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PRIVATE PROVISION OF SOCIAL SERVICES
GABORONE, BOTSWANA

Phase II Feasibility Report on Disposal Alternatives

Report prepared for:

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and

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CITY OF GABORONE

SOLID WASTE MANAGEMENT

PRIVATE PROVISION OF SOCIAL SERVICES

PHASE II FEASIBILITY REPORT ON

DISPOSAL ALTERNATIVES

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1.0 EXECUTIVE SUMMARY

1.1 Objectives

This portion of Phase II project evaluated the feasibility of the various technical and management alternatives for operation of the new sanitary landfill, sorting/transfer facility and a composting plant. Secondary objectives included the evaluation of several special wastes that due to their unique characteristics, present specific problems for environmentally safe disposal. These wastes included hazardous commercial and industrial waste, medical waste, waste oil and tires.

1.2 Existing Conditions

The conditions at the landfill found during the Phase II evaluations were surprisingly similar to those observed during Phase I of the project, despite the many recommendations for improvements to landfill operations made in the Phase I report. Inadequate cover soil, poor compaction, uncontrolled scavenging, frequent fires, and poor overall management continue to be major problems. This failure to make recommended improvements, supports the earlier Phase I findings that an effective middle management structure does not exist and that accountability for operations is difficult to obtain under present conditions.

Phase II evaluations performed a more detailed analysis of existing collection and disposal practices for hazardous and medical waste. These evaluations confirmed a lack of practical knowledge of hazardous waste generators and medical waste collection and disposal practices that are well below acceptable standards. Existing medical waste disposal practices present a serious threat to collection workers and scavengers at the landfill. Air pollution from inefficient medical waste burning at the Princess Marina Hospital and the health clinics also create a serious threat to air quality in the City.

Several positive aspects of the City's waste management systems were noted during the Phase II evaluations. These included the increased paper and plastic recycling being performed by Waste Paper Recovery and the increased oil recycling by several of the oil supply companies. During March, the GCC tendered the landscaping of the existing landfill, primarily due to a major international conference held at the show grounds, adjacent to the landfill. Although the grading and covering of the landfill, dramatically improved conditions at the landfill, it required that landfilling be transferred to the former Mara Pula site which has been closed for approximately 15 years.

1.3 Recommendations

1.3.1 Special Wastes

An inventory and data base of hazardous and medical waste generators was initiated during the Phase II consultancy. Upon completion of the inventory, a feasibility study should be performed to determine the facilities and services needed to dispose of these wastes. As a minimum, an

area at the landfill for receiving and processing hazardous waste is recommended, plus a centralized medical waste incinerator and collection system to handle all medical waste generated in Gaborone and surrounding communities.

A new cement plant to be constructed in Palapye will have the ability to burn tires in its combustion chamber. Tires should be collected and stored in a secure area of the landfill and eventually shipped to Palapye for burning. A good waste oil market exists at the BP-Shell refinery in Zimbabwe and local businessmen are beginning to organize collection and storage systems to access this market. The GCC can assist in this process by leasing a former sewage pumping station as a storage facility.

1.3.2 New Landfill Design and Operations

The design and construction of the new landfill is proceeding much slower than expected and the April 1 target start-up date will not be met. Initial soil testing shows a highly variable site that will require careful grading, drainage and base preparation before landfilling can begin in an environmentally safe manner. Although the soils are highly variable, they are deeper and less permeable than anticipated, and may be suitable for an unlined landfill. Interim solutions should be implemented until the new landfill has been properly designed and constructed.

Due to extensive bedrock found on the site, an area of only 75,000 square metres can be developed as a landfill, resulting in only a 9 to 11 year capacity which is much shorter than earlier estimates. The remainder of the site can be used for brush and demolition waste, waste sorting and other waste processing facilities.

DUE TO THE LIMITED NEW LANDFILL CAPACITY OF ONLY 9 TO 11 YEARS, THE GABORONE CITY COUNCIL SHOULD BEGIN THE PLANNING PROCESS NECESSARY TO LOCATE ANOTHER LANDFILL IN MORE DESIRABLE SOIL CONDITIONS AWAY FROM DEVELOPED AREAS.

Section 5.0 presented several options for operation of the new landfill. This report recommends the full privatization of landfill operations rather than the "management only" option. It is our opinion that the "management only" is not privatization in a defined sense and this option will not provide the accountability for landfill operations that is needed to improve current conditions. If the GCC proceeds with recruiting an expatriate manager for "management only" operation of the landfill site, it will defeat the privatization option and may not qualify for future USAID funding under the PPSS program.

1.3.3 Sorting/Transfer Facility

Phase I recommended a sorting facility to reduce the amount of waste requiring landfilling. Due to the limited life of the new landfill, the feasibility design of the sorting facility also included it's potential use as a transfer station to access the next GCC landfill which should be located at least 10 to 15 kilometres from the City Center. The conceptual design was prepared in phases,

with the ability for expansion of capacity to meet both sorting and transfer requirements for the next 20 years. Initial Phase I construction costs are estimated at 3.6 million pula and total net annual costs are estimated at P258,000 for a unit cost of P28 per ton of recycled material. These costs are based on 1992 construction and operating costs. A limited amount of funding under the USAID, PPSS program is available to reduce capital costs through the purchase of American made sorting equipment.

1.3.4 Composting

Although the Phase I study recommended composting in addition to sorting, as a method of reducing the amount of waste requiring landfilling, the market evaluation performed during Phase II did not identify sufficient potential markets to justify a full scale compost facility at this time. The market evaluation determined the need for more information regarding compost quality and agricultural applications, and therefore a pilot compost program is recommended. This program should be a joint effort between the Agricultural College, the Ministry of Agriculture and the GCC. The pilot program should also evaluate the potential of co-composting of refuse and wastewater sludge from the proposed wastewater treatment facility, to be completed in 3 years.

1.4 Time Schedule

The completion of the landfill design and construction should be the GCC's priority goal in the next few months. The next component of the Phase II consultancy program should include the following tasks:

- After completion of the final landfill design, prepare an operating plan for the new landfill.
- Begin the tender process for fully privatized operation of the new landfill.
- Prepare feasibility studies for hazardous and medical waste processing facilities.
- Begin the tender process for design and construction of a sorting/transfer facility.
- Assist the GCC in negotiating market contracts for recycle materials from the sorting facility.
- Begin the tender process for operation of the sorting/transfer facility.
- Conduct a seminar on composting and work with the various government and educational groups to organize a pilot composting project.

2.0 INTRODUCTION

2.1 Background

Botswana, a resource-rich country located in southern Africa is experiencing unprecedented growth in its economy and population, and a transformation from a rural to a relatively urbanized country. The population of Gaborone, is expected to grow by approximately 10% per year as this trend continues. This rapid population and economic expansion has placed great pressure on public facilities and services provided by the Gaborone City Council (GCC).

To effectively address the increased infrastructure and efficiency of operations, required to maintain basic services for its growing population, the GCC has been considering the privatization of several public services, including solid waste collection and disposal.

In 1989, the GCC discussed the potential of privatization of solid waste collection and disposal services with the United State Agency for International Development (USAID). As a result, the USAID prepared a request for technical assistance under the Private Provision of Social Services Program. This request was approved in March 1990 for a two phased project consisting of technical assistance for the development and implementation of privatization strategies for solid waste services. Phase I of the program was completed in August, 1991.

The Phase I consultants worked with the assistance of a Steering Committee, composed of City Council and Central Government representatives. The Steering Committee provided feedback on alternatives and recommendations that were developed for consideration by the GCC.

2.2 Phase I Results

The Phase I portion of the program included an extensive evaluation of existing solid waste management systems, in order to identify those areas where privatization offered advantages in either the cost or quality of services. The Phase I report concluded that the public collection system was inefficient due to an inadequate organizational structure, minimal supervisory training, low productivity, equipment downtime and poor collection truck routing.

Disposal of waste at the City's landfill was also found to be deficient, resulting in many environmental health problems. Scavenging, frequent fires and unauthorized waste oil dumping were noted as significant operational problems. The lack of qualified middle management and appropriate organizational structure, contributed to minimal accountability for landfill operations.

In addition to making recommendations for privatizing both collection and disposal systems, the Phase I report provided many recommendations for upgrading existing services and dealing with special waste problems.

2.3 Phase II Scope of Services

After lengthy discussions among USAID, the Steering Committee and the GCC, a final Statement of Work (SOW) was prepared for Phase II of the project. Phase II of the project is intended to provide the technical assistance to the GCC to implement the recommendations of Phase I, and consists of the major objectives listed below. The full text of the SOW is included in the Appendix.

- Privatize the collection service for approximately one third of Gaborone, consisting of the area of Gaborone South, to include residential as well as commercial/industrial waste generators.

- The solid waste strategy for the City of Gaborone will result in the development of a sanitary landfill, incorporating sorting and composting.

- The operation of the landfill site will be privatized by way of contracting the management of landfill operations to the private sector in the form of a "Management Contract".

- Under subsequent phases of the Solid Waste project, funded by USAID, technical assistance be undertaken in the form of operation and management of solid waste collection, disposal services and staff training, in addition to other items of work.

The SOW included defined tasks in the two general areas of Solid Waste Collection and Landfill Management. The Landfill Management tasks were further broken down into a feasibility report task and an implementation task. This report covers only the work tasks described under the Landfill Management feasibility report which included the evaluation of landfill operations and appropriate sorting and composting technology. Other tasks included the commercial viability of each alternative, the potential for private sector involvement and impacts to the GCC.

The feasibility study also included the evaluation of waste oil, tires, medical waste and hazardous wastes. Existing disposal methods and recommended improvements were to be evaluated.

After completion of the feasibility study, review by GCC and the Steering Committee, the consultant will return to Gaborone to assist in the implementation of the selected alternative.

5

3.0 WASTE QUANTITY AND COMPOSITION UPDATE

3.1 General

The waste quantities and composition evaluations, which were presented in the Phase I report, were based on waste sorting that was performed in 1985 and on the two week weighing program performed in 1991 during Phase I of the project. Future projections were made of total waste generation based on various population estimates prepared by governmental organizations. Due to the more detailed nature of the Phase II scope of work, these projections must be expanded to project the future generation of individual waste components as well as total waste quantities.

The design of both the Sorting/Transfer Facility and the Compost Facility will rely on these projections to determine system sizing, cost estimates and manpower requirements both now and in the future. For the purposes of this report we will assume that the proposed facilities are placed in operation in 1995 and will be in service for 20 years. Total waste generation will be based on the 1991 weighing program and assumed to increase at the rate of 10% per year.

3.2 Waste Quantity Projections and Landfill Life

Since the Sorting/Transfer Facility and the Compost Facility are being evaluated as a means of extending the life of the new proposed landfill, initial waste projections will be made to determine the impacts to landfill life if the facilities are constructed. Figure 3.1, entitled Landfill Life Without Processing, projects waste generation and landfill capacity through the year 2020 assuming that no new facilities are added. Since landfill capacity is calculated on volume rather than weight, Figure 3.1 assumes density values of 250 kg/M for as-received refuse and 750 kg/M for in-place density assuming upgraded landfill operating procedures. Since the actual design of the new landfill has not been completed, we will use the volume of 3.28 million cubic meters, which was estimated by NZA in their 1989 preliminary design report. Adjusting this volume for cover soil requirements results in a net waste volume of 2.92 million cubic meters.

Assuming that the landfill begins operations in 1994, the 2.92 M cubic meters will be reached during the 20'th year of operation in the year 2013. This calculation assumes that the private recycling of paper and plastic continues, increasing at the same annual rate as total waste.

Figure 3.2, Landfill Life With Sorting and Recycling, is a similar calculation to Figure 3.1 but assumes that a sorting facility begins operation in 1995. The column labelled "Estimated Recycling" includes the existing private recycling as well as the recycling that is projected from the new facility. This figure shows that the landfill life will be extended by 3 years to 2016 by the sorting and recycling of the waste. These three additional years represent 855,014 cubic meters or approximately 30% of the available landfill capacity.

The next calculation, presented in Figure 3.3, Landfill Life with Sorting, Recycling and Composting, assumes that a full scale composting facility, as well as a sorting and recycling facility are operational in 1995. With the addition of a compost facility, the life of the landfill would be extended to the year 2023 for total life of 30 years, a 10 year extension compared to the life of the landfill if no processing were to occur. These additional 10 years represent a volume of 1,958,000 cubic meters or 67% of the landfill's capacity.

3.3 Composition Analysis and Projections

In order to prepare a preliminary design of the sorting and recycling facility, an estimate must be made of the individual materials in the mixed waste which are to be separated and recycled. This is especially important in this case, given the rapid growth that is projected in Gaborone over the next 20 years. The facility must be designed with sufficient capacity to handle the region's waste for that period and have sufficient flexibility to accommodate changes in the composition of the waste or materials market conditions that may occur during that period.

Figures 3.4 and 3.5, entitled Waste Composition Projections, present an estimate of the waste components, as determined by the 1985 NZA study, projected ahead to the years 1995, 2000, 2005 and 2010. This assumes that the processing facilities begin operations in 1995.

The column (1) presents the estimated annual amount of each material component. Since the facilities are assumed to operate only 6 days per week, column (2) presents the daily rate which is the annual rate divided by 312 operating days per year. Column (3) estimates the average annual capture percentage for each material. This percentage includes the projected efficiency of the sorting facility, the amount of contaminated unrecyclable materials, and fact that some of the paper materials are burned for heat during the winter months, thereby reducing the average capture percentage. Waste Paper Recycling reports that a 20% drop in recovered paper can be anticipated during the winter months. Column (4) calculates the daily amount of each sorted material by multiplying column (2) by column (3), the estimated capture rate.

After sorting through the waste and removing the recyclable materials, the remaining waste will be taken to the landfill or to a composting facility. Column (5) lists the individual materials that will remain mixed in the waste that leaves the sorting facility. Based on the total figures shown at the bottom of each column, 51 TPY of materials will be removed from the mixed waste, leaving 93 TPD to be landfilled or composted for a reduction of approximately 35% by the sorting facility.

Column (6) in the table estimates the amount of the remaining waste that is compostable. This is a very approximate estimate at this point in the evaluation, since composting depends on many variables which are unknown at this time. The last column in the table represents the final amount after sorting and composting that would still have to be landfilled.

The values presented in Figures 3.4 and 3.5 will be used to determine the overall size of the Sorting Facility and the processing systems for individual materials to be presented in Section 6.0.

3.4 Design Parameters

The preceeding evaluations and projections of waste quantities has shown the results of compounding a 10% growth rate over a 20 year planning period. Total waste generation estimated to be 138 TPD in 1995 will grow to 926 TPD in 20 years, nearly a 7 fold increase. Similar increases are projected in the materials to be sorted and recycled. These dramatic long term increases point to the need to plan and design facilities that can be flexible and expandable in order to handle future waste materials. This flexibility and expansion of capacities will be provided by a combination of increased physical facilities, expansion of the work force and extension of the hours of operation. The intent will be to maximize the use of the local labor force, minimize capital expentitures while providing adequate capacity for the entire 20 year planning period. The failure to properly plan for the future is the primary reason why Gaborone is facing a near crisis situation with its solid waste disposal facilities.

LANDFILL LIFE WITHOUT PROCESSING

YEAR	TOTAL WASTE GENERATED (TPD)	TOTAL WASTE GENERATED (TPY)	ANNUAL AS-RECEIVED VOLUME (CU.M.)	ANNUAL IN-PLACE VOLUME (CU.M.)	CUMULATIVE IN-PLACE VOLUME (CU.M.)	LANDFILL LIFE (YEARS)
1991	84	30,660	122,640	40,880		
1992	92	33,726	134,904	44,968		
1993	102	37,099	148,394	49,465		
1994	112	40,808	163,234	54,411	54,411	1
1995	123	44,889	179,557	59,852	114,264	2
1996	135	49,378	197,513	65,838	180,101	3
1997	149	54,316	217,264	72,421	252,523	4
1998	164	59,748	238,991	79,664	332,186	5
1999	180	65,722	262,890	87,630	419,816	6
2000	198	72,295	289,179	96,393	516,209	7
2001	218	79,524	318,097	106,032	622,241	8
2002	240	87,477	349,906	116,635	738,877	9
2003	264	96,224	384,897	128,299	867,176	10
2004	290	105,847	423,387	141,129	1,008,305	11
2005	319	116,431	465,725	155,242	1,163,546	12
2006	351	128,074	512,298	170,766	1,334,312	13
2007	386	140,882	563,527	187,842	1,522,155	14
2008	425	154,870	619,880	206,627	1,728,781	15
2009	467	170,467	681,868	227,289	1,956,071	16
2010	514	187,514	750,055	250,018	2,206,089	17
2011	565	206,265	825,061	275,020	2,481,109	18
2012	622	226,892	907,567	302,522	2,783,632	19
2013	684	249,581	998,323	332,774	3,116,406	20
2014	752	274,539	1,098,156	366,052		
2015	827	301,993	1,207,971	402,657		
2016	910	332,192	1,328,768	442,923		
2017	1001	365,411	1,461,645	487,215		
2018	1101	401,952	1,607,810	535,937		
2019	1211	442,148	1,768,591	589,530		
2020	1332	486,362	1,945,450	648,483		

1. Assumes all waste is disposed at the landfill, except current paper and plastics recycling, estimated at 10 TPD in 1991 and assumed to continue and increase at the same 10% rate as total waste generation.
2. Based on total landfill volume of 3.28M cubic meters and 2.92M cubic meters of refuse, allowing for cover soil.
3. As-received density assumed at 250 kg/M based on the 1991 weighing program updated to 1993 collection vehicles.
4. In-place density of 750 kg/M assumed based of upgraded operation.
5. Volume calculation assumes that waste soil is used as cover material.

FIGURE 3.1

LANDFILL LIFE WITH SORTING AND RECYCLING

YEAR	TOTAL WASTE GENERATION (TPD)	ESTIMATED RECYCLING (TPD)	NET WASTE TO LANDFILL (TPD)	ANNUAL AS-RECEIVED VOLUME (CU.M.)	ANNUAL IN-PLACE VOLUME (CU.M.)	CUMULATIVE IN-PLACE VOLUME (CU.M.)	LANDFILL LIFE (YEARS)
1991	94	10	84	122,640	40,880		
1992	103	11	92	134,917	44,972		
1993	114	12	102	148,408	49,469		
1994	125	20	105	153,466	51,155	51,155	1
1995	138	51	87	126,473	42,158	93,313	2
1996	151	56	95	139,379	46,460	139,773	3
1997	167	62	105	153,317	51,106	190,879	4
1998	183	68	116	168,649	56,216	247,095	5
1999	201	74	127	185,514	61,838	308,933	6
2000	222	82	140	203,885	67,962	376,894	7
2001	244	90	154	224,472	74,824	451,718	8
2002	268	99	169	246,919	82,306	534,025	9
2003	295	109	186	271,611	90,537	624,562	10
2004	325	120	205	298,772	99,591	724,152	11
2005	357	132	225	328,449	109,483	833,635	12
2006	393	145	248	361,514	120,505	954,140	13
2007	432	160	272	397,665	132,555	1,086,695	14
2008	475	176	300	437,432	145,811	1,232,505	15
2009	523	193	330	481,175	160,392	1,392,897	16
2010	575	212	363	529,292	176,431	1,569,328	17
2011	632	234	399	582,222	194,074	1,763,402	18
2012	696	257	439	640,444	213,481	1,976,883	19
2013	765	283	483	704,488	234,829	2,211,712	20
2014	842	311	531	774,937	258,312	2,470,025	21
2015	926	342	584	852,431	284,144	2,754,168	22
2016	1018	376	642	937,674	312,558	3,066,726	23
2017	1120	414	706	1,031,441	343,814		
2018	1232	455	777	1,134,585	378,195		
2019	1356	501	855	1,248,144	416,015		
2020	1491	551	940	1,372,148	457,616		

1. Estimated recycling includes existing paper and plastic recycling in addition to proposed sorting facility.
2. Based on total landfill volume of 3.28M cubic meters and 2.92M cubic meters of refuse, allowing for cover soil.
3. As-received density assumed at 250 kg/M based on the 1991 weighing program updated to 1993 collection vehicles.
4. In-place density of 750 kg/M assumed based of upgraded operation.
5. Volume calculation assumes that waste soil is used as cover material.

FIGURE 3.2

LANDFILL LIFE WITH SORTING, RECYCLING AND COMPOSTING

YEAR	TOTAL WASTE GENERATION (TPD)	ESTIMATED RECYCLING AND COMPOST (TPD)	NET WASTE TO LANDFILL (TPD)	ANNUAL AS-RECEIVE VOLUME (CU.M.)	ANNUAL IN-PLACE VOLUME (CU.M.)	CUMULATIVE IN-PLACE VOLUME (CU.M.)	LANDFILL LIFE (YEARS)
1991	94	10	84	122,640	40,880		
1992	103	11	92	134,904	44,968		
1993	114	12	102	148,540	49,513		
1994	125	20	105	153,466	51,155	51,155	1
1995	138	40	98	142,533	47,511	98,667	2
1996	151	100	51	75,026	25,009	123,675	3
1997	167	117	50	72,839	24,313	147,988	4
1998	183	128	55	80,233	26,744	174,732	5
1999	201	141	60	88,256	29,419	204,151	6
2000	222	155	66	97,081	32,360	236,511	7
2001	244	171	73	106,790	35,597	272,108	8
2002	268	188	80	117,469	39,156	311,264	9
2003	295	207	89	129,215	43,072	354,336	10
2004	325	227	97	142,137	47,379	401,715	11
2005	357	250	107	156,351	52,117	453,832	12
2006	393	275	118	171,986	57,329	511,160	13
2007	432	302	130	189,184	63,061	574,222	14
2008	475	333	143	208,103	69,368	643,589	15
2009	523	366	157	228,913	76,304	719,894	16
2010	575	402	172	251,804	83,935	803,828	17
2011	632	443	190	276,985	92,328	896,157	18
2012	696	487	209	304,683	101,561	997,718	19
2013	765	535	230	335,151	111,717	1,109,435	20
2014	842	589	253	368,667	122,889	1,232,324	21
2015	926	648	278	405,533	135,178	1,367,501	22
2016	1018	713	306	446,087	148,696	1,516,197	23
2017	1120	784	336	490,695	163,565	1,679,762	24
2018	1232	863	370	539,765	179,922	1,859,683	25
2019	1356	949	407	593,741	197,914	2,057,597	26
2020	1491	1,044	447	653,115	217,705	2,275,302	27
2021	1640	1,148	492	718,427	239,476	2,514,778	28
2022	1804	1,263	541	790,269	263,423	2,778,201	29
2023	1985	1,389	595	869,296	289,765	3,067,966	30
2024	2183	1,528	655	956,226	318,742		
2025	2401	1,681	720	1,051,849	350,616		

1. Estimated recycling includes existing paper and plastics recycling in addition to the proposed sorting and composting facility.
2. Based on total landfill volume of 3.28M cubic meters and 2.92M cubic meters of refuse, allowing for cover soil.
3. As-received density assumed at 250 kg/M based on 1991 weighing program updated to 1993 collection vehicles.
4. In-place density of 750 kg/M assumed based of upgraded operation.
5. Volume calculation assumes that waste soil is used as cover material.

FIGURE 3.3

WASTE COMPOSITION PROJECTIONS
1995 & 2000

	(1) 1995 GENERATION (TPY)	(2) 6 DAY WEEK (TPD)	(3) RECYCLE CAPTURE RATE (%)	(4) SORTED MATERIALS (TPD)	(5) REMAINING WASTE (TPD)	(6) COMPOST WASTE (TPD)	(7) WASTE TO LANDFILL (TPD)
PUTRESCIBLES	9,247	30	0%	0.0	29.6	29.6	0.0
KRAFT/CORRUGATED	5,710	18	85%	15.6	2.7	2.7	0.0
NEWSPRINT	1,626	5	60%	3.1	2.1	2.1	0.0
OTHER PAPER	6,823	22	50%	10.9	10.9	10.9	0.0
PLASTIC	3,133	10	45%	4.5	5.5	0.0	5.5
GLASS	4,071	13	50%	6.5	6.5	0.0	6.5
TIN CANS	3,631	12	80%	9.3	2.3	0.0	2.3
OTHER METALS	664	2	50%	1.1	1.1	0.0	1.1
TEXTILES/RUBBER	1,666	5	0%	0.0	5.3	0.0	5.3
UNCLASSIFIED	2,383	8	0%	0.0	7.6	1.5	6.1
ASH/FINES	11,415	37	0%	0.0	36.6	29.3	7.3
TOTALS	50,370	144		51.0	92.9	76.2	34.2

	2000 GENERATION (TPY)	6 DAY WEEK (TPD)	RECYCLE CAPTURE RATE (%)	SORTED MATERIALS (TPD)	REMAINING WASTE (TPD)	COMPOST WASTE (TPD)	WASTE TO LANDFILL (TPD)
PUTRESCIBLES	14,870	48	0%	0.0	47.7	47.7	0.0
KRAFT/CORRUGATED	9,185	29	85%	25.0	4.4	4.4	0.0
NEWSPRINT	2,617	8	60%	5.0	3.4	3.4	0.0
OTHER PAPER	10,976	35	50%	17.6	17.6	17.6	0.0
PLASTIC	5,040	16	45%	7.3	8.9	0.0	8.9
GLASS	6,550	21	50%	10.5	10.5	0.0	10.5
TIN CANS	5,842	19	80%	15.0	3.7	0.0	3.7
OTHER METALS	1,069	3	50%	1.7	1.7	0.0	1.7
TEXTILES/RUBBER	2,680	9	0%	0.0	8.6	0.0	8.6
UNCLASSIFIED	3,834	12	0%	0.0	12.3	2.5	9.8
ASH/FINES	18,363	59	0%	0.0	58.9	47.1	11.8
TOTALS	81,030	260		82.1	177.6	122.6	55.0

FIGURE 3.4

4.0 SPECIAL WASTES

4.1 General

As Gaborone continues to grow, its wastes will increase in quantity and become more diverse. Although there is a primary emphasis on managing the growing total volume of waste, there is a specific and acute need to also address several special waste items which because of their nature are more problematic in their disposal needs and the potential environmental and health impacts that may result from improper disposal. These special wastes include hazardous industrial and commercial wastes, medical wastes, waste oil and tires.

4.2 Hazardous Industrial and Commercial Wastes

4.2.1 Data Base

Botswana's economic growth is unique in southern Africa with many new industries and businesses moving into the many industrial parks throughout Gaborone. Although there are licensing agreements needed to establish a new industry, that require a listing of materials used, there is little, if any, follow-up on industrial and commercial wastes or where they are disposed of. Environmental by-laws dealing with hazardous materials are very general and seldom, if ever, enforced.

Prior to addressing the overall issue of hazardous materials, it will be necessary to establish a data base of the potential generators of hazardous wastes, what those wastes are and how they are presently being disposed of. Once the data base is established, facilities or services can be identified to manage these wastes in an environmentally acceptable manner.

Using several reference documents, including the 1993 Botswana Telephone and Telex Directory Yellow Pages and the Botswana Review of Commerce and Industry, 73 industries and businesses in 16 categories were identified as potential generators of hazardous waste. Categories such as chemical manufacturing and distribution, automotive and heavy equipment, clothing and textile manufacturing, dry cleaning, leather tanning, pesticide application and printing, all have the potential of generating hazardous waste materials. The list of potential hazardous waste generators is not meant to be inclusive but to serve as an example and starting point for the GCC Health Department to begin building a data base of hazardous waste generators.

In addition to the preliminary list of hazardous waste generators, a questionnaire and accompanying letter has been prepared to begin the inventory process. Ideally, these questionnaires should be hand delivered to each potential hazardous waste generator in the City and an interview conducted to obtain the information required. If sufficient qualified personnel

are not available to conduct the interviews, the questionnaires should be mailed to each industry on the list. If no response is given within a two week time period, a follow-up letter, phone call or personal visit should be made to collect the information. Copies of the preliminary list of potential waste generators, the questionnaire and accompanying letter are included in Appendix A of this report.

4.2.2 Disposal Options

Once a data base of hazardous material has been assembled, waste disposal alternatives can be evaluated. Hazardous wastes must be separated into chemically compatible categories for collection, storage and disposal. These categories are based on the material's flammability, reactivity, odour or toxicity. For instance acids should not be stored or disposed of with base materials and highly reactive chemicals should be isolated in separate areas for handling and disposal, away from all other chemicals.

Although the initial list of potential hazardous waste generators suggests a wide variety of materials, the total volume of materials is anticipated to be relatively small. Ideally the materials should be received at a central location and packaged in 210 litre drums. Larger volume materials such as solvents and cutting oils would be placed directly in individual drums, while smaller quantities of chemicals would be "lab packed" in a drum along with an inert absorbent material. Since each category of waste would require a separate drum, a covered secure area should be established, capable of handling 3 to 5 different categories of waste depending on the results of the waste inventory and data base. Once a drum is full it could either be kept in temporary storage, shipped to a licensed hazardous waste disposal landfill, or disposed of on-site. On-site disposal options could include pretreatment and processing, consisting of neutralization, precipitation, or stabilization with ash. These processing options should only be performed by qualified personnel under controlled conditions. A final disposal option would be to encapsulate the drums of collected waste in concrete, in a separate area of hazardous waste landfill if an existing licensed facility is not an available option. Due to environmental risks, hazardous waste should not be landfilled at the proposed site.

Due to the highly technical nature of hazardous waste handling and disposal, it should be made part of the private operation of the landfill and/or sorting facility.

4.3 Medical Waste

4.3.1 General

Medical and infectious waste is another special waste that if improperly handled can lead to major health problems. Although the City's two hospitals produce the majority of the medical waste generated in Gaborone, clinics, private doctors, veterinarians and testing labs all produce medical waste as well. In addition to these typical health service providers, infected food should also be placed in the category of infectious waste.

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WASTE COMPOSITION PROJECTIONS
2005 & 2010

	(1) 2005 GENERATION (TPY)	(2) 6-DAY WEEK (TPD)	(3) RECYCLE CAPTURE RATE (%)	(4) SORTED MATERIALS (TPD)	(5) REMAINING WASTE (TPD)	(6) COMPOST WASTE (TPD)	(7) WASTE TO LANDFILL (TPD)
PUTRESCIBLES	23,922	77	0%	0.0	76.7	76.7	0.0
KRAFT/CORRUGATED	14,770	47	85%	40.2	7.1	7.1	0.0
NEWSPRINT	4,208	13	60%	8.1	5.4	5.4	0.0
OTHER PAPER	17,650	57	50%	28.3	28.3	28.3	0.0
PLASTIC	8,104	26	45%	11.7	14.3	0.0	14.3
GLASS	10,532	34	50%	16.9	16.9	0.0	16.9
TIN CANS	9,394	30	80%	24.1	6.0	0.0	6.0
OTHER METALS	1,719	6	50%	2.8	2.8	0.0	2.8
TEXTILES/RUBBER	4,310	14	0%	0.0	13.8	0.0	13.8
UNCLASSIFIED	6,165	20	0%	0.0	19.8	4.0	15.8
ASH/FINES	29,530	95	0%	0.0	94.6	75.7	18.9
TOTALS	130,305	418		132	286	197	88.5

	2010 GENERATION (TPY)	6 DAY WEEK (TPD)	RECYCLE CAPTURE RATE (%)	SORTED MATERIALS (TPD)	REMAINING WASTE (TPD)	COMPOST WASTE (TPD)	WASTE TO LANDFILL (TPD)
PUTRESCIBLES	38,530	123	0%	0.0	123.5	123.5	0.0
KRAFT/CORRUGATED	23,790	76	85%	64.8	11.4	11.4	0.0
NEWSPRINT	6,777	22	60%	13.0	8.7	8.7	0.0
OTHER PAPER	28,428	91	50%	45.6	45.6	45.6	0.0
PLASTIC	13,053	42	45%	18.8	23.0	0.0	23.0
GLASS	16,964	54	50%	27.2	27.2	0.0	27.2
TIN CANS	15,131	48	80%	38.8	9.7	0.0	9.7
OTHER METALS	2,768	9	50%	4.4	4.4	0.0	4.4
TEXTILES/RUBBER	6,942	22	0%	0.0	22.3	0.0	22.3
UNCLASSIFIED	9,930	32	0%	0.0	31.8	6.4	25.5
ASH/FINES	47,562	152	0%	0.0	152.4	122.0	30.5
TOTALS	209,875	673		213	460	317	142.5

FIGURE 3.5

Typical medical waste disposal includes disinfection through sterilization followed by landfilling, or high temperature incineration. Due to the difficulties in sterilizing large volumes of waste, or documenting that sterilization has in fact occurred, high temperature incineration is the most practiced and preferred form of medical waste disposal. To insure complete combustion of the waste, the incinerators should include multiple chambers with auxillary burners and temperature controls.

In addition to disposal, the collection and handling of medical waste can pose a risk to medical staff and waste handlers. Color coded heavy weight plastic bags and rigid containers for "sharps" are standard in most hospitals. Red bags identify waste originating from operating theaters, and yellow bags designate waste from patient care areas. Rigid "sharps" containers are used for needles, syringes, razor blades, disposable scalpels, broken glassware, thermometers etc.

4.3.2 Existing Methods

In order to evaluate the current medical waste disposal in the City, we inspected both hospitals and interviewed key staff members.

The Gaborone Private Hospital was opened last year and has instituted an excellent waste identification and handling system. All medical and infectious wastes are placed in color coded plastic bags, as described above, and burned in a small multi-purpose incinerator having a capacity of 40kg per hour and uses LP gas as its auxillary fuel. Wastes from the kitchen, offices and non-medical areas of the hospital are placed in black plastic bags and taken to the landfill. During a normal 10 hr day the unit will burn approximately 400 kg of waste.

The design of the incinerator is based on the calorific value of the waste being burned and when typical waste is burned, the incinerator runs fine. Unfortunately, due to its design and small size it is susceptible to overloading with waste that has a higher calorific value than the design specifications allow. This frequently occurs when a high plastic waste is burned. This causes the incinerator to overheat which automatically turns off the primary air supply. As a result, the waste receives insufficient oxygen and produces black smoke and toxic fumes, until operating temperature return to normal levels.

Since the waste is concealed in plastic bags, the operator is unable to identify the contents of the bag or its calorific value. Some suggestions were made as a result of our inspection to identify the high plastic waste and place it in smaller containers that would not exceed the capacity of the incinerator.

The medical waste handling and disposal practices at the Princess Marina Hospital were found to be below acceptable standards. Although a color coded bag system was recommended in the past, it has not been implemented. All wastes generated at the hospital are placed in thin gauge black plastic bags. Although the wastes are reportedly kept separate from kitchen waste and office waste, a bag of medical waste could be mistakenly taken directly to the landfill since they are all the same color.

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The medical waste is burned in one of two waste incinerators. The first is an oil fired unit located near the central boiler facility. This incinerator is improperly designed and operated. Proper operation should consist of preheating the combustion chamber to 500 or 600 degrees C before feeding in the waste. We were told that this was not possible since opening the door during operation causes smoke and soot to blow out through the loading door. This condition is a sign that the unit has insufficient draft, caused by too short a stack or a gas flow that is partially blocked with debris. As a result of this condition, the cool combustion chamber is filled with several bags of waste, the door is closed, then the burner is switched on. Since this results in very uneven heating of the waste, the waste burns incompletely, giving off a characteristic black smoke.

The second incinerator is a smaller, coal fired unit located within the central boiler facility. The stack from the incinerator is connected to one of the chimney flues of the boiler facility and has a much stronger draft than the first unit. Prior to burning waste, a coal fire is built on the combustion chamber hearth. When the coal fire is well established, and up to operating temperature, bags of medical waste are placed in the combustion chamber. Due to the higher chimney, there are no backdraft problems with this unit. Coal is added to the combustion chamber as needed to maintain temperatures. This unit is operating more efficiently than the first unit, due to the more constant high temperature, but overloading with several bags of waste is also a common problem, causing incomplete combustion and black smoke.

The amount of waste actually burned at Princess Marina Hospital is not known since there are no records kept. We have requested that a log be started so that a total amount of waste burned can be determined. The operator estimated that at least 100 bags are burned each day. At 15 kg per bag, that would be 1,500 kg per day or 1.5 tons.

The City Health Department operates 16 clinics throughout the City of varying sizes. These clinics offer a variety of services but in general do not have operating theaters. The current disposal practice includes burning of all wastes on-site in open pits. After the pit fills with ashes, it is covered and a new pit is dug. This procedure is obviously below acceptable standards and is likely causing significant air pollution problems in the local area. Similar to the Princess Marina Hospital, the clinics do not keep records of the amount of medical waste that is disposed in this manner. At our request, a log will be kept at each clinic so that a total waste quantity can be determined. The City Matron, who is in charge of the clinics has requested funds to install an incinerator at each clinic, but the request has not been processed.

Although not a common occurrence, there have been past incidence of infected meat that required disposal. At the present time, infected meat from the abattoir is given to a lion park located several kilometers south of the City. Occasionally, infected meat and poultry is tipped at the landfill where it can be removed by the waste pickers. A rough estimate provided by the Health Department indicates that abbatoir generates approximately 1 ton of infected meat per day. Severely infected meat should be incinerated along with medical and infectious wastes.

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4.3.3 Other Medical Waste Generators

As stated in Section 4.2.1, there are many other generators of medical and infectious wastes in the City of Gaborone. Private doctors offices, dentists, veterinarians, and testing labs will all generate medical and potentially infectious wastes. Although these wastes will to be less problematic than the wastes generated by the hospitals and clinics, they will still present the potential of significant public health impacts if improperly disposed of. Food products, found to contain infectious diseases should also be included in this category.

4.3.4 Data Base

Before evaluating the effectiveness of existing disposal systems, or the proposal of new facilities, it is necessary to obtain a better estimate of the total amount of medical and infectious waste being generated in Gaborone. A questionnaire and accompanying letter, similar to the one prepared for industrial and commercial waste, has been prepared for medical and infectious wastes. These questionnaires should be sent to all potential waste generators mentioned in Section 4.3.3 above. Upon receipt of all requested information, a data base will be prepared summarizing all medical and infectious waste quantities. The data base will also be used to project the generation of waste throughout a 20 year planning period so that adequate future disposal capacity will be assured.

4.3.5 Disposal Methods

The use of high temperature incineration is the preferred method to dispose of medical and infectious waste. Although the amount of such waste generated in Gaborone will not be known until the completion of the questionnaires and data base, it can be assumed that the current capacity is insufficient. The existing incinerators at the two hospitals are operating at or above their capacities and wastes from all other generators is likely being tipped at the landfill or disposed of without adequate sterilization.

Although the operations of the two hospital incinerators could be improved to acceptable standards, their existing capacities will still be insufficient to meet existing or future needs. The location of the incinerator at the Private Hospital, within the building, is physically constrained and it would not be possible to increase its capacity. Although there may be adequate space at the Princess Marina Hospital for a larger incinerator, the space for receipt and storage of outside wastes would be very limited. Also its location within the City Center may create adverse air impacts should the capacity of the existing incinerators be increased.

In consideration of the above issues, the existing and future disposal of medical and infectious wastes should be provided by a new, dual chamber incinerator located in an outlying area of the city. The incinerator should be designed with sufficient capacity, delivery and storage areas for the next 20 years. Due to the highly technical nature of the waste incineration, the construction and operation of the facility should be privatised.

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The current proposal by the City to equip each clinic with its own medical waste incinerator should be discouraged in favor of one central incinerator. The relative risks of transporting medical waste to the central location will be significantly less than the risks of operating 16 small incinerators. It will be difficult to maintain these small incinerators and to provide experienced operators. The risk of air pollution will be much greater with the 16 smaller incinerators than a central facility.

4.4 Waste Oil

4.4.1 General

Waste oil is defined as lubricating oil from engine crankcases and gearboxes from automobiles, trucks and other heavy equipment. Due to marketing specifications it should not include asphalt oil, cutting oil, vegetable oil, synthetic oil, solvents, furnace oil, grease, or antifreeze.

Waste oil disposal was the topic of a workshop sponsored by Environment Watch Botswana in May, 1992. This workshop concentrated on the difficulties in identifying the many generators of waste oil and the problems associated with collection and transportation to existing re-refiners in South Africa. Low prices paid for the oil, high transportation costs and strict contamination requirements were all cited as constraints to waste oil recycling. Due to these constraints, the majority of waste oil continues to be dumped in the bush or at the landfill.

Small amounts of oil are used for dust control, wood preservatives and other farm related activities but these are of minimal value considering the large volumes of oil that must be properly addressed.

4.4.2 Waste Oil Generators

The approximate 20 automobile service stations generate an estimated 8,000 litres of waste oil per month for a total annual generation of 96,000 litres. In addition to the service stations, there are three other major generators of waste oil; the Botswana Railways, Central Transportation Organization and the Botswana Defence Force. Various organizations have estimated the total waste oil generation to be between 500,000 and 600,000 litres per year.

4.4.3 Disposal Options

Based on several interviews conducted during this phase of the project, the indiscriminate dumping of waste oil is still widespread but is decreasing due to a stable market in Zimbabwe, Shell-BP refinery, that will pick up waste oil in Gaborone and pay a modest amount between 5 and 10 thebe per litre. The contamination specifications are reported to be much lower than similar markets in South Africa. The one major drawback of this market is that the minimum amount that they will pick up is 40,000 litre. Therefore, adequate storage capacity will be a key to accessing this market. At least one oil supplier, is offering a collection service to his customers and storing the oil in two 20,000 litre tanks.

Although the market in Zimbabwe is paying for the oil, the amount plus the nature of the economy in Zimbabwe is not conducive to a cost effective private venture. Even if all 500,000 gallons were collected and marketed through a single vendor, a revenue of only P30,000 per year would be realized. This would hardly be sufficient to finance the mobile equipment, storage facilities and manpower needed for a citywide collection service. Therefore the most effective means of collecting the waste oil would be for each oil dealer to install storage tanks and accept waste oil from its customers. If the revenue produced from recycling the waste oil is not sufficient to cover the costs, then the recycling of oil should be subsidized by an increase in the price of new oil. In this manner, the user of the oil pays for the increased costs of recycling the used oil.

The City Engineering Department has indicated that an abandoned sewage pumping station along Old Lobatse Road, with an underground storage vault with a capacity of approximately 400,000 litres could be made available for a waste oil receiving and storage facility. Although City Council approval would be required, the private operation of such a receiving and storage facility would a more efficient system than individual storage tanks.

In addition to the Shell-BP refinery in Zimbabwe, Oil Kol in South Africa will accept waste oil if delivered to their facility in Chamdor. Unfortunately the price paid will barely support the transportation costs and contamination requirements are very strict, often resulting in the rejection of a load or no payment made.

4.4.4 Alternative Methods

The burning of waste oil is common practice in many countries. Special furnaces are manufactured in the United States that operate on 100% used oil. Used oil is often blended with fuel oil and used in industrial applications such as asphalt plants and cement kilns. One precaution that must be taken before burning waste oil is the lead content, which could result in ecessive air emmissions of lead. Although many countries have converted to lead-free fuels, Botswana and South Africa continue using leaded gasoline and waste oil will contain lead residues. Before considering the use of waste oil as a fuel, the lead content of the oil should be determined.

The Botswana Development Corporation (BDC) will construct a cement manufacturing facility in Palapye over the next 3 years and has expressed an interest in using the facility to burn waste materials in addition to the primary coal fuel. The engineers who are designing and constructing the facility, PEG, S.A., also have experience in waste incineration. This interest is based on using the facility to solve waste disposal problems rather than needing additional fuel supplies. The facility will operate at very high temperatures and will be equipped with pollution control devices. The potential of airborne lead contamination from the burning of waste oil will be greatly reduced by the pollution control devices. When completed in 1996 this facility could serve as a backup disposal location for waste oil and other waste materials.

4.5 Tires

Tires continue to be a major problem at the Gaborone landfill. Due to their composite construction they are of no value as a recycle material and they are very difficult to place in a landfill due to their elastic nature. Piles of tires placed at the landfill by tire dealers and recapping plants, trap water and become breeding grounds for mosquitoes and other insects. Piles
of tires are burned frequently, either accidentally or intentionally by the waste pickers who frequent the landfill. During a three week period there were two large tire fires at the landfill, and based on evidence found at the site this is a frequent occurrence.

The design engineers for the Palapye Cement Kiln have also expressed an interest in burning tires as an additional fuel source. The calorific value of a tire is actually higher than coal and the high operating temperatures and pollution control devices will assure that any air pollution will be minimal. Other components of the tires, such as the steel reinforcing and carbon black will be beneficial to the final cement product. Passenger and small truck tires could be burned whole but larger truck tires would have to be cut in half before burning.

Although the cement facility will not be completed for three years, the engineers have suggested that tires could be stockpiled at Palapye for the next three years, then burned when the facility begins operations in 1996. Tires could be shipped to Palapye either by truck or rail transport. A separate area of the new landfill site should be reserved for receiving tires and which would be immediately placed in a truck. If rail transport is used, the truck would deliver the tires to a rail siding and load them into an empty coal hopper returning to the Serule mines. Tire dealers could deliver the tires directly to the rail siding. A modest fee should be charged for each tire to offset the cost of transporting them to Palapye. This fee could then be passed on to the individual vehicle owner either at the time of purchase or when the tire was removed from the vehicle.

At Palapye the tires would be unloaded from the coal hopper and stockpiled in a remote area near the site of the new cement facility. Due to the large numbers of tires that will be collected in three years, they should be stored in small piles of 100 to 200 tires, separated by at least 50 meters. In this manner, if a fire occurs, only one pile will burn rather than all of them if they are stored in one large pile.

4.6 Global Perspective

Although the previous discussions are limited to waste generators within the Gaborone City limits, all of the above facilities could be expanded to process waste from a wider region. Transportation costs may impact the areas that could be serviced by regional facilities but certainly towns and villages within 50 kilometres of Gaborone could be served.

5.0 LANDFILL DESIGN AND OPERATIONS

5.1 General

The Phase I report, completed in August 1991, presented the history of the existing and proposed landfills and outlined the steps that have been taken to locate and design the new landfill. At the time of the Phase I evaluations, a detailed survey of the proposed new site had not been completed and subsurface hydrogeological features had not been investigated. The emphasis at that time was being placed on completing the design and construction of the entrance road and receiving facilities.

The Phase I study recommended that hydrogeological investigations be performed before proceeding with the final design of the landfill. At the beginning of the Phase II study,. in February 1993, 18 months after the completion of the Phase I study, a new entrance road and receiving facilities were nearing completion but the hydrogeological investigations, needed to complete the final landfill design had not begun. Although the Phase II Statement of Work includes the preparation of an operations plan for the new landfill, this task cannot be completed until the landfill design is finalized. The following sections will address existing landfill problems and offer some suggestions for proceeding with the design of the new landfill.

5.2 Existing Landfill

The existing landfill continues to operate in the same general manner that was observed in August 1991, in spite of many recommendations made in the Phase I report for improvements. Waste was being dumped along the edges of the site then pushed over the embankment forming a steep side slope of loose material. This method provides little, if any, compaction, and the loose, uncompacted waste contributes to frequent fires. The fires are reported to be set by the waste pickers to expose more refuse for picking or by fires set by government workers to destroy confidential documents. Fires during the winter are sometimes caused by scavenger camp fires, or hot coals brought into the landfill with a "hot" load of waste.

Part of the frequent fire problem is the limited space in the southern end of the site where brush, tires and waste oil are dumped. This is also the area where the confidential documents are burned. When this area is relatively full of materials, which can occur within a week or two, the document fires spread very easily to the brush and then the tires. A separate area or incinerator for burning documents should be provided at the new landfill to reduce the potential of fires.

The landfill continues to receive a large amount of earth material and construction debris. This continues to be mixed with the waste rather than separated out to be used as cover soil. A centralized gate or receiving area has not been established and often there is no guidance from GCC staff as to where to dump. All of these issues have led to many problems being experienced at the landfill.

After several inspections, I prepared a sketch of the site and directions for the construction of proper landfill cells in the middle of the site, rather than tipping over the edges. This method was implemented in the middle of February. The lack of adequate cover soil and the lack of adequate supervision and security continue to be the major problems at the existing landfill.

Conditions at the existing landfill have been the subject of numerous discussions by civic organizations and public officials in the past few months. Although the ACP/ECC conference, held in March 1993, had been the origin of much of the discussion, the increased environmental awareness by groups such as the Kalahari Conservation Society and Environment Watch Botswana has increased publicity of the landfill's problems. In response to this public concern over landfill conditions, the GCC authorized P400,000 to make improvements to the landfill. These improvements, completed in mid March 1993 included regrading the steep side slopes and applying .5 metres of final cover material. Excess material from City road projects and on-site borrow, provided material for the landfill cover. While work was being performed on the landfill and during the ACP/ECC conference, landfilling of waste was terminated at the existing site and moved to the former closed landfill at Mara Pula.

Although these measures have improved the appearance of the landfill, the major issues of limited capacity still remain. In simple terms the landfill is nearly full and a new site is needed as soon as possible.

5.3 Proposed New Landfill

As stated above, the design of the new landfill has proceeded much slower than expected. The final design, including the actual size of the landfill, liner details, and environmental controls have not been completed.

The detailed topographic map that was completed after Phase I of this project, contains some significant features which may impact the design and certainly the capacity of the proposed landfill. This map shows many areas of bedrock outcropping on the site, reaching heights of 2 to 3 metres. An on-site inspection of the rock outcroppings and other bedrock in the area has indicated that the rock is granite with many fractures and weathered zones. These ground conditions are not conducive to environmentally secure landfill construction.

In addition to the hydrogeological investigations being performed for the new landfill, groundwater testing is being performed by the Department of Water Affairs to assess the existing landfill's impacts on local groundwater and surface water resources.

Given the close proximity of the proposed landfill to a major drainage ditch, the Ngotwane River and two water pipelines forming the eastern boundary of the site, the presence of the fractured bedrock is cause for concern. Leachate which will be produced by the new landfill may enter the bedrock fractures and travel long distances without filtration or natural treatment. Common practice is to maintain at least 2 or 3 metres of fine grained soil between the bottom of the landfill and any groundwater or bedrock. The layer of fine grained soil will act as a treatment

zone, providing a limited amount of filtration and treatment of the highly organic leachate before it reachs the bedrock fractures. Although there are few groundwater resources in the vicinity of the landfill, any contamination of groundwater should be avoided, due to the potential development that may take place in the forseeable future.

5.4 Leachate Generation

When organic matter is placed in a landfill, organic decomposition begins almost immediately. Initial biological activity produces strong organic acids that dissolve other materials in the waste, including many toxic heavy metals, such as lead, mercury, and cadmium. Later stages of decomposition occur under anaerobic conditions which produce methane gas as one of the by-products in addition to a strong organic leachate. The methane gas must be vented to the atmosphere when the landfill is closed and covered with soil.

The process of decomposition and leachate production is proportional to the amount of water that is allowed into the waste originating from rainwater or surface water flow. Efficient landfill operations should be designed to direct rainwater away from the waste to reduce leachate generation. In the semi-arid climate of southern Botswana it may be possible to prevent leachate formation through efficient water management procedures. A water balance calculation should be performed as part of the final landfill design to estimate annual leachate production.

The above description of leachate generation applies to a properly operated landfill that does not burn. A landfill that burns frequently, like the present Gaborone landfill, will not decompose in the same manner. The burning organic waste produces ash consisting of carbonates and oxides which have an alkaline PH. Although some heavy metals such as lead will dissolve under alkaline conditions as well as acidic conditions, most metals will remain relatively stable under alkaline conditions. Without as much organic matter to decompose, the formation of acid is limited and those acids that do form are buffered or neutralized by the alkaline ash remaining from the burning waste.

The Gaborone waste contains a high percentage of plastics including PVC containers. When these plastics burn under incomplete combustion, they produce many complex hydrocarbons, some of which can be very toxic. The incomplete combustion of PVC plastic, for instance, can produce dioxins and furans which are among the most toxic substances known to man. The environmental, as well as the aesthetic impacts of a burning dump, are major issues that need to be adequately addressed in the new landfill.

Current plans call for private operation of the new landfill, and a sorting and recycling center. The sorting facility will remove most of the items that are currently being scavenged and the final waste going to the landfill should be very high in organic matter. Without the scavenging, the threat of fires will be greatly minimized and the highly organic waste will produce a very strong organic leachate unlike the relatively weak leachate being produced by the existing landfill. Fortunately the sorting facility should also remove many of the typical sources of heavy

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metals such as printing inks in magazines and newspapers and lead solder from tin cans. Other sources of heavy metals, however, will remain in the waste such as batteries and discarded electrical appliances.

In summary the existing landfill, due to frequent burning, is most likely producing a relatively benign leachate, of minimal environmental impact to ground water. This situation, however is more than off-set by serious air pollution problems as a result of the frequent fires. The new landfill will be better managed and operated and due to the sorting facility will have a high organic content. Without the frequent fires, the leachate anticipated from the new landfill will be much stronger in organic content (BOD) and heavy metals than the existing landfill. Due to these significant differences, the current chemical testing of groundwater under the existing landfill should not be used to gauge the impacts of the new landfill.

5.5 Design Parameters and Risk Evaluation

The design of a landfill must take into account many technical, economic and political issues. All parties involved with the new landfill appear to agree that the new proposed landfill site is not a good one and that it has many technical limitations, including the amount of surficial bedrock, its proximity to populated areas and the potential contamination of surface and groundwater supplies. Unfortunately the decision to place the new landfill at that location appears to be cast in stone and there is insufficient time or existing disposal capacity to consider alternative sites. The challenge to those designing the landfill will be to work within these limitations and produce and environmentally acceptable design at an affordable cost.

The first issue to be resolved in the final design is the degree of risk that the GCC is willing to accept regarding the potential of future contamination of surface and groundwater water resources, and neighborhood impacts. The acceptance of risk is usually a balance between environmental and economic factors. Generally, the lower the risk, the higher the cost and vice versa. In this instance there is a significant environmental risk associated with building a landfill over fractured bedrock. This risk can be reduced by building the landfill only in those portions of the site without surface bedrock, and reduced further if 2 to 3 metres of fine grained soil separates the landfill from the bedrock. The risk would be reduced still further by constructing an impermeable liner of clay or plastic. Each of these lower risk designs carries progressively higher costs.

5.6 Conceptual Design

Figure 5.1 is a sketch of the proposed landfill site showing the approximate locations of the surface bedrock. It will be difficult and expensive to construct a landfill on top of these bedrock areas, and this is not recommended. An area designated as "New Landfill Area" consists of approximately 75,000 square metres where no surface bedrock has been encountered. Test pits will be required to verify the actual depths to bedrock in this area and soil characteristics.

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Although the area is free of surface bedrock, the surface soil appears to be relatively sandy and may not function as a suitable treatment layer above the bedrock. The test pits to be installed in mid March will define subsurface soil conditions and establish final design conditions.

Upon verification of bedrock depths and soil characteristics, the design of the landfill base can proceed. If the proposed landfill were constructed as shown in Figure 5.1, and filled to an average height of 10 metres, it would have a life of approximately 9 years if no other waste processing were to be installed. This capacity would increase to 11.5 years with the proposed sorting facility and 16.5 years if both sorting and composting were installed.

Although this conceptual design does not utilize the entire site for mixed waste disposal, there are many other wastes that the GCC must contend with that will also require space for disposal or processing. Figure 5.1 shows an area assigned for brush and demolition waste. Since these wastes do not produce a leachate, they can be safely placed in an unlined area or on top of the surface bedrock. The brush area should be compacted and covered periodically. The use of chippers would conserve space in the brush disposal area and produce a product that may have other uses such as landscape mulch. In Section 4, several special wastes were discussed that will also require special handling areas at the landfill. These include hazardous wastes, waste oil and tires.

Since tire storage is currently a major problem, Figure 5.1 shows a tire storage area within a fenced area along with the scrap metal yard. This will restrict access to the stored tires and reduce the potential of fires. As mentioned in Section 4, the tires should be periodically shipped to the Palapye cement plant for final disposal.

The uncontrolled burning of confidential documents is also a major source of fires at the landfill. Therefore the conceptual design includes the location of a document incinerator located near the receiving facilities for controlled burning of documents.

5.7 Landfill Privatization Options

5.7.1 General

Although the detailed operations plan and private management tenders cannot be finalized until the landfill design has been completed, the following discussion of privatization options will provide the GCC with a general description of each option. Advantages and disadvantages will be stressed.

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5.7.2 Private Management

The term "management", without reference to operation, implies that only the management of the landfill will be privatized and the equipment, labor and operation will continue under the control of the GCC. This scenario is not privatization in a defined sense but is merely an educational and training exercise channeled through an experienced manager or consultant. Although this system may improve current operating procedures through its training component, it will not provide the accountability and enforcement of operating procedures and specifications that are the primary objectives of privatization of municipal services. The division of labor and equipment between the Engineering Department and the Department of Health will still exist without a central authority over both.

Unless the managers of the landfill have authority over the landfill workers, their efficiency and productivity, and over the operation and maintenance of the equipment, significant improvement in the quality and efficiency of operation may be difficult to achieve.

The advantages of the "management only" scenario are that it will be relatively easy to initiate from the existing system, since little change will take place except the creation of a middle manager with administrative and training responsibilities. Another obvious advantage will be that no jobs will be lost to the private sector.

In our opinion, the advantages will be more than outweighed by the disadvantage of failing to achieve accountability for the operations of the landfill in accordance with a set of specifications established in a tender document. Under the full privatization option the tender document establishes accountability through the payment provisions and liquidated damages which are not an available option under the "management only" scenario.

Since the current USAID program, which is providing technical assistance for this project, is intended to promote full privatization of municipal services, it is probable that USAID would terminate its involvement in the landfill operations program should the GCC pursue the "management only" option for landfill operation.

5.7.3 Private Management and Operations

Under a more typical full privatization program, an operations manual and specifications are prepared and incorporated into the tender document, for which the contractor is held responsible. The accountability is provided through the performance specifications, payment provisions and liquidated damages. In simple terms, if performance falls short of the specifications, payment is withheld.

The objective in preparing the tender documents is to establish performance standards that are equitable to both parties and measurable. They must be strict enough to insure performance but flexible enough to accommodate changes in the site conditions, weather, and unforeseen events. An arbitration provision should be included to resolve disputes in an equitable manner.

Although incentives can be included in the tender documents to hire existing qualified GCC workers, or to purchase/lease existing equipment, it should be at the contractor's option. The contractor must have absolute authority over the work force and equipment in order to achieve the desired accountability for performance.

The disadvantages of the full privatization of operations is the apparent loss of control, and potential loss of some jobs. The degree of control that the GCC wishes to exercise over the contractor is determined by the tender document and performance specifications. These can be as simple or involved as the GCC wishes. Control provisions must be established early in the tender process.

The major advantages to the full privatization of the landfill operations are its accountability for operations according to an enforceable set of performance specifications. This accountability insures proper operations and provides the enforce through payment provisions.

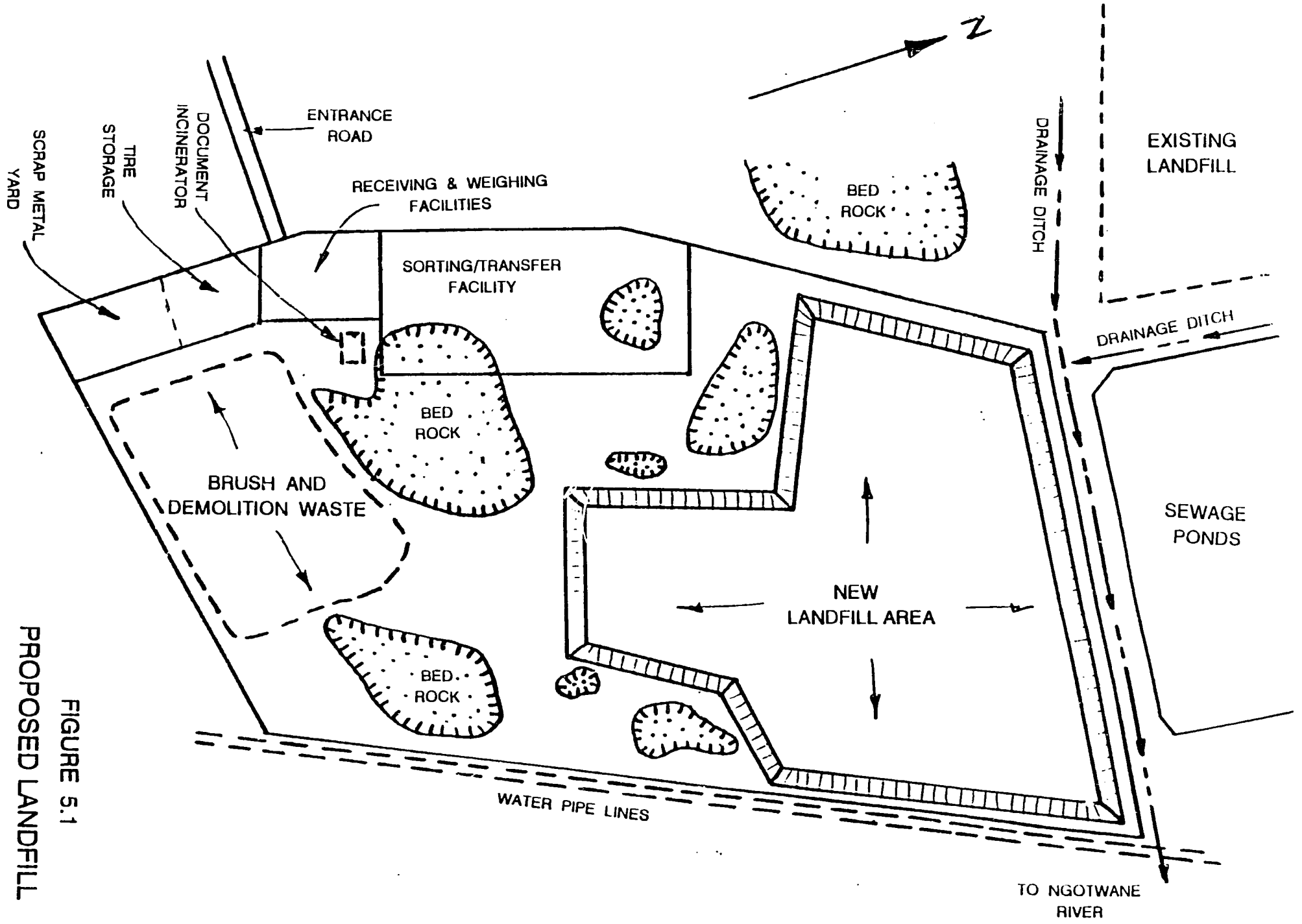


FIGURE 5.1
PROPOSED LANDFILL

6.0 SORTING/TRANSFER FACILITY

6.1 General

The Phase I report recommended a sorting and recycling facility, primarily as a means of extending the life of the proposed landfill. As presented in Chapter 5, the long term capacity of the proposed landfill may be severely restricted by physical site conditions that could create groundwater contamination problems as well as high construction costs. These site conditions may restrict the usable capacity of the site to between 7 and 9 years, during which time a new landfill will have to be located.

The next long term landfill should be located 10 to 15 kilometers outside of Gaborone City limits in order to avoid the aesthetic, contamination and scavenger problems currently being experienced with the existing landfill. This distance would make it inefficient for individual collection trucks to make a round trip with each load of refuse. Therefore, a centrally located transfer station will be required, to consolidate the refuse from the smaller collection trucks into larger transfer trucks that can make the trip to the landfill in a more efficient manner. The use of a transfer station will also reduce traffic impacts along the route to the new landfill and for the host community. Therefore the sorting and recycling facility will also be designed to serve as a transfer station in the long term.

6.2 Existing Sorting and Recycling

The City of Gaborone is very fortunate to have two private companies who are actively recycling materials from the waste stream. Waste Paper Recovery employs over 100 people, has 9 specially designed wire cage trucks and a processing facility with a capacity of 60 tons per day. At the present time, the trucks collect cardboard, mixed paper, newsprint, plastic bags and packaging film from industrial and commercial areas. In addition to the trucks that collect paper and plastic at the source of generation, waste pickers at the landfill also separate cardboard, paper and plastic film which is picked up several times per day. Approximately 4 loads per day are separated from the landfill waste.

Mr. Ian MacDonald of Waste Paper Recovery estimated that the facility recycles approximately 250 to 300 tons of materials per month or about 11.5 tons per day (6 day week). With a current processing capacity of 60 tons per day the facility has an additional capacity of approximately 50 tons per day.

Metal Box Botswana also has a recycling program and facility for recycling food and beverage cans. The Metal Box program targets schools, civic organizations and high volume steel can generators such as bars and restaurants. They will supply, free of charge, large burlap sacks that hold approximately 800 cans weighing approximately 26 kilograms. If the full sack of cans is brought to the Metal Box Distribution Center in West Gaborone, they will pay P3.40 for each full sack. Metal box also has a collection trailer that holds 100 full sacks of cans which will collect cans from locations within the City. If the full sacks are collected by Metal box, the

price paid is P2.38 per sack. Unfortunately, the collection of full sacks of cans is very erratic and several sources commented that it is difficult for them to get Metal Box to collect a small number of full sacks. The current collection system is therefore inefficient given the large volumes of tin cans sold and disposed in Gaborone. Estimates of total returned cans are between 10 and 20 percent.

The full sacks of cans are processed through a small baler with a capacity of approximately 14 tons per day which is under utilized at the present time. Metal box is scheduled to release details on a new expanded recycling program in June 1993. Although specific details are not yet available, a Metal Box representative indicated that the expanded program would increase collection as well as processing capacity.

Both of these private companies have made considerable investments in equipment and employ over 100 people in their recycling operations, and have expressed interest in participating in an expanded recycling program at the landfill. Since both facilities have excess capacity, the new sorting facility will utilize that excess capacity and sort materials into wire cage trailers which will be transported to Waste Paper Recovery and Metal Box for processing. By using existing processing capacity, both capital and operating costs of the new facility will be reduced considerably.

6.3 General Sorting Facility Description

The proposed Sorting/Transfer facility should be designed to serve the City of Gaborone for the next 20 years. This required many separate evaluations involving material flows through the facility, storage capacity and labor requirements. The design must be flexible in order to accommodate increases in the amount of materials processed as Gaborone continues to grow, and potential changes in the way that recyclable materials are collected. The basic design will involve tipping the waste on a concrete tipping floor, in a large covered storage area where large items or obvious problem waste can be identified and removed prior to placing the material on the processing conveyor. Small amounts of very wet organic wastes that would foul the conveyor belts should also be removed and shovelled into a skip for direct dumping in the landfill. Small containers of liquids, which may contain hazardous waste should also be removed from the tipping floor. After inspection, the mixed waste is pushed onto a conveyor by a front end loader. The waste is then conveyed up an incline and deposited on a second conveyor which is horizontal and elevated approximately 3.5 meters above the tipping floor.

Waste pickers, standing on a sorting platform, will then hand pick through the waste, removing specific items for recycling. The items removed from the belt will be placed in a chute, connecting the elevated sorting platform with a storage area located beneath each sorting station. The current preliminary design includes 6 sorting stations that can accommodate up to 4 waste pickers at each station, although initial waste quantities may require only 2 or 3 waste pickers per station. Based on current market conditions, the 6 sorting stations will include the following:

1. Kraft/Corrugated Cardboard
2. All other mixed paper
3. Plastic Film
4. Plastic Containers (HDPE)
5. Steel Cans and Tins
6. Glass

Each sorting station contains two chutes which are large enough to be broken down into additional categories if necessary. For instance plastic containers could include up to four categories by segmenting the sorting chutes and providing smaller skips underneath for storage. The same could be done at the glass sorting station, providing sorting for brown and green glass as well as clear.

The only material proposed to be removed by mechanical means will be tin cans which will be separated from the mixed waste by a magnetic cross drive belt. This belt will lift all ferrous materials including beverage cans, tin food containers and steel scraps from the mixed waste and deposit them in the chute. Several pickers at this station will remove larger steel items and pull off any non-ferrous materials that may be attached to the tin cans such as plastic or paper bags.

The waste remaining on the sorting conveyor after passing the 6 sorting stations should be relatively free of the 6 materials that were sorted. Materials that are badly contaminated with food waste should be left on the belt and not removed. The end of the sorting belt would then dump into a transfer truck that would take the sorted waste to the on-site landfill or to a remote landfill located outside the city.

The general operation of the sorting conveyor, platform and waste pickers is shown graphically in Figure 6.1, which has been taken from a sales brochure from "Mayfram International" a leading manufacturer of recycling systems. This drawing shows the general process as described above plus a second materials conveyor and baler. Our initial preliminary design will include of-site baling but the material conveyor and baler may be required at a future time as proposed in Section 6.5.

If a full scale compost facility is constructed, the waste would enter a separate building where further processing would screen the waste into undersized compostable material and oversized reject material which will go to the landfill. The composting process will be explained in more detail in Section 7.0.

6.4 Technical Design Criteria

6.4.1 General

Due to the rapid growth in waste quantity predicted over the next 20 years, specific attention must be directed toward the design of the major sorting components and how the capacities of those components can be increased in the future. The following discussion presents the

preliminary design parameters that have been incorporated into the preliminary designs found on Figures 6.2 through 6.4. The primary reference for these design parameters is the United States Environmental Protection Agency Handbook entitled "Material Recovery Facilities for Municipal Solid Waste" published in September 1991.

6.4.2 Conveyor Belt Design

The design of the sorting conveyor belt is the most important design feature of the sorting facility. The following design capacities have been determined in Section 3.0 and will be used to design the conveyor belt.

1995 - 123 TPD
2000 - 198 TPD
2005 - 240 TPD
2010 - 514 TPD

The design width of the sorting belt will depend on the type of wastes being sorted and the desired efficiency. For the purposes of this preliminary design, we have selected a belt width of 60 inches or approximately 1.5 meters. Although this width is slightly wider than the handbook recommends, the additional waste pickers at each station should compensate for the wider width. With picking from both sides of the conveyor, each picker must cover 1/2 of the belt width or 750 cm. Since this may be beyond the reach of some smaller pickers, each picker should be supplied with a small wooden handled rake to pull in materials from the center of the belt.

The combination of conveyor belt width and speed will determine its capacity. The handbook recommends belt speeds between 20 and 30 feet per minute (6.1 to 9.1 meters per minute) to obtain good sorting efficiencies. This equates to 10.2 to 15.2 cm per second, and belt capacities of 14 tons per hour at a speed of 10.2 cm per second and 21 tons per hour at 15.2 cm per second. The belts will be installed with variable speed drives. Assuming an 80% efficiency rating, the following daily capacities are obtained:

Belt Speed	10.2 cm/sec	15.2 cm/sec
8 hr shift	90 TPD	135 TPD
10 hr shift	112 TPD	169 TPD
2 shifts (16 hrs)	180 TPD	270 TPD

A comparison with the estimated generation rates with the above conveyor belt capacities indicates that one conveyor belt running at 15.2 cm/sec will provide adequate capacity for the initial few years of operation. Figure 6.2, Phase I Construction, shows the proposed building and equipment layout for the initial construction. By the year 2000 the estimated waste generation will be 198 TPD and it will be necessary to increase the operation to two shifts or

add a second conveyor belt as shown in Figure 6.3., Phase II Construction. After 15 years of operation we will be nearing the maximum capacity of one conveyor belt, operating with two shifts and the second conveyor belt will be needed as shown on Figure 6.3. A third sorting shift, or 24 hour operation is not recommended since there will be time needed for clean-up and maintenance which could be performed at the completion of the second shift or by a maintenance crew during the third shift hours.

6.4.3 Sorting Platform Design

A sorting platform will be constructed on both sides of the horizontal sorting conveyor as shown in Figure 6.1. The platform will be divided into 6 sorting stations, one for each type of material to be sorted. Additional sorting stations could be added in the final design.

The height of the sorting conveyor above the sorting platform is an important design feature to avoid back strain for the waste pickers who will be leaning over the belt to remove materials. A height of 107 cm (42") is the recommended height for the average American worker. Workers who are shorter than average can work from individual raised platforms.

Two, 1 meter square openings will be located at each sorting station, one on each side of the conveyor. The top of these openings or chutes will be level with the conveyor and will allow the sorted materials to be dropped into separated storage areas located under each sorting station.

6.4.4 Material Markets

As stated in Section 6.2, adequate local markets and processing facilities exist for kraft/corrugated cardboard, mixed paper, plastic film, and steel beverage and food tins. Prices for these materials have been estimated and are used in the economic projections included in Section 6.6. These material prices will be subject to negotiation when final operation begins.

Plastic containers are a relatively small component of Gaborone's waste and include several different types of plastic which are not compatible with each other. Based on visual inspections made at the landfill, plastic containers made of high density polyethylene (HDPE) appear to be the largest volume of plastic material. These containers include translucent milk bottles and some juice containers. A local plastic bag manufacturing facility, Kgalagadi Plastics, has expressed an interest in using recycled HDPE in their facility. They would accept whole HDPE plastic containers which would then be washed, shredded and granulated at their facility. The price that they would pay for the material has not been determined. A market survey of plastic prices performed in 1991 indicated that a strong HDPE market exists in Johannesburg at P200-250 per ton, F.O.B. Gaborone. Similar markets are known to exist in Zimbabwe.

In addition to the HDPE containers, there are also food and other containers made of Polyester and Polyvinylchloride (PVC). Until a market is found for these materials they should not be sorted, but left on the conveyor to be sent to the landfill. The waste pickers at the plastic sorting station will need to be trained to recognize the differences in plastic materials.

Glass is also a relatively small component of the waste stream, with clear glass being the predominant color. Separated glass containers should not contain metal caps or rings and should be relatively clean. Glass containers which contain food residues should not be sorted but left on the conveyor belt to be taken to the landfill. A glass cullet market exists in Johannesburg at Consol Glass. In 1991 the cullet price was estimated at P80 to P100 per ton, F.O.B. Gaborone. Due to current economic conditions that market fluctuates widely due to a large surplus of material. After sorting the glass, it can be stored in the enclosure under the sorting platform or placed in a smaller skip which can be dumped in an outside storage area. If a suitable market cannot be located, the glass can be stored on site until market conditions improve. For the purposes of this report, we have shown the market price of glass cullet at P30 per ton.

6.5 Preliminary Designs

The preliminary design of the Sorting/Transfer Facility is shown on Figures 6.2 through 6.4. Figure 6.2, Phase I Construction, would be the initial construction layout. As stated above, one conveyor should be sufficient for the first 3 to 5 years of operation. The building size of 50 x 60 meters was selected to provide adequate storage and processing room for a 20 year operating period. The initial floor construction should include "cut-outs" in the concrete floor for the second floor conveyor and the baler conveyor should it be required. The large building will permit the wire cage trailers to be positioned under the sorting stations and provide adequate tipping floor storage and for sorted materials. Although the building is shown enclosed with many access doors, this may not be required and the sides could be left open or constructed with wire fencing to catch wind blown debris.

In addition to the building and sorting equipment, two front end loaders should be purchased for loading the floor conveyor and positioning the wire cage trailers. The number of wire cage trailers will depend on negotiations with Waste Paper Recycling and Metal Box. A preliminary evaluation of material flows through the facility suggests that at least 8 trailers will be required.

The time period for constructing Phase II, adding the second conveyor, will depend on the growth in waste volume, the efficiency of the labor force and the management of the facility. As stated earlier the second conveyor could be delayed by adding a second shift. With one shift operation the second conveyor would be needed in the 4th or 5th year operation. With two shifts and a highly efficient labor force, the second conveyor could be delayed until year 8 through 10.

Phase II, shown on Figure 6.3, includes a second sorting conveyor located parallel and identical to the first. The operation of the facility will change slightly in that the wire cage trailers will be accessed from only one side of the building and an additional transfer truck will be necessary.

The third construction phase adds a material conveyor and baler to the sorting facility. Current processing capacities at Waste Paper Recovery and Metal Box will eventually be exceeded. At that point, a decision must be made to either increase these off-site processing capacities or add processing equipment in the sorting facility. Phase III Construction, shown on Figure 6.4, requires a 25 metre addition to the building to accommodate the baler and bale storage areas.

A third material conveyor would be installed between the two sorting conveyors at floor level, which would convey sorted materials into the baler, to be located in the new addition, under the refuse conveyors which also must be extended 25 metres. At this point, the wire cage trailers would no longer be used and sorted materials would be stored on the concrete floor beneath each sorting station. When sufficient materials have been sorted to make a bale, they would be pushed onto the conveyor and into the baler.

The completed bales could be stored inside until a full truck load has been accumulated or loaded directly onto storage trailers which would take the material to a rail siding or directly to the material markets.

As stated previously the preliminary design is based on a 10% per year increase in waste generation. Accurate records should be kept of all incoming waste and sorted materials. Annual reports, summarizing the past year's activities will used to determine the timing for increasing the facility's capacity by adding manpower, extending the hours of operation or constructing the additional sorting conveyor or adding the baler.

6.6 Cost Estimates

6.6.1 Construction Costs

The cost estimates for the Sorting/Transfer facility are shown on Figure 6.5. Construction costs are based on the Phase I building and equipment as shown on Figure 6.2. Unit costs for the building and sorting conveyors are approximate and subject to revisions during final design. Costs shown for mobile equipment, including the loaders, wire cage trailers and transfer trucks are also general and subject to change upon final design and specifications. The total construction cost for the Sorting/Transfer Facility is estimated at P3,672,000. If these costs were financed over 25 years at an 8% interest rate the annual cost would be P344,000.

The USAID program, which is primarily providing funding for technical assistance for privatization projects, also includes a budget item to defer the costs to purchase of equipment used in privatization programs. These funds are available only for purchase of American made equipment and only if full privatization of operations is initiated.

6.6.2 Operating Costs

The estimated operating costs for the Sorting/Transfer Facility are shown in Figure 6.5. These costs apply only to the Sorting/Transfer Facility and do not include other site operating costs such as landfill operating costs, receiving and weighing facilities, or general administration. The costs also assume a one shift operation, to include one supervisor and 15 waste pickers. This number includes 2 pickers on the tipping floor, 10 on the sorting platform and 3 working on general maintenance. The operating costs also assume that waste is landfilled on-site. If a remote landfill is utilized, the cost estimate for supplies, fuel and maintenance will need to be increased. Total operating costs are estimated at P222,000 per year.

6.6.3 Revenues

The revenue portion of the cost estimate is based on current prices for recycled materials and is subject to changes due to changing market conditions. Over the past two years, there have been significant fluctuations of prices paid for recycled material. Factors that influence material prices are supply and demand economics, international trade issues, and the economic stability of the countries in which the markets are located. Since all of the current markets are in Zimbabwe and South Africa, significant changes in market prices may occur in the future. Any contract for private operation of the Sorting/Recycling Facility must take this into account. Total revenues are estimated at P308,000 per year, based on current market prices and materials estimated to be recycled in 1995.

6.6.4 Net Costs

Based on the above cost estimates, the net cost for operating the Sorting/transfer facility is P258,000 in 1995. Dividing by the estimated amount of recycled material yields a net cost of P28 per ton to operate the Sorting/Transfer facility. Although these net costs per ton of material recycled appear high, relative to landfill costs, one must consider that approximately 60% of the total annual costs are fixed capital costs for a facility with a 20 year capacity. Although operating costs will rise over the 20 year planning period, revenues from materials are projected to increase in greater proportion. In addition to increases in market prices due to inflation, revenues will also increase due to increases in the amount of waste generated and the materials reclaimed. The net result is that material revenues will increase at a faster rate than operating costs with the result of decreasing net costs per ton.

6.7 Management Options

6.7.1 General

The management options for the Sorting/Transfer Facility must be evaluated in the context of the total site management. If the operation of the landfill is fully privatised, the Sorting/Transfer Facility should also be privatised, preferably under the same or amended operating tender. Although separate operators could be possible, there would be several areas of overlap that may be difficult to coordinate. Due to the unknown condition of the materials markets for recycled materials, the risks for capital improvements and operating costs must be shared between the GCC and the contractor.

6.7.2 Facility Ownership

As mentioned above, the market prices to be paid for the recovered materials are variable and effected by conditions beyond the ability of private vendors to control. In particular the current market prices are influenced by the political and economic stability of Zimbabwe and the Republic of South Africa. Therefore, it is not likely that a private contractor will be willing to invest in constructing a capital intensive sorting facility. In consideration of this risk to the

private sector, it is our recommendation that the facility be constructed and financed by the GCC. In addition to removing the market risk from the private contractor, by maintaining ownership the GCC also retains control and the option of changing contractors without involving property ownership transfer.

6.7.3 Operation Options

Section 5.7 presented the various options for privatizing the operation of the landfill. Since the operation of the landfill will precede the construction and start-up of the Sorting/Transfer Facility, it is appropriate that the management option selected for the Sorting/Transfer facility be the same as that for the landfill operations. It is our recommendation that the operation of the Sorting/Transfer facility be fully privatized. The reader is referred to Sections 5.7.2 and 5.7.3 for a description of the privatization options.

As stated in Section 5.7.2, USAID involvement under the PPSS program, including technical assistance and equipment will probably be terminated if the GCC pursues a "management only" option for the sorting plant operation.

6.7.4 Revenues

The operation of the Sorting/Transfer facility differs from the Landfill in that a revenue is produced from the sale of recycled materials. This revenue can be handled in several different ways.

In the tender documents the revenue can be totally retained and controlled by the operator to offset operational expenses. The Cost estimate shown in Figure 6.5 shows that under current market conditions, revenues from materials are estimated to exceed operating expenses by P86,000. Under this scenario, the tender may actually become a lease, where the contractor leases the building and equipment from the GCC and will make a lease payment to the GCC. This method provides the maximum incentive to the contractor to remove as many materials as possible.

The alternative method of handling revenues would be for the GCC to receive all revenues from the sale of materials. In this manner the operator submits a fixed price tender for operations only. Although he would be responsible for arranging for the marketing of the materials, all revenues would be paid directly to the GCC. The major disadvantage of this arrangement is that it removes the incentive for the operator to be more efficient in removing materials since his profit will be fixed by the tender. A variation of this option would allow the operator to retain a portion of the revenue as an incentive to operate at higher efficiencies.

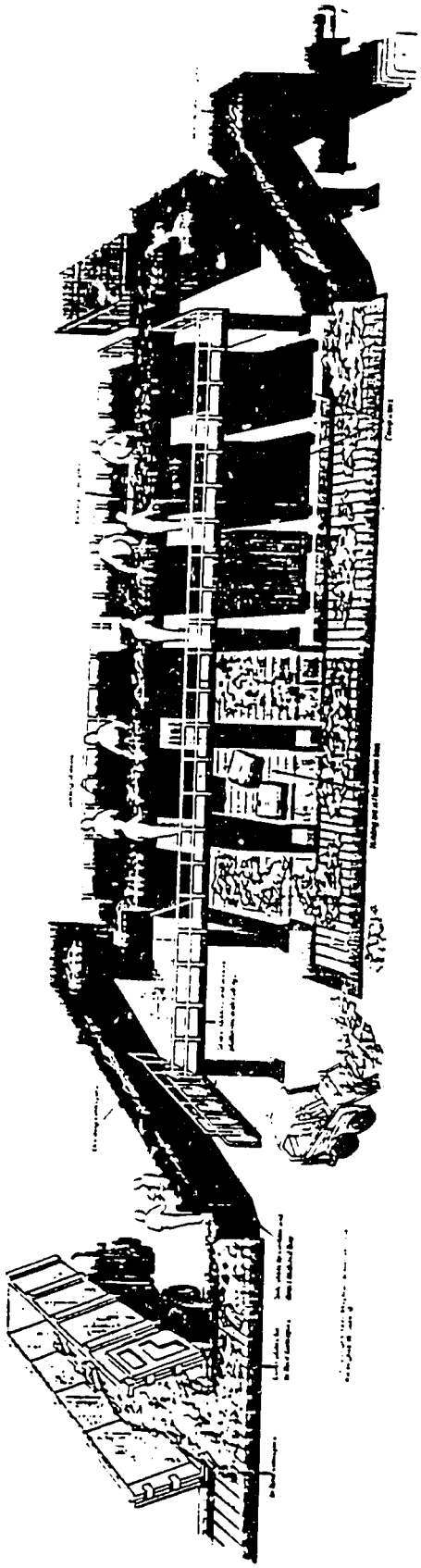


FIGURE 6.1
TYPICAL SORTING SYSTEM
"MAYFRAM INTERNATIONAL"

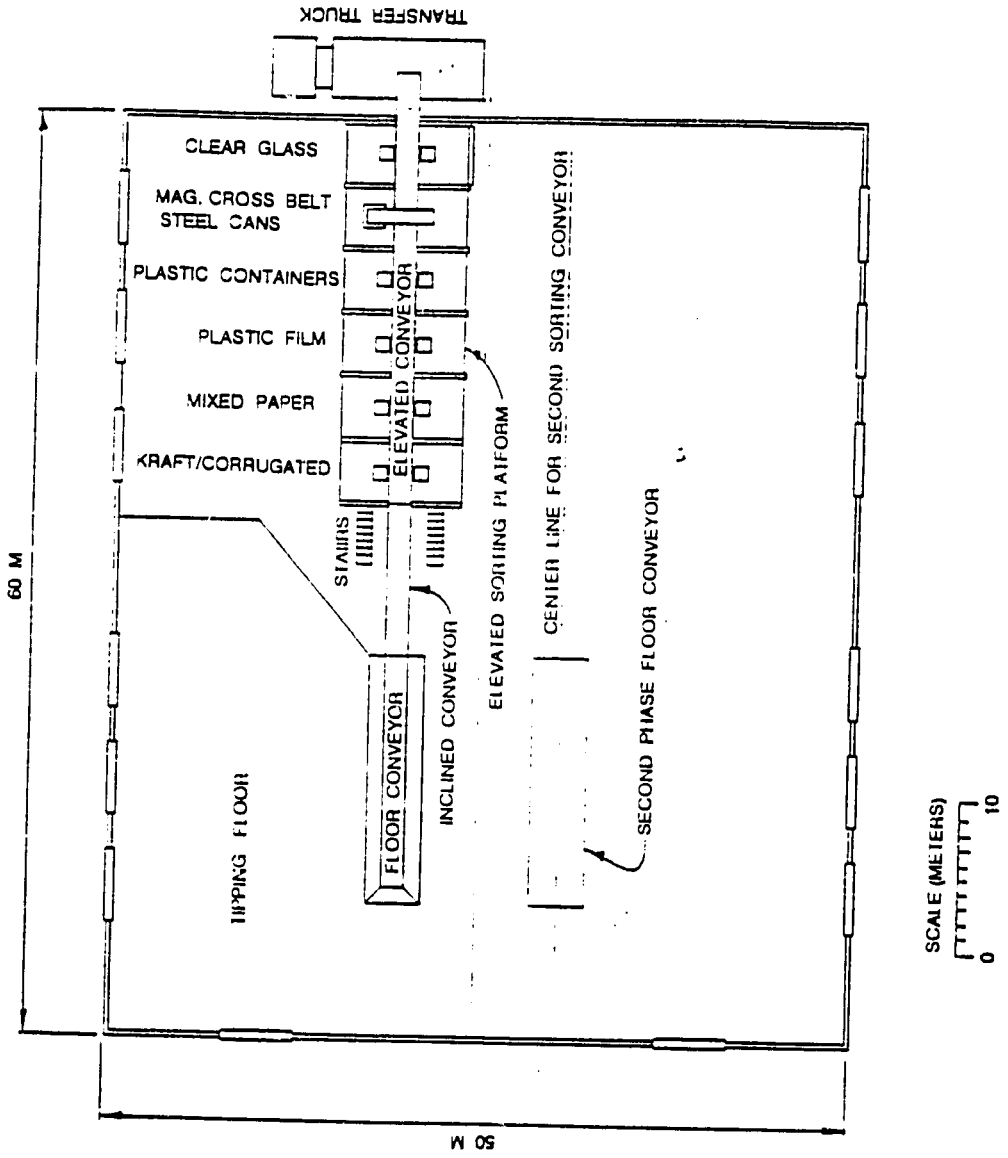


FIGURE 6.2

PHASE I CONSTRUCTION

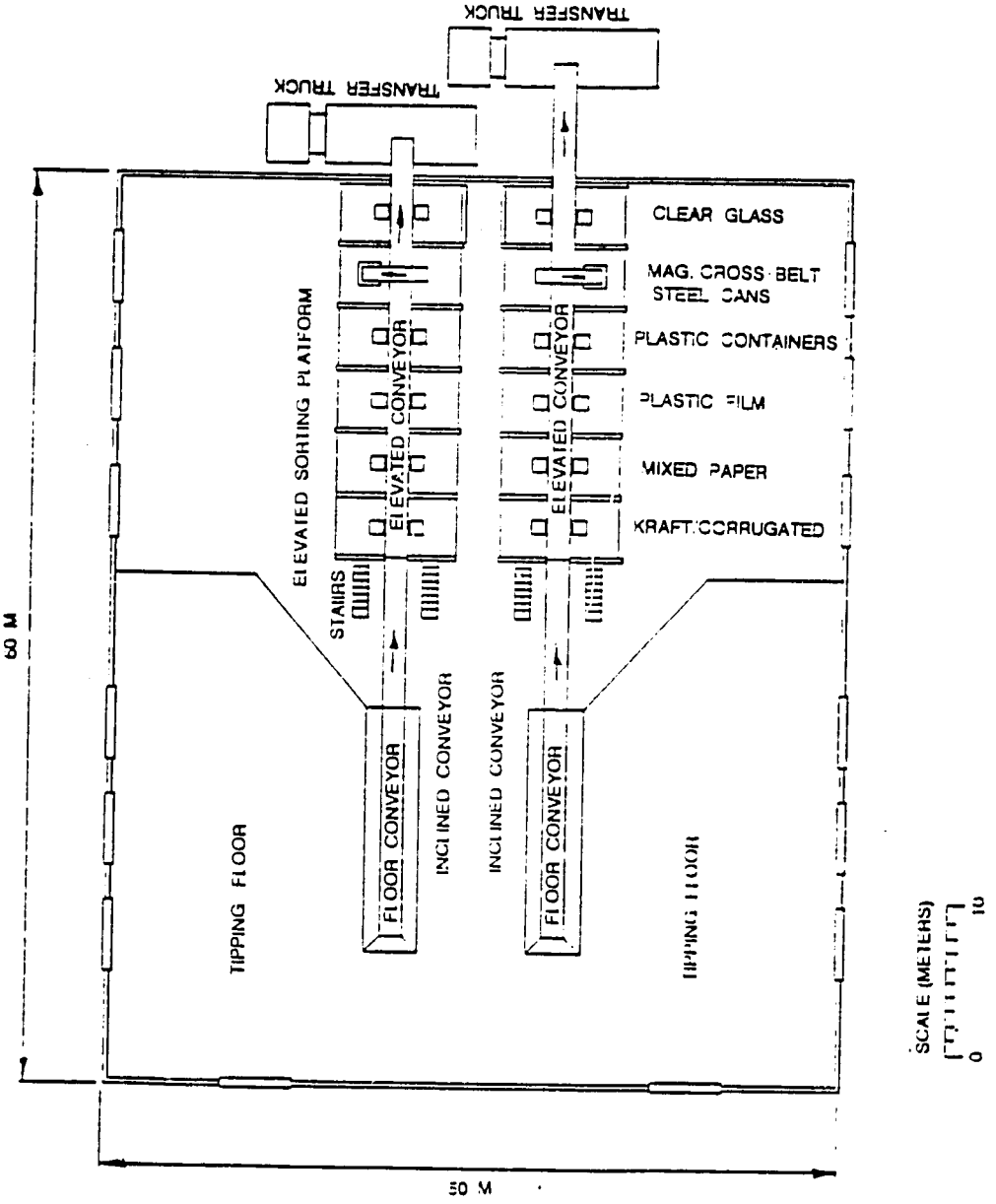


FIGURE 6.3

PHASE II CONSTRUCTION

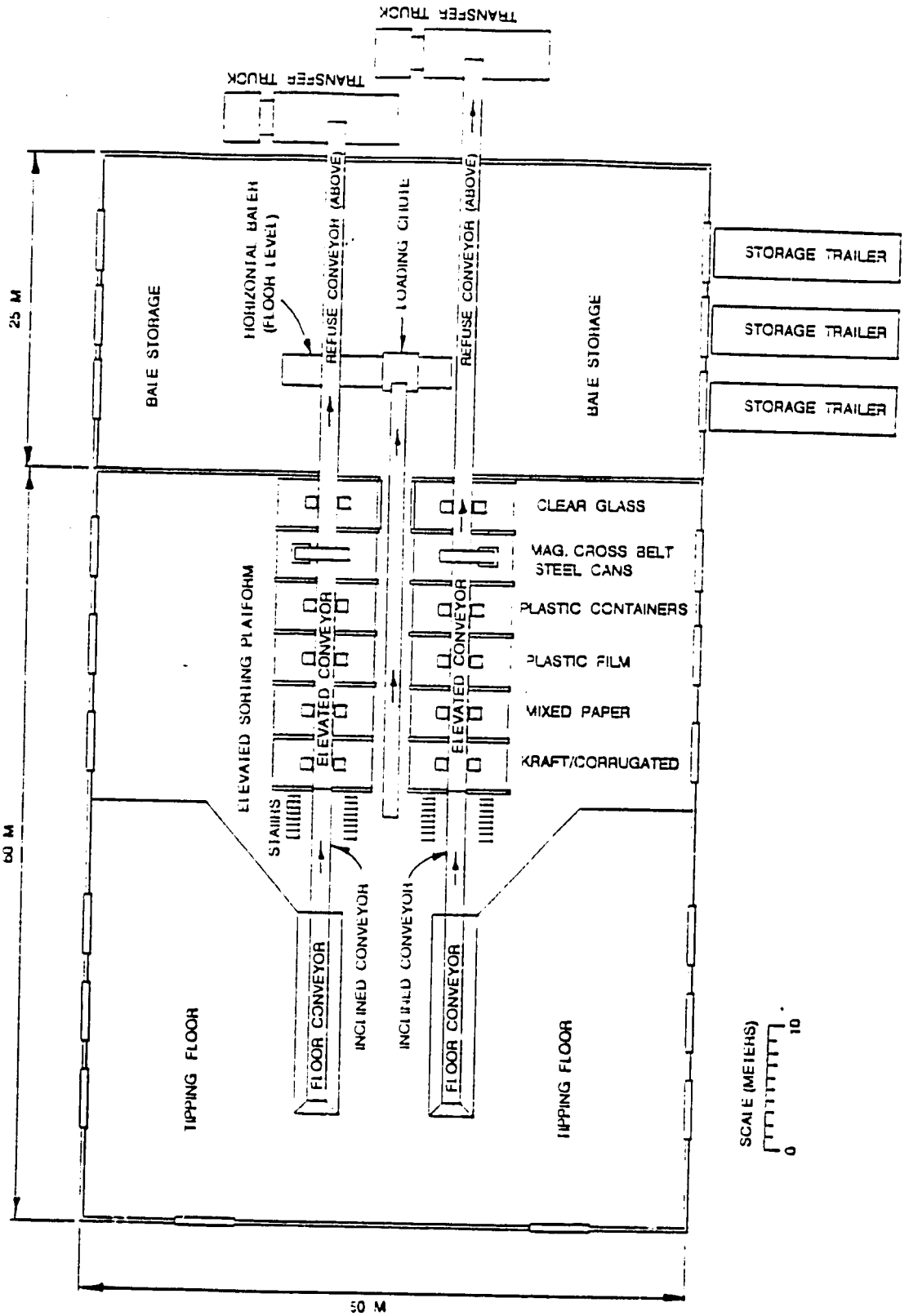


FIGURE 6.4

PHASE III CONSTRUCTION

SORTING/TRANSFER FACILITY PHASE I
ESTIMATED CONSTRUCTION COSTS

ITEM DESCRIPTION	PULA
1. SITE WORK, ROADS, GRADING	50,000
2. BUILDING 3,000 SQ.M @ P500/SQ.M	1,500,000
3. UTILITIES	5,000
4. CONVEYORS 53 m @ P14,000/m	742,000
5. SORTING PLATFORM 25 m @ P8,000	200,000
6. MAGNETIC SEPARATOR	5,000
7. MATERIAL STORAGE	20,000
8. WIRE CAGE TRAILERS 8 @ P10,000	80,000
9. BUCKET LOADERS 2 @ P100,000	200,000
10. TRANSFER TRUCKS 2 @ P300,000	600,000
SUBTOTAL	3,402,000
DESIGN & ADMINISTRATION @8%	270,000
TOTAL	3,672,000
ANNUAL COST 25 YRS @ 8% INTEREST	344,000
ESTIMATED OPERATING COSTS (1995)	
1. SUPERVISOR	60,000
2. WASTE PICKERS 15 @ P5,000/YR	75,000
3. EQUIPMENT OPERATORS 4 @ P8,000	32,000
4. SUPPLIES, FUEL, MAINTENANCE	40,000
5. ADMINISTRATION, INSURANCE	15,000
SUBTOTAL OPERATING COSTS	222,000
TOTAL ANNUAL COSTS (1995)	566,000
REVENUES (1995)	
PAPER/PLASTIC 5,200 T/YR @ P15	78,000
HDPE PLASTIC 100 T/YR @ P100	10,000
STEEL CANS 2,000 T/YR @ P80	160,000
GLASS 2,000 T/YR @ P30	60,000
SUBTOTAL REVENUES	308,000
NET OPERATING COSTS	258,000
NET COST PER TON (1995)	28

FIGURE 6.5
COST ESTIMATES

7.0 COMPOSTING

7.1 General

The Phase I report included a conceptual evaluation of composting as a method of further reducing the amount of solid waste requiring a landfill for final disposal. That evaluation concluded that there is sufficient organic material in the waste stream after sorting out the recyclable materials to justify composting as a processing option. The semi-arid nature of the climate, plus poor soils in the local region appear to favor compost use as an aid to agriculture.

Additional waste composition analysis, performed in Section 3 of this report, has provided estimated quantities of organic matter. Figures 3.4 and 3.5 present the composition analysis at 5 year intervals throughout the 20 year planning period. In 1995 approximately 93 tons per day of material would exit the sorting plant. If a full scale composting facility were implemented it would include a screening operation added to the sorting facility. The undersized portion of the screened waste, consisting of an estimated 76 tons per day would be subject to organic decomposition. The remaining 34 tons per day of oversized material would be transported directly to the landfill.

The 76 tons of raw compostable material, consisting primarily of food waste, paper and fines, will decompose during the compost process to an estimated 40 to 45 tons per day of finished compost at a moisture content of 20%. Final screening would reduce the final finished compost to approximately 35 tons per day based on 1995 estimates. The estimated annual amounts of finished compost to be produced during the 20 year planning period are summarized below:

Year	Total Waste (6 Day) TPD	Finished Compost TPD	Tons Per Year	Cubic Meters Per Yr
1995	144 TPD	35	10,900	18,000
2000	260 TPD	62	19,500	32,800
2005	418 TPD	65	31,300	52,800
2010	673 TPD	160	50,400	85,000

7.2 Facility Design

7.2.1 Screening facility

Although later discussions in this section will evaluate the viability of full scale composting, consideration must be given to the equipment and space required at the sorting and transfer facility, should the GCC decide to move forward with a full scale composting system. Figure 7.1 shows a building addition that would contain the primary processing equipment for preparing the composting substrate. This equipment is shown for spacial planning only, since actual design

of this equipment will depend on many variables which are not defined at this time. For instance, Figure 7.1 shows the waste passing through a hammer mill prior to being screened. Depending on the quality of the compost required, the hammer mill may be eliminated since it will shred inorganics as well as organic material before screening. This will produce a higher plastic and glass content in the compost but will reduce the oversized rejects that are taken to the landfill. If a higher quality compost is required, then the hammer mills could be eliminated.

The trommel screens are inclined, circular rotating screens, similar to the one shown on Figure 7.2. Fine material passing through the screen, called "undersize", becomes the composting substrate and is collected and conveyed into a transfer truck. This material is then transported to the compost curing area at a remote site. The size of the trommel screen openings will be determined in the final design. In general, a screen size in the range of 5 cm is preferred for high quality compost. The screen could be divided into two different sized sections for differing grades of compost. In this case, additional hoppers and conveyors would be required to keep the grades separate. Larger primary screen openings will require additional screening of the cured compost material.

The oversized material from the screens, consisting of plastic bags and other oversized objects, would be taken directly to the landfill.

7.2.2 Curing Area, Aeration

The undersized material will be taken to a curing area. There are many designs for curing areas that differ in the degree of mechanization and space requirements. Most curing areas use the windrow method where the raw compost substrate is formed into long piles called windrows. The size and shape of the windrows will depend on the method used to aerate the compost material to maintain aerobic conditions. For the purposes of this report we will assume a conservative, low technology design, that uses a front end loader to turn the windrows every 5 to 7 days. This method uses the largest amount of curing space but includes the least amount of specialized equipment.

Assuming windrows that are 3 metres high and 5 metres wide, each day's production of raw compost substrate will require a windrow that is 9 meters long. Since a high quality compost will take up to 90 days to fully mature, a large area will be required. Using the estimated generation rates for 1995 a curing area 100 metres by 80 metres will be required for the first year of operation. As shown in the preceding table, the compost to be generated in 20th year of operation will be more than 4 times the original generation, so a very large site will be needed for the full 20 year curing pad design. An area of approximately 10 hectares is recommended for the future compost curing site. This would allow adequate space for the curing pads, final screening and buffer areas.

The space for the curing pads can be reduced by increasing the mechanization of the process. If specifically designed windrow turners are used rather than a front end loader, the area required between rows can be significantly reduced. The space can be reduced still further by

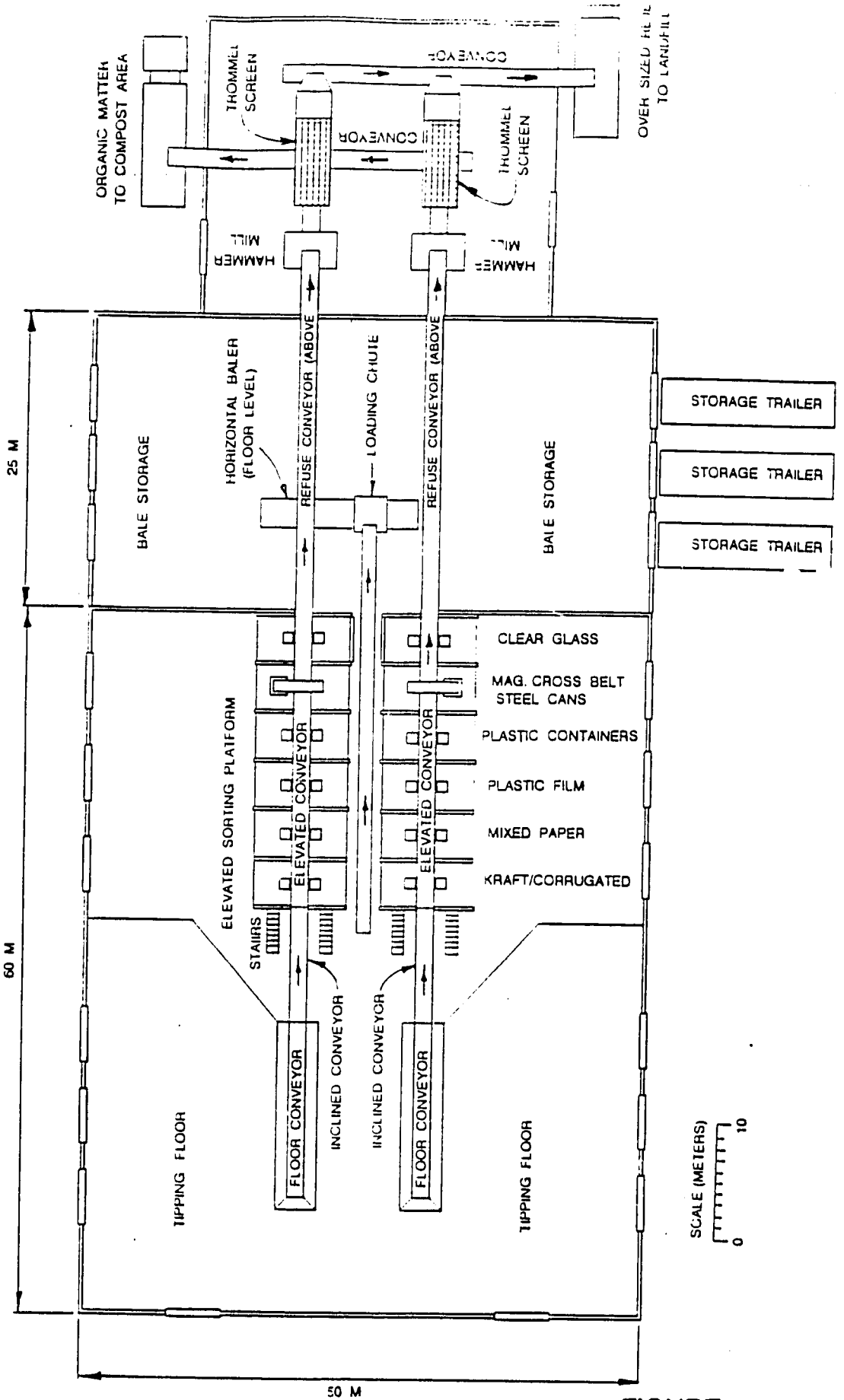
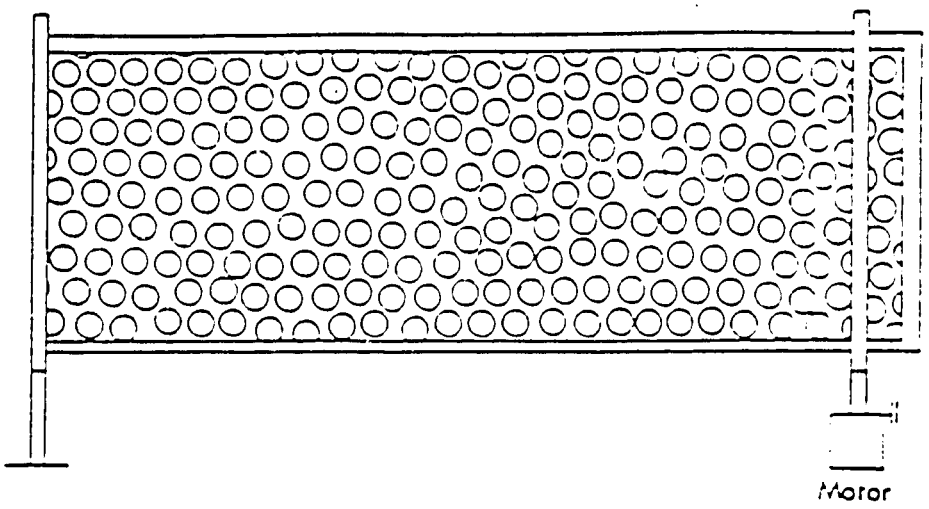
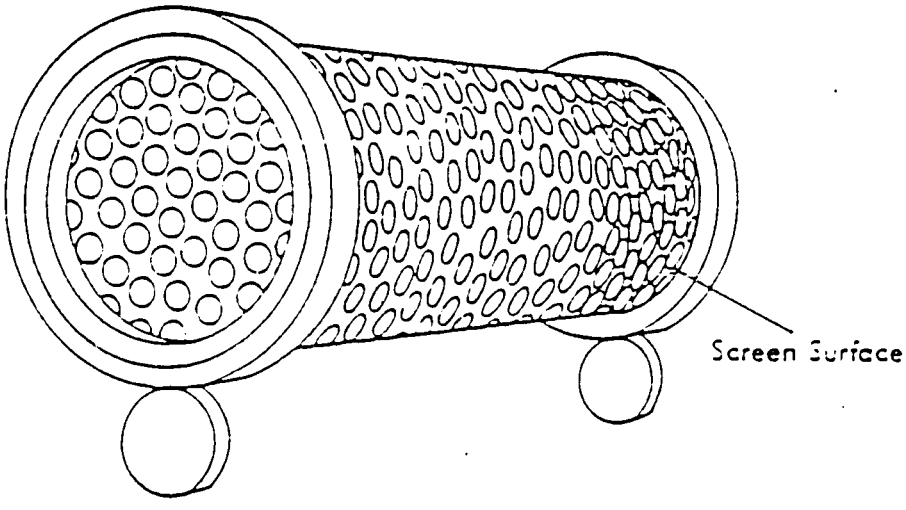


FIGURE 7.1

COMPOST SCREENING FACILIT



Side View



End View

FIGURE 7.2

TROMMEL SCREEN

using static pile windrows rather than mechanical turning. A static pile windrow has perforated pipes built into the windrows, which are attached to the suction of a blower. Using the blower, air is drawn through the compost pile, into the suction pipe, providing air to the curing compost. Using this method, the windrows can be placed close together since no turning is required.

In order to conserve moisture and maintain better control over the curing process, the curing pads should be covered.

7.2.3 Moisture

Next to maintaining aerobic conditions in the compost windrows, moisture content is the most important factor in maintaining the compost process. In order to allow the biological decomposition of the organic material, the moisture content of the compost substrate should be kept in the 45 to 50 percent range. This normally requires the addition of water every time the windrows are turned or every 5 to 7 days, if a static pile system is used. In the summer, more frequent watering may be required. Therefore the compost curing area must be located near a dependable source of water. If optimum moisture content is not maintained, the time for complete compost maturity will be increased. If too much water is added, the compost substrate will become saturated, preventing air from getting to the decomposing compost. This will cause the process to convert to anaerobic conditions which will produce unpleasant odors.

7.3 Compost Quality

Since compost is derived from waste products, the quality of the compost will depend, in part, on the materials making up the organic substrate that begins the decomposition process. Contrary to some popular beliefs, compost is not a substitute for fertilizer and in fact is relatively low in the typical growth nutrients, nitrogen, phosphate and potassium. Its primary agricultural benefits are increased aeration, improved moisture and nutrient retention, decreased soil erosion, and reduced soil surface crusting. On the negative side, compost can be a source of heavy metals, disease vectors and odours. Although these negatives are cause for concern they can be managed through proper material and process controls.

Although the residential waste in Gaborone is predictable, the wastes generated by industrial and commercial businesses are less defined. The industrial, commercial, and medical waste questionnaires and data base, described in Section 4, when completed, will provide better details of total waste quality and define the need for specific processing steps to control compost quality.

In many market applications, the physical appearance of the compost is as important as its content. Small particles of glass, plastic or other inert objects may impact higher quality markets such as landscaping or home gardening. If these markets become a major focus, then changes to the materials handling systems may be necessary. These will be discussed in a later portion of this Section.

7.4 Compost Markets

7.4.1 General

One of the first rules in solid waste processing is "don't produce a product unless you have a stable market to sell it". This rule applies especially to capital intensive facilities such as compost production facilities. There are many examples of composting plants that have been constructed but were unable to sell their finished product, which has severely impacted the project economics. Therefore, prior to proceeding with the feasibility design of a composting facility, it is prudent to assess the markets in and surrounding Gaborone that would purchase the finished compost material. This analysis will also help to define the specifications and quality controls of the processing system required by the markets.

Typical compost Markets include the following:

- Landscape Contractors
- Nurseries
- Public Works Projects
- Golf Courses
- Landfill Cover
- Agriculture

In assessing each market segment, the quality and appearance of the material must be considered in addition to the volume needed. As mentioned above, landscape contractors and nurseries will require a cleaner material, free of plastic or glass fragments, whereas public works or land reclamation projects may accept a lower grade of material. Agricultural markets may be less concerned with the appearance of the compost but will be more concerned with chemical characteristics such as the level of nutrients and heavy metals. The heavy metal content of the compost is often a limiting factor in the agricultural use, where food or forage crops are grown.

Although the Scope of Work for this Phase of the project does not include a detailed survey of compost markets, the following discussions and market estimates are based on limited interviews with area businessmen, ministry personnel, the Botswana Agricultural College and operators of compost facilities located in similar regions in South Africa.

7.4.2 Landscape Contractors and Nurseries

The potential compost market of landscape contractors and nurseries is limited. Although many high income homes, businesses and government installations are professionally landscaped, in general the low and middle income, and most public areas are not landscaped and low maintenance, bare earth appears to be preferred in these areas. The high costs of watering and maintaining landscaped areas has limited their use. The largest application would appear to be construction of lawns and gardens, in higher income homes and government facilities.

Sanitas Nursery, by far the largest and most successful nursery in Gaborone, sells compost/top soil in 5 kg bags. This is produced on-site using a variety of materials including chicken manure, saw dust, bark and waste vegetation depending on availability. The owner of the nursery expressed concern over selling refuse derived compost due to the high quality of soil required by his customers. He expressed high interest in composting clean homogeneous materials that have been identified in the waste stream including paunch contents from the abattoir, manure, and waste mash from the breweries. He uses compost in his potted plants but would not use it in vegetable or fruit production, preferring instead to use clean river sand in these applications.

For the purposes of this report we will assume that landscaping and nursery uses will consume an estimated 1,500 cubic metres of compost per year. This would require a high quality compost with a minimum of glass fragments and plastic.

7.4.3 Public Works Projects

The GCC maintains many parks, garden areas and highway planting strips throughout the City, which require year round maintenance and watering during the dry season. All of these areas would benefit from an application of compost to increase moisture retention. New areas could be planted in compost enriched soil. Although actual quantities could vary widely, it is estimated that an additional 1,500 cubic meters could be utilized for public works projects. Assuming that the compost facility is privately operated, the public works department would be expected to purchase the compost at the commercial retail rate established by the private operator. This may limit its use in public works projects.

7.4.4 Golf Courses

Golf courses periodically apply a fine topsoil mix to their fairways and greens as a turf conditioner. Finely screened compost could be used for this purpose but would have to be of a very high quality. Lower quality compost could also be used in other planting applications. Since there is only one golf course in Gaborone, this market is considered limited and estimated at only 300 cubic metres per year.

7.4.5 Landfill Cover

The existing landfill is due to close later this year. This landfill has reached a height of approximately 10 meters above the surrounding land and requires extensive landscaping as part of its closure. The addition of a layer of compost, tilled into the upper earth cover will improve the soil conditions and promote growth of grass. Based on rough estimates, an area of approximately 8 hectares will require covering with earth material and top soil. If compost were to be applied at a depth of 15 cm, approximately 13,500 cubic meters will be required. Although this amount represents nearly one year of compost output, it is a one time application.

7.4.6 Agriculture

The use of compost in agriculture involves many economic as well as technical issues. Botswana imports approximately 80% of its food and due to the semi-arid nature of the local region, Gaborone and the surrounding area imports an even higher percentage of its food than the national average. The reasons for the region's low agricultural production are varied, and include the unpredictable wet/dry seasons, frequent droughts, the poor nature of the soil, the lack of financial resources to utilize modern farming techniques, such as irrigation, and the readily available agricultural products from South Africa at competitive prices. With the established availability of South African products there is little incentive to venture into large scale agricultural production in the local area. Although there are a few exceptions such as Sanitas nursery, and several vegetable farms, Gaborone and the surrounding region are not considered to be in a highly productive agricultural area.

Although the minimal amount of active agriculture occurring in Gaborone and the surrounding area appears to be an impediment to compost use in the short term, the long term benefits of compost should be evaluated by the agricultural community and could help them increase productivity in the future.

The production of compost for agricultural uses requires establishing high standards for the control of heavy metals and other chemicals that may be toxic to plant life or that may bioaccumulate in plants and be harmful to those who consume the crops grown on compost amended soils. Since the waste in Gaborone is unique in many respects and undefined in others, reference materials regarding impacts to agricultural use are lacking. Unfortunately, the only way that these impacts can be defined is through a pilot project, where actual compost is produced and tested on specific plants under controlled conditions.

7.4.7 South African Markets

Two full scale compost facilities in South Africa, one in Randburg and the other in Cape Town, are currently experiencing difficulty in marketing their finished compost. Although the compost quality is reported to be high, farmers, gardeners and landscape contractors have been slow to accept the new product. They have preferred instead to use traditional manures and chemical fertilizers.

7.4.8 Market Summary

In summary, the non-agricultural markets in Gaborone are limited and significant agricultural usage appears to be the only market that could justify a full scale compost facility, given the projected compost quantities to be produced over the next 20 years. Unfortunately, this market is also limited at the present time but based on current research and development efforts being performed through the Botswana Agricultural College and the Ministry of Agriculture, local farming is expected to increase in the future.

In consideration of the above, there does not appear to be an adequate long term compost market to justify a full scale compost facility at this time.

7.5 Co-Composting

Final design has been completed and construction is due to begin in the near future on a new activated sludge sewage treatment facility. The current facility design includes sludge digesters with a capacity of approximately 200 cubic meters per day of wet sludge at 5% solids, followed by sludge drying beds. The 10 year design capacity would produce approximately 10 TPD of dry filter cake that would be taken to the landfill. Since wastewater sludge has been found to be a good source of compost substrate, the possibility exists to combine the two products for compost production. The composting of mixed solid waste and wastewater sludge is called co-composting.
Although there are many benefits to combining the two materials for composting, there are also several disadvantages to co-composting. The major advantages will be the added moisture that the sludge will add to the mixture and the additional biological organisms that will "jump start" the solid phase compost process.

Two major disadvantages are the physical characteristics of the mixed substrate and the nutrient balance. The addition of sludge to the substrate will produce a wetter mix with fewer voids and air passages needed to allow air into the substrate. If the voids in the solid waste substrate are filled with sludge, then the substrate will have a tendency to go anaerobic. This potential condition can be minimized by adding a bulking agent such as wood chips to create the air voids needed to maintain aerobic conditions. Since brush disposal is a significant problem in Gaborone, this potential problem can be easily managed.

The second more serious disadvantage may be the nutrient balance of the compost substrate. The primary nutrient balance is the ratio of carbon to nitrogen, usually referred to as the C/N ratio. A waste mixture having 25 parts of carbon to 1 part of nitrogen has a C/N ration of 25. Most references indicate that a C/N ratio in the 25 to 30 range is ideal for composting. Higher ratios (more carbon) will slow down the compost process and lower ratios (more nitrogen) can result in nitrogen loss through ammonia formation and unpleasant odors. Several co-composting plants in the United States have experienced significant odor problems.

The amount of paper in a mixed waste compost substrate will often be the determining factor in determining the C/N ratio. Mixed paper, for instance has a high carbon content and C/N ratio of 200 to 220, while food waste has a relatively high nitrogen content and low C/N ration of 15 to 20. With the amount of paper recycling, projected in the sorting facility, the C/N ratio of the sorted waste is expected to be on the low side, in the 20 to 25 range. In this range, additional sources of carbon may be required, such as dry yard waste or sawdust, to raise the C/N ratio.

A major problem with co-composting is that the sludge has a very low C/N ratio (high nitrogen) in the 6 to 10 range that when mixed with the solid waste substrate will reduce the overall C/N ratio into the range where nitrogen loss and ammonia formation can be expected. Under this

scenario, the amount of sludge that can be mixed with the solid waste substrate will be very limited. If the sludge content of the mixture is to be increased, additional sources of carbon material must be added to the substrate mixture. As stated above, these sources could include dry yard waste and sawdust. Wood chips are not a good source of carbon due to their larger size and limited surface area but are useful as a bulking agent.

Another potential problem with co-composting will be the chemical quality of the sludge. With the growth of local industry, the wastewater sludge may contain high amounts of heavy metals, organic chemicals, fats and oils which may prove to be problems in the compost process, especially given the market dependence on agricultural usage of the finished compost. This potential also points toward the need to perform a pilot project before considering full scale facilities.

In agricultural terms, the loss of nitrogen through ammonia formation is an undesirable process, since nitrogen is an important growth nutrient. If the the wastewater sludge is to be considered for agricultural applications, direct landspreading of the digested sludge may be a more appropriate technology.

7.6 Pilot Facility

7.6.1 General

Although the market evaluation has concluded that an insufficient compost market does not justify a full scale composting facility, at this time, the evaluation has identified many agricultural areas where compost could be of significant benefit. Since one of the major impediments to agricultural compost use is the unknown characteristics of the compost that would be derived from Gaborone's waste, a pilot facility is recommended to produce small quantities of compost from local waste for testing purposes.

Once an adequate supply of compost is produced, laboratory tests would be performed to determine the chemical content of the compost, especially heavy metals, and controlled test plots would be planted to determine the advantages and disadvantages of compost amended soils. Particular attention should be given to increased crop yields and heavy metal uptake by the food crops. As mentioned earlier, heavy metal uptake and the potential for bioaccumulation in the plant tissue are normally the limiting factors in determining compost application rates.

Since the first production of compost will take approximately 90 days, mature compost could be purchased from one of the South African plants to begin the laboratory tests. The waste substrate used to make the compost should be comparable to the waste generated in Gaborone to insure similar conditions. If the mix of residential and commercial waste is not similar to that of Gaborone, then adjustments should be made to the data results.

7.6.2 Reference Document

Although composting is basically a simple process there are many, design and operational issues that need to be addressed in either a pilot facility or full scale operation. These issues include substrate mixtures, control of odours, moisture requirements, temperature controls, pathogen destruction, and insect control. Rather than explain each of these issues within the body of this report I will instead refer to a reference document entitled "The Art and Science of Composting", published by Biocycle, a leading authority on composting in the United States. In conjunction with this report, one copy of the reference document will be on file with the Gaborone Senior Health Officer and two copies will be available from the Agricultural College.

7.6.3 Pilot Sizing and Design

The sizing and design of the pilot facility will be a factor of available resources. Preliminary discussions have been held with the Botswana Agricultural College and they have expressed interest in sponsoring a compost pilot facility with assistance from the GCC and the Ministry of Agriculture. If the pilot facility is to include co-composting with wastewater sludge, the Ministry of Local Governments and Lands should also be included as a participant.

The primary resources needed to begin a pilot facility are a covered concrete pad, with adequate water available and a means of turning the compost windrows at 5 to 8 day intervals. Although a covered area is not absolutely necessary, it will be much easier to control moisture content if the windrows are covered and shielded from the hot sun. The pilot facility should be conducted with representative organic waste taken from the landfill or several local restaurants. The size of the curing pad will determine how large a windrow can be constructed, and how many different types of substrate mixtures can be tested. As a minimum, the pilot study should include one aerated pile windrow and one static pile windrow with equal watering.

7.6.4 Private Pilot Project Tender

As an alternative to a pilot program sponsored by the Agricultural College, the construction and operation of a pilot facility could be tendered to a private research company. Through the tender process, the precise goals and objectives of the pilot study could be defined and a broader range of compost mixtures would be possible. The private operation of the pilot program may limit the political issues that may develop between the various public parties involved.

8.0 RECOMMENDATIONS

8.1 General

The disposal of solid waste in Gaborone is nearing a crisis situation. The existing landfill is for all practical purposes full, but it continues to operate while the new site is being prepared. Although the City Council has authorized funds to improve the appearance of the site, the problems at the existing sites are extensive and will most likely continue until the new site begins operations and new procedures are instituted.

The following recommendations are based on the feasibility study performed as Phase II of the Private Provision of Social Services program that was initiated in August 1991. The recommendations take several forms, including capital improvements, revised operating procedures and new bylaws. The recommendations are divided into technical recommendations, to be considered by the various consultants and engineers involved with the waste management systems, and action items which will require City Council input and action.

8.2 New Landfill Site

8.2.1 Summary

The new landfill site was selected in a 1985 study with a minimum amount of site investigation. As more information becomes available, the site is becoming less viable as a landfill, primarily due to major bedrock outcrops, poor soil conditions and risks to groundwater and surface water resources. Based on these limitations, the area of the site which can be safely developed as a general waste landfill is approximately 75,000 square metres as shown on Figure 5.1. Final design of this area by ARUP will proceed upon the completion of hydrogeological testing. Assuming a total depth of 10 meters, the new landfill will have a life between 9 and 12 years, depending on whether the GCC proceeds with a sorting and recycling facility.

Although the remaining portions of the landfill are not viable for a general waste landfill because of the bedrock outcrops, there are many other wastes that will require disposal or processing areas within the proposed site which will not produce a harmful leachate. A separate area for brush and demolition waste is shown on Figure 5.1. Separate areas for tire collection, hazardous waste processing and storage, waste oil collection, and the controlled burning of government documents are also recommended.

8.2.2 Technical Recommendations

- Limit the new landfill to the 75,000 square metre area shown on Figure 5.1.

- The site design should include areas for the disposal of brush and demolition waste. Brush chippers should be utilized to reduce the volume required for landfilling. The wood chips may also be used for landscaping mulch.

- The site design should include an area for receiving, storing and shipping tires.

- Upon completion of the final design, prepare an operating plan to become the basis of the tender for landfill operations.

8.2.3 Action Items

- Select a privatisation option for the new landfill, either private management only, or full privatisation.

- Issue a Request for Qualifications for privatisation of the new landfill.

- Begin a long term process for siting a new landfill outside the current City limits.

- Purchase 3 portable, trailer mounted wood chippers for collection of brush and yard debris and chipping of brush at the landfill.

8.3 Special Wastes

8.3.1 Summary

Section 4.0 presented a discussion of several special wastes that will require special handling either at the landfill site or at other locations in Gaborone. These wastes include hazardous wastes, medical waste, waste oil, and tires.

Hazardous and medical wastes are the subject of a questionnaire survey being prepared through the Department of Health. Upon completion of this inventory process, facilities or services should be designed to properly handle these special wastes. Preliminary evaluations indicate that hazardous waste generation in Gaborone is small but diverse, indicating the need for a specialized receiving and processing facility located at the new landfill. Due to the environmental risk factors at the proposed landfill, disposal of hazardous waste at the new landfill site is not recommended.

Medical waste is also a growing problem in Gaborone. Subject to the completion of the generation data base. a dual chamber incinerator should be designed and constructed to burn all medical waste produced in the City and outlying communities. The incinerator design and operation should be privatised through a tender process and located in an outlying area of the City to avoid the effects of frequent thermal inversions during the winter months.

A good market exists for waste oil recycling in Zimbabwe, but a network for the collection and storage of the waste oil has not been established, with the lack of adequate storage facilities being the primary shortcoming. The GCC has indicated that an abandoned sewage pumping station with a large underground storage tank could be made available for privatized operation as a waste oil collection and storage depot. This would provide the foundation for an effective collection and storage system. The proposed cement plant in Palapye could serve as a secondary disposal market where the oil would be burned in the plant's combustion chamber.

The proposed cement plant in Palapye will also have the ability to burn tires in its combustion chamber. Tires, collected at the new landfill could be shipped by rail to the site of the new cement plant and stored until the plant begins operations in 3 years.

8.3.2 Technical Recommendations

- Complete the questionnaire surveys and data bases for Hazardous and Medical wastes.

- Based on the results of the hazardous waste data base complete a feasibility study of the services or facilities required to dispose of these wastes. Include both local and regional generators.

- Based on the results of the medical waste data base, complete a feasibility study of the capacity and siting of a new medical waste collection system and incinerator. Include both local and regional generators.

- After completion of the landfill design, prepare a landfill operations manual which will serve as the basis of a private tender for landfill operations.

8.3.3 Action Items

- Prepare a bylaw requiring all generators of infectious medical waste, including hospitals, clinics, doctors offices, dentists, veterinarians, testing laboratories and research facilities to institute a colored bag system to identify their wastes as potentially infectious, regardless of their current disposal methods. The by-law shall require all medical to be disposed of in approved incineration facilities, meeting strict requirements

- Issue a Request for Qualifications for the operation of a medical waste collection and disposal system.

- Issue a Request for Qualifications and Tenders for the private operation of a waste oil collection and storage facility at the abandoned sewage pumping station on Old Lobatse Road. (see Appendix)

- Begin negotiations with the Botswana Development Corporation and Botswana Railways for the collection and transportation of waste tires to the site of the proposed cement plant in Palapye.

8.4 Sorting/Transfer Facility

8.4.1 Summary

Considering the limited capacity of the existing landfill and the future need for a central transfer station to access a long term remote landfill, a preliminary design of a Sorting/Transfer Facility at the site of the proposed landfill has been completed. The design includes several phases based on a 20 year projection of total waste and recyclable materials.

Materials sorted at the facility will utilize existing processing facilities and markets located in Gaborone for kraft/corrugated, mixed paper, plastic film and metal cans and tins. A local market for HDPE plastic has expressed interest in receiving sorted HDPE containers but additional negotiations will be necessary to establish processing capacity. Current glass markets in South Africa are depressed and glass may not be economical to recycle at this time.

8.4.2 Technical Recommendations

- Authorize ARUP to design the necessary infrastructure, roads, utilities, fencing etc. to incorporate the Sorting/Transfer Facility into the landfill site plan.

8.4.3 Action Items

- Issue a Request for Qualifications for the Design of the Sorting/Transfer Station.

- Begin negotiations with Waste Paper Recovery and Metal Box for the purchase of materials to be sorted at the proposed facility.

- Begin negotiations with Kgalagadi Plastics concerning material specifications, processing and prices for the recycling of HDPE containers.

8.5 Composting

8.5.1 Summary

Section 7 of the report has presented a feasibility study for the composting of the organic material that has remained in the waste after the sorting of recyclable materials. Primary screening would be performed at the Sorting/Transfer Facility but the 90 day curing of the compost would be performed at a remote site due to the large amount of space required.

A preliminary evaluation of the potential local compost markets has indicated that these markets are not sufficient to support a full scale compost facility at this time. A significant increase in the agricultural use of compost will be necessary to justify such a facility in the future.

Although the current markets do not justify a full scale compost facility, several individuals and organizations expressed interest in compost usage and the future market for compost material could increase. Concern over heavy metal content and toxic materials were cited as concerns for widespread agricultural use. Since compost quality will be dependent on the materials being composted, a pilot facility is recommended to produce a sufficient amount of compost for research and testing to determine its characteristics and potential for agricultural use. The Agricultural College has expressed an interest in sponsoring the pilot facility.

The proposed wastewater treatment facility will produce waste sludge that will require disposal. The potential of mixing the two materials for compost production should also be included in the pilot facility.

8.5.2 Technical Recommendations

- Conduct a 1/2 day seminar on solid waste composting theory and methods at the Agricultural College.
- Subsequent to the seminar assess the interest and resources available to conduct a pilot composting program.

8.5.3 Action Items

- Issue a Request for Qualifications for consultants or research and testing firms to conduct a pilot compost program in cooperation with the Agricultural College.

8.6 Interim Operations

8.6.1 General

During the first week of March, landfill operations were terminated at the existing site in order to permit the grading and covering of the site. Although the closure of the site had been planned for some time, the ACP/ECC conference which took place in late March at the adjoining show grounds, provided the justification for closing the existing at this time. During this period landfilling has resumed at the former landfill site in Mara Pula which was closed approximately 15 years ago. This has created some confusion among waste haulers and aesthetic problems in the local neighborhood, surrounding the Mara Pula site.

The existing schedule calls for the new landfill site to begin operations on 1 April 1993. The field work for the hydrogeology study at the new landfill will be completed during the week of 15 March and the final report will be completed by 1 April. After completion of the hydrogeology report, the final design and layout of the new landfill can proceed. Assuming that the hydrogeology report will permit the new landfill to be designed without a liner, the design, reviews, tendering and initial excavation of the site could take another 10 to 12 weeks to complete, bringing us to 1 July as the earliest date to begin operations at the new site.

Considering the above schedule, and the impacts to the Mara Pula site and surrounding neighborhood, landfilling should return to the existing site after the completion of the ACP/ECC Conference. The following interim operational plan if presented for consideration by the GCC.

8.6.2 Interim Operations Plan

An Interim Operations Plan is presented on Figure 8.1. The new entrance facilities should be activated when landfilling resumes at the existing or new site. All entrances from Tlokweng Road should be permanently blocked off. Existing problems with tires and brush fires will be reduced by providing separate areas for these materials at the new site. Tires will be stored within the fenced area to the south of the entrance facility. The area designated as brush and demolition area will be activated for these materials. Before landfilling of brush or demolition waste, the area should be cleared of all vegetation and overburden soils before landfilling the materials. The overburden soil should be stockpiled for future use as cover material. This separation of special waste relies on inspection of all waste entering the facility and signs directing the drivers to the appropriate disposal location.

Under the previous operating procedures, brush and tires were placed in an area to the south of the existing landfill, where frequent fires burned the materials. With these materials being placed in specific areas on the new site, this area can now receive additional waste. An additional access road will be needed to the interim landfill area that will not conflict with the preparation of the new landfill cells.

8.7 Project Schedules

The estimated completion of future tasks is shown graphically on Figures 8.2 and 8.3. The landfill schedule is based on current on-going work and discussions with ARUP, the design engineers for the landfill site. Preliminary test pit results have indicated good soil conditions exist within the area identified in Figure 5.1 and therefore the schedule shown on Figure 8.2 assumes that no liner will be required. In addition to the major work tasks shown on the schedule, other investigative tasks will be occurring during March and April during the final design. These include excavation of soils for the first cell construction and continued assessment of bedrock conditions. If the final design indicates that a liner will be required, then the time schedule for completion of design and construction will be expanded by 3 to 6 months.

Although we have included a recommended interim landfill plan, there is a possibility that landfilling will begin in portions of the new site before the July 93 time frame shown on Figure 8.2 due to insufficient interim capacity.

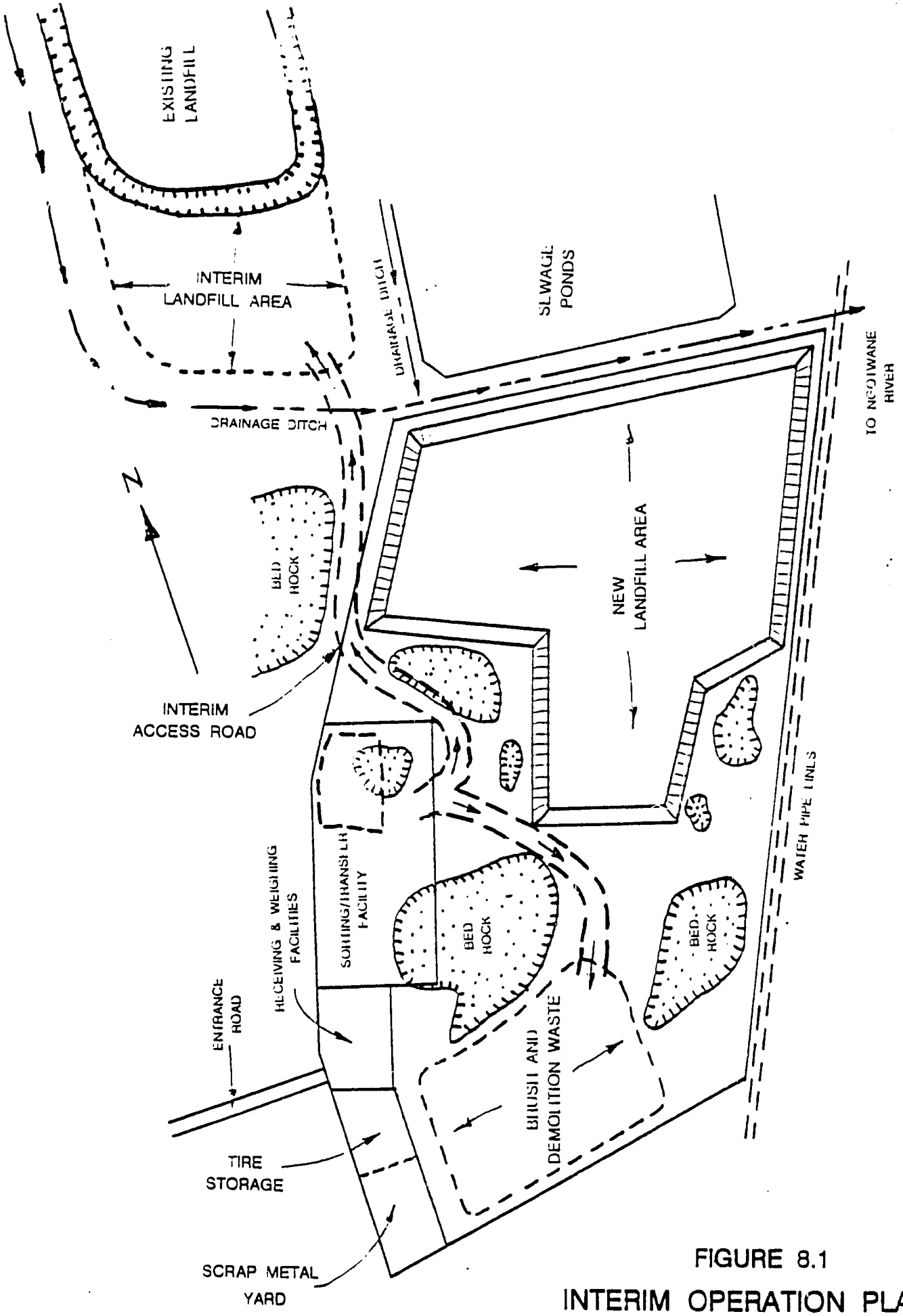


FIGURE 8.1

INTERIM OPERATION PLAN

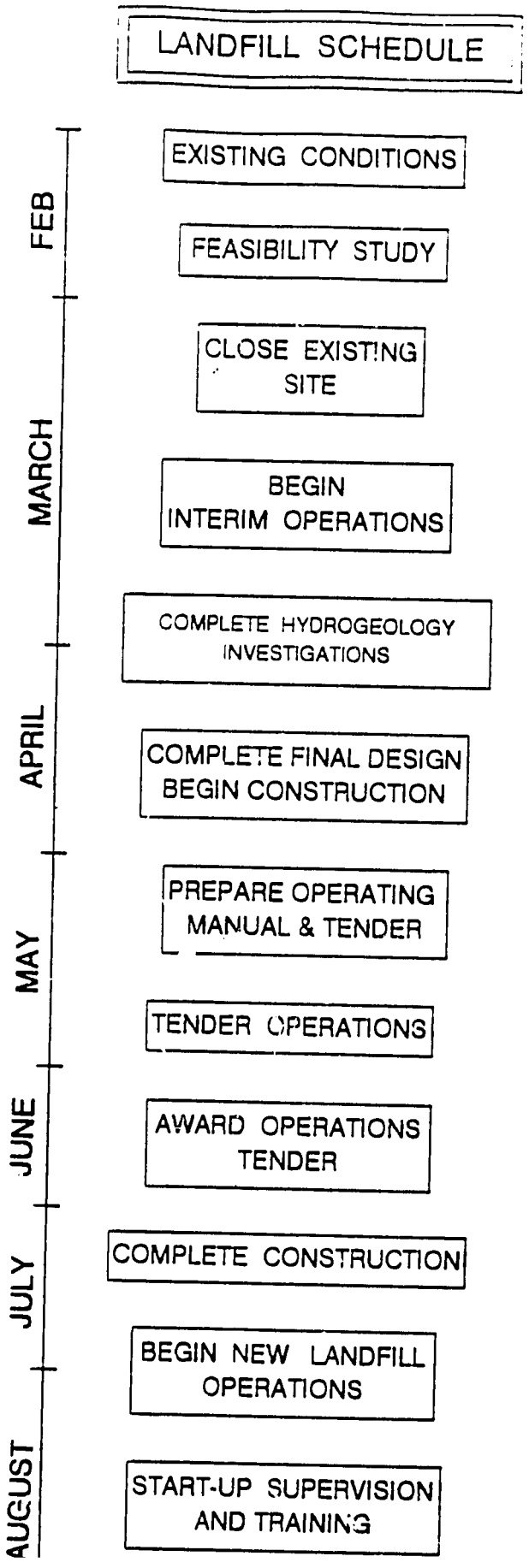


FIGURE 8.2
LANDFILL SCHEDULE

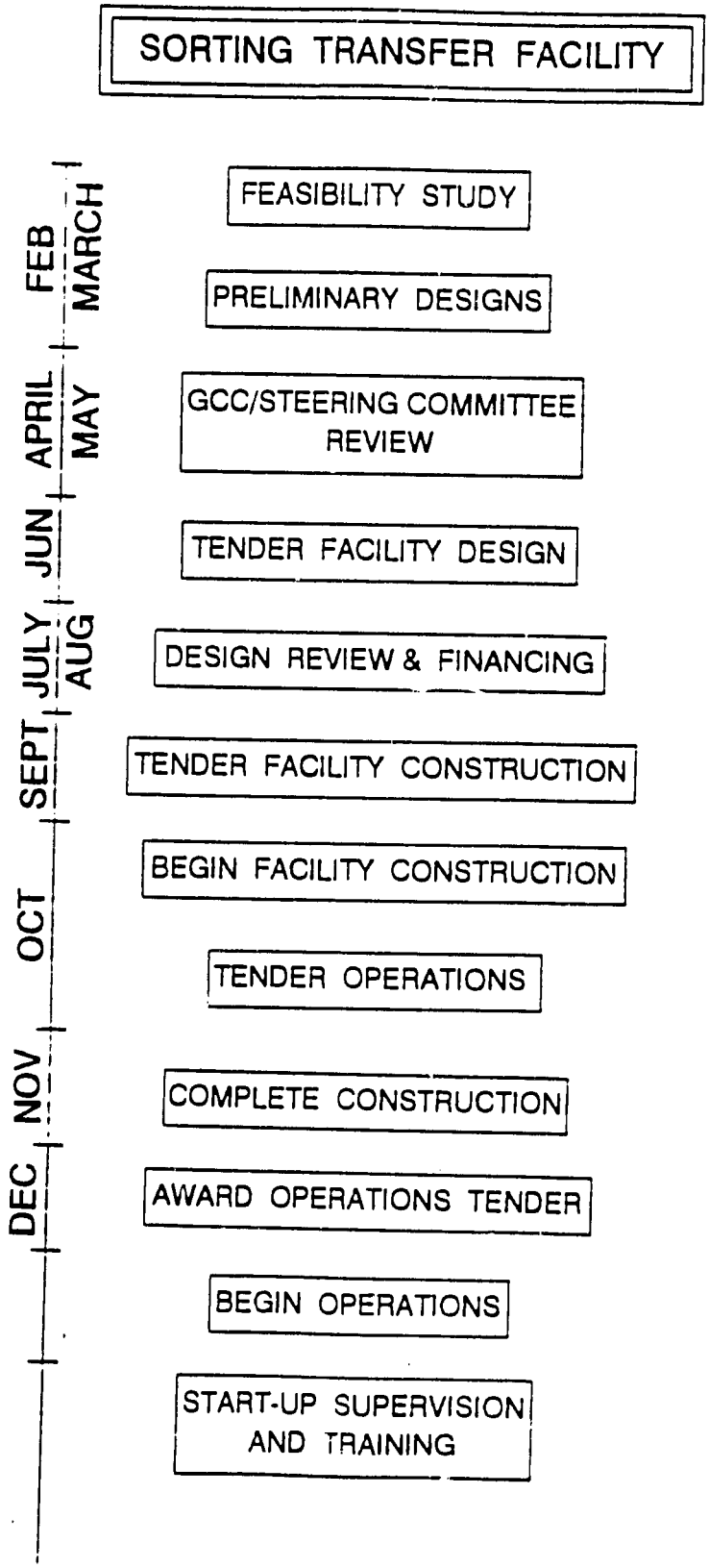


FIGURE 8.3
SORTING/TRANSFER FACILITY
SCHEDULE

Appendix A - Statement of Work

STATEMENT OF WORK

PRIVATE PROVISION OF SOCIAL SERVICES

GABORONE CITY COUNCIL

PRIVATIZATION OF SOLID WASTE COLLECTION AND DISPOSAL: PHASE 2

Year One Activities to Be Undertaken

I. BACKGROUND

Under USAID's Private Provision of Social Services (PPSS) program, Gaborone City Council (GCC) was given a grant to develop and subsequently implement a strategy for privatizing municipal solid waste (MSW) collection and disposal, which is currently undertaken by the public sector. The grant finances feasibility studies, technical assistance and commodities for privatizing its current operations in whole or in part.

As a first stage in this process, a team of consultants from the International City Managers Association (ICMA), namely Jim Dohrman, Don Manning and Brian Spielman worked with the GCC from May through July 1991. Their objectives included the collection and analysis of basic data, including conducting a weighing program, institutional and financial analysis, and a study of the existing system of collection and disposal. This was followed by an analysis of the options which included a variety of methods of management and total and partial privatization of the system, and a variety of different approaches to treatment of the landfill site. Their recommendations were:

1. To privatize the collection service for approximately one third of the residential part of Gaborone.

2. To privatize all of the industrial/commercial collection system, by means of franchising a private operator.

3. To establish a community based organization, or small local firm, to make the collections in Old Naledi (an upgraded informal settlement).

4. To privatize the management of the landfill site, and add sorting and composting facilities to reduce the net volume of fill, thus increasing the lifespan of the new landfill.

5. To give technical assistance to the GCC to help it improve its own services and to impart the skills necessary to supervise private contractors effectively.

In January 1992, the Council wrote as follows to USAID:

"The recommendations by the Council are as follows:

1. The refuse collection services should be considered for partial privatization, by way of contracting out to the private sector selected areas of the City. Initially only one such area has been identified as a pilot project.

2. The area identified for the pilot project is Gaborone South. (see the attached area map)

3. The solid waste disposal strategy for the city of Gaborone will result in the development of a sanitary landfill, incorporating sorting and composting operations.

4. The operation of the landfill site be privatized by way of contracting the management of landfill operations to the private sector in the form of a "Management Contract".

5. Under subsequent phases of the Solid Waste project, funded by USAID, technical assistance be undertaken in the form of operation and management of solid waste collection, disposal services and staff training, in addition to other items of identified works."

(Note: "Gaborone South" or approximately half of Gaborone on the east side of the railway line comprises the central business district, much of the high income housing area, Old Naledi and a limited amount of SHHA [low income] housing).

The Gaborone City Council has already contracted for the development of the new landfill site; and the new site will be commissioned for operation by early March 1993.

The activities covered by this Scope of Work (SOW) are intended to assist the GCC to implement the consultants recommendations.

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II. OBJECTIVES

The objectives of this consultancy are to provide technical assistance to the GCC in implementing the recommendations of Phase I described in Section I above. In summary this will include:

- Technical assistance in conducting a feasibility study of the proposed landfill operation, including making recommendations regarding appropriate sorting and composting technology and appropriate management methodologies. The study will also include a comprehensive survey of hazardous waste and oil products and recommendations on the collection and safe disposal of these products.

- Technical assistance in implementing the privatization strategy for the collection of refuse in specified areas of Gaborone; developing specifications for refuse collection and disposal equipment by type and quantity. The equipment will be procured from a U.S. source and locally maintained and operated.

- Provide technical assistance to evaluate the training needs of the GCC personnel to effectively manage the privatization program and subsequently expand privatization concepts. The training needs assessment will include the scope and extent of training required and will identify possible local, regional or international sites for such training.

- The consultant will also advise the GCC on improving the efficiency of its present operations, for example, to incorporate among others Refuse Transfer Stations (RTS) or Civil Amenity Sites, where sorting and bailing can be carried out.

III. SCOPE OF WORK

A. Solid Waste Collection

1. Confirm with the GCC the resources to be made available to the successful bidder in terms of vehicles, facilities and equipment.

2. Propose any additional procurement of equipment that may be required to make the project viable. The consultant will provide adequate specifications to procure such equipment from the USA including equipment recommended for the composting and sorting at the landfill site. (The equipment proposed to be procured from the USA must be locally maintainable and parts and services locally available).

3. Propose conditions under which GCC vehicles and property should be made available (e.g. leased) to private contractors.

4. Assist the GCC in preparing contract documents necessary for prequalification of interested firms.

5. Assist the GCC in evaluating the prequalification data and make recommendations on which firms should be prequalified to tender.

6. Assist the GCC in preparing contract tender documents for privatizing the municipal solid waste collection and disposal system for the city of Gaborone.

7. Provide assistance to prospective bidders in understanding the tendering documents and requirements for the proper completion of tender formalities.

8. Evaluate tenders and make recommendations to the GCC.

9. Advise and assist the successful bidder (contractor) in post contract operations, e.g., developing a work program, training of work crews, efficient and cost-effective routing, reducing down time on the equipment, and other various tasks leading to an efficient and profitable operation.

10. Closely monitor the contractor's operations during the start-up period; and based on the observations provided return instructions to the contractor to improve/remedy work operations.

11. Train and assist GCC staff in effective supervision of the private contractor.

12. Advise the GCC on appropriate public relations material and to inform the public on the changes caused by privatization and their consequences.

B. Landfill Management

1. Undertake a feasibility study of the proposed landfill operations, including making recommendations regarding appropriate sorting and composting technology and appropriate management methodologies.

Specifically this would comprise:

- the cost of various alternative technologies for sorting and composting,
- the commercial viability of each alternative,
- the potential for private sector firms to finance and build the sorting and composting plant,
- the impact of GCC finances if the composting sorting plant has to be financed and built by the public sector, potential sources of funds, including donor finance.

2. After the review of the feasibility report prepared under B.1 above, and subsequent to the acceptance of one of the proposed alternative activities at the landfill site by the GCC and the Government of Botswana (GOB), the GOB will request USAID/Botswana to provide the technical assistance to undertake implementation of the approved activity at the landfill site.

3. Undertake the activities required for tender actions as listed under A.1 - A.12 above.

IV. LEVEL OF REPORT

1. The estimated level of effort for items A.1 - A.12 is 14 person months including 2 person months level of effort for the equipment specifications specialist described in A.2.

2. The estimated level of effort for item B.1 is three person months.

3. The estimated level of effort for items B.2 and B.3 is seven person months.

V. REPORTS

The contractor will provide a written report in English to the Municipal Management Steering Committee/Gaborone City Council through the USAID/Botswana as follows:

1. A brief monthly report indicating work done and progress achieved as compared with the agreed work program.

2. A draft final report in respect to the implementation of the privatization strategy of solid waste collection.

3. The final report on item 2 above will be submitted after incorporating comments received from the GCC and USAID.

3. A feasibility report on the proposed plant for solid waste treatment at the landfill site, and recommendations for its financing and management.

VI. TERM OF PERFORMANCE

The work will commence in January 1992.

VII. TECHNICAL DIRECTION

The USAID/Botswana Assistant Project Development Officer (APDO) is the designated Project Manager and will be responsible for the overseeing of this activity, and limited technical direction may be provided by the RHUDO/ESA.

VIII. FUNCTIONAL PERSON POWER REQUIRED

1. Private Sector Solid Waste Management Expert

This position requires a person with the following qualifications and experience:

1.1 Experience in management of private sector solid waste collection systems, and supervision of private sector contractors on behalf of municipalities.

1.2 Familiarity and proven work experience with bidding and contracts appropriate for conditions such as prevail in Gaborone, and knowledge of production/supply firms in the U.S.A. Knowledge and experience in drafting contract documents for prequalification and tendering for privatization such civic works is a prerequisite.

1.3* Experience in developing procurement specifications for the collection related equipment/commodities, and knowledge of production/supply firms in the U.S.A.

1.4 Experience in training of management and workforce in the management of solid waste collection systems.

1.5 Proven experience in developing countries, preferably Africa.

2. Landfill Management Expert

This position requires a person with the following qualifications and experience:

2.1 Experience in the management of privately managed landfills, or the supervision of private sector contractors on behalf of municipalities. Familiarity with all aspects of landfill operation. Experience in managing an operation of composting and sorting equipment at landfill sites.

2.2 Experience in developing procurement specifications for the equipment for composting and sorting at the landfill and knowledge of production/supply firms for such equipment in the U.S.A. (Knowledge of maintenance/replacement problems in third world countries is desirable.)

2.3 Familiarity with bidding procedures and contracts appropriate for conditions such as prevail in Botswana

2.4 An engineering qualification or equivalent sufficient to equip the person to undertake the feasibility study on technology alternatives for the landfill.

* For this work an equipment specialist for a maximum of one person month may be more appropriate.

Appendix B - Hazardous Waste Questionnaire

(CITY OF GABORONE LETTERHEAD)

(OFFICE OF THE CHIEF HEALTH INSPECTOR)

Gentlemen:

As Gaborone continues to grow, the generation and disposal of waste material is becoming an increasing problem. The disposal of industrial and commercial waste is of particular concern due to their potential impacts to the Environment.

The Gaborone City Council is completing the final phases of opening a new solid waste landfill, and new expanded wastewater facilities are planned in the future. As part of our future planning process we are assembling a data base of the generators of commercial and industrial waste so that these new facilities can be properly designed and operated to handle all wastes generated in Gaborone.

With the assistance of USAID we have compiled a preliminary list of potential users or generators of industrial or commercial materials that may require special handling at their respective disposal facilities. Your company has been placed on this list due to the nature of your business, or the materials that are generated by your normal operations or maintenance procedures. We are most interested in chemical materials, containers that contain chemical residues, cleaning solvents, waste battery acid, waste oil and other automotive fluids, degreasing agents, textile dyes and conditioners, printing inks, painting solvents and any other solid or liquid waste.

The sources for this list were very general and we may have incorrectly included your company. If your company does not generate a commercial or industrial waste product but is merely a warehouse, wholesale or retail outlet for products produced at other locations, please indicate this on the questionnaire. Please take a moment to fill in the attached questionnaire and return it to the Chief Health Inspector at the above address at your earliest convenience.

Sincerely:

INDUSTRIAL-COMMERCIAL QUESTIONNAIRE

A. NAME AND ADDRESS OF COMPANY:

_____

_____

_____

_____

B. GENERAL DESCRIPTION OF YOUR COMPANY AND NORMAL OPERATIONS:

_____

_____

_____

_____

C. RAW MATERIALS USED IN YOUR BUSINESS - BE SPECIFIC AS POSSIBLE:

DESCRIPTION	(Kg/month)

D. WASTE MATERIALS GENERATED - BE SPECIFIC AS POSSIBLE:

E. HOW ARE THESE MATERIALS CURRENTLY DISPOSED OF:

_____

_____

F. GENERAL COMMENTS:

_____

_____

Appendix C - Medical Waste Questionnaire

MEDICAL WASTE

(CITY OF GABORONE LETTERHEAD)

(OFFICE OF THE CHIEF HEALTH INSPECTOR)

Gentlemen:

As Gaborone continues to grow, the generation and disposal of waste material is becoming an increasing problem. The disposal of medical and infectious wastes is of particular concern due to the potential impacts to the health of sanitation workers and waste pickers at the landfill, and the spread of infectious diseases.

The Gaborone City Council is completing the final phases of opening a new solid waste landfill, and new expanded wastewater facilities are planned in the future. As part of our future planning process we are assembling a data base of the generators of medical and infectious wastes so that we can be assured of proper disposal practices. Although much of the medical and infectious waste, generated in Gaborone is being disposed of in existing incinerators, these incinerators are small and due to their design may not meet minimum performance standards. As Gaborone continues to grow, the needs for effective disinfection and disposal of medical and infectious waste may require that new and more efficient facilities be made available.

With the assistance of USAID consultants we have compiled a preliminary list of potential generators of medical or infectious wastes. Your organization has been placed on this list due to the nature of your business in the medical profession. We are most interested in the types and amounts of medical and infectious wastes produced at your facility, and your current disposal practices.

Please take a moment to fill in the attached questionnaire and return it to the Chief Health Inspector at the above address at your earliest convenience.

Sincerely:

MEDICAL & INFECTIOUS WASTE QUESTIONNAIRE

A. NAME AND ADDRESS OF DOCTOR OR ORGANIZATION:

_____

_____

_____

_____

B. GENERAL DESCRIPTION OF YOUR AREAS OF PRACTICE OR SPECIALTY:

_____

_____

_____

_____

C. WASTE MATERIALS GENERATED - BE SPECIFIC AS POSSIBLE:

DESCRIPTION OF WASTE	(Kg/Mo)

D. HOW ARE THESE MATERIALS CURRENTLY DISPOSED OF:

_____

_____

E. GENERAL COMMENTS:

_____

_____

_____