rain reaching the ground surface will either infiltrate into the soil or runoff on the ground surface. The rain remaining on the ground surface will first fill up the depression storage before surface runoff can begin. The water infiltrating will percolate into the saturated ground zone beneath the water table.

If there will be any pollution reaching the groundwater, it will be in the form of leachate. Leachate may be defined as liquid that has percolated through solid waste and has extracted dissolved or suspended materials. Leachate is composed of the liquid that has entered the solid waste stockpile from external sources, such as surface drainage, rainfall, groundwater, and water from underground springs and the liquid produced from the decomposition of the wastes, if any. When water percolates through solid wastes that are undergoing decomposition, both biological materials and chemical constituents are leached into solution.

Rain falling on unsheltered solid waste, placed for temporary or permanent storage, causes leaching to occur into the soil; this may transport heavy metals, salts, and other inorganic and organic constituents as pollutants to the groundwater. Important pollutants frequently found in leachate include BOD, COD, iron, manganese, chloride, nitrate, hardness, and trace elements.

The solid waste dumped on the ground surface must first be percolated by the rainwater and then pollution carried in leachate as it infiltrates and percolates through the underlying soil. Since infiltration and percolation are the main mechanism of pollutant transport, the infiltration rate through the ground surface and into the aquifer as percentage of annual rainfall (commonly known as recharge rate of groundwater) have to be known.

Leachate potential for waste dumped on ground surface

The potential for the formation of leachate can be assessed by preparing a water balance of the solid waste stockpile. The water balance involves summing the amounts of water entering the stockpile and subtracting the amounts of water consumed in chemical reactions and the quantity leaving as water vapour. The potential leachate quantity is the quantity of water in excess of the moisture-holding capacity or field capacity, FC of the solid waste material.

The FC, which varies with the overburden weight, is estimated using the following equation.

$$FC = 0.6 - 0.55\,(W / (10{,}000\ W + W))$$

where W is the overburden weight calculated at the midheight of the waste in question

To determine whether any leachate will form the field capacity of solid waste is compared with the amount of water that is present. If the field capacity is less than the amount of water present, then leachate will be formed.

Typical values from literature of moisture content in percentage by weight are paper and cardboard (5), ferrous and non-ferrous (3), plastics and glass (2), rags (10), food (70) and dirt, ashes (8) [5]. The moisture content of the solid waste is then computed by weighting the compositions and it is:.

Moisture content = 23.0%

This value is close to the typical value of municipal solid waste of 20% given in the literature [5]. The value of 20 % is used to represent the worst scenario.

Rainfall that infiltrates the solid waste (I) is determined from the water balance equation below

$I = P - E - R$ where P is precipitation, E is evaporation and R is runoff

Runoff is considered to be zero since runoff from surrounding area will add water to solid waste. The value of E_t used was computed using the total value for the rainy season only (November-March) which represents the worst scenario. The monthly average for this period is 4.06 mm/d. Therefore $E_t = 313$ mm

Calculations for the leachate produced were based on the height of solid waste dump of 0.7 m and density of 350 kg/m^3. The leachate formed was found to be 451 kg per m ^{2}This is the weight of leachate produced from rainfall per year. This translates to 0.451 kg m^3 or 451 mm of leachate per year per m^2. Therefore 451 mm of leachate infiltrates into the soil below the dump per m^2 on ground surface. This is equivalent to 5.9 mm per day or 5.9 liters per m^2 per day. This is a small amount.

Nature of leachate

The 65.6% others is mainly inert material and almost excluded from leachate except its contribution to suspended solids. The remaining components are mainly organic materials which are biodegradable. Biodegradability is the biological conversion of organic components to gases and relatively inert organic and inorganic solids. The putrescibles, and paper and cardboard constituting 80% of the remaining components are rapidly biodegradable. Rags are slowly biodegradable. Plastics, ferrous, non-ferrous and glass, constituting 5.4 % of the total waste, are generally considered non biodegradable.

The nature of the solid waste disposed at the illegal dump site from Zone 21 is non-hazardous. Hazardous wastes have been defined as wastes or combinations of wastes that pose a substantial present or potential hazard to humans or other living organisms because (1) such wastes are non degradable or persistent in nature, (2) they can be biologically magnified, (3) they can be lethal, or (4) they may otherwise cause or tend to cause detrimental cumulative effects. Examples of such materials from residences are household batteries, household cleaners, personal care products, automotive products (e.g., batteries), pesticides, herbicides and fertilizers. Hazardous wastes are significant to consider because of their persistence when discharged into the environment. The residents of George complex are not expected to dispose of such items due to the low income, the reuse of most of such waste and lack of farming within the complex. Therefore the leachate from the waste at the dump site is not expected to contain hazardous material.

Leachate movement

This leachate will infiltrate into the soil and then percolate at very low velocities in the upper layers due to the sluggish nature of natural groundwater movement. Usually, velocities tend to decrease with depth as porosities and permeabilities also decrease. The other contributing factor to the slow movement is the lack of drains and wells drawing from the upper laterite aquifer which would have acted to accelerate flows.

For Lusaka urban the recharge rate into the aquifer is 8% [6]. This amounts to a depth of 69 mm based on the annual rainfall of 857 mm. The average rainy days for Lusaka Province is 77 days per year. This will result in an average recharge of groundwater of about 0.9 mm (equivalent to 0.9 l/m^2/day) whenever there is rain assuming that the rainfall is evenly distributed over the rainy days. Assuming that the leachate is moving at the same rate as percolating water will result in a leachate flow rate of 0.9 mm / day into the groundwater. This figure is far much less than the potential flow rate of 101 m/day for laterite. The potential rate is computed by assuming that the material below the ground surface to the top of the water table is saturated and that a small layer of leachate exists on the ground.

Leachate produced by waste dumped in quarries

The solid waste dumped in the quarries is assumed to be saturated to represent the worst scenario. The water table in nature is undulating according to topography. Since the area is almost flat and small and there is no surface discharge through streams, the differences in water table level in the quarries is assumed negligible.

Hence, it is assumed that there is no horizontal groundwater flow in the quarry and therefore through the solid waste because there is no head difference. Vertical flow is not possible also due to lack of head difference since material is in the same aquifer. The above are based on the assumption that the water in the quarries does not dry up through out the year due to being directly in contact with groundwater in the unconfined aquifer. It is possible to have water in the quarries flowing into the surrounding water table when there is increase, resulting from rainfall, in the water level in the quarries and it rises above the water table surrounding the quarry. Flow into the aquifer from the quarry is also possible when the water table is fluctuating. Therefore the principal mechanism of leachate movement is diffusion. It is expected that the waste has undergone bio-degradation by the time leachate enters the underlying soil.

Impact on groundwater

Since the supply of leachate is limited to 69 mm per year through rainfall for waste dumped on the ground surface and probably a similar amount for the dump in quarries which do not dry up, the amount of pollutants in the leachate which might reach groundwater is predicted to be negligible. This is due to the following reasons:

- Low recharge rate into the aquifer
- The biodegradable nature of the solid waste and the likelihood that the leachate does not contain hazardous material.
- The bulk of the solid waste is not easily dissolved by infiltrating water. Therefore the leachate will not be rich in pollutants
- Pollutants in the infiltrating and percolating leachate will be removed or reduced in concentration with time and with distance travelled. Mechanisms involved include filtration, sorption, chemical processes, microbiological decomposition and dilution.

Clogging of any water channels

There are no water channels near the dump site. Therefore, this impact does not arise.

Aesthetic degradation and property value loss

There is aesthetic degradation as the place is littered with waste. The dumps are seen from the Mungwi Road on the dry season when vegetation is dry and has been burnt. There is no property value loss caused by dumping the waste as the place has a lot of quarries which will make the place have low value in future when it is being allocated by the Lusaka City council.

Disease vectors (flies, rats, cockroaches)

Due to the presence of the dump, it is expected that disease vectors will breed and increase in number. On the day of visit, there were very few flies. However, we were informed that during the dry season, there are plenty of flies The vectors may carry disease to the surrounding area. However, the effect is expected to be almost negligible as the nearest residences are more than 600 m away. The complex itself has a lot of clandestine dumps which may already cause a greater effect than the illegal dump.

Dust from loading and unloading operations at the dump site

This is expected because of the characteristics of the waste (being mainly soil) in midden boxes and the dumps. This has an effect only on the loaders. It will not affect the communities, located North, because the wind will blow the dust in the SouthWestern direction which is not inhabited.

Dust and litter along roadways used by refuse collection vehicles

There is no litter along the roadways. Since the waste is not covered when being transported, it is expected that there is dust during transportation. However, the effect of this dust will be minimal considering that the yards in the complex are bare and most roads are unpaved. The dust generated by moving vehicles will surpass the one resulting from waste transportation.

Odours from dump

In the rainy season, there is little or no odour. It is expected that there are odours in the dry season. This was confirmed by the driver of the tractor. However, the odours will not affect people since they will be blown by the winds towards the SouthWest.

Loss of flora and fauna

Interference to flora and fauna is not important in the area due to disturbance of the natural habitats in the past and the continuing small scale quarrying. Additional negative impact due to dumping waste is limited.

Conclusion

There is no expected significant environmental impact resulting from the illegal dump site across Mungwi Road. There is no expected contamination of groundwater and surface water. Although the dump promotes the breeding of disease vectors, its effect will not affect the people due to distance and existing waste dumps near the houses. Odours and dust are blown in a direction which is away from the complex.

6.2 Environmental impact assessment of the transfer stations

Since all the proposed sites for transfer stations are within the same locality, environmental settings are similar except in terms of land use and the surrounding area.

6.2.1 Significant environmental impacts

Contamination of groundwater and/or surface water by leachate

The analysis is similar as the one for the illegal dump site in Section 6.1 above. However in this case, the transfer stations are expected to be according to engineering design and construction. It is possible to eliminate leachate e.g., by leachate evaporation and discharge to municipal wastewater collection systems. However, if any leachate will reach the ground surface (e.g. from accidental spillage of liquid), it will move in a similar way to the one produced by waste dumped on the ground surface at the illegal dump site.

The possibility of groundwater pollution is unlikely to occur due to the following reasons:

- Low leachate flow rate
- The base of transfer stations, on which the solid waste will be stored, will consist of an impermeable material.
- Overall sanitation of the stations will be maintained by monitoring the operation continually.
- Spilled waste will be picked up immediately or not allowed to accumulate for more than 1 or 2 hours.
- Wastewater from washing down of the area will be collected and discharged into a local sewer.
- Pollutants in any leachate reaching the ground surface will be attenuated by filtration, sorption, chemical processes, microbiological decomposition and dilution.

Clogging of any water channels

There are no water channels near the proposed sites and so this impact does not arise.

Aesthetic degradation and property value loss

Will not be significant as the sites are vacant and the stations will be maintained with clean surroundings. There should be no scattered litter and clandestine dumping.

Disease vectors (flies, mosquitoes, rats, and cockroaches)

Flies and mosquitoes should be controlled by storing the waste for few days at the transfer stations and the elimination of standing water. Rats should be controlled using anti-rat chemicals and/or mechanical means.

Dust from loading and unloading operations at the transfer station

One way of controlling dust is by using water sprays to keep the dust down. However, this might not be possible for the complex due to limited water supply. If good windbreaks are provided, the dust generated will not have a significant effect due to the existence of dust in the area as most of the ground surface is bare. Use of closed containers is another possibility but could cost more.

Litter along roadways used by refuse collection vehicles

Waste should be covered during the haul operation.

Odours from dump

The odours discharged into the atmosphere from the dump are not likely to be of special concern if the waste is transported before it decomposes to an extent where it emits odours above the approved levels. However, if this is not done, then it is likely to be of concern.

Loss of flora and fauna

Interference to flora and fauna is not important in the area due to disturbance of the natural habitats in the past and the continuing development of the surrounding area. The land requirement for the project is small and therefore land use changes do not arise.

Contamination of air quality from incineration or resource recovery

There will be no intentional incineration at the stations. However, it is possible that people could light fires as keeping the transfer stations completely inaccessible might be costly. If this was to occur, it would lead to negative impacts. It is recommended that there should be resource recovery at the stations. This would generate income and also discourage scavenging.

Public opposition to proposed solid waste facilities

Two members of the Resident Development Committee from Zone 21 welcome the waste collection system to be introduced. Residents want transfer stations to be located within the Complex but say there is no space because they want the stations to be located about 100 to 200 m away from the houses. The reasons given are the following:

- Stations might have negative impact e.g. flies,
- Children might be attracted to play at the stations
- Lusaka City Council might not transport the waste from the station and can therefore cause an effect that is more negative if the station is near residences
- Station might be seen as a waste of resources because the waste will still be seen by residents. Therefore, it will seem as if those responsible for the solid waste transport do not want to get rid of it after moving it from midden boxes. It will also be seen as loading and unloading the waste twice.

Therefore, residents would like the transfer stations to be sited outside the Complex boundaries and suggested the area across Mungwi Road. CARE PROSPECT, on the other hand, would like the stations to be within the complex for legal reasons.

6.2.2 Mitigation and monitoring measures

Overall sanitation of the stations will be maintained by monitoring the operation continually. Any Spilled waste will be picked up immediately or not allowed to accumulate for more than 1 or 2 hours. The area will also be washed down.

6.2.3 Conclusion and recommendations

The proposed project will provide healthy living environment, as the solid waste will be removed from the Complex. This will only be possible if the waste is transported frequently and regularly to the Libala Dump site and the midden boxes and station are properly operated and maintained. It might also create some jobs in future like composting and material recovery. Paid labour might be required for loading and unloading operations. The project is therefore likely to have a positive net social impact on the area.

The Lusaka City Council has indicated that it can consider an application to build a transfer station within the vicinity of the present illegal dump site. This area has been zoned for industrial activities. If the transfer station will be well managed, the Council can allow the station to be located within the area but it has to be approved or disapproved. We recommend that CARE pursues this as it is more suitable to have the transfer stations in the industrial area (across Mungwi Road) than in a residential area. A bigger site might be acquired which will allow more space for other activities such as material recovery and composting. However, this might require constructing an accessible road which could be costly.

7. Legal implications of reclaiming disused quarries

The Environmental Protection and Pollution Control Act (Act No. 12 of 1990) Statutory Instrument No. 71 of 1993, the Public Health Act, Local Government Act, ECZ/LCC report and land ownership were considered to examine the legal implications of reclaiming disused quarries.

The Local Government Act sets out the functions of the local authorities very explicitly in relation to solid waste management. One aspect of solid waste management covered by the Township Regulations is the unauthorised disposal of refuse, thereby prohibition or denying the local authority reasonable access to the removal of refuse and disposing of it in an unauthorised manner.

The Public Health Act regards as a nuisance any garbage receptacle or refuse pit so foul or in such a state or so situated or constructed as, in the opinion of the Public Health Officer , to be offensive or to be injurious or dangerous to health. The local authorities are empowered under the Act to require the owner to remove any nuisance within a specified time.

The Environmental Protection and Pollution Control Act (Act No. 12 of 1990) Statutory Instrument No. 71 of 1993 Section 6 (2c) states that the waste disposal site or plant shall be operated in a way which would avoid polluting surface and underground water. According to this, it is possible to dispose waste into the disused quarries as long as measures are taken to ensure that there is no pollution to surface and underground water.

There is also need to obtain a licence to operate a waste disposal site or plant. The inspectorate issues a licence to own or operate a waste disposal site or plant if

a. approval has been obtained from the town and country planning authority on the location of the waste disposal site or plant:
b. the Inspectorate is satisfied that the owner or operator of the waste disposal site or plant has the ability and the appropriate facilities to manage the waste disposal site or plant without causing significant damage to the environment; taking into account the summary of the environmental impact statement submitted by the owner or operator.

The land where the disused quarries are located across Mungwi Road is Council land and has been designated as an industrial zone.

It would be illegal to dispose waste there unless the land is allocated by the Council for such purposes and Environmental Council of Zambia has also approved.

Reclaiming disused quarries would be legal when the following conditions are fulfilled:

- The Lusaka City Council allocates the land to the owner (residents) for such purposes
- The Lusaka City Council authorises the land to be used for reclamation considering the manner of waste disposal
- The Environmental Council of Zambia has to be satisfied that there will be no significant damage to the environment
- A licence has to be obtained from the Environmental Council of Zambia to operate the waste disposal site.

8. Conclusion and recommendations

It is estimated that George Complex will have a population of 136,890 in the year 2000.The total amount of solid waste expected to be generated in that year 2000 is 568.4 tons per week with a volume of 1624 m^3. Inert and bidegradable materials make up about 90 % of this waste. Eliminating the two categories by composting and better yard cleaning method will result in lower transport costs to the final tipping site. The maximum reduction would be 90 %, so a minimum amount of 57 tons (or 162 m^3) per week would remain for transport to the final destination site. The waste can further be reduced by separating some materials for recycling/reuse.

It is proposed that 191 midden boxes can be used to cover the whole complex in such a way that any midden box is not further than 200 m away from a house.

There is no expected significant environmental impact resulting from the illegal dump site across Mungwi Road. There is no expected contamination of groundwater and surface water as the leachate flow rate into the aquifer is estimated at 69 mm per year and it does not contain hazardous material. Although the dump promotes the breeding of disease vectors, its effect will not affect the people due to distance and existing waste dumps near the houses. Odours and dust are blown in a direction which is away from the complex.

Significant environmental impacts for the transfer stations are the breeding of disease vectors and a strong public objection to locating the stations within the complex. Public objection has to be looked into by CARE PROSPECT and find a solution before going ahead with the project. It is recommended that the Lusaka City Council be approached so that land can be acquired for transfer station across Mungwi Road or in the vicinity of the complex. Hazardous waste will have to be separated at the place of generation and handled according to ECZ guidelines.

Reclaiming disused quarries would be legal when the following conditions are fulfilled:

- The Lusaka City Council allocates the land to the owner (residents) for such purposes
- The Lusaka City Council authorises the land to be used for reclamation considering the manner of waste disposal
- The Environmental Council of Zambia has to be satisfied that there will be no significant damage to the environment
- A licence has to be obtained from the Environmental Council of Zambia to operate the waste disposal site.

The proposed project will provide healthy living environment, as the solid waste will be removed from the Complex. This will only be possible if the waste is transported frequently and regularly to the Libala Dump site and the midden boxes and station are properly operated and maintained

For the proposed solid waste project we have fully taken into account all foreseeable social, economic and environmental impacts within the limits of the current state of knowledge and reasonable practice.

Recopmmendations for the design of the transfer stations should consider the following:

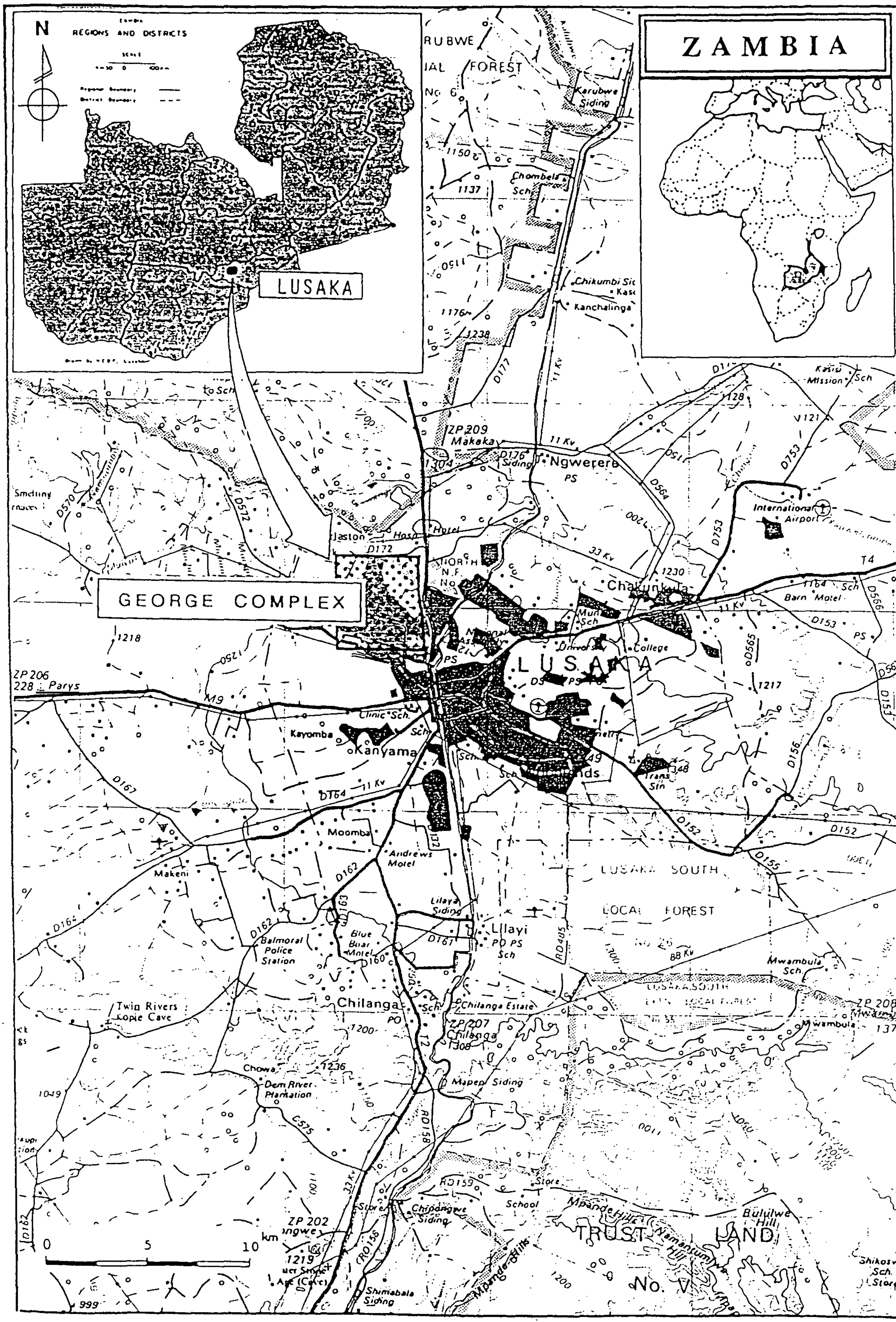
- Construction should have a floor slab, wall, fence, gates, office and latrine
- Provide a means of colecting and discharging leachate into a local sewer
- Provide windbreak
- Have a means of controlling dust during loading and unloading.
- Control the breeding of disease vectors

Appendices

Appendix 1:	Location map of George Complex
Appendix 2:	Cost of transfer stations
Appendix 3	Expected contribution of each household based on varying percentage of contributors

Appendix 1:

LOCATION MAP OF PROJECT AREA



Appendix 2 Cost details for the transfer stations

Element	Sizes	Unit costs (estimated)	Estimated cost
Floor slab and foundation	60 m^3	K 130,000 / m^3	K 7,800,000
wall	160*8 courses= 1280 blocks	K 2000	K 2,560,000
fence	2 * 20 + 2 * 12 - 6 = 58 m	K 460,000 / m^1	K 26,680,000
gate	6 m wide	K 1,500,000	K 1,500,000
office	5 * 4 * 3 m	K 15,000,000	K 15,000,000
latrine			
Total:			K 53,540,000

Appendix 3 Expected contribution of each household based on varying percentage of contributors

Households	23000
Stalls, shops and others	1400
Total	24400

Element	Total Cost	Percentage of contributors to the costs									
		10	20	30	40	50	60	70	80	90	100
Capital costs											
Midden boxes	116,892,000	47,907	23,953	15,969	11,977	9,581	7,984	6,844	5,988	5,323	4,791
Transfer stations	214,160,000	87,770	43,885	29,257	21,943	17,554	14,628	12,539	10,971	9,752	8,777
Wheel barrows or handcarts	2,000,000	820	410	273	205	164	137	117	102	91	82
Total	333,052,000	136,497	68,248	45,499	34,124	27,299	22,749	19,500	17,062	15,166	13,650
Operation and maintenance costs per month											
Transport from midden box to station	2,600,000	1,066	533	355	266	213	178	152	133	118	107
Transport from station to tipping site	8,000,000	3,279	1,639	1,093	820	656	546	468	410	364	328
Transfer station attendants	1,000,000	410	205	137	102	82	68	59	51	46	41
Dumping	0	0	0	0	0	0	0	0	0	0	0
Organization and management	223,100	91	46	30	23	18	15	13	11	10	9
Total	11,823,100	4,846	2,423	1,615	1,211	969	808	692	606	538	485

Note: All costs are in Kwacha

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