North West District Council

Environmental Health Department

and

Okavango Delta Management Plan, Project Secretariat

ODMP Waste Management Component

Management of liquid and solid waste in the Okavango Delta Ramsar Site, Botswana

Tender No: NWDC/EH/04/04

WASTE MANAGEMENT STRATEGY
DRAFT

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Submitted by

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DEFINITIONS/SCOPE

Solid Waste: refers to all solid and semi-solid waste materials discarded by the community and shall include household, institutional/commercial, tour operations and clinical waste streams.

Liquid Waste: refers to any waste material generated by communities that is determined to contain 'free liquids' and shall include sewage from on-site systems and off-site system (septic tank influent and effluent, conservatory influent) and used lubricating oil

EXECUTIVE SUMMARY

Improper management of solid and liquid waste presents two types of risk. The first and more obvious one is the public health risk that may emerge as a result of transmission of pathogenic organisms from waste to humans. The second and perhaps less obvious one is the environmental risk as a result of contamination by waste and waste by-products. In recent years, the human population in the Okavango Delta Ramsar Site has grown significantly as a result the growth in the tourism industry. This population growth has resulted in an increase in both waste quantity and variability. However, these increases have not been accompanied by corresponding improvements in waste management infrastructure and practices. The aim of this project is to develop a solid and liquid waste management strategy for the Okavango Delta Ramsar Site that could lead to improved waste management practices to minimize potential environmental impacts. The project methodology involved waste characterization studies, key informants interviews, wastewater sampling and analysis and household interviews.

Solid Waste

The main generators of solid waste are households, tourism operations, institutions and commercial enterprises. It is estimated that the solid waste generation rate for the entire Okavango Delta Ramsar Site is 0.39kg/capita/day with the majority of it (72%) coming from households. A large component of the waste generated is putrescible (64%).

There are a variety of primary storage containers currently in use including backyard pits, refuse bags, galvanized metal bins with lid, pole mounted bins and predator proof bins. However, the majority of households use backyard pits and/or have no primary storage containers, which makes their waste not available for collection. Secondary storage is provided through skips in major settlements and transfer stations in small villages. Some of the transfer stations are used for final disposal, resulting in over spilling of the waste.

Primary collection of waste is largely door-to-door in cases where it is provided, with frequency of collection that varies from once a day to once after seven months. Waste collection is mainly provided by the local authority through compactor trucks, tractor and trailers and skip carriers. The local authority has contracted out some of the waste collection service to private collectors and micro-enterprises. Despite these initiatives, littering is prevalent and collection coverage is poor with only 20% households reporting regular collection. Tourism operations in remote areas hardly receive any collection service. It has been established that the local authority has enough collection capacity to collect all the waste generated during the strategy period. However, the performance of local authority collection fleet is poor, as indicated by collection of 31% of the waste they had planned to collect annually. This also raises issues of efficiency. While the private sector manages to collect 173 tonnes/year with $1m^3$ of capacity, the local authority only manages 45 tonnes/year with the same capacity.

Clinical waste is mainly treated through incineration. However, during the duration of this project, there was only one working incinerator in the whole of the Okavango Delta Ramsar Site, resulting in most of the waste being crudely incinerated or even dumped in ungazetted places.

Recycling initiatives exist at a small scale, mainly targeting steel metal cans. However, most tourism operators are willing to separate their waste at source for recycling, with the major constraints being the availability of markets for recyclables. Disposal of waste is predominately through open dumps either fenced or unfenced. There are also incidences of illegal disposal. However a sanitary landfill has been constructed in Maun and will soon be operational.

Liquid Waste

Typical wastewater generation rates were difficult to establish, but were assumed to be in the same magnitude as the national average generation rate of 83 litres/capita/day. Most households do not use waterborne sanitation systems. The majority of wastewater comes from institutions, commercial enterprises and tourism operations, and is collected and treated through septic tank and soakaway system. However, there are limited capacity sewer networks in Maun, Boro Farm and Gumare. The effluent quality parameters from the existing wastewater treatment systems are generally above the desired levels.

Used oil is mainly collected from on-site storage facilities for collection for recycling in South Africa. It however emerged that some of the used oil generators are not aware of the used oil waste collection network.

Environmental Impact

The environmental impacts of the existing waste management practices are predominately negative ranging from -72 and +32. The most severe impacts are threats to terrestrial and aquatic life followed by water contamination and public health hazard.

Institutional Capacity

The main institutions responsible for solid and liquid waste are Environmental Health Department (EHD) and Water and Wastewater Department (WWD). These departments are generally under-resourced in terms of waste management skills. Generally, there is a disproportionate distribution of staff between the two Sub-Districts of North West District Council (Okavango and Ngami), with the majority of staff stationed in Ngami Sub-District. It was also revealed that proposals for investment in waste management through District Development Plans are hardly approved for funding. The investment budget is expected to come from national government disbursements. Apart from that, cost recovery initiatives yield minimum revenue. In the case of solid waste; it only constitutes 1% of the waste collection recurrent budget.

Stakeholder perception

The general perception of most stakeholders is that waste management in the Okavango Delta Ramsar Site is poor. However, improvements on the waste management service are expected to come from the local authority.

Recommendations

This strategy covers a 5 year period from 2006 to 2011. The vision of the strategy is to increase investment in waste management initiatives to improve service performance. It is anticipated that improved service performance with public education will attract public attention to the importance of waste management, which could lead to improved cost recovery. To realize this vision there is a general need to create the necessary stakeholder linkages. The strategy proposes eight components towards improving waste management within the Okavango Delta Ramsar Site.

Component 1 – Waste Information Systems

To facilitate planning and monitoring, it is proposed that information on waste quantity, fractions, collection, treatment and disposal be recorded and stored in a format that is easily accessible whenever it is required.

Component 2 – Waste Collection

It is proposed that to facilitate collection, the local authority should develop a standard bin policy for different categories of generators to make waste easily accessible for collection. The local authority should also develop a prototype transfer station that will facilitate easy reception and removal of waste for possible replication in small villages. It is also proposed that for settlements with more that 3,000 inhabitants, waste collection services should be privatized, with micro-enterprises providing primary collection for other settlements. The emphasis of local authority should be on providing secondary collection from transfer stations to disposal sites. In the spirit of stakeholder linkages and participation, it is proposed that tourism operations and the local authority should establish the tourism waste collection fund (TWCF) to finance waste collection in remote tourism operations.

Component 3 – Waste treatment and disposal

The local authority should support local recycling initiatives through appropriate incentives. It is also proposed that instead of having numerous open dumps, which constitute numerous point sources of pollution, and may be difficult to close and rehabilitate properly in the long run, a centrally located disposal site should be established for Okavango Sub-District with operational controls.

Component 4 – Liquid waste collection and treatment

While septic tank – soakaway system presents some risk to the environment, it is still generally accepted as a viable wastewater treatment technology where there is no sewer network. It is recommended that all new

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wastewater management systems should be approved by the local authority before construction. Collection of wastewater/sludge from remote tourism operations should be done through the TWCF. It is also proposed that Maun sewer network should be upgraded to increase capacity and spatial coverage. The local authority should install capacity to monitor water and effluent quality on a regular basis.

Component 5 – Institutional and logistical capacity

It is proposed that the EHD should be restructured to align it with its main mandate of solid waste management. Management of wastewater from on-site systems should be the responsibility of the WWD. In order to overcome some of the organizational procedures that often compromise service delivery, it is proposed that waste management departments should have some autonomy in relation to funding and budgeting. Appropriate manpower skills should be developed within waste management departments.

Component 6 – Cost recovery

It is recommended that an effective cost recovery policy should be developed. Variable charges on the quantity of waste collected should be introduced for institutions, commercial enterprises and tourism operations. It is also proposed that EHD and WWD should be given some leverage to use revenue from service charges to augment their recurrent budget for waste management.

Component 7 – Public education and awareness

The local authority should develop and launch a public education and awareness programme. It should enlist the support of NGOs and private sector to realize programme success. Key elements of the programme should include pilot projects, recycling, waste avoidance, litter prevention campaigns and other best practices.

Component 8 – Strategy implementation

An implementation action plan (IAP) has been developed towards the realization of strategic intentions. Apportionment of responsibilities at different levels of the departments is provided within the IAP to facilitate the definition of roles within the organizational structure of waste management institutions.

1 INTRODUCTION

Waste Management is a major practical undertaking. Most of the time, those involved in waste management usually concentrate their energies on day-to-day issues. A major role of strategic planning is to provide an opportunity for these and other stakeholders to take a step back from day-to-day problems and focus on defining their vision for the future. At a national level, the Waste Management Act of 1998 requires local authorities to prepare waste management plans covering the area under their control. The purpose of such plans is to improve waste management processes and practices both in the short and long term. In particular, the planning initiatives should be intended to protect public health and the natural environment. The Solid and Liquid Waste Management Strategy presented here is a culmination of the national legislative requirements as outlined above and the requirements of the Okavango Delta Management Plan (ODMP). The objective of the ODMP is to develop a comprehensive, integrated management plan for the conservation and sustainable use of the Okavango Delta and its surroundings. The ODMP is designed in thematic areas with twelve (12) components, among them waste management, which is the subject of this strategy.

This strategy is expected inculcate among waste management stakeholders an understanding on where they are in terms of waste management services by providing baseline information of existing waste management systems and their benefits and/or limitations in terms of environmental protection of the Okavango Delta Ramsar Site. It will also help them define where they want to be in five (5) years in terms of level of service, technical input and resources to minimize the possible environmental impacts of waste generation. The strategy covers the period 2006 to 2011.

1.1 Project Scope and Objectives

This Solid and Liquid Waste Strategy is for the Okavango Delta Ramsar Site (ODRS). The overall objective of the strategy is to improve management of solid and liquid waste to minimize their current and potential harm on the ODRS environment. More specifically the strategy;

i. Compiles an inventory of existing waste streams from representative communities and tourism operations within the ODRS.
ii. Compiles an inventory of current waste management practices in the ODRS.
iii. Assesses the environmental impact of the existing waste management practices.
iv. Recommends strategic options for improving waste management in the next 5 years
v. Recommends potential pilot project(s) towards fulfilling strategic objectives.

1.2 Methodology

In order to fulfil the primary objectives of the project, the methodology employed was divided according to the key parameters of investigation as outlined in the terms of reference. These were:

i. Solid waste quantity and composition
ii. Liquid waste quantity and effluent quality
iii. Existing waste management practices
iv. Environmental impact of existing waste management practices
v. Institutional and logistical capacity of waste management structures
vi. Identification of best waste management options

The first four parameters above were investigated through fieldwork in the ODRS as well as analysis of information from secondary sources. The fieldwork was conducted at a number of sites selected to represent a wide cross section of communities and tourism operators in the ODRS (Figure 1.1). The approaches that were used to investigate each of the parameters above are detailed in the following sections.

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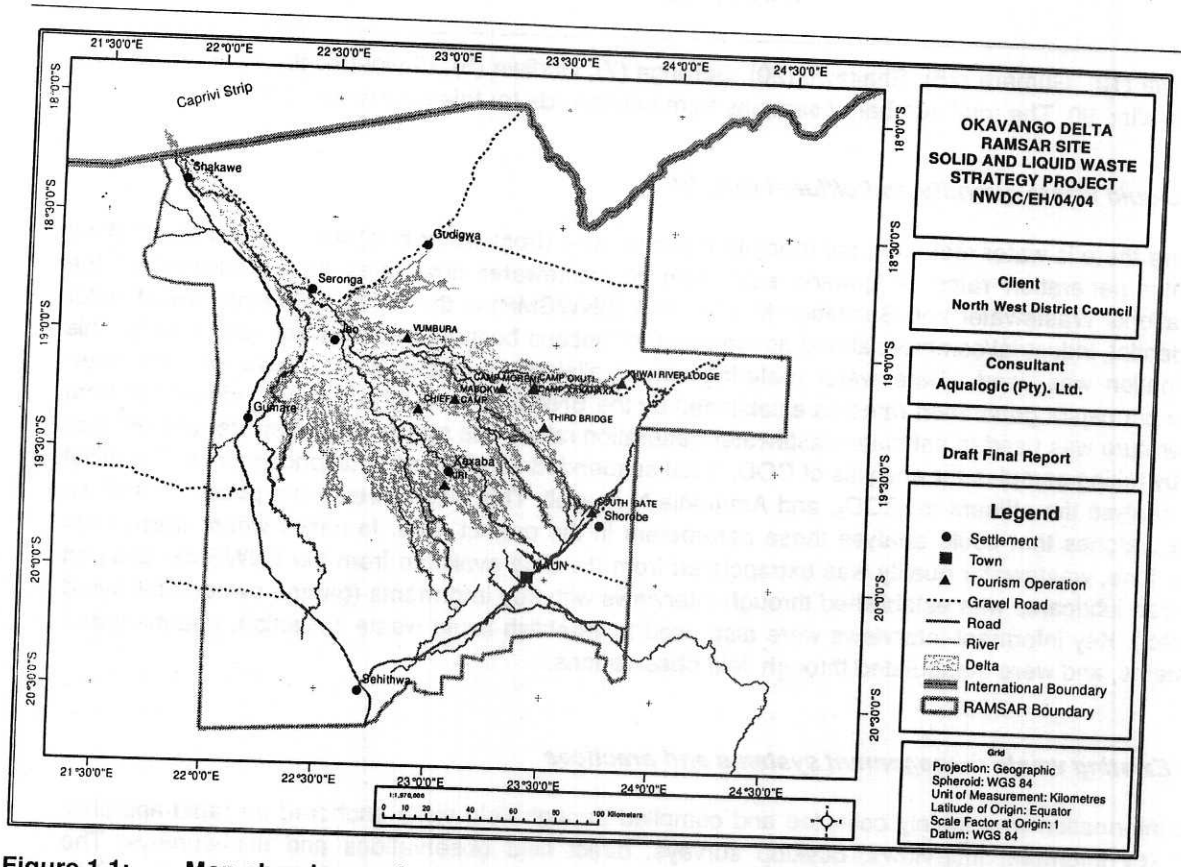

Figure 1.1: Map showing project area and selected sampling sites

1.2.1 Solid waste quantity and composition

The determination of solid waste quantity and composition involved three categories of waste generators of institutions/commerce, tourism operations and households. Solid waste quantity and characterisation for institutions/commerce and tourism operations was carried out through key informant interviews and a characterization and weighing programme. This was carried out with a representative sample of institutional/commercial entities and a selection of tourism operations. Key informants were mainly asked questions on their experience on typical number of primary waste storage containers that they fill in any given day. A typical container with waste was weighed to determine the weight of the waste and an inference on waste generation rates was made based on the information provided by the key informant(s) and that obtained by the weighing programme. After weighing, the waste was disaggregated into seven (7) main components of putrescible waste (food and garden waste), paper, plastic, glass, metal, textile and other to establish their quantities through weighing. However, establishing the generation rate of clinical waste was mainly informed by key informant interviews and a weighing protocol because of the special nature of the waste. Key informant questions focused on incinerator capacity, where it existed, and number of times that it is operated. Key informant interviews were also used to establish solid waste collection, treatment and disposal systems, and were triangulated through observations.

The determination of quantity and composition of household waste was carried out by sampling the waste at source. This involved supplying a given number of conveniently sampled households with plastic bags to deposit their waste for 24 hrs (1 day), which was then collected daily for weighing and characterization. The process was repeated for the same households for 3 consecutive days. The characterization involved identification of similar components as for institutional/commercial waste. The number of households selected for sampling was 2% of established households in each community. The approximate number of households in each community was derived by dividing the population of that community by 4.8, which is a representative number of people in a household in Botswana (e.g. Population of Shorobe is 955: Number of households = 955/4.8 =199, 2% of 199 = 4). Where the settlement population is less than 300, all households were targeted for sampling. Using the above computation the distribution of households in the selected communities was as

follows: Sehitwa (10), Gumare (25), Shakawe (20), Seronga (7), Gudiwa (5), Khwai (5), Shorobe (4), Jao (5), Xaxaba (9), totaling 90. The total number of samples from households for this survey was 270.

1.2.2 Liquid waste quantity and effluent quality

In cases where there is water metering, the monthly water reading (from water bills) was used to establishing the wastewater generation rates. A generic estimation of wastewater flow rates as established by the Botswana National Wastewater and Sanitation Master Plan (BNWSMP) is that 80%, 55% and 65% of water used in residential, industrial/commercial and government/institutions becomes wastewater respectively. This generic estimation was used where water metering was available. In places where there was no water metering, the per capita generation rates as established by the BNWSMP and other generic information from published literature was used to estimate wastewater generation rates. The quality of wastewater effluent was established by taking samples for analysis of COD, Total suspended solids, and Total phosphorus. The initial idea was to analyse the effluent for BOD_5, and Ammonia-N as well. This was however not possible because of lack of laboratories that could analyse these parameters in the project area. In cases where these tests could not be done, wastewater quality was extrapolated from the data available from the BNWSMP. Data on quantity of used lubricants was established through interviews with key informants (garage owners, backyard mechanics etc.). Key informant interviews were also used to establish liquid waste collection, treatment and disposal systems, and were triangulated through field observations.

1.2.3 Existing waste management systems and practices

Background information was mainly collected and compiled through field visits anchored on rapid appraisal methods of key informant interviews, desktop surveys, direct field observations and mini-surveys. The objective of this process was to develop a database on waste sources, waste management practices, key stakeholders and other relevant information. It included a visit to Maun (Headquarters of North West District Council) to identify and interview key informants for purposes of snowballing other key informants in communities of study of Sehithwa, Gumare, Shakawe, Seronga, Gudingwa, Khwai, Shorobe, Jao and Xaxaba. Key informants in these communities were interviewed on the principal parameters of investigation of solid and liquid waste sources, existing management systems and practices and key stakeholders. Questionnaires were developed for soliciting information from key informants on waste management systems and practices. More specifically, questionnaires were developed for administration to institutions/commerce, tourism operations and households.

1.2.4 Environmental impact of existing waste management practices

The Rapid Impact Assessment Matrix (RIAM) (Pastakia and Jensen, 1998), a technique that improves the more descriptive previous assessment methods, was applied in this study. RIAM was preferred because it is intuitive, systematic and quick to apply (particularly because it is a computerized technique that allows easy and faster corrections). Perhaps the strength of RIAM lies in that impact assessments are quantified and can be presented numerically and graphically. Essentially RIAM recognizes that certain specific criteria (e.g. magnitude, temporal status, reversibility and cumulativeness of impacts) are common to all impact assessments, and by scaling these criteria it is possible to record the values of judgments in a matrix in an objective and transparent way. The composite score known as Environmental Score (ES) varies between +108 or +E and –108 or –E and signifies the severity of the impact as indicated in Table 1.1.

Table 1.1: RIAM scheme for rating the severity of environmental impacts

Environmental Score	Range Band	Description of Range Band
+ 72 to +108	+ E	Major positive change/impacts
+36 to + 71	+ D	Significant positive change/ impacts
+19 to +35	+ C	Moderately positive change/ impacts
+10 to +18	+ B	Positive change / impacts
+1 to +9	+ A	Slightly positive change / impacts

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Environmental Score	Range Band	Description of Range Band
0	N	No change/ Status quo/ Not applicable
-1 to -9	- A	Slightly negative change / impacts
- 10 to -18	- B	Negative change / impacts
-19 to -35	- C	Moderately negative change/ impacts
-36 to - 71	- D	Significant negative change/ impacts
-72 to - 108	- E	Major negative change/impacts

Source: Pastakia, C. and Jensen, A. (1998)

The assessment criteria used with the RIAM technique fall into two groups:

Group A: Criteria that are of importance to the condition, that individually can change the score obtained; and
Group B: Criteria that are of value to the situation, but should not individually be capable of changing the score obtained.

The value ascribed to each of these groups of criteria is determined by the use of the formulae shown below.

(A1) x (A2) = AT (1)
(B1) + (B2) + (B3) = BT (2)
(AT) x (BT) = ES (3)

Where:

(A1) and (A2) are the individual criteria scores for group A;
(B1), (B2) and (B3) are the individual criteria scores for group B;
AT is the result of multiplication of all (A) scores;
BT is the result of summation of all (B) scores; and
ES is the Environmental Score for the condition under study.

The judgments on each component are made in accordance with the criteria and scales shown in Table 1.2.

Table 1.2: Criteria for judging the significance of environmental impacts

Group	Code	Criterion	Scale	Description
A. Criteria that are of importance to the condition, that individually can change the score obtained	A1	Importance of condition	4	Important to national/ international interests
			3	Important to regional/ national interests
			2	Important to areas immediately outside the local condition
			1	Important only to the local condition
			0	No importance
	A2	Magnitude of change or effect	+3	Major positive benefit
			+2	Significant improvement in status quo
			+1	Improvement in status quo
			0	No change/status quo
			- 1	Negative change to status quo
			- 2	Significant disbenefit of negative change
			- 3	Major disbenefit or change
B. Criteria that are of value to the situation, but should not individually be capable of changing the score obtained	B1	Permanence	1	No change/ Not applicable
			2	Temporary
			3	Permanent
	B2	Reversibility	1	No change/ Not applicable
			2	Reversible
			3	Irreversible
	B3	Cumulative	1	No change/ Not applicable
			2	Non-cumulative/ single
			3	Cumulative/ Synergistic

RIAM allows for the assessment of the key components of the environment in relation to the proposed activity/project, as shown in Table 1.3.

Table 1.3: Key components of the environment

Environmental component	Description
Physical/Chemical (PC)	Physical and chemical aspects of the environment
Biological/Ecological (BE)	Biological and ecological aspects of the environment
Sociological/Cultural (SC)	Human aspects of the environment, including cultural aspects
Economic/Operational (EO)	Economic consequences of environmental change, both temporary and permanent

1.2.5 Institutional and logistical capacity of waste management structures

The North West District Council, Environmental Health Department (EHD) is the designated authority for managing solid waste in the project area, while the Water and Wastewater Department (WWD) is responsible for sewerage. Institutional capacity assessment was established through an analytical framework made up of the following attributes:

- Institutional Resources (importance in terms of the level in local authority structure, human resources – staffing and qualifications, financial resources – percentage of total local authority budget and distribution in relation to key performance areas, equipment),
- Institutional performance (fulfilment of assigned responsibilities, service delivery, networking and inter-institutional linkages), and
- Institutional sustainability (organizational autonomy).

The above attributes were assessed through desktop study and key informant interviews.

1.2.6 Identification of best waste management options

The waste management scenarios were development for any type of waste, based on the Best Practicable Environmental Options (BPEO). To identify BPEO, a nine-step process of Defining objectives, Identifying decision criteria, Developing scenarios, Applying constrains, Evaluating options, Weighting decision criteria, Generating final option scores, and Identifying BPEO was adopted. The process was not followed linearly, but used as a guiding framework. Each option in BPEO included collection, processing and final disposal.

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2 WASTE MANAGEMENT POLICY AND LEGISLATIVE FRAMEWORK

2.1 Waste Management Policy

The main policy instruments for the management of solid and liquid waste are described below.

2.1.1 Botswana's Strategy for Waste Management of 1998

The central message of the strategy is that waste management in Botswana will be taken in a manner, which adequately protects human health and the environment. It adopts the Waste Management Hierarchy as the guiding principle. Among the key components of the hierarchy are; reduction of waste, reuse of waste recycling of waste and final disposal. The other key principles adopted by the strategy are, the Prevention Principle (emphasis on pollution prevention), the Polluter Pays Principle (costs of environmental damage must be borne by those who caused the damage in the first place) and the Principle of Co-operation (emphasis on stakeholder involvement). These principles are inline with international practice aimed at achieving best practicable environmental options (BPEO).

2.1.2 Botswana Policy for Wastewater and Sanitation Management of 2001

The overall purpose of the Botswana Policy for Wastewater and Sanitation Management (BPWSM) is stated as to promote the health and well-being of the population through the provision of appropriate and sustainable wastewater/sanitation management. The policy also aims at introducing mechanisms for the protection and conservation of water resources. Among the specific objectives of the policy are:

- To promote and develop appropriate, affordable and sustainable wastewater/sanitation systems in both urban and rural contexts,
- To establish basic principles and guidelines for pricing and cost recovery for wastewater/sanitation facilities.

The BPWSM culminated in the development of the Botswana National Master Plan for Wastewater and Sanitation (BNMPWS).

2.2 Legislative framework

Although there is quite a number of legislation that is related to the environment in general, a limited number specifically relates to waste. Among others, these are:

- Public Health Act of 1981: provides for the regulation of sanitation, housing and the protection of water supplies.
- The Waste Management Act of 1998: makes provision for efficient waste management so as to prevent harm to human, animal and plant life and to minimize pollution of the environment, to preserve the natural resources and to cause provisions of the Basel Convention to prevail.

The Waste Management Act of 1998 provides for the establishment of the Department of Sanitation and Waste Management (now Department of Waste Management and Pollution control) in the Ministry of Local Government to oversee and regulate sanitation and waste management. It embodies regulatory measures, which are aimed at managing controlled waste to minimize impact on human, animal and plant life. Primarily, the Act:

- Sets out the institutional framework, with local authorities designated as collection and disposal authorities of all the controlled waste in their area of jurisdiction.
- Requires local authorities to prepare waste management plans.
- Empowers a local authority to collect and dispose all waste other than household waste at an agreed fee.

- Requires the local authority to deliver all the waste it collects to a licensed waste management facility, with the exception of any household waste, which the local authority may decide to retain for recycling.
- Sets out penalties for non-compliance with some aspects of the Act. For example, operating a waste management facility without a license carries a fine not exceeding P8000 or imprisonment not exceeding seven years.

However, there are no incentives or disincentives for local authorities (councils) to comply with the provisions Waste Management Act through the formulation and implementation of waste management plans. This lack of incentives and/or disincentives can limit the councils' participation in developing and implementing waste management plans.

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3 DESCRIPTION OF THE PROJECT AREA

3.1 Physical Boundaries of the Okavango Delta Ramsar Site

The project area boundaries are as demarcated and shown previously in Figure 1.1.

3.2 Topography, Climate, Geology, Hydrogeology and Vulnerability of Water

3.2.1 Topography

The Okavango Delta Ramsar Site can be characterized as a gently sloping alluvial fan situated in a graben structure. Typical topographic gradients are on the order of 1/5000. The site generally displays a very low topographic relief. Some isolated rock outcrops (Tsodilo Hills, Gcoha Hills) rise about 100 m above the surrounding plain, whereas the elevation of the plain varies between 1,025m in Mohembo and 920m in the Mababe Depression. Over an area of roughly 70,000km^2, the total topographic range is only 105 m. The land surface generally slopes from northwest to southeast. The characteristic feature of the regional topography in the Okavango Delta Ramsar site is its extreme flatness. The virtual absence of significant topographic gradients has implications for the flow of surface water and groundwater in the region. Large-scale surface water dispersal over the Okavango Delta sensitively depends on minor changes in topographic elevation, which can be produced by sedimentation or tectonic activity.

3.2.2 Climate

The climate of the Okavango Delta Ramsar Site can be characterized as semi-arid to arid. Rainfall is generally increasing from southwest to northeast and annual rainfall is strongly seasonal. The major part of the rainfall occurs between November and March. Rainfall is unreliable and the inter-annual variability of rainfall is large. Annual precipitation varies between 250 mm and almost 1000 mm. Unreliable rainfall causes significant risks for water supply, cattle farming and agriculture in the region. In some years, flooding causes problems, particularly when strong local rainfalls coincide with large discharges in the Okavango River.

3.2.3 Geology

The Okavango Delta Ramsar site is located in the Kalahari sedimentary basin. The Kalahari group sediments are underlain by Precambrian basement rocks and the Carboniferous to Jurassic Karoo supergroup, though, in places, the Precambrian rocks lie unconformably beneath the Kalahari sediments. A number of faults cut through the project area and define the structural framework of the region. The Okavango Delta region displays considerable seismic activity and neo-tectonics are believed to have significant influence on surface water dispersal in the Okavango Delta.

The Okavango Graben structure, which hosts the Okavango Delta, is presently delineated by the Thamalakane and Kunyere faults to the southeast and the Gumare fault to the northwest. The Thamalakane and Kunyere faults downthrow to the northwest, whereas the Gumare fault downthrows to the southeast. The thickness of the Kalahari beds is increasing from the Gumare fault towards the Kunyere fault. In addition to these major fault lines a secondary set of northwest-to-southeast trending faults exists. Its most prominent expressions are the two faults confining the Panhandle floodplain. In the area between the Kunyere and Thamalakane faults, river valleys (Shashe, Nxotega etc.) are associated with the secondary lineament trends.

3.2.4 Hydrogeology

The hydrogeology of the Okavango Delta Ramsar site is characterized by a close connection between the swamp waters of the Okavango Delta and the surrounding shallow unconfined aquifers. The streams and floodplains in the Okavango Delta continuously lose water that infiltrates into the shallow aquifers, feeding a fringe of dense riverine vegetation. Another characteristic feature of the hydrogeology in the region are very pronounced salinity contrasts between the shallow unconfined aquifers that are connected to the rivers and

floodplains and the stagnant groundwater in the interfluve areas. Whereas the groundwater salinity in the interfluve areas ranges from about 10 g/l to about 40 g/l, the water quality next to the rivers and floodplains is generally high and the salinity does not exceed 1 g/l.

Groundwater flow in the Okavango Delta region is generally directed from the flooded areas towards the drylands. At the interface between the flooded areas and the drylands, a belt of lush, vigorous riverine groundwater-fed vegetation is found. The transpirative demand by the riverine vegetation establishes strong hydraulic gradients that in turn trigger infiltration from the surface water bodies into the shallow unconfined aquifer.

3.2.5 *Vulnerability of surface and groundwater*

The surface water resources in the Okavango Delta Ramsar Site are generally highly vulnerable. Traveling times in the surface water system are rather short (typical flow velocities on the order of 1-10 km/d), the dilution potential in some of the minor channels of the Delta is rather low due to low discharge and some of the water intake points of the various lodges and tourist resorts are quite close to each other, thus posing problems of cross-contamination. Since the surface water in the floodplains is stagnant and exposed to abundant sunlight, there is a great potential for nutrients to cause toxic algal blooms. Prevention of eutrophication and nutrient discharge into surface waters should therefore be a priority for wastewater management in the region.

Moreover, McCarthy et al. (2004) pointed out that wastewater disposal into surface waters or artificial wetlands creates the risk of pathogens being spread by animals. It is virtually impossible to prevent wild animals from passing through certain areas without seriously disturbing the wild character of the area, which is one of the prime tourist asset of the Delta. Wastewater discharge into controlled artificial wetlands or ponds is therefore no attractive option.

The shallow groundwater of the Okavango Delta Ramsar Site can be divided into young freshwater parts and old, stagnant saline parts. Wastewater discharge into the freshwater pockets appears to be a bad option, as groundwater travelling times are short, wastewater may re-emerge in surface water bodies elsewhere and the injected wastewater may spoil water supply wells drilled into the fresh aquifer. As pointed out by McCarthy et al. (2004), wastewater disposal into the saline patches located on islands may be a good option. Their conclusion was based on a groundwater model of Chitabe Island and the surrounding floodplains. However, their model did only consider one vertical layer and did not resolve possible vertical variations in the flow field. Depending on the magnitude of the regional hydraulic gradient relative to the transpirative demand of the island, several flow patterns may be established below an island. Due to the lack of vertical discretization, McCarthy et al. (2004) basically considered a situation as depicted in the lowest panel of Figure 3.1. Such a situation emerges as an attractive solution for wastewater disposal, since all the streamlines are directed into the island and no large-scale dispersal of contamination can occur. If, however, the situation is more like in the second panel, wastewater could diffuse into the regional flow field and cause large-scale contamination.

Islands in the Okavango Delta vary with respect to the flow pattern and all intermediate stages depicted in Figure 3.1 are probably present. It is difficult to a priori establish the conditions on an island considered for wastewater disposal. Therefore wastewater disposal on islands has some inherent risks.

The most secure option for wastewater disposal is into the massive saline water bodies of the interfluve areas. Water in saline interfluve areas is old and stagnant (Bauer et al., 2006b), and residence times of the wastewater is probably on the order of several thousand years. Appropriate saline portions of the aquifer can be identified from AEM data. Due to flood hazards, most lodges are located close to large interfluve areas (e.g. Chief's island) and wastewater disposal into massive saltwater bodies should therefore be feasible.

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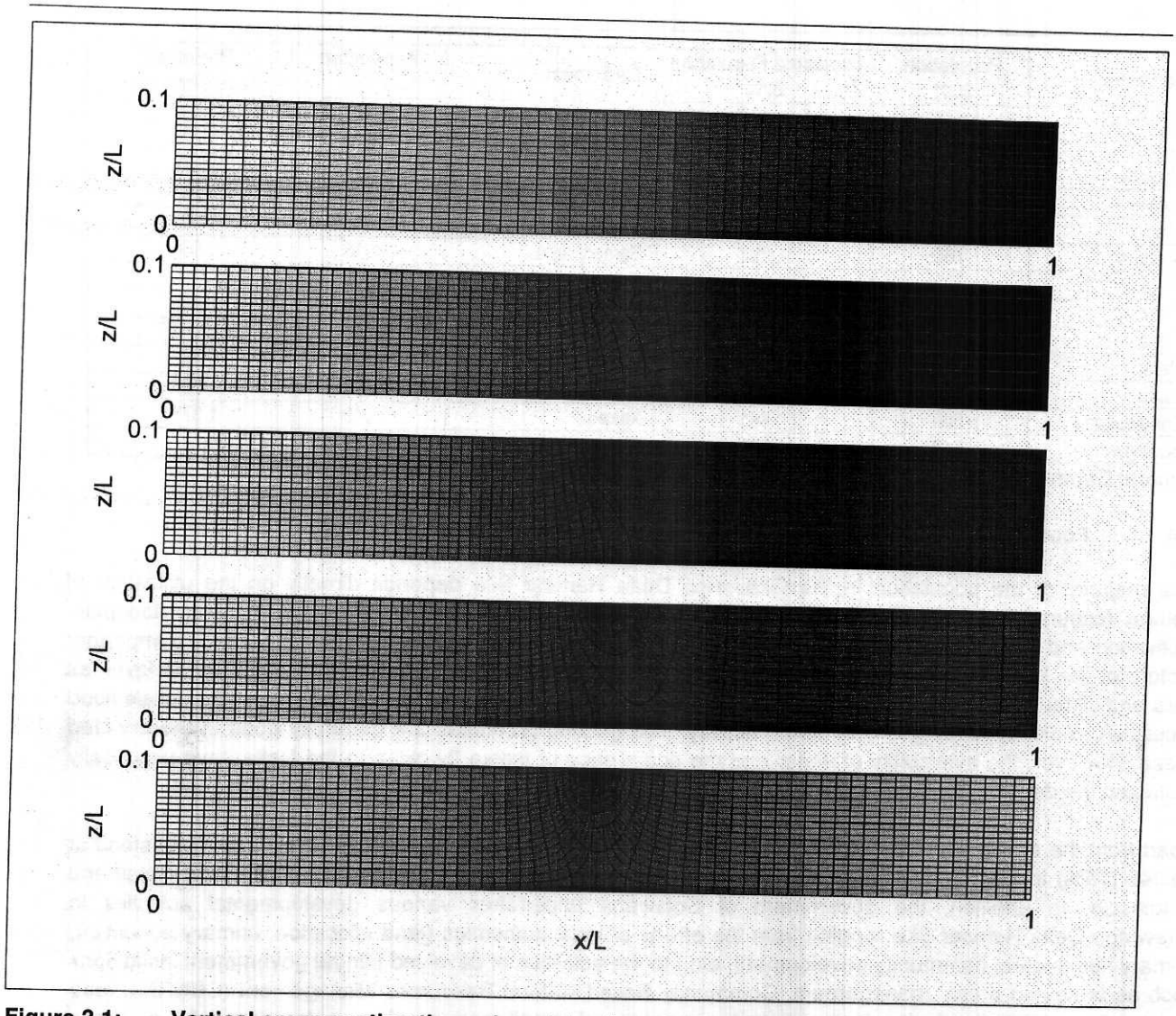

Figure 3.1: Vertical cross section through an island

NOTE: *The magnitude of the regional hydraulic gradient is decreasing from top to bottom. Blue lines are streamlines, black lines are equipotential lines.*

3.3 Settlement and Population Patterns

The Main population centers in the ODRS are around the Okavango Delta almost taking a similar distribution pattern as that of the delta itself over a wide spatial area. However, the majority of these centers are to the west and south of the delta along the main road (See Figure 1.1). Table 3.1 shows the population of these centers as recorded by 2001 Population and Housing Census and their projections for 2011, which is the end of the strategy period. It is clear from 2001 population statistics shown in Table 3.1 that the main population centers are Maun (43,776), Gumare (6,067), Shakawe (4,389) and Etsha 6 (2,629). The rest of the population is scattered in smaller settlements of 1,500 people and less.

Table 3.1: Main settlements and population distribution in the ODRS

Settlement	Population 2001	Projected Population 2011	Settlement	Population 2001	Projected Population 2011
Boro	842	816	Gumare	6 067	7 927
Kareng	599	580	Ikoga	699	913
Matlapana	1 169	1 133	Kauxwhi	859	1 122
Maun	43 776	42 411	Mohembo East	580	758

Settlement	Population 2001	Projected Population 2011	Settlement	Population 2001	Projected Population 2011
Sehithwa	1 478	1 432	Mohembo West	1 299	1 697
Sexaxa	534	517	Ngarage	948	1 239
Shorobe	955	925	Nokaneng	1 590	2 078
Toteng	509	493	Nxamasere	1 328	1 735
Tsao	1 290	1 250	Roye	847	1 107
Beetsha	760	993	Samochema	615	804
Eretsha	732	956	Sekondomboro	655	856
Etsha 13	1 975	2 581	Sepopa	1 519	1 985
Etsha 6	2 629	3 435	Seronga	1 641	2 144
Etsha 1	614	802	Shakawe	4 389	5 735
Etsha 8	503	657	Shaowe	557	728
Gonutsoga	506	661	Xakao	1 049	1 371
Gudingwa	616	805	Others	40 583	44 947

Source: Central Statistics Office (2005)

3.4 Economy and Tourism

The majority of the population in the Okavango Delta Ramsar Site depends directly on the utilization of natural resources of the Okavango delta for subsistence. Fishing, hunting, livestock grazing, floodplain cultivation and collection of raw materials for building, fuel, and the production of handicrafts are important factors of the local economy. Arable agriculture is practiced in Ngamiland mainly at a subsistence level, as soils and climate are generally not well suited for crop production. At the fringes of the Delta small-scale flood recession (molapo) farming is a common activity. The grazing resources are generally good in the dry land areas. However, the availability of water and the occurrence of tsetse fly close to the Delta have historically restricted the development of the livestock sector. The Okavango Delta itself is a livestock free zone.

Apart from the above subsistence activities, formal sector employment in Ngamiland East and West stood at 19,046 (15%) in 2001 (CSO 2001). The main employers were public administration at 23% and Retail and Wholesale. In addition, the government of Botswana undertakes various developmental activities in Okavango Delta Ramsar Site ranging from the efforts of local authorities (land allocation, primary education, primary health care, community development, etc.) to the activities of devolved central government institutions such as protected areas' management, Community Based Natural Resources Management (CBNRM), road construction, agricultural development and promotion of small and medium enterprises. All of these interventions relate to the management of the Okavango Delta and play a role in the development of the district in general and of the CBNRM and tourism activities in particular.

The outstanding natural beauty and the abundant wildlife resources form the basis of a fast growing tourism industry, which is offering alternative employment opportunities to people in the rural communities of Ngamiland District. The tourism industry in and around the Delta mainly consists of close 120 lodgings with about 1000 beds comprising of; guest lodges, luxury photographic lodges, tented camps and few budget type facilities and hunting camps. Mostly, the luxury photographic lodges and tented camps have small bed-night capacities and this is in keeping with government's policy of 'high value low volume' tourism which results in relatively low tourist volumes, high returns for relatively few entrepreneurs and substantive regard for the conservation of the Okavango ecosystem. It is estimated that on average, 50 000 tourists visit the Okavango Delta every year (Mbaiwa 2002). This estimation is based on the number of tourists that pass through Moremi Game Reserve. Table 3.2 shows the number of tourists that visited Moremi Game reserve between 1995 and 2001. While the figures in Table 3.2 shows variability in tourist visits, the established figure of 50 000 looks appropriate for planning purposes.

Table 3.2: Total number of tourists who visited Moremi Game Reserve, 1995-2001

Year	Number of Tourists
1995	36,074
1996	38,204
1997	42,987

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Year	Number of Tourists
1998	49,556
1999	46,707
2000	30,835
2001	31,076

Source: Mbaiwa (2002)

This tourist turnover in the Okavango Delta has created employment for the population in and around the ODRS. Even though there appears not to be a consensus on the number of jobs created by the tourism in the ODRS, mainly because some of them are seasonal, Mbaiwa (2002) established that about 1650 people were employed by the tourism sector in the Okavango Delta in 2001. The disaggregating of the jobs by the nature of tourism business and whether they are permanent or seasonal is provided in Table 3.3. The majority of the jobs (91%) are permanent and most of them are in accommodation and lodging.

Table 3.3: Number of workers in tourism businesses, 2001

Type of Workers	Safari camps/lodges	Tourism businesses (Maun)	Totals	Percentage
Permanent	872	631	1503	91
Seasonal	51	96	147	9
Totals	**923**	**727**	**1650**	**100**

Source: Mbaiwa (2002)

4 REVIEW OF EXISTING WASTE MANGEMENT SITUATION

4.1 Solid Waste

This section discusses the current solid waste management practices in the Okavango Delta Ramsar Site. By solid waste, we refer to all solid and semi-solid waste materials generated and discarded by communities and include household, institutional, tour operations and clinical waste streams.

4.1.1 Household Solid Waste Quantity and Composition

The household quantity and composition survey obtained 261 samples daily from 87 households in different settlements as selected in the methodology. The collected samples were sorted into a 7 class categorization system of putrescible, paper, plastic, glass, metal, textile and other.

From the analysis of survey data, it was found that the average waste generated in the selected settlements is 0.22 kg/capita/day. The established household waste generation rate is comparable to the household waste generation rate established for Gaborone of 0.33kg/capita/day (Bolaane and Ali 2004). The main difference between the waste generation rate for Gaborone and that of selected settlements in the Okavango Delta Ramsar Site could be brought about by that the selected settlements are predominantly rural and may be experiencing different economic conditions and life styles to those prevalent in Gaborone.

However, considering that the main settlement in the Okavango Delta Ramsar, Maun, was not included in estimating the waste generation rate, it is possible that the actual rate within the site is higher than 0.22kg/capita/day and less than that of Gaborone of 0.33kg/capita/day. It is therefore not an unreasonable estimation to assume that for planning purposes, the household waste generation rate for the Okavango Delta Ramsar Site lies in range between 0.22kg/capita/day and 0.33kg/capita/day, which is 0.28kg/capita/day. This waste generation rate is comparable to that established by Ecosurv (2003) for the North West District Council when they estimated the household waste generation rate to lie between 0.18 and 0.28kg/capita/day.

Figure 4.1 shows the average composition of household waste in the selected sites in the Okavango Delta Ramsar Site. As shown in the figure, putrescible waste, at 63.75% of the total waste generated, constituted the largest portion of household waste, which is as expected in a developing country. It can also be observed from the figure that the components that are often a target for recycling of paper (8.43%), plastic (7.90%), glass (9.04%) and metal (5.43%) represent a significant component of the waste stream.

An assessment of household waste generation rate by material component, based on the assumed generate rate of 0.28kg/capita/day, is reflected in Table 4.1, and shows that the highest average generation rate was that of putrescibles at 0.18kg/capita/day. A combined average generation rate for the traditional recyclables of paper, glass, plastic and metal was 0.086kg/capita/day.

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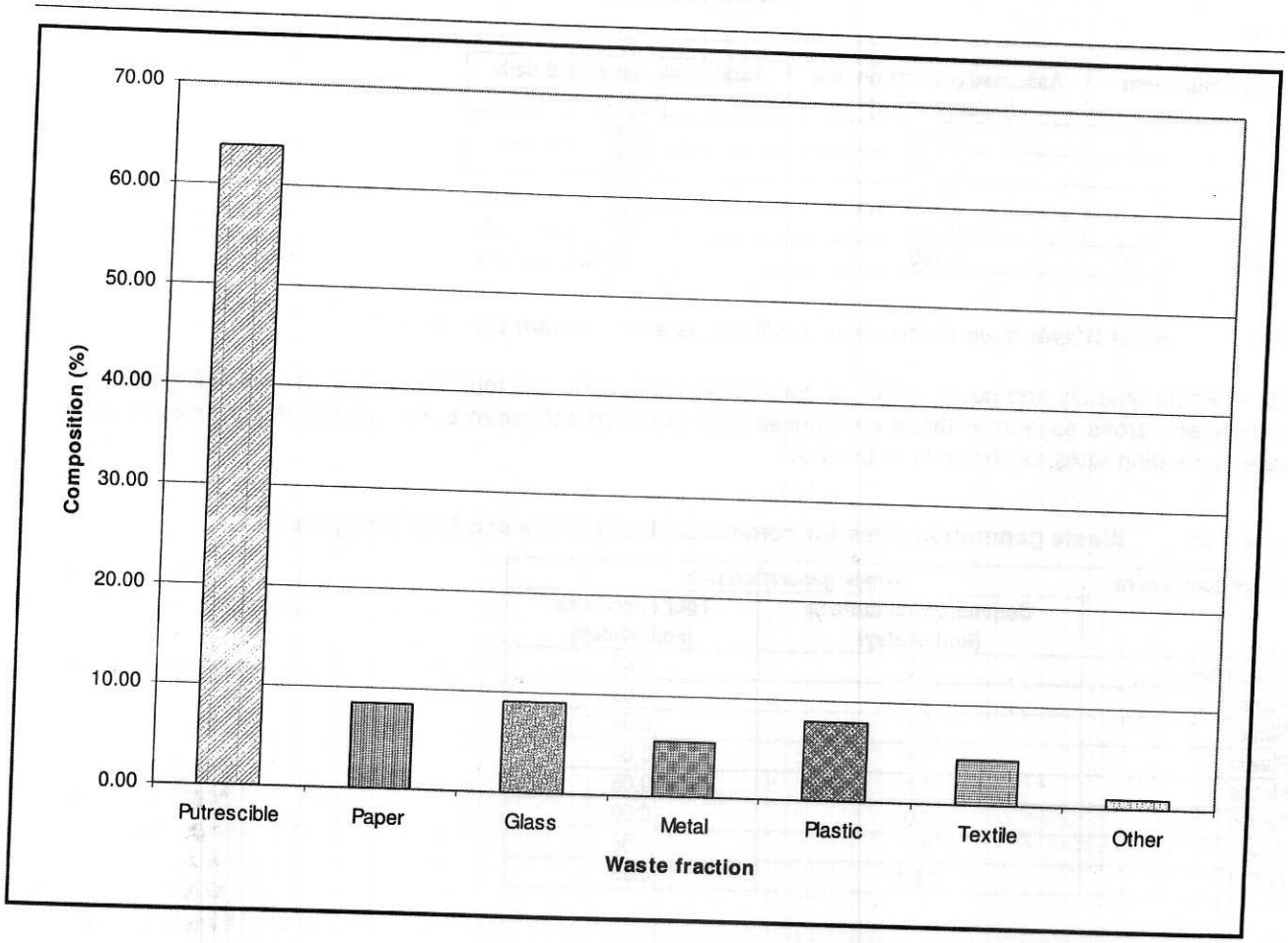

Figure 4.1: Household waste composition

Table 4.1: Waste generation rates by components

Waste component	Waste composition (%)	Actual generation rate (kg/capita/day)	Assumed generation rate (kg/capita/day)*
Putrescibles	63.75	0.140	0.179
Paper	8.43	0.019	0.024
Glass	9.04	0.020	0.025
Metal	5.43	0.012	0.015
Plastic	7.90	0.017	0.022
Textile	4.58	0.010	0.013
Other	0.86	0.002	0.002
Total	**100.00**	**0.22**	**0.28**

* Includes potential generation rate for Maun

Using the projected population of 129,652 and an assumed generation rate for the entire Okavango Delta Ramsar Site for 2006, the total household waste generated by components can be distributed as shown in Table 4.2. The total waste generated is 36 tonnes with the majority of it being putrescibles at 23 tonnes.

Table 4.2: Estimated waste generation rate for 2006

Waste component	Assumed generation rate (kg/capita/day)*	Total waste generated daily (kg/day)
Putrescibles	0.179	23 208
Paper	0.024	3 112
Glass	0.025	3 241

Waste component	Assumed generation rate (kg/capita/day)*	Total waste generated daily (kg/day)
Metal	0.015	1 945
Plastic	0.022	2 852
Textile	0.013	1 685
Other	0.002	259
Total	**0.280**	**36 302**

4.1.2 Solid Waste from Commerce, Institutions and Tourism Operations

Data of waste quantity and composition for commerce, institutions and tourism operations was collected from a variety and cross section of these enterprises from selected settlements. Analysis of these data showed waste generation rates as shown in Table 4.3.

Table 4.3: Waste generation rates for commerce, institutions and tourism operations

Waste component	Waste generation rate	
	Commerce/Institutions (tonnes/day)	Tour operations (kg/bed/day)
Putrescible	7.0	0.60
Paper	3.1	0.05
Glass	0.7	0.08
Plastic	1.4	0.04
Metals	0.7	0.06
Textile	0.0	0.00
Other	0.1	0.02
TOTAL	**13.0**	**0.85**

4.1.3 Total waste generation rate

The total waste generation rate for the Okavango Delta Ramsar Site was established by adding the waste generation rate for households, commerce/institutions and tourism operations and is shown in Table 4.4. It was established that the total waste generated for the Okavango Delta Ramsar Site is 18,305 tonnes/year, which represents an average waste generation rate of 0.39kg/capita/day . The majority of the waste (72%) comes from households.

Table 4.4: Total waste generated in the ODRS

Waste source	Generation rate in 2006 (tonnes/year)
Households	13 250
Commerce/Institutions	4 745
Tourism operation	310
TOTAL	**18 305**

4.1.4 Primary and Secondary Storage

The local authority does not have a primary storage bin standardization policy. There are various types of primary storage containers currently in use. These containers vary across sectors and areas. They range from black refuse bags, red refuse bags (clinical waste), 100-210 litre galvanized metal (see Figure 4.4) and plastic bins (with or without lids), predator proof (mainly in parks and reserves, but also at some lodges and camps) (see Figure 4.2), predator proof pole-mounted bins (see Figure 4.3). In addition to primary storage containers, some secondary storage containers such as transfer stations and skips are used in some villages. A typical transfer station is made up of brick roofed structure with a lockable gate (see Figure 4.5). Transfer stations (refuse bays) have been provided in nine (9) settlements. Table 4.5 shows settlements provided with transfer stations in the district. It was however observed that there appears to be limited understanding on the

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primary purpose of transfer stations, since they were hardly emptied. It addition, some of them are located in inaccessible areas as if they are supposed to be permanent disposal sites.

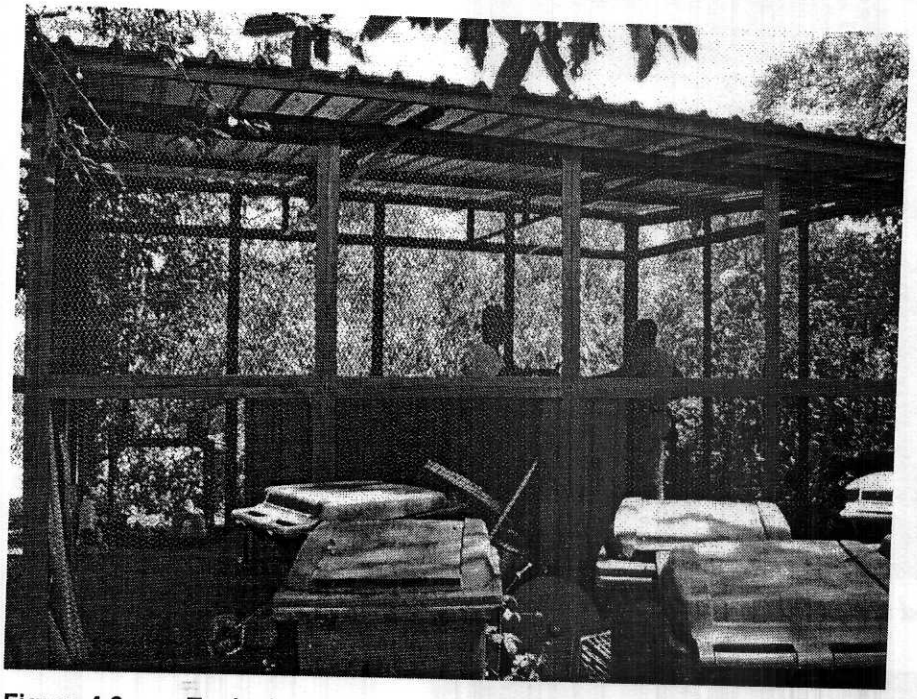

Figure 4.2: Typical predator proof cage

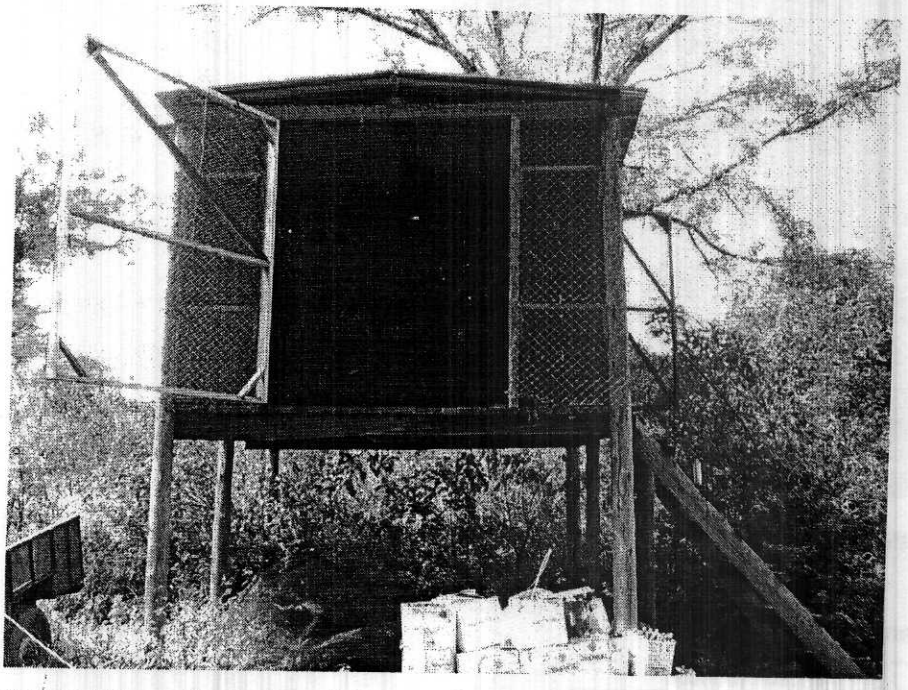

Figure 4.3: Typical predator proof pole-mounted bin

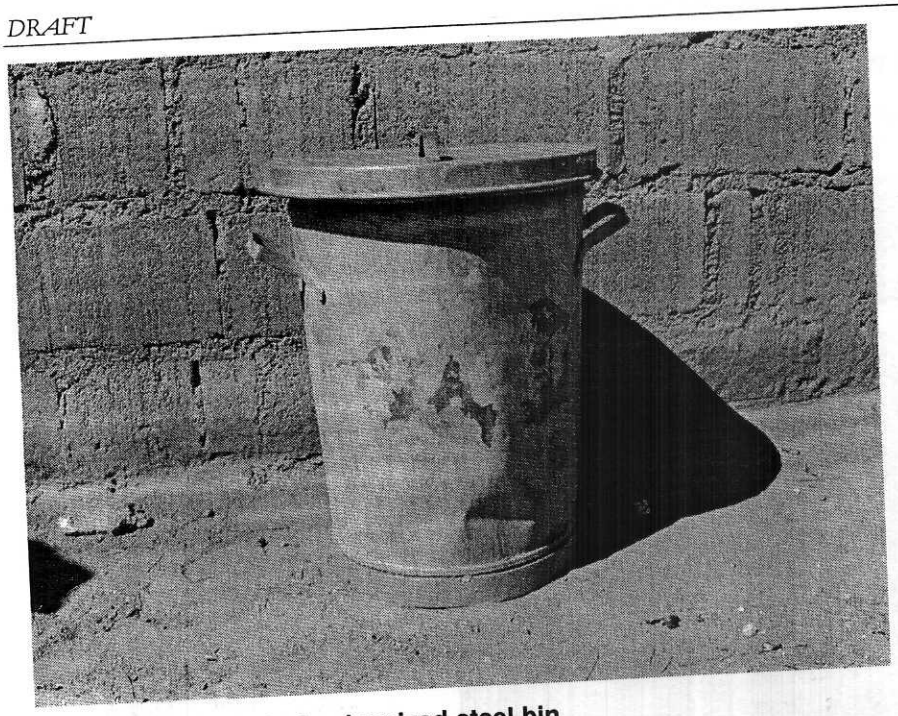

Figure 4.4: Typical galvanized steel bin

Figure 4.5: Typical transfer station (Khwai)

Table 4.5 Settlements with transfer stations

Sub-District	Settlement	Fenced/unfenced
Ngami	Khwai	Fenced
	Mababe	Fenced
	Sankoyo	Fenced
	Shorobe	Fenced
	Matsaodi	Fenced
	Phuduhudu	Fenced
	Makalamabedi	Fenced
	Toteng	Unfenced
	Legotlhwana	Unfenced

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Sub-District	Settlement	Fenced/unfenced
Okavango	Qangwa	Fenced
	Habu	Fenced
	Nokaneng	Fenced
	Etsha 6	Fenced
	Etsha 13	Fenced
	Ikoga	Fenced
	Nxamasere	Fenced
	Ghani	Fenced
	Xakao	Fenced

The household survey revealed that 64.7% of households use backyard pits for storage and final disposal of their waste, while 22.4% used refuse bags. Storage of waste in backyard pits does not facilitate collection. This essentially means that only 22.4% of household waste from communities that participated in the survey could possibly be collected for safer disposal.

4.1.5 Collection

The EHD is the designated authority for waste collection for both Ngami and Okavango Sub-districts. It is responsible for collecting waste from households, institutions and commercial enterprises. Table 4.6 shows the existing waste collection fleet at the disposal of the two EHDs of the North West District Council. Most of the equipment is fairly new. For example, in Ngami Sub-District, out of the nine (9) vehicles used for solid waste collection, seven (7) are less than 10 years old and only three (3) are reported to be in bad condition. However, the type of equipment such as large compactor trucks is probably difficult to use in the prevailing conditions of difficult terrain, poor and sandy roads and sparsely distributed settlements with no established pattern of street network. In addition, the waste stream that is mainly characterized by putrescibles, with lower compaction ratio.

Table 4.6: Current waste management equipment for North West District Council

Sub-District	Registration	Make/Type of equipment	Year of purchase	Capacity
Ngami	B 366 ADP	Nissan Compactor	1995	17 m^3
	B 931 AES	Toyota Compactor	1998	17 m^3
	B 929 AES	Nissan Compactor	1998	17 m^3
	B 190 AGS	Nissan Compactor	2000	17 m^3
	B540 AIW	Toyota Compactor	2003	17 m^3
	B 295 AIB	Skip Truck	2002	-
	B 595 ADT	Skip Trailer	1997	6 m^3
	B 880/947 AIX	Tractor and Trailor	2003	5 m^3
	B 331 ADJ	Tractor	1994	-
	B 569 AIT	Nissan Vacuum Tanker	2003	7 000 litres
	B 680 AEY	Mercedes Vacuum Tanker	1998	7 000 litres
Okavango	B 884 AIH	Hino Compactor Truck	2002	17 m^3
	B 854 AIT	Hino Compactor Truck	2003	17 m^3
	B 192 AGR	16-224LA Vacuum Tanker	2000	3 000 litres

The council has privatized some of its waste collection service. Private contractors have been engaged to collect waste in four service areas of Maun to four separate private entities. The contractors involved are Wave Sanitation Services, DM Environmental Services, Cleaning Wizards and Base Agencies. In addition to these large-scale contractors, micro-entrepreneurs using indigenous technology of donkey carts have also been contracted out to collect waste in some small villages to transfer stations and/or final disposal sites. Table 4.7 shows settlements that use donkey carts for collection service. The actual performance of this method of waste collection is unknown. It has however been reported by service recipients that it is inadequate and irregular, because of frequent breakdown of donkey carts.

Table 4.7: Settlements that use donkey carts for collection

Sub-district	Settlement	Number of donkey carts	Frequency of collection
Ngami	Sehithwa	2	Once weekly
	Tsau	2	Once weekly
	Toteng	2	Once weekly
	Makalamabedi	1	Once weekly
Okavango	Etsha 6	1	Twice weekly
	Etsha 13	1	Twice weekly
	Nokaneng	1	Twice weekly
	Mxamasere	1	Twice weekly
	Seronga	1	Twice weekly

Despite these micro-enterprises initiatives, 80% of households interviewed reported that they were not receiving any collection service. The majority of households (67%) who do not receive a collection service reported that they burn their waste in backyard pits

Collection service provided by both the EHD and private contractors is largely door-to-door. The frequency of collection where it is provided by EHD varies from daily to once a week (for commercial enterprises and households in Maun respectively), while in other settlements it varies from once a month to once in seven months. Of the 20% of households who reported to be receiving a collection service from the local authority, 59% of them received it once a month. In Khwai Village, it was reported that waste from the transfer station had not been collected for seven months, hence an over spill that is even an eyesore (see Figure 4.5).

It was however apparent that collection service is hardly provided for tourism operations, such as lodges and camps. Most of these operations collect their waste for disposal through their own private arrangements. This is probably understandable because of the geographical spread and remoteness of these operations. There is also a provision in the Waste Management Act of 1998 that the local authority can rely upon for not extending collection service to such operations. Section 29(1) of the Act reads 'A local authority shall, at a prescribed fee, arrange for the collection and disposal of all household waste in its area except waste which is situated at a place which in the opinion of the local authority is isolated, inaccessible, or which is produced in small quantities that the cost of collecting it would be high, or that the person who controls the waste is capable of collecting it'. While this legislative exception is understandable, it should probably be viewed differently in ODRS because it is heartland of Botswana's tourist industry and poor waste management could compromise its attractiveness as a tourist attraction.

4.1.6 Waste collection equipment performance

There is no monitoring of performance of waste collection fleet. However, on the basis of the information provided by the waste collection sector, and assumption from solid waste literature, the approximate quantity of waste collected for disposal at designated disposal sites is as shown in Table 4.8. The table shows that the approximate quantity of waste collected in ODRS by both the public sector and private sector initiatives is 7,827.7 tonnes/year. It was established earlier in Table 4.3 that the total waste generated in the ODRS is 18,305 tonnes/year. This represents a waste collection rate of approximately 43%, which is relatively poor.

Actual performance of local authority waste collection fleet is shown is Table 4.9. The total waste collected by local authority fleet is 6357.46 tonnes for 2005. However, the planned waste collection for the local authority fleet for 2005 as shown in Table 4.10 was 20,715.68 tonnes. This represents a collection performance rate of 31%. This is relatively poor and is mainly attributed to continuous breakdown of collection equipment, and low maintenance turnover. It should however be noted that, the planned quantities of waste to be collected by the local authority equipment of 20,715.68 tonnes/year, exceeds the quantity of waste generated annually over the strategy period. This essentially means that the local authority alone has enough collection capacity to collect all the waste within the Okavango Delta over the strategy period. The low level of performance can be attributed to underutilization of equipment at their disposal. Collection performance information in Table 4.10 shows that the private sector collects 173 tonnes/year with 1 m^3 capacity, while the local authority collects 45 tonnes/year with the same amount of capacity.

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Table 4.8: Estimated quantity of waste collected within the ODRS

Sub-district	Collection equipment	Compaction ratio (assumed)	Loading volume (m^3)	Filling rate (fraction)	Loads/trips in a year	Waste density (tonnes/m^3)	Total waste collected (tonnes)
Ngami	Nissan compactor	1.5	17	0.5	67	0.4	341.70
	Toyota compactor	1.5	17	0.5	146	0.4	744.60
	Nissan compactor	1.5	17	0.5	2	0.4	10.20
	Nissan compactor	1.5	17	0.5	55	0.4	280.50
	Toyota compactor	1.5	17	0.5	149	0.4	759.90
	Skip trailer	1	6	0.8	219	0.4	420.48
	Tractor and trailer	1	5	0.8	219	0.4	350.40
	Private contractor (open truck)	1	4	0.8	126	0.4	161.28
	Private contractor (refuse truck)	1	4.5	0.9	808	0.4	1308.96
Okavango	Hino compactor truck	1.5	17	0.5	312	0.4	1591.2
	Hino compactor truck	1.5	17	0.5	260	0.4	1326.00
	Tractor and trailer	1	5	0.8	156	0.4	249.60
All	Donkey carts	1	1	0.8	884	0.4	282.88
						TOTAL	**7827.7**

Table 4.9: Actual quantity of waste collected by the local authority

Sub-district	Collection equipment	Compaction ratio (assumed)	Loading volume (m^3)	Filling rate (fraction)	Loads/trips in a year	Waste density (tonnes/m^3)	Total waste collected (tonnes/year)
Ngami	Nissan compactor	1.5	17	0.5	67	0.4	341.70
	Toyota compactor	1.5	17	0.5	146	0.4	744.60
	Nissan compactor	1.5	17	0.5	2	0.4	10.20
	Nissan compactor	1.5	17	0.5	55	0.4	280.50
	Toyota compactor	1.5	17	0.5	149	0.4	759.90
	Skip trailer	1	6	0.8	219	0.4	420.48
	Tractor and trailer	1	5	0.8	219	0.4	350.40
Okavango	Hino compactor truck	1.5	17	0.5	312	0.4	1591.2
	Hino compactor truck	1.5	17	0.5	260	0.4	1326.00
	Tractor and trailer	1	5	0.8	156	0.4	249.60
All	Donkey carts	1	1	0.8	884	0.4	282.88
						TOTAL	**6357.46**

Table 4.10: Planned waste collection by the local authority for 2005

Sub-district	Collection equipment	Compaction ratio (assumed)	Loading volume (m^3)	Filling rate (fraction)	Loads/trips in a year	Waste density (m^3)	Total waste collected (tonnes)
Ngami	Nissan compactor	1.5	17	0.5	520	0.4	2652
	Toyota compactor	1.5	17	0.5	520	0.4	2652
	Nissan compactor	1.5	17	0.5	520	0.4	2652
	Nissan compactor	1.5	17	0.5	520	0.4	2652
	Toyota compactor	1.5	17	0.5	520	0.4	2652
	Skip trailer	1	6	0.8	365	0.4	700.8
	Tractor and trailer	1	5	0.8	365	0.4	584
Okavango	Hino compactor truck	1.5	17	0.5	520	0.4	2652
	Hino compactor truck	1.5	17	0.5	520	0.4	2652
	Tractor and trailer	1	5	0.8	365	0.4	584
All	Donkey carts	1	1	0.8	884	0.4	282.88
						TOTAL	**20715.68**

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4.1.7 *Reuse and Recycling*

The EHD is not directly involved in any reuse and recycling activities. However, there are some individual and private sector initiatives that could be complemented. There are indications that recyclables such as plastic and metal can are reused for different purposes. Plastics are used in making crafts such as hats and mats, while metal cans are used for constructing huts as some form of brick. The main private sector initiative is by a Collect-A-Can agent who collects beverage metal cans at Maun dumpsite and local bars. Recently the agent extended the can collection to other villages around Maun, such as Sehithwa and Shorobe. The agent employs 15 people to pick metal cans from the dumpsite. Reportedly about 20 000 cans are collected per week, which represents about a third of the cans that enter the district. The cans are baled, delivered to Segwana, who transports them to Collect-A-Can in Gaborone for onward transportation to South Africa for reprocessing. Even though this performance information could not be verified, it represents a promising recycling initiative that needs to be sustained and improved upon. The collaboration between the different stakeholders i.e. entrepreneur, distributor and producer is a lesson that could be tapped upon. It however emerged that not all tour operators, institutions, and communities are aware of the metal can collection service. This may require more effort to publicize the scheme and probably some incentives to encourage wider public participation.

Tour operators generally practice separation of solid waste at source. The waste is sorted and stored in different components of glass, plastic, paper and metal cans. Figure 4.6 shows typical separation of solid waste at source at lodges and campsites. The object of this exercise is essentially to enhance recycling, but is proving to be a futile exercise because the source separated materials are finally disposed at dumpsite with the rest of the waste stream. The main constraints to recycling the materials separated could be the markets for such materials and associated transportation costs. The variables have been established as the main barriers to recycling (Bolaane and Ali 2005).

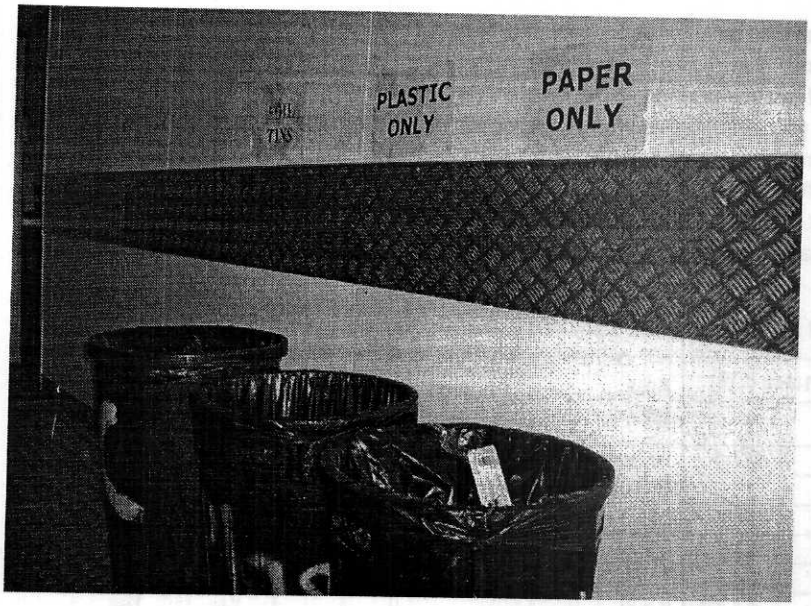

Figure 4.6: Waste separation at lodges/campsites

4.1.8 *Disposal*

At the time of the fieldwork, Maun landfill was still under construction but nearing completion. Hence waste collected by the local authority was mainly disposed through open dumping. Figure 4.7 shows a typical open

dumpsite in Gumare. The picture shows that there is no compaction and covering of the waste. It also shows that a significant proportion of the waste could potentially be targeted for diversion from disposal.

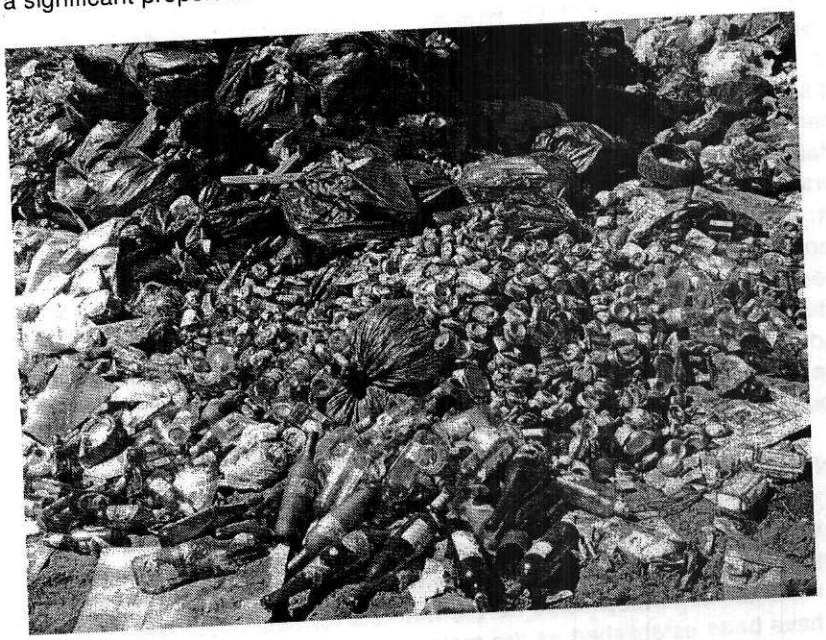

Figure 4.7: Typical open dumpsite (Gumare)

There are currently ten gazetted disposal sites that are in operation. Table 4.11 shows a brief description of these, as well as illegal dumping sites at various locations. The table compiled from questionnaires and field visits, shows that there is a significant level of waste picking. This should not be discouraged because it is a livelihood strategy and contributes significantly to reduction of waste disposed. However, improving the working conditions of the pickers through appropriate regulation and education could enhance this livelihood strategy. There is also a prevalence of open burning at these sites, this could have public health effects on waste pickers, and could be an indication that their activities are not properly regulated. There is also a possibility that the continuous burning is a consequent of the methane gas generated by waste decomposition.

Table 4.11: Description of some disposal sites in use

Settlement	Type	UTM coordinates (z34)		Area (m^2)	Distance from collection points (km)	Approx. remaining life span	Waste picking	Open burning
		X	Y					
Maun	Village Dump Site	756163	7780341	Unfenced	8	1	Yes	Yes
Tsau				10 000	8	10	No	Yes
Sehithwa	Village Dump Site	674884	7742006	10 000	4.5	7	No	Yes
	Illegal Dump site	677253	7737812					
	Illegal Dump site	677093	7737812					
Toteng				3 600	3	4	Yes	Yes
Shorobe	Refuse Transfer Station	779654	7813435					
	Illegal Dump site	779684	7813462					
Gumare	Village Dump Site	618927	7850436	Fenced	10	Unknown	No	Yes
	Illegal Dump site	621216	7850436					
	Illegal Dump site	622113	7857263					
Nokaneng				Fenced	8	Unknown	No	Yes
Etsha 6				Fenced	15	Unknown	No	Yes
Nxamasere				Fenced	7	Unknown	No	Yes

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Settlement	Type	UTM coordinates (z34)		Area (m^2)	Distance from collection points (km)	Approx. remaining life span	Waste picking	Open burning
		X	Y					
Shakawe	Village Dump Site	578772	7976132	Fenced	7	Unknown	No	Yes
	Illegal Dump site	580765	7976444					
	Illegal Dump site	581007	7976747					
Seronga	Village Dump Site	655351	7916544	Fenced	8	Unknown	No	Yes
Mogotlho	Refuse Transfer Station	621974	7951024					

In addition to designated disposal sites as outlined in Table 4.11, some of the waste that is not collected is disposed of in backyard pits. In many cases, waste in the pits is burnt causing smoke and possible air contamination. Figure 4.8 shows a typical backyard pit at a campsite.

Figure 4.8: Typical backyard pit

In addition to the disposal practices outlined above, there are other waste treatment options being used. These practices are referred to as controlled burning of waste or incineration. There is only one incinerator located at Maun General Hospital to treat clinical and hazardous waste from the entire district. Consequently, there are possible unacceptable levels of contamination in parts of settlements in the ODRS. However, the new Maun landfill is equipped with an incinerator with a capacity to treat 160kg/hr of waste. This is expected to complement the treatment facility at the hospital. Another treatment facility, 'rudimentary incinerator', was found at Camp Moremi lodge. Figure 4.9 shows a picture of the incinerator. The incinerator is reported to be working well and can handle both combustible and putrescible waste quite effectively. There is a possibility that this technology could be replicated by other remotely located waste generators with waste of similar characteristics and magnitude to that produced at Camp Moremi.

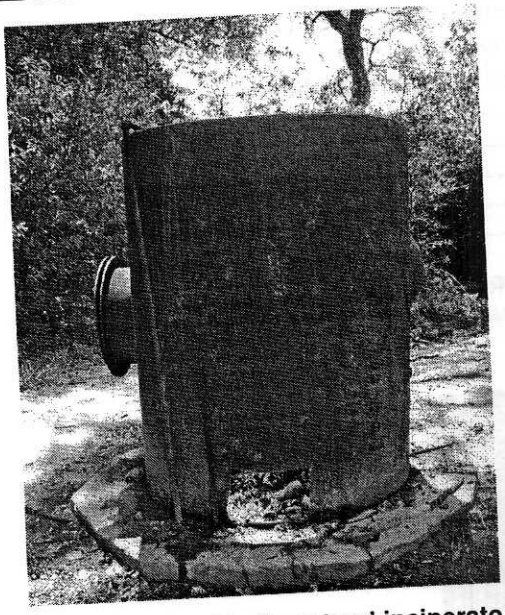

Figure 4.9: 'Rudimentary' incinerator

4.1.9 Littering

Littering is another form of waste disposal albeit not permissible. The practice is wide spread in the ODRS and manifests itself in many forms. The majority of households interviewed (39%) cited littering as the main waste management problem, particularly in settlements. Beverage cans and plastic were reported to be the main constituent of litter. Community residents and local fishermen in particular, were cited as the main culprits when it comes to littering. Some littering was also attributed to the nature of primary storage containers. For example, refuse bags were reported to often burst open when transported in open vehicles over long distances, hence spreading litter. In addition, wild animals like baboons were reported to often invade waste receptacles in wilderness areas and often spreading litter. In addition, some of the waste that is collected is disposed of illegally at non-designated places. Figure 4.10 shows a typical case of illegal dumping.

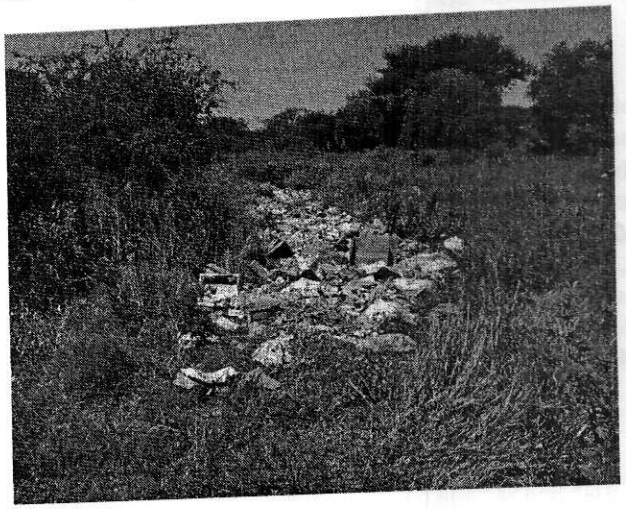

Figure 4.10: Illegal dumping

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4.1.10 Solid waste collection user fees

The local authority does not provide solid waste collection free of charge. Table 4.12 shows the schedule of fees charged by the local authority for solid waste collection. While cost recovery is an important component of sustainable waste management, it could possibly encourage illegal disposal depending on the level at which the fees are set. The fees are flat rates and are not dependent upon the quantity or components of waste generated. This could be a disincentive for reduction of waste that is generated.

The current practice is to pay on demand of service. Usually waste generators (households and commercial premises) who want their waste to be collected will approach the local authority and pay the required fee, either for a month or for the whole year. During financial year 2005/06 a total of 51 households and 43 commercial enterprises paid for waste collection.

Table 4.12: Schedule of charges for solid waste collection

Type of property/generator	Collection charge
Residential	P5.00/month
Lodges, bars, liquor restaurants, hotels, furniture shops, wholesalers	P120.00/month
Bottle Store, hardware, hair salon, fresh produce, filling station, takeaways	P100.00/month
Government offices, government schools, private schools, hospitals, clinics	P100.00/month
Skip hire	P150.00/month
Scraps removals	P20.00/scrap

4.1.11 Clinical Waste

Clinical waste is universally stored in red plastic bags except for sharp containers. In Gumare, the Environmental Health and Sanitation Department has a clinical waste collection van that collects the waste from clinics in Okavango Sub-District. Other health facilities, clinics and health posts that do not get a collection service, dispose of their clinical waste in a variety of ways including;

- Burning outside the clinic on the ground, in a drum or pit
- Transporting to Maun Hospital for incineration
- Adding to the household waste for collection with no treatment at all

The actual quantity of waste generated was difficult to establish, because in most cases during the fieldwork, the waste would either have been burnt or collected. However, a study on medical wastes in Botswana (GoB 1996) established the waste generation rates shown in Table 4.13 for different types of health facilities.

Table 4.13: Typical waste generation rates by health facilities for NWDC

Type of health facility	Waste generation rate by type		
	Clinical (kg/day)	Sharps (boxes)	Municipal solid waste (kg/day)
General hospitals	92	1.83	366
Primary hospitals	15.5	0.31	62
Clinics with beds	20	0.07	40
Clinics	15	0.07	30
Health posts	2	0.03	10
Doctors	2.5	0.03	5

Source: GoB (1996).

4.1.12 *Emerging Issues*

A synthesis of the discussions on solid waste reveals the following issues that the strategy has to address:

- Information on waste management is hardly kept, and where it exist is of poor quality
- Primary waste storage facilities are poor and are an impediment to effective waste collection
- In general, collection coverage is poor
- Waste collection is hardly provided for tourism operations
- Collection of waste from transfer stations is poor. This is probably exacerbated by that the design does not facilitate easy emptying.
- The emphasis on local authority equipment is on compactor trucks, that is probably not suited for poor roads and type of waste generated
- Performance of local authority collection fleet is poor
- The local authority espouses privatization of waste collection service, including the use indigenous technology such as donkey carts
- While the use of indigenous technology of donkey carts is welcome development, it appears ineffective
- Disposal of waste is mainly through backyard pits and open dumping
- Littering is cited as the main waste management problem
- The incinerator at Maun Hospital is the only clinical and hazardous waste treatment facility for the entire ODRS
- Recycling activities are at a minimal because of market constraints for recyclables, but there is a Collect-A-Can scheme that could be used to enhance recycling of metal cans.

4.2 Liquid Waste

This section discusses the current liquid waste management practices in the Okavango Delta Ramsar Site. By liquid waste, we refer to any waste material generated by communities that is determined to contain 'free liquids' and shall include sewage from off-site systems and on-site (septic tank influent and effluent, conservatory influent) and used lubricating oil.

4.2.1 *Wastewater generation rates*

Information on wastewater generated is very difficult to obtain, primarily because most wastewater generators do not have waterborne sanitation systems. The Environmental Health Department in Ngami reported to have collected 1,631m^3 and 1,099m^3 of wastewater in 2004 and 2005 respectively. But this information alone is inadequate to establish the waste generation rate in the sub-district. In addition, the reported inflow at Maun wastewater treatment ponds was 400m^3/day in 2003 (NMPWS 2003). However, the National Master Plan for Wastewater and Sanitation established that the average wastewater generation rate is 376-416 litres/household/day. If the median wastewater generation rate and average number of people in a household of 4.8 are used, then the approximate average national wastewater generation rate is 83 litres/capita/day.

4.2.2 *On-site wastewater collection and treatment systems*

In villages/settlements household water-borne sanitation facilities hardly exist; people mainly use pit latrines, enviro loos, or the bush. Grey water in villages/settlements is normally spilled out onto the ground or used to water plants and/or hedges surrounding homes.

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Waterborne sanitation facilities are mainly installed at government offices/housing, clinics and staff residences, schools, teacher's residences, NGO establishments, commercial premises, private residences (usually middle and higher income categories) and tourism operations. The wastewater disposal systems at these places are largely on-site, typically comprised of conservatories and septic tanks-soakaway system. Figure 4.11 shows a schematic diagram for a typical septic tank and soakaway system that is used by both households and tour operators in the ODRS. These systems present a possibility of numerous point sources of pollution.

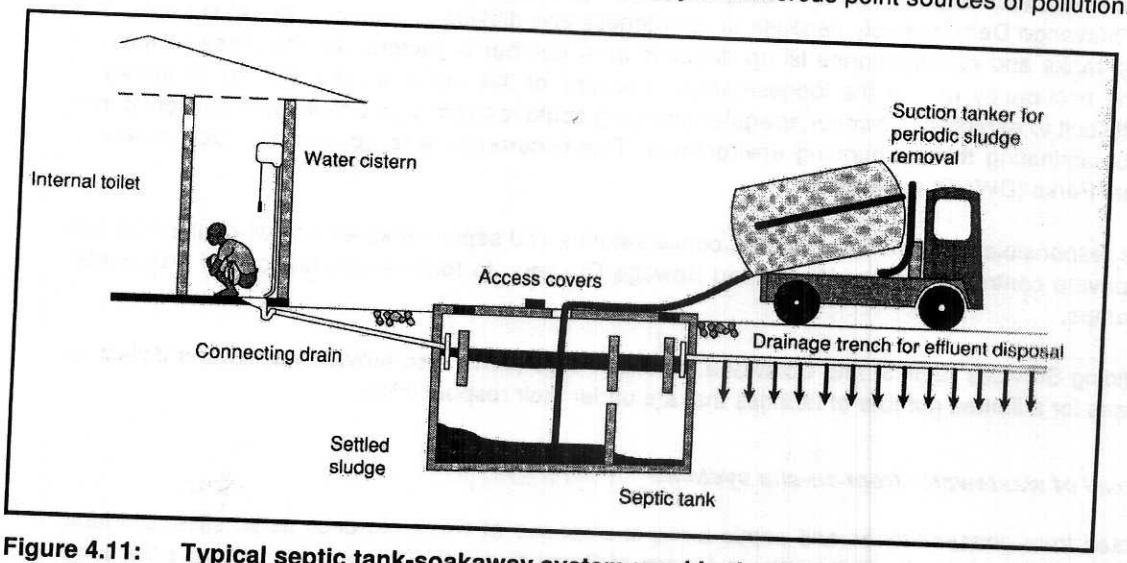

Figure 4.11: Typical septic tank-soakaway system used in the ODRS

Source: Cotton and Franceys (1991).

Apart the conventional septic tank-soakaway system, two lodges; Vumbura Lodge and Xaxanaka Lodge owned by Okavango Wilderness Safaris (OWS) and Moremi Safaris respectively use what appears to be an innovative wastewater treatment system. The systems which has been designed by SIYAGEZA technologies (PTY) LTD involves passing wastewater through a series of tanks that includes a primary settling tank, aerobic digester, a secondary settling tank and a chlorination tank. The effluent from the systems is discharged into a 'rudimentary' artificial wetland for infiltration. Figure 4.12 shows a schematic diagram of the wastewater treatment plant at these lodges. OWS reported that it plans to introduce this system at its other premier lodges when it is sure that the system works properly at Vumbura Lodge.

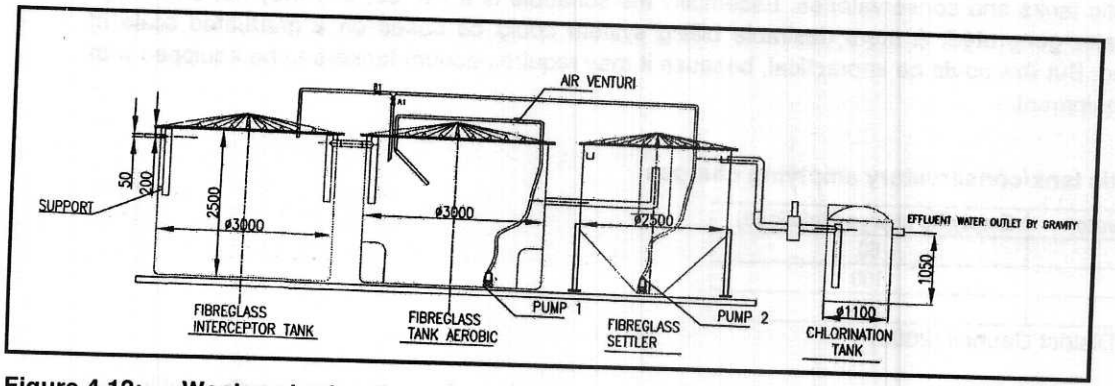

Figure 4.12: Wastewater treatment system at Vumbura and Xaxanaka Lodges

Source: Vumbura Lodge (2006)

Fat traps to capture grease and fatty substances from wastewater generated in lodges and camps kitchens were found at most places visited except for the smaller hunting camps. The object of removing fats is mainly to improve efficiency of wastewater treatment facilities.

The local authority provides a service for emptying and disposal of septic tank and conservatory influent primarily in villages/settlements and tour facilities that are easily accessible. The service is not extended to remote lodges and camps in the Okavango Delta possibly because of remoteness and difficult access during wet seasons. The rate at which septic tanks and conservatories fill up depends on a number of factors; among these factors are design capacity and occupancy rate of the lodges/camps. Because of this variation, the desired frequency of emptying is often difficult to establish. However, irregular emptying could result in septic tanks and conservatories overflowing and contaminating the surrounding environment. This occurrence was observed at Department of Wildlife and National Parks (DWNP) campsites.

Tour operators are responsible for desludging of their conservatories and septic tanks as and when they are full. They usually use private contractor, Ngami Waste and Sewage Drainers, to remove and dispose of wastewater from lodges and camps.

Department of Building Services (DBES) and Botswana Defence Force (BDF) also provide wastewater collection and disposal services for a limited number of facilities that are under their responsibility.

4.2.3 Disposal of wastewater from on-site systems

Wastewater collected from conservatories and septic tanks is disposed at two main designated sites, of Maun and Gumare sewage treatment ponds. There is no evidence of illegal disposal. This could possibly be because apart from the local authority, there are few other wastewater collectors. This facilitates easy monitoring. Apart from Maun and Gumare treatment ponds, there is a local authority approved wastewater disposal site at Tekane open pit in Seronga. The site is used by Okavango Houseboats to dispose of wastewater from their houseboats. There was however no monitoring of the possible impact of the wastewater on the surrounding environment. It may be possible that the wastewater could be contaminating the groundwater.

4.2.4 On-site wastewater collection user fees

Emptying of septic tanks and conservatories is usually done for a fee. The local authority's fee schedule is based on the number of loads of sewage within the established radius of emptying. Table 4.14 shows the fee schedule for emptying the septic tanks and conservatories. Essentially the schedule is a flat fee, and may not encourage reduction of wastewater generated. A more desirable billing system could be based on a graduated scale of wastewater generated. But this could be impractical, because it may require vacuum tankers to be equipped with volume measuring equipment.

Table 4.14: Septic tank/conservatory emptying charges

Type of property/generator	Emptying charge (Pula/load)
Residential	60
Commercial	100
Institutional	100

Source: North West District Council (2003)

In addition to local authority service, there are private sector services for emptying septic tanks and conservatories. It was reported that for lodges and/camps, private contactors can charge up P5000 per load of sewage depending on the distance. The fee charged by the only private company that desludges septic tanks in and around Maun is P220 per load.

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4.2.5 Off-site wastewater collection and treatment systems

An approximately 4km off-site wastewater collection and treatment system has been constructed in Maun in 1994 with a design capacity of 600m^3/day. The system consists of a primary sewer line, with pump stations and oxidation ponds. At the time of the fieldwork, the system was experiencing frequent breakages as a result of power failure, which often results in foul odour for a number of days. This could be an indication that the design capacity of the scheme has been exceed and needs upgrading. The reported inflow in 2003 at treatment ponds was 400m^3/day (NMPWS 2003). This represented two-thirds of its design capacity. It is possible that with the increased connections to the primary line, the design capacity has already been reached. Apart from that, sewer networks are usually designed to take advantage of the natural slope of the ground and flow by gravity. But the provision of numerous pump stations on this system could mean that the reverse has been the case, hence frequent breakdowns. To qualify for connection to the scheme, one had to be within a distance of 60metres from the line. This limits accessibility to the sewer line for the majority of the possible service recipients. The connection fee to the network is P295 with an annual service charge of P295.

Another small sewer network with wastewater treatment facility is at Boro Farm. The scheme was constructed in 2002 and the design capacity for the treatment ponds is 100m3/day. Just a year after its construction, 50 percent of its capacity was already utilized. Thuso Rehabilitation Centre uses constructed wetlands that have been operational since 1994. The system has a capacity to treat 10m^3/day of wastewater, and that capacity is fully utilized.

A sewer network with a wastewater treatment plant is currently under construction in Gumare. The scheme is expected to be fully operational in 2007. The scheme is expected to provide service to households, commercial areas and institutions.

4.2.6 Effluent quality

One of the responsibilities of the Water and Wastewater Department is to monitor the effluent quality into the environment. But this has never been done because they do not have the capacity to do so. However, the National Master Plan for Wastewater and Sanitation reported effluent quality from Maun Wastewater Treatment Works, and the levels of these parameters are shown in Table 4.15. Table 4.15 also shows the effluent quality that is discharged into the environment from some of the wastewater treatment facilities in the ODRS. It is clear from Table 4.15 that the effluent quality from these sources, varied, while some treatment facilities are effective in reducing the level of one parameter; they are not that effective for the other. But generally the effluent quality parameters are above the desirable levels. This is particularly evident for the Maun Waste Water Treatment Works. An interesting wastewater treatment technology in terms of effluent quality is the treatment plant used at Vumbura Lodge, while the effluent from the plant does not meet the desirable levels of effluent quality, the difference is quite marginal. It is possible that further polishing of the effluent could meet the desired levels.

Table 4.15: Effluent quality from different sources in the ODRS

Source of Effluent	UTM (Zone 34)		Parameter (mg/l)			
	X	Y	BOD	COD	Total Suspended Solids	Total Phosphorus
Desirable Effluent Quality Level*	-	-	30	100	30	1.0
Maun Wastewater Treatment Works			82	299	-	6.3
Vumbura Lodge Treatment Plant	694114	7898859	-	118	24	1.78
Chiefs Island Septic Tank	700635	7865918	-	47	247	4.03
Jao Health Post Septic Tank	661028	7896258	-	19	2	0.15
Boro Prison Septic Tank	753446	7801994	-	90	94	5.79
Shorobe Clinic Septic Tank	780184	7812375	-	60	40	0.23
DBES Shakawe Septic Tank	589330	7969986	-	350	23	3.18
Gudigwa P. School Septic Tank	701896	7942557	-	150	170	4.13

Source of Effluent	UTM (Zone 34)		Parameter (mg/l)			
	X	Y	BOD	COD	Total Suspended Solids	Total Phosphorus
Gumare Sewage ponds	621299	7852852	-	60	8	-
Sehithwa VDC compound Septic Tank	677917	7736059	-	149	18	0.29

*Source: Metcalf and Eddy (1991) and NMPWS (2003)

4.2.7 *Used oil generation, collection and disposal*

The amount of used lubricating oil (engine and gearbox) generated on a monthly basis in lodges and camps varies from approximately 5 liters to 800 liters. The used oil is stored on site in 20-liter or 200-liter containers or large overhead tanks until transport is available to take it to Maun for bulk storage and transportation to South Africa for recycling. Figure 4.13 and Figure 4.14 show typical on-site storage of used oil systems. While there appears to be some control in storing the used oil, sand containment areas where used oil was stored, appeared saturated and substantial areas of ground at these sites was contaminated with oil and fuel spillage. There is a possibility that some of the oil could have seeped into the ground.

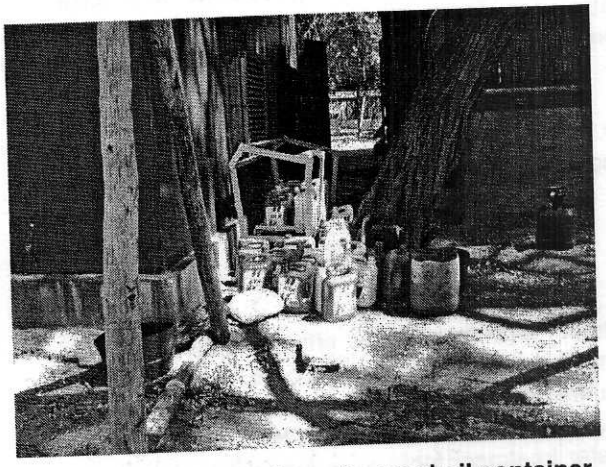

Figure 4.13: Typical on site used oil container

Figure 4.14: Typical used oil storage tank

Five facilities exist in Maun where used lubricating oil is temporarily in tanks ranging from 14 000 liters to 23 000 liters. These facilities are at Rileys Garage, Total, Depot, Ngami Toyota, Pony Transport and Mulbridge

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Transport. The used oil facility at Rileys Garage is a public facility and members of the public, garage owners and others are allowed to deposit their used oil there. The other four facilities store their own used oil or offer the storage for use by their clients and a limited number of private garages. Private haulage companies then transport the used oil mainly to ROSE in South Africa for recycling. ROSE (Recycling Oil Saves the Environment) is a non-profit organization registered in South Africa. It manages the collection, storage and recycling of used lubricating oil in South Africa and has extended this service to Botswana.

It however emerged that not all used oil generators are aware of the storage facilities in Maun. For example, in one, a safari operator disposed of used by putting it in 5 liter containers and dumping it at Maun dumpsite.

4.2.8 Emerging issues

A synthesis of the discussions on liquid waste reveals the following issues that the strategy has to address:

- Information on waste management is hardly kept, and where it exist is of poor quality
- Most communities do not use waterborne sewerage at household level
- In cases where waterborne sewerage is used, treatment and disposal systems mainly include conservatories and septic tank-soakaway system
- There are other innovative wastewater treatment systems used by some tourism operations
- Apart from small sewer network and treatment facility at Boro farm, the Maun sewer network is the only functional off-site wastewater collection and treatment system in the entire ODRS
- However, the Maun system is of limited capacity and covering a small part of the village, and is also prone to frequent breakdowns
- Off-site wastewater collection and treatment system in Gumare is expected to be functional in 2007
- Effluent quality for both on-site and off-site systems is not monitored because of lack of capacity, but there indications that is below the desired levels.
- Wastewater collection from on-site systems is provided on request, but is not extend to isolated and remote areas, particularly lodges/camps
- Wastewater collection fees charged by the local authority are relatively low compared to those charged by private sector
- There are established systems in place for collection and recycling of used oil that could be utilized

4.3 Environmental Impacts of Existing Waste Management Practices

The impacts of the current waste streams and waste management practices on the various components of the environment are presented numerically in Table 4.16 to Table 4.19 and graphically in Figure 4.15. Table 4.20 shows a summary of the impacts.

Table 4.16: Physical and chemical components (PC)

Components		ES	RB	A1	A2	B1	B2	B3
PC1	Water contamination	-63	-D	3	-3	2	2	3
PC2	Soil contamination	-14	-B	1	-2	2	2	3
PC3	Air pollution	-14	-B	2	-1	2	2	3
PC4	Visual impact	-6	-A	1	-1	2	2	2
PC5	Foul smell	-6	-A	1	-1	2	2	2
PC6	Re-use and Recycle practices	9	A	1	1	3	3	3

Table 4.17: Biological and ecological components (BE)

Components		ES	RB	A1	A2	B1	B2	B3
BE1	Threat to terrestrial and aquatic life	-72	-E	3	-3	3	2	3
BE2	Oxygen depletion	-28	-C	2	-2	2	2	3
BE3	Eutrophication	-42	-D	3	-2	2	2	3

Table 4.18: Sociological and cultural components (SC)

Components		ES	RB	A1	A2	B1	B2	B3
SC1	Public health	-63	-D	3	-3	2	2	3
SC2	Rodents and flies transmitting diseases	-28	-C	2	-2	2	2	3

Table 4.19: Economical and operational components (EO)

Components		ES	RB	A1	A2	B1	B2	B3
EO1	Waste Pickers Reuse of Waste	9	A	1	1	3	3	3
EO2	Direct Employment of waste pickers	8	A	1	1	2	3	3
EO3	Micro-Enterprises for waste collection	32	C	2	2	2	3	3

Table 4.20: Summary of scores

Range	-108 to -72	-71 to -36	-35 to -19	-18 to -10	-9 to -1	0	1 to 9	10 to 18	19 to 35	36 to 71	72 to 108
Class	-E	-D	-C	-B	-A	N	A	B	C	D	E
PC	0	1	0	2	2	0	1	0	0	0	0
BE	1	1	1	0	0	0	0	0	0	0	0
SC	0	1	1	0	0	0	0	0	0	0	0
EO	0	0	0	0	0	0	2	0	1	0	0
Total	1	3	2	2	2	0	3	0	1	0	0

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Waste Management

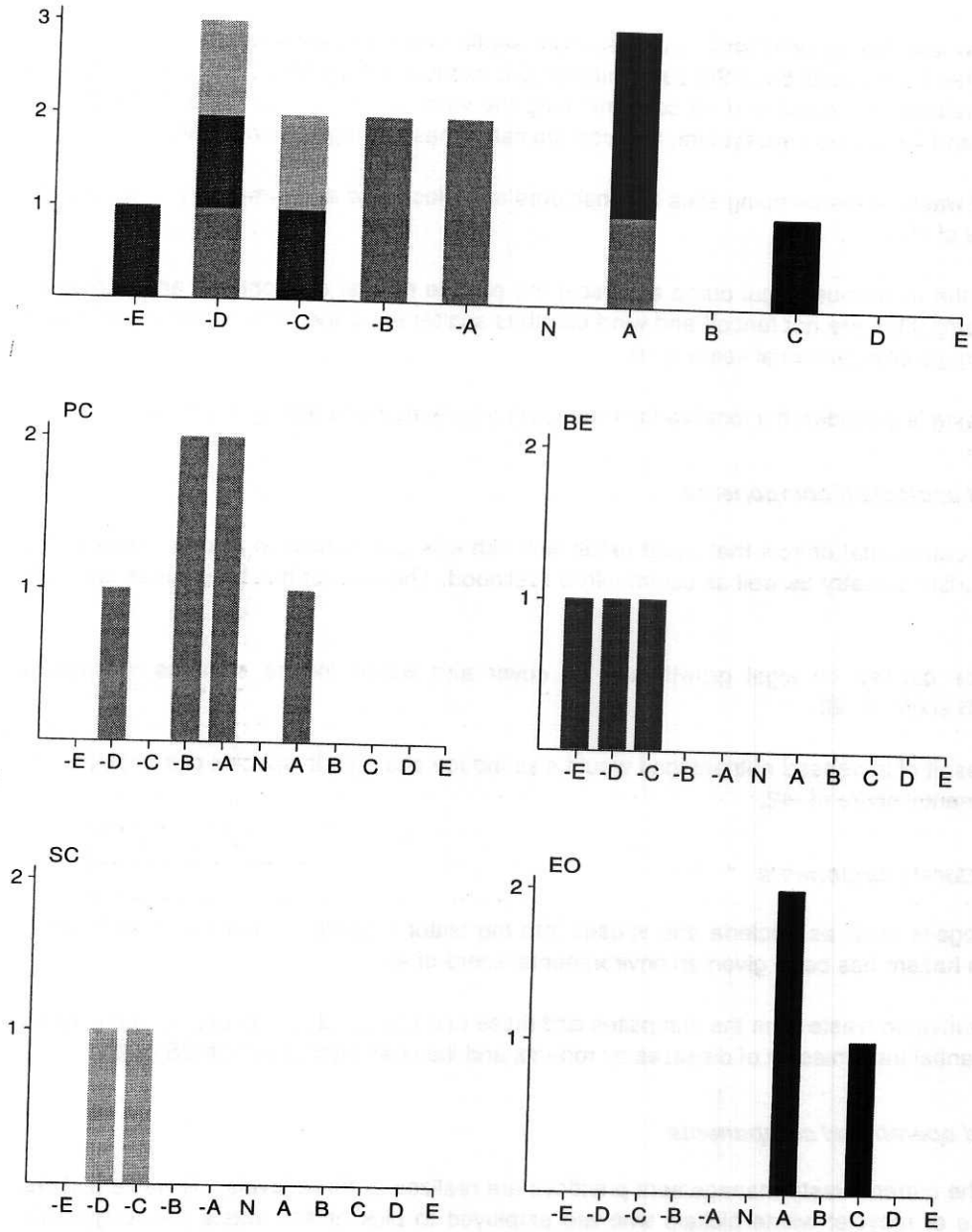

Figure 4.15: Environmental effects of existing waste management practices

4.3.1 Physical and chemical components

Pollution of the surface water would have more adverse consequences where the water is shallow and stagnant. Such consequences would result with increased nutrient load that would stimulate algal growth (creating a shift in species composition) and can result with fish kills. In mobile waters the pollution plume would travel downstream

and cause damage to the ecosystem along its travel path. Evidently polluted waters would harm the ecosystem and would be a health hazard to the communities that exploit the waters. Contamination of water has been given an environmental score of -63.

The soils in the area can be affected by pollutants that seep from septic tanks and oil containers. Some of the pollutants would be attenuated by the soils but if the contaminants are excessive they would adversely affect the associated vegetation and wildlife and could end up contaminating the water system, resulting with detrimental effects on the public health and the aquatic ecosystem. Soil contamination has been given an ES score of -14.

Air pollution from burning of waste at the dumping sites is considered to be localized and temporary nuisance that has been given an ES score of -14.

The dump sites, especially the numerous illegal dump sites scar the pristine natural environment and can be an eye sore. Typically these dump sites are not fenced and wind can thus scatter the paper and plastic waste over a bigger area. This has a negative environmental score of -6.

Foul smell from exposed waste is considered a localized and temporary nuisance and has an ES of -6.

4.3.2 Biological and ecological components

Polluted water would have detrimental effects that could result with fish kills and extinction of other aquatic life. This has direct effect on tourism industry as well as community's livelihood. This impact has been given an ES of -72.

Oxygen depletion would be caused by algal growth and oil cover and would induce changes in species composition. This has an ES score of -28.

Eutrophication which is a result of increased nutrient load would also induce changes in species composition and has been given an environmental score of -42.

4.3.3 Social and cultural components

Continued release of pathogens such as bacteria and viruses into the water creates human health and safety concerns. The public health hazard has been given an environmental score of -63.

Typically rodents and flies thrive on waste from the dumpsites and these can spread diseases and as such create human health hazards. Potential transmission of diseases by rodents and flies has been given an ES of -28.

4.3.4 Economic and operational components

The economic benefits of the current waste management practices are realized at three levels: (1) waste pickers who collect waste to re-use or recycle: waste pickers who are employed to pick or sort waste (these typically include local residents who at times use donkey carts to collect waste or are employed by agencies and (3) medium to large sized companies that collect sorted waste (e.g. collect-a-can and Tshole trust) to supply the recycling industry and those that are engaged by the District Council to either collect waste or maintain sewage systems. The environmental scores are positive and are 9, 8 and 32 respectively.

4.3.5 Emerging Issues

From the above analysis, it can be seen that:

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- The environmental impacts are predominantly negative. The impacts range from -72 to +32. Out of thirteen impacts only three are positive.
- The most severe impacts are threat to terrestrial and aquatic life followed by water contamination and public health hazard.
- Evidently in the Okavango Delta Ramsar Site the most significant factor is the water and particularly its quality.
- It is the unique water features and their associated ecosystem that sustain the communities within the site and makes it an important international tourist destination.
- The risk of pollution will be lowest at areas where both water flow and volume are high as this would induce flushing and dilution of the contaminants.

4.4 Institutional and Logistical Capacity for Waste Management

Solid and liquid waste management is the responsibility of North West District Council through its two sub-district councils of Okavango and Ngami. Within the sub-districts, the departments responsible for solid and liquid waste management are Environmental Health and Sanitation (EHD) and Water and Wastewater (WWD), respectively.

4.4.1 Environmental Health Department

The Environmental Health Department (EHD) of NWDC has two separate units apportioned by sub-districts but with similar responsibilities. Among the main responsibilities of these units are:

- Solid waste collection from all types of premises
- Grass cutting
- Removal of dead animals
- Emptying of septic tanks
- Public education
- Solid waste management campaigns

Figure 4.16 shows the organization structure for the Environmental Health Department of Ngami Sub-district and an insert showing the organization structure for Okavango Sub-district. The Overall head of the EHD is Principal Environmental Health Officer, at salary scale D3, and is reported to be spending 80% of his time on waste management. The most senior person responsible for waste management on a full time basis is Principal Technical Officer, at salary scale C1. On analyzing the EHD organization structure, it appears there is no officer with the specific responsibility of waste management planning. This responsibility has been apportioned to the engineering department of the local authority. However, waste management planning is a key component of waste management process and is required by Waste Management Act of 1998. Separating waste management planning from the other aspects of waste management such as collection and disposal could compromise the ability of the local authority to deliver on its public health mandate.

Table 4.21 and Table 4.22 show the staffing of the Environmental Health Department units in Ngami and Okavango sub-districts and related financial implications, respectively. It emerges from the two tables that a large proportion of personnel expenditure is in waste collection. While the Ngami to Okavango sub-districts population ratio is 1.5:1, the personnel expenditure ratio is 2.4:1. This means that the Okavango sub-district has relatively lower staffing levels per population served. This raises issues of equitable distribution of service delivery.

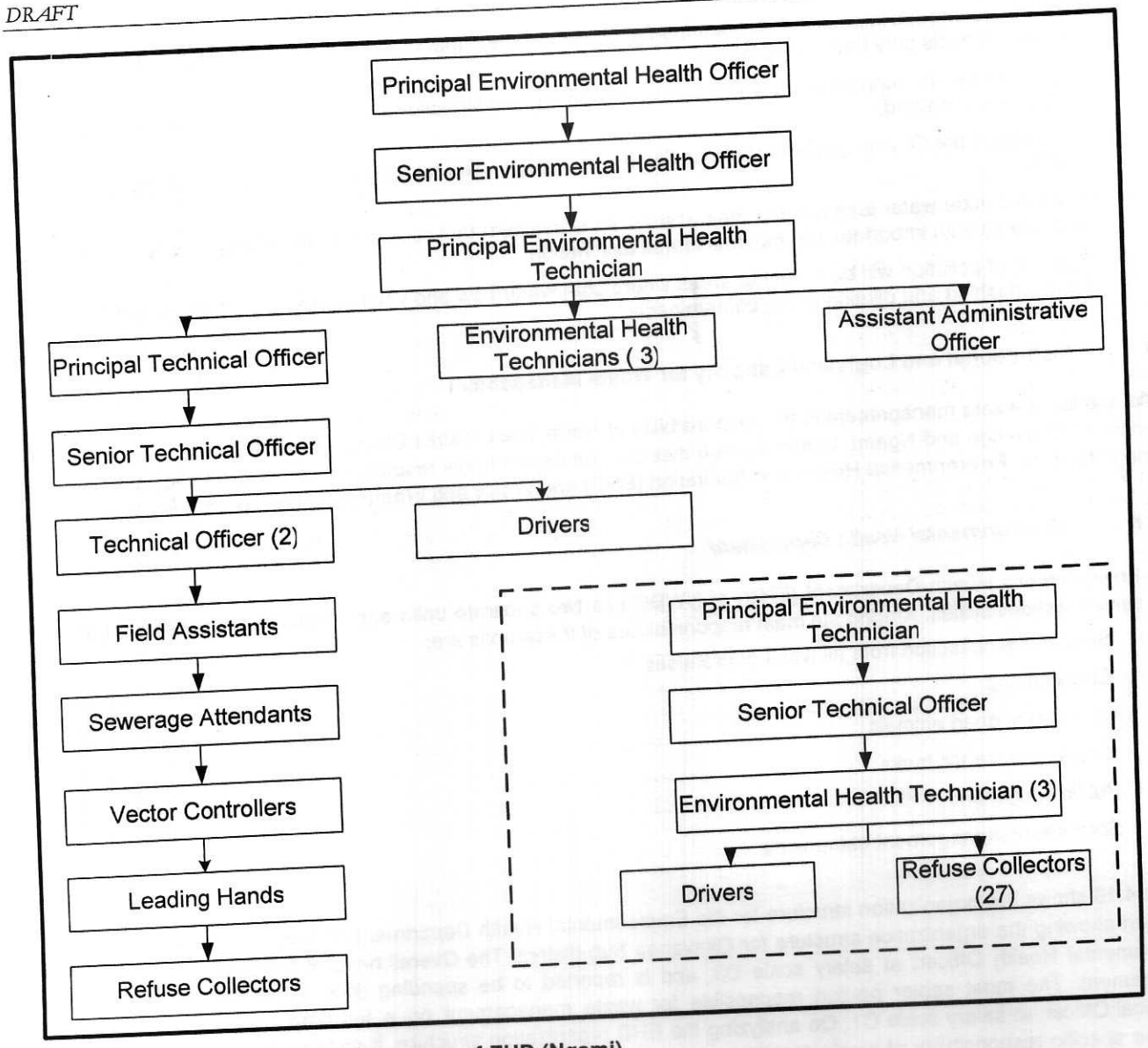

Figure 4.16: Organizational Structure of EHD (Ngami)

Some areas of competency are required for the solid waste management section to effectively discharge their mandate. Primarily, the section entrusted with solid waste management should have the capacity to plan waste management operations of storage, collection, processing and disposal. It should also be able to analyze problems associated with these processes for possible remedial action. More specifically, the desired competency areas for solid waste management will include (but not exclusively) capacity to understand and effect:

- Solid Waste management policy and legislation
- Short term and long term planning
- Waste collection routing
- Equipment maintenance
- Equipment and supplies acquisition

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- Service fees collection
- Landfill operation
- Public education

However, an evaluation of qualification for waste management staff indicates that their specific line of training is in environmental health. The emphasis of environmental health training programmes as revealed by analysis of curriculum in reputable universities seems to be on discussion of health problem stemming from contamination of air, water, food, the work place and other special environments. It also examines links between environment and infectious diseases and possible remedial actions to avert them. While environmental health education is necessary to equip people with the necessary skills to understand the problems that can emanate from improper solid waste management, it does not equip them with the knowledge to design and plan solid waste management processes, such a storage, collection, recycling and disposal. This means that, discrepancies exist between job requirements and actual staff qualification at planning and implementation levels of Environmental Health Department. It is generally accepted though that someone trained in environmental health should be able to design and carryout effective public education programmes.

It must however be acknowledged that other skills required for solid waste management could be sourced from within the local authority such as supplies, finance and maintenance. But for effective implementation of waste management programmes, there must be provision of such skills within the Environmental Health Department.

Table 4.21: Waste management staffing of the Ngami Sub-district

	Position	Service level	Posts filled	Posts vacant	Reported % time on waste management	Median Salary (P/annum)	Total Cost
Overhead (NWDC)	Principal Environmental Health Officer	D3	1	-	80	136 428	109 142
	Senior Environmental Health Officer	D4	1	-	70	117 522	82 265
	Principal Environmental Health Technician	C1	1	-	60	91 338	54 803
Total overhead							***246 210***
Waste Collection (Ngami)	Environmental Health Technician	C3	2	1	50	5 942	8 913
	Principal Technical Officer	C1	1	-	100	91 338	91 338
	Senior Technical Officer	C2	1	-	100	73 668	73 668
	Technical Officer	C3	1	-	100	5 942	5 942
	Assistant Administration Officer	B2	1	-	50	32 202	16 101
	Field Assistants	B5	5	-	100	18 636	93 180
	Sewerage attendants	A1	4	-	100	15 534	62 136
	Vector Controller	A2	15	-	50	12 942	97 065
	Leading hands	A2	4	-	100	12 942	51 768
	Drivers	B5/4	13	-	100	20 664	268 632
	Refuse collectors	A3	61	-	100	10 788	658 068
Total waste collection							***1 426 811***
Grand total							**1 673 021**

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Table 4.22: Waste management staffing of the Okavango Sub-district

	Position	Service level	Posts filled	Posts vacant	Reported % time on waste management	Median Salary (P/annum)	Total Cost
Overhead (NWDC)	Principal Environmental Health Officer	D3	1	-	80	136 428	109 142
	Senior Environmental Health Officer	D4	1	-	70	117 522	82 265
	Principal Environmental Health Technician	C1	1	-	60	91 338	45 669
Total overhead							***237 076***
Waste Collection (Okavango)	Senior Technical Officer	C2	1	-	100	73 668	73 668
	Environmental Health Technician	C3	3	-	50	5 942	8 913
	Sewerage attendants	A1	3	-	100	15 534	46 602
	Technical Officer	C3	1	-	50	5 942	2 971
	Drivers	B5/4	2	-	100	20 664	41 328
	Refuse collectors	A3	27	-	100	10 788	291 276
Total waste collection							***464 758***
Grand total							**701 834**

4.4.2 *Water and Wastewater Department*

The main responsibilities of this department in relation to liquid waste, is operation and maintenance of sewer networks. Figure 4.17 shows the organization structure for Water and Wastewater Department of the NWDC. The staffing details of the department are provided in Table 4.23. Key observations from the staffing situation within the department are that:

- 14% of positions are vacant
- Despite the responsibilities associated wastewater collection and treatment, the section head is a Senior Technical Officer, at salary scale C2, which probably signifies a limited decision making power.
- Even though the responsibilities of the department will be similar in 2007 when the sewer network in Gumare opens, only 21% of the department's establishment is based in Okavango Sub-district with the highest position being that of Technical Officer.

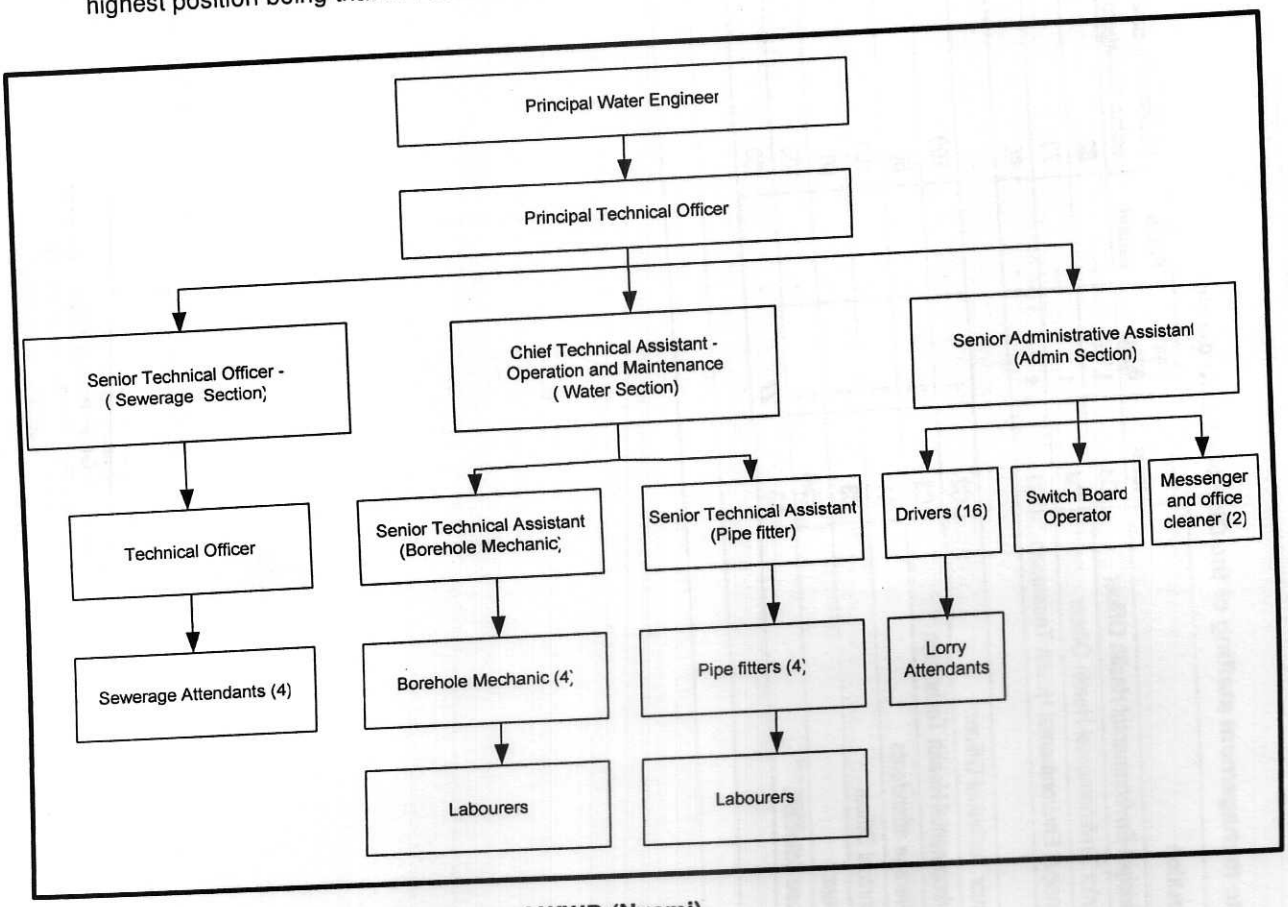

Figure 4.17: Organizational Structure of WWD (Ngami)

The key competency areas required for wastewater management are:

- Wastewater policy and legislation
- Short and long term planning for wastewater facilities
- Equipment acquisition

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- Wastewater system maintenance and operation
- Design and operation of on-site and off-site systems
- Wastewater chemistry
- Pipe fitting
- Service charge collection
-

An analysis of the staff qualifications of Water and Wastewater Department shows that the majority of staff has training in potable water technology. While some of the skills acquired through portable water training are applicable to wastewater management, in general the skill level within the department has to be improved through recruitment and or training of staff who are more rounded to deal with water and wastewater management. Two senior staff position are held by Mechanical Engineers, who are not necessarily relevant professionals for water and wastewater management.

Table 4.23: Water and Wastewater Department staffing

	Position	Service level	Posts filled	Posts vacant	Reported % time on wastewater management	Median Salary	Total Cost
Overhead (NWDC)	Principal Water Engineer	D3	1	-	50	136 428	68 214
	Principal Technical Officer	C1	2	-	50	91 338	91 338
Total overhead							***159 552***
Operation and Maintenance	Senior Technical Officer	C2	1	1	100	73 668	73 668
	Technical Officer	C3/C4	3	3	50	54 174	162 522
	Senior Administrative Assistant	B2/B3	2	-	50	29 754	29 754
	Senior Technical Assistant (Pipefitter)	B3	2	1	50	26 832	40 248
	Pipefitters	B3	4	-	50	26 832	53 664
	Sewerage attendants	A1	8	-	100	15 534	124 272
	Labourers (semi-skilled)	A2/A3	4	-	50	11 958	23 916
	Messenger	A2	1	-	50	12 942	6 471
	Cleaner	A2	1	-	50	12 942	6 471
	Switchboard operator	A2	1	-	50	12 942	6 471
Total operation and maintenance							***527 487***
Grand total							**687 039**

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4.4.3 *Support organizations, stakeholders and stakeholder linkages*

Apart from Environmental Health Department, which is the designated department for waste management, there are other local authority departments with a supporting role. Table 4.24 shows the supporting departments and nature of support. The supporting role of these departments is appreciated, but the ideal situation would be for all planning and operational activities of waste management to be under a single department. For purposes of this report, this support from other departments will not be reflected in budgeting.

Table 4.24: Support departments in waste management and their roles

Department	Nature of support
Secretariat	Includes waste management in physical development plans
Treasury Department	Responsible for revenue collection, accounts and supplies
Engineering Department	Planning, tender preparation (technical specification) and evaluation, site control of buildings and landfill site
Transport and Mechanical Workshop	Maintenance of waste collection equipment, fuel supply, preparation technical specification) and evaluation of tenders, provide drivers
Parks and Gardens	Organize waste collection in public gardens
Labour Intensive Public Works Programme	Labour involved in public cleaning programmes

It has been established that there are other stakeholders apart from the designated authorities for waste management activities in the Okavango Delta Ramsar Site. Among the identified stakeholders are; tour operators, Botswana Defence Force, Department of Building and Engineering Services (DBES), Private sector, micro-entrepreneurs and waste generators. Their participation in waste management is varied and has been discussed in the previous sections of this report. The linkages between the different stakeholders are primarily informal except in cases where the local authority has contracted some of its services to the private sector. There were also some private sector linkages in the recycling sector that could offer valuable lessons for emergence of other collaborative efforts. For example, access to end-user markets for used oil and metal can is achieved through input of oil and metal can suppliers.

While it is appreciated that the role of Department of Waste Management and Pollution Control (DWMPC), is mainly regulatory, it appears that it does not have a direct and visible working relationship with local authorities. This is probably even made more difficult by that the DWMPC is under the Ministry of Environment Wildlife and Tourism, while the responsibility of waste management at local authority level falls under the Ministry of Local Government. The demands of the Waste Management Act of 1998, (which is the regulatory framework guiding DWMPC) on local authorities are immense, including among others preparation of waste management plans, recycling plans and obtaining up to date information on controlled waste in areas of jurisdiction. But enforcement of the Act of these matters will be difficult to achieve without a direct link that could ensure that capacity has been built at local authority level to enable them to carry out the set responsibility.

4.4.4 *Emerging Issues*

A synthesis of the discussions on institutional and logistical capacity reveals the following issues that the strategy has to address:

- Departments responsible for waste management are poorly staffed to deal with all aspects of waste management, particularly planning
- While the largest proportion of EHD recurrent budget is used for solid waste management, the solid waste management section is headed by a relatively junior member of staff
- There appears to be a disproportionate distribution of staff between the two sub-districts of NWDC

- Wastewater section of WWD is headed by a relatively junior officer
- There are private sector institutions linkages, particularly in recycling that could be built upon
- There appears to be no direct operational link between the national regulatory department and waste management departments in local authorities, except for capital financing of large-scale infrastructure
- The EHD handles solid waste and wastewater, despite the factor that there is another local authority department responsible for wastewater and wastewater infrastructure

4.5 Financing and Cost Recovery

4.5.1 Departmental Budgets for NWDC

The budget estimates for the financial year 2004/05 for the North West District Council are shown in Table 4.25. The total budget for the local authority for 2005/06 was P150,016,070. Only about 8% was supposed to be financed from the local authority's own revenue sources while 92% would come from revenue support grant from the central government. The proportion of the budget for the EHD and WWD, which are responsible for solid and liquid waste management, is 15% of the local authority budget. This represents the second highest expenditure for the local authority, and reflects the importance of these departments in its structure. An examination of the budgets for the local authority, both proposed estimates and approved from 2004-2007, shows that the pattern of distribution of the expenditure across departments appears to be consistent over the years.

Table 4.25: Approved budget estimates for NWDC 2005/06

Departments	Approved estimates 2005/06 (Pula)
Secretariat	21 071 450.00
Treasury	7 755 780.00
Education	18 556 660.00
Clinics	28 675 180.00
Environmental Health o Administration o Inspectorate o Communicable diseases o Landfill o Waste management (65% of EHD)	10 060 060.00 1 716 330.00 912 820.00 546 950.00 349 640.00 6 534 320.00
Engineering	9 520 700.00
Architecture and Buildings	4 937 220.00
Social and Community Development	14 801 320.00
Remote Area Development Project	3 315 980.00
Self Help Housing Agency	1 665 880.00
Transport	15 683 510.00
Water and Wastewater o Water o Sewerage (12.5% of WWD)	12 141 580.00 10 627 190.00 1 514 390.00
TOTAL	**150 016 070.00**

Source: North West District Council

4.5.2 Investment and Recurrent Budgets for EHD

Investment budgets for different developmental projects are usually provided for in national development plans through different ministries. The budgeted projects will then be included in District Development Plans. Table 4.26

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shows projects that were earmarked by the Environmental Health Department for the project area during North West District Council Development Plan 6 over different financial years and their current status. While there are some good intentions by the Environmental Health Department to invest in waste management infrastructure, the majority of these projects are never implemented on proposed timeframes. This could incapacitate the department to deliver on their mandate.

Table 4.26: Investment budget for EHD during DDP6

Project	Project location	Proposed investment for financial years (Pula)				Remarks
		2003/04	2004/05	2005/06	2006/07	
SOLID WASTE						
200 Refuse Skips	Whole District	220 000	220 000	220 000	220 000	Never approved
Tipper Truck	Maun	-	250 000	-	-	Never approved
JCB	Maun	-	700 000	-	-	Never approved
2 Refuse trucks	-		1 200 000	-	-	Never approved
Tractor Trailer	-	70 000		-	-	Never approved
T/Cabs	Ngami		200 000	-	-	Never approved
	Okavango		200 000	-	-	Never approved
7 Ton Truck	Ngami		200 000	-	-	Never approved
	Okavango		200 000	-	-	Never approved
Landfill Design Gumare	Gumare	1 500 000		-	-	Never approved
Landfill Construction	Gumare	6 000 000	6 000 000	-	-	Never approved
OTHER						
Ventilated Pit Latrine sub-structures	Whole District	-	1 500 000	1 500 000	1 500 000	Funds approved for 2004/05 only
Slaughter slab	Gumare	-	250 000	-	-	Never approved
	Shakawe	-	-	300 000	-	

Table 4.27 shows the recurrent budget for waste management services over three (3) financial years. Over these years, the recurrent budget has been increasing by 17% and 12%, respectively. A large proportion of these increases could be attributed to privatization of waste collection services. It is however not immediately clear if this resulted in improved waste collection in the entire Okavango Delta Ramsar Site. It is however possible that it may have resulted in improved waste collection in Maun, since most of these privatization efforts are targeted for the place, particularly large scale contracts. Other settlements with private waste collection services involve the use of micro-entrepreneur using donkey carts.

Table 4.27: Recurrent expenditure for waste management services

Budget item	Location	Budgeted amounts (Pula) for financial years		
		2004/05	2005/06	2006/07
Remuneration	Ngami	1 695 450	2 054 990	1 605 120
	Okavango	1 017 470	860 850	1 000 940
Material supplies (bins and refuse bags)	Ngami	122 400	131 900	128 440
	Okavango	100 000	105 500	67 700
Privatization (refuse contract)	Ngami	878 000	1 319 430	2 186 990
	Okavango	48 000	36 000	43 200
TOTAL		**3 861 320**	**4 508 670**	**5 032 390**

4.5.3 *Investment and Recurrent Budget WWD*

Table 4.28 shows projects that were earmarked for Water and Wastewater Department during District Development Plan 6. Among the key projects is to rehabilitate and or extend sewer network in Maun. However, funding for these projects was never approved.

Table 4.28: Investment budget for WWD during DDP6

Project	Project location	Proposed investment for financial years (Pula)				Remarks
		2003/04	2004/05	2005/06	2006/07	
T/cabs	Ngami	-	-	200 000	-	Never approved
	Okavango	-	-	200 000	-	Never approved
7 Ton truck	Ngami	200 000	-	250 000	-	Never approved
	Okavango	200 000	-	250 000	-	Never approved
Sewerage design	Maun	2 000 000	-	-	-	Never approved
Sewerage rehabilitation/extension	Maun	-	15 000 000			

Table 4.29 shows the recurrent budget for Waster and Wastewater Department for three consecutive financial years. The recurrent budget has relatively been constant over the three financial years.

Table 4.29: Recurrent expenditure for WWD

Budget item	Budgeted amounts (Pula) for financial years		
	2004/05	2005/06	2006/07
Personnel Emoluments	6 508 574.96	5 957 100.00	5 917 020.00
Running Expenses	3 036 495.25	3 599 260.00	3 632 030.00
Establishment expenses	759 179.22	472 530.00	608 960.00
Special	207 946.28	598 300.00	451 600.00
TOTAL	**10 512 195.71**	**10 627 190.00**	**10 609 610.00**

4.5.4 *Cost Recovery Initiatives in Waste Management*

The Botswana Waste Management Strategy of 1998 seeks to encourage local authorities to develop a cost recovery system that was supposed to enable them to collect at least 50% of actual costs of waste management during the period of NDP 9. While it is not clear what specific costs the strategy envisaged, it could reasonably be assumed that it refers to recurrent expenditure. Achievement of this target is expected to give the said local authority some more independence in decision-making. It is not clear if this autonomy also anticipates allowing local authority some leverage on spending the collected revenue on improving waste management service. However, the current practice is that revenue collected by the Environmental Health Department is submitted to the Ministry of Finance and Development Planning, and there is no direct advantage connected to the local authority's performance in collection of fees.

The local authority has devised some fee schedule for waste management services. The fee schedules for different service categories were previously shown in Table 4.12 and Table 4.14. These were last revised in 2003. The projected and actual revenue generated in applying these fee schedules is shown in Table 4.30. During 2005/06 financial year, the project revenue for refuse collection was more than the collected one, while the

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reverse scenario prevailed for effluent removal. It is possible that the amount of projected revenue actually doubled because of the variation in collection fee depending on the distance to be traveled.

Certainly the revenue collected from waste collection service fees will be very minimal compared to the actual cost of collection. This is mainly because few waste generators are paying for the service and the fees involved are relatively low. For example in 2005/06 financial year, the waste collection revenue represented approximately 0.75% of the waste collection recurrent budget.

Table 4.30: Projected and actual revenue from waste 2005/06

Service type	Projected (Pula)	Actual (Pula)
Refuse collection	27 880	19 955
Effluent removal	7 000	14 760
TOTAL	**34 880**	**34 715**

4.5.5 Emerging Issues

A synthesis of the discussions on financing and cost recovery reveals the following issues that the strategy has to address:

- Proposals for investment in waste management by EHD and WWD are hardly approved for funding. This could be a reflection of lack of autonomy in decision-making on investment in waste management
- Recurrent expenditure for solid waste management has been increasing primarily as a result of privatization of waste collection services
- Cost recovery initiatives are yielding minimal revenue, for solid waste, they cover less than 1% of the waste collection recurrent budget
- This could mainly be because the service fees are paid on a demand for the service basis. But section 29(1) of the Waste Management Act authorizes local authorities to charge fees for all households in its area of jurisdiction.

4.6 Stakeholder perceptions

4.6.1 Service quality

The general perception by most waste generators is that the local authority is offering poor service delivery in relation to waste management. Poor service delivery is characterized by irregular waste collection and non-provision of waste receptacles. It was also reported that private contractors that have been engaged to collect and dispose of waste, particularly micro-enterprises with donkey carts are not fulfilling their mandate. Poor service delivery was mainly attributed to lack of capacity by the local authority to properly manage waste.

4.6.2 Potential areas of improvement

There was a wide variety of perceived problems and potential areas of improvement. Some of these problems and suggested improvements are outlined below.

- There was a general concern by stakeholders that existing wastewater management systems were old and contributing to environmental degradation. There were suggestion that improvements are required in this area including construction of sewer networks in Seronga, Shakawe and Sehithwa.

- Department of Wildlife and National Parks campsites were reported as poor in relation to management of both solid and liquid waste. There were suggestions that DWNP should improve their campsites to international standards or even privatize them.
- There were suggestions for improvement of waste management in HATAB and Non-HATAB sites through provision of on-site wastewater treatment systems and engagement of private contractors to collect and dispose of waste.
- There is a general public perception that waters of the Okavango Delta are heavily polluted through the discharge of effluent into the system. It was suggested that such discharges must be prevented. To buttress this suggestion, the public leveled some complaints against Okavango Houseboats for illegal disposal of effluent in the Okavango River, but this operation was visited, inspected, and the Operations Manager was interviewed and no evidence of this practice was found.
- There was a general desire, particularly in Maun, for the local authority to provide recycling centers to encourage waste separation at source to enhance recycling.
- Littering and illegal disposal were perceived as the main waste management problems, mainly attributed to lack of environmental awareness by waste generators. About 33% of household respondents cited littering as the most serious waste management problem.
- Failure to enforce local authority byelaws was seen as a major problem that needs improvement.

4.6.3 *Emerging issues*

A synthesis of the discussions on stakeholder perceptions reveals the following issues that the strategy has to address:

- Perception of stakeholders is that waste management in the project area is generally poor.
- Improvements on the waste management service are expected to come from the local authority

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5 FUTURE SITUATION

5.1 Population Forecast

Population projects are based on 2001 population and obtained from population projection statistics from central statistics office (CSO). Projections for intermediate years for each settlement during the strategy period are not available apart from 2011. Table 5.1 shows population projections for the two sub-districts. The population of the ODRS is expected to grow by 6 percent over the strategy period.

Table 5.1: Projected population for the Okavango Ramsar Site

Sub-District	2001 population	Projected population					
		2006	2007	2008	2009	2010	2011
Ngami	75 070	72 163	71 997	71 982	72 106	72 358	72 729
Okavanago	49 642	57 489	58 885	60 316	61 788	63 302	64 864
TOTAL	**124 712**	**129 652**	**130 882**	**132 298**	**133 894**	**135 660**	**137 593**

Source: CSO (2005)

5.2 Solid Waste Generation Forecast

Solid waste generation rates in ODRS may depend on a number of factors and the influence of these factors may vary. But because of lack of detailed information on these factors, it has been assumed that waste generation rates will be influenced by;

- Economic development
- Waste avoidance
- Waste reuse and recycling

However, because of the short planning horizon for this strategy, it is not anticipated that these factors will result in large variations in waste quantity and composition. The influence of these factors has been assumed and detailed in Table 5.2. Economic development has been assumed to increase waste generation by 1% every two years, waste avoidance has been assumed to decrease waste generation by 1% every two years and waste reuse and recycling has been assumed to decrease waste generation by 1% every two years.

Table 5.2: Solid waste generation rates forecast 2006-2011

Influencing factors	Years					
	2006	2007	2008	2009	2010	2011
Economic development	1.000	1.000	1.010	1.010	1.020	1.020
Waste avoidance	1.000	1.000	0.990	0.990	0.980	0.980
Waste recycling	1.000	1.000	0.990	0.990	0.980	0.980
Adjustment factor	1.000	1.000	0.989901	0.989901	0.979608	0.979608
Projected waste generated by source (tonnes/year)						
Household	13 250	13 376	13 384	13 546	13 582	13 775
Tourism operations*	310	310	307	307	304	304
Institutions/commerce	4 745	4 745	4 697	4 697	4 648	4 648
TOTAL	**18 305**	**18 431**	**18 388**	**18 550**	**18 534**	**18 727**

* based on existing bed capacity of 1000 beds

5.3 Liquid Waste Generation Forecast

In absence of adequate information on wastewater flow measurements, the National Master Plan for Wastewater and Sanitation projects the wastewater generation rate shown in Table 5.3 for the two main settlements within the Ramsar site of Maun and Gumare with wastewater treatment works. However, the 2001 population and housing census estimated that there were 2,162 and 526 waterborne sanitation systems in Ngami and Okavango, respectively. Of the 2,162 waterborne systems in Ngami, 15% were sewer system and 85% were conservatory/septic tank systems, while in the Okavango, 17% were sewer systems while 83% were conservatory/septic tank systems. The National Master Plan for Wastewater and Sanitation estimated that the average wastewater generation rate in Botswana is 396 litres/household/day. This figure is used to compute the potential wastewater generated by on-site systems during the strategy period. It is assumed that the number of waterborne systems will increase by 1% each year for each generator category with no substantial increase in per capita wastewater generation rate. Table 5.3 shows that the majority of wastewater will continue to be collected and treated by on-site systems. This could present numerous point sources of pollution particularly if the existing on-site systems are not effective in improving effluent quality.

Table 5.3: Projected wastewater generation rates, 2006-2011

Wastewater sources	Year					
	2006	2007	2008	2009	2010	2011
On-site systems (Projected no. for ODRS)	1832	1850	1869	1888	1906	1925
Waste water generation rate (m^3/sytem/day)*	0.396	0.396	0.396	0.396	0.396	0.396
Generation rate (m^3/day)	725	733	740	748	755	762
Projected wastewater from off-site systems (Maun)* (m^3/day)	308	337	371	408	662	716
Projected wastewater from off-site system (Gumare)* (m^3/day)	21	21	21	21	21	21
% collected by on-site systems	69	67	65	64	52	51
TOTAL (m^3/day)	**1054**	**1091**	**1132**	**1177**	**1438**	**1499**

*Source: NMPWS (2003)

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6 SOLID AND LIQUID WASTE MANAGEMENT STRATEGY

Waste management is a multifaceted issue, and different stakeholders will have different perspectives on the key areas of attention. Identifying areas that needs attention is a function of the existing level of waste management activities. This means that there cannot be a blue print waste management strategy. Every waste management strategy is area specific. In recognition of this, it is often recommended that to arrive at some of consensus on the key areas that need attention, the different stakeholders must agree on a broader vision for waste management. This broader vision is the waste management strategy. The waste management strategy focuses on 'high level' issues, leaving some of the more detailed issues to the action planning stage. This strategy adopts a 'middle of the road approach' in that it does not only deal with the 'level issues' but also contains some details in the form of an implementation action plan.

6.1 Objectives of the Strategy

The general objective of the strategy is to improve waste management practices to minimize their potential harm to the human and natural environment of the Okavango Delta Ramsar Site. More specifically; the strategy seeks to:

- Improve solid waste collection service within the Okavango Delta Ramsar Site;
- Improve solid waste treatment and disposal practices within the ODRS;
- Improve liquid waste management practices to minimize their potential environmental impact on the environment;
- Improve institutional and logistical capacity of local authority departments charged with the responsibility for solid and liquid waste management;
- Create stakeholders linkages towards improved waste management;
- Inform stakeholders and public on key issues relating to waste management, to gain support for waste management initiatives and raise the overall profile of waste management within the community.

6.2 Period covered by the Strategy

The period covered by the Strategy is 2006 to 2011. It is however important to keep the Strategy under review and revise it as necessary.

6.3 Strategic Framework

There is a general need to improve waste management practices in the ODRS. More effective waste management is essential to protecting public health, improving the living environment and protecting the natural environment of the Okavango Delta Ramsar Site. An effective framework, including infrastructure and services, organizational structures should be put in place to achieve sustained improvement of waste management services. To reflect on the importance of improving and developing this sector, the Solid and Liquid Waste Management Strategy should be incorporated into District Development Plans for the North West District Council. The strategy should be used by key decision-makers as a major consideration when defining operational policies, approving investments and allocating budgets.

6.3.1 Strategy principles

The overall principles of this strategy are espoused in Botswana's Strategy for Waste Management and international waste management best practices. The key principles applied in the strategy are:

- **The Waste Management Hierarchy** – is a list of approaches to managing waste arranged in order of preference, with the least preferred option, disposal located at the bottom and the most preferred option, waste minimization located at the top.
- **The Proximity Principle** – requires waste to be disposed of as close to the place of generation as possible. This avoids passing the environmental costs of waste management to communities that are not responsible for its generation and reduces the environmental costs of transporting waste.
- **The Polluter Pay Principle** – says simply that those who pollute the environment must pay for the damage they have caused.
- **Integrated Sustainable Waste Management** – decisions that are intended to realize sustainability of waste management systems should take into account; stakeholders involved in waste management, the practical and technical elements of the waste system and aspects of the local conditions.

The above general principles are applied to the Okavango Delta Ramsar Site to generate more specific principles as detailed below, to be used as a guide in subsequent proposals of the strategy.

Stakeholder Involvement	The local community, tour operators, micro-enterprises and private sector will play an important role in improving and developing waste management services. The involvement of these stakeholders will be introduced into different parts of solid and liquid waste management services, and in different geographical areas within the ODRS, through the creation of the necessary linkages.
Waste and Effluent Pollutants Minimization	All solid and liquid waste generators must minimize quantities of waste and effluent pollutants respectively, to avoid unnecessary impacts to the communities and environment in the ODRS. Improved public education and awareness will play an important role in ensuring that all opportunities for waste minimization are taken. Standardization, regulation and enforcement could ensure improved effluent quality.
Roles and Responsibilities	There must be a clear definition of roles and responsibilities amongst those agencies involved in waste management (see section 7.6). In addition, those who benefit from solid and liquid waste management services must be prepared to pay some part associated with their provision.
Environmental Protection	Solid and liquid waste management in the Okavango Delta Ramsar Site must contribute to protecting both the living environment of residents and the natural environment of the ODRS. Effective solid and liquid waste management services are an essential contribution to sustainable development in the area and to preserve the Okavango Delta, a prime tourism attraction.
Waste Collection Targets	The Solid and Liquid Waste Management Strategy for the Okavango Delta Ramsar Site sets targets for waste collection and safe disposal..
Use in Decision Making	The Solid and Liquid Waste Management Strategy should be incorporated into the District Development Plan for the North West District Council. Decision-makers in defining operational policies, approving investments and allocating budgets, should use the strategy.

6.3.2 Strategic Vision

This strategy puts in place a framework that is intended to significantly improve waste management practices in the Okavango Delta Ramsar Site. The strategic vision is illustrated in Figure 6.1 and described briefly below.

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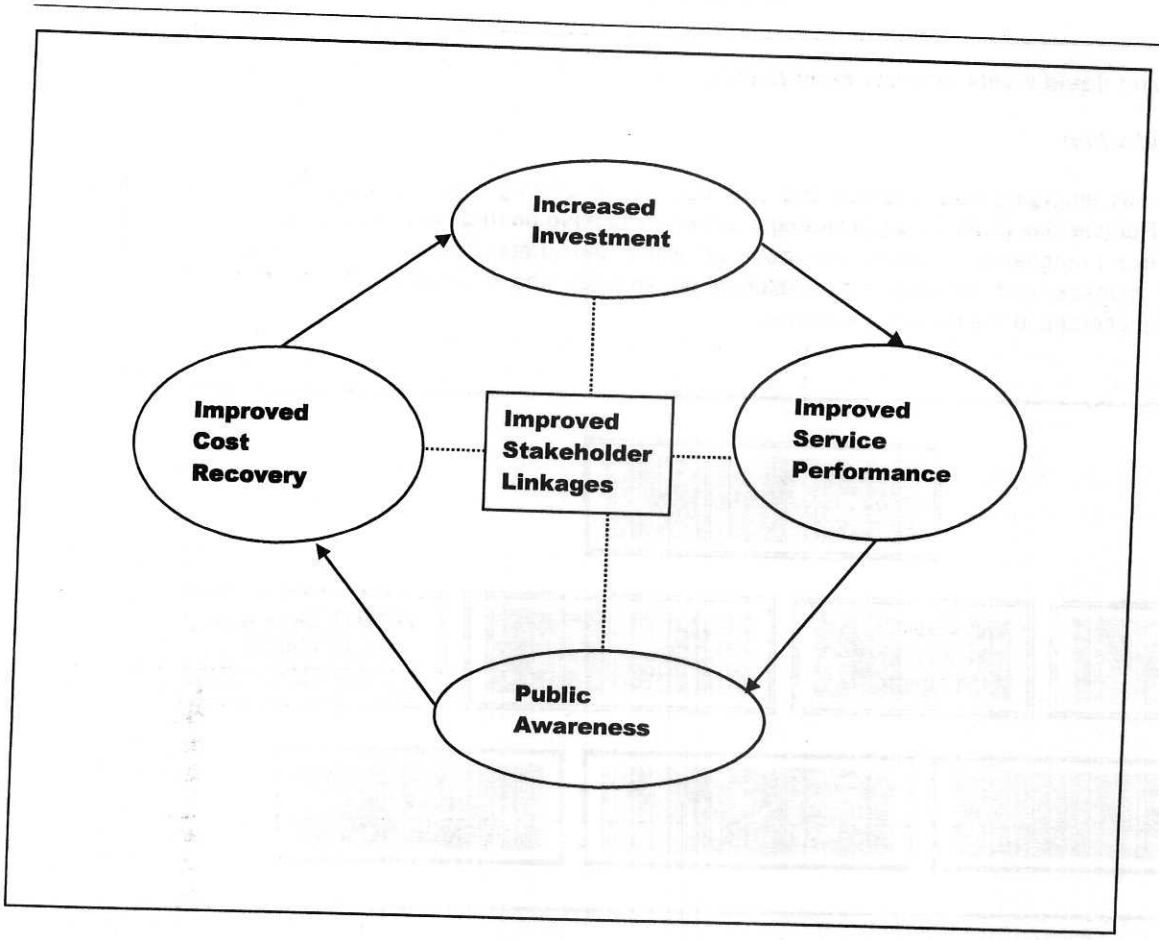

Figure 6.1: Strategic Vision

Investment	Increased investment in waste management infrastructure, personnel, vehicles and equipment is essential to improving waste management services. Investment in this areas could lay the foundation for overall service performance. However, this should be financially sustainable and focused on the key needs as outlined in this Solid and Liquid Waste Management Strategy.
Service Performance	Improved service performance in the area of solid and liquid waste is required to protect the human and natural environment in the ODRS. Improved service performance would ensure the realization of the objectives of the strategy. It will also be an incentive for service recipients to pay for the service.
Public Awareness	Significant improvement in awareness of waste management issues is required across all stakeholder groups to assist the local authority to improve its service delivery. The public must be made aware of the need for proper waste management, and strongly encouraged to actively participate in protection of their living environment and that of the ODRS. Local by-laws should be devised to impose fines for littering and improper dumping of waste.
Cost Recovery	Improved cost recovery will be essential to improving waste management practices, and ensuring that waste management services are financially sustainable. Appropriate mechanism for levying and collecting waste management fees should be phased in overtime. The fees should be set at reasonable levels to avoid illegal disposal and equitable access to service.
Stakeholder Linkages	Significant strides towards stakeholder linkages are required to assistant the local authority to deliver on its mandate on waste management. Public and private sector partnership should be forged, particularly with tour operations to minimize the unit cost of waste management in relatively inaccessible areas.

6.4 Solid and liquid waste strategy components

6.4.1 Introduction

In view of the issues emerging from analysis and synthesis of the existing waste management practices in the Okavango Delta Ramsar Site (ODRS), eight strategic components have been developed and are shown in Figure 6.2. Different waste management options are identified within the strategic components. Proposals towards improving waste management services are developed on analysis and evaluation of the options within the components and presented in the following sections.

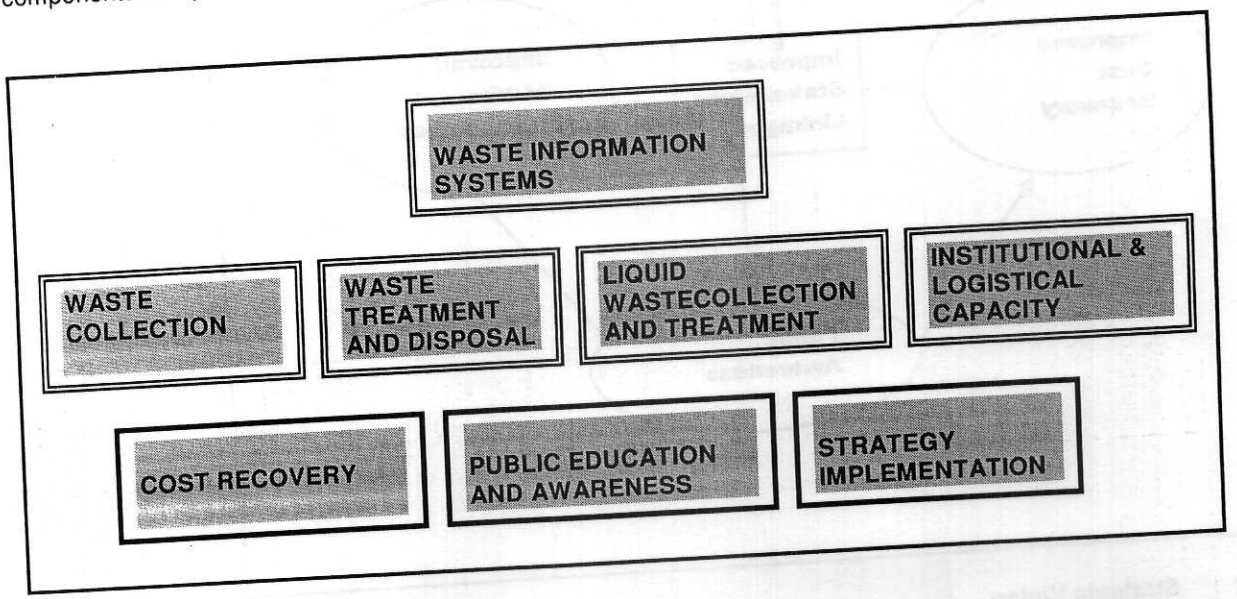

Figure 6.2: Strategy components

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6.4.2 Component 1: Waste Information Systems

Objective (s)	Existing scenario	Issues/Assessment	Proposals
Provide an accurate and up to date source of information on waste streams, effluent quality, storage, collection, treatment and disposal facilities to facilitate effective planning and performance monitoring	Poor data capture for waste management activities	Presents difficulties for planning, monitoring and justification of investments	• Record and archive information on waste, streams, collection, treatment and disposal • Monitor effluent quality and its impacts on groundwater and surface water quality (see APPENDIX D) • Make it readily accessible for decision making

6.4.3 Component 2: Waste collection

Objective(s)	Existing Situation	Issues/Assessment	Proposals
Primary and Secondary Storage			
Provide adequate primary storage containers to facilitate collection	Black refuse bags	• Easily breaks if collection frequency is poor • Easily destroyed by scavengers	• Develop standard bin policy for households, institutions and commercial enterprises • Criteria for the bin should be sufficient capacity, durability, easy to empty and clean and well fitting lid • Enforce section 30 of Waste Management Act in relation to provision of waste receptacles • Discourage backyard pit waste disposal through public education and by-laws and improve waste collection service
	Galvanized metal bins with lid	• Appropriate if properly located away from scavengers • May not be affordable to most generators	
	Pole mounted bin	• Heavy and vulnerable to tragedy of the commons • Easily corroded my water and wet waste	
	Predator proof bin at lodges/campsites	• If properly designed for easy emptying, good for predator prone areas • Appropriate for campsites	
	Backyard pits/burning	• Makes waste not available for collection • Presents public health risks	

Objective(s)	Existing Situation	Issues/Assessment	Proposals
Provide adequate secondary storage to facilitate transfer	Typical transfer stations used in NWDC	• Are not easy to empty • Located in inaccessible areas • Can be an eyesore if they over flow due to ineffective collection • If designed properly and emptied frequently, appropriate and cost effective technology for dispersed population with low waste generation rates	• Develop a prototype transfer station that facilitate easy reception and removal of waste for possible replication in villages • Provide adequate capacity of transfer stations related to collection frequency • Locate transfer stations in accessible areas to facilitate emptying • Where skips are used, they must have lids and of appropriate height to facilitate reception of waste
	Open skips	• Attracted rodents and predators • Promote litter dispersal • Can be an eyesore if they overflow due to ineffective collection	
Collection			
Improve collection coverage for households, institutions and commerce	Out sourcing • Large scale contracts • Micro-enterprises	• Micro-enterprises appropriate for community empowerment and are relatively cheap • Private sector provides efficiency provided the contracts are done properly with clear bench marks • Micro-enterprises are ineffective mainly because of poor supervision and performance terms	• Outsource waste collection services in settlements of more than 3000 inhabitants • Micro-enterprises with donkey carts should be used to collect waste from door to door to transfer station in all settlements of less than 3000 inhabitants • Performance monitoring of Micro-enterprises should be assigned to village level institutions to promote community ownership • Payment of Micro-enterprises should be performance-based to improve efficiency instead of fixed monthly rates • Local authority vehicles should be used to transport waste from transfer stations to final disposal sites in settlements with less than 3000 inhabitants • Plan in advance waste collections targets for waste collection fleet
	• Collection by local authority is largely provided door to door through compactor trucks • Micro-enterprises used for collection in some settlements but reported ineffective	• Inappropriate vehicles for local terrain and road conditions • Poor contracting, supervision and monitoring	

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Objective(s)	Existing Situation	Issues/Assessment	Proposals
	Performance of collection fleet is poor	• Monitoring of collection performance for appropriate remedial action is hardly done	• Monitor performance targets for each vehicle on a quarterly basis • Suggest possible areas of improvements if targets are not met • Qualified mechanics should be specifically attached to waste management section to improve maintenance turnover for collection fleet
Improve collection frequency	Collection frequency ranges from once daily to once in 7 months	• Leads to over flow of secondary storage facilities making them an eyesore and public health hazard • Discourages waste generators from bringing their waste to these facilities	• Plan for collection frequency of at least once a month in isolated settlements such as Khwai • Plan for collection frequency of fortnightly for settlements along the main road
Extend waste collection coverage to tourism operations	• Collection is hardly provided by the local authority • Buried in backyard pits • Generator collection and disposal • Illegal dumping	• Local authority cannot uncertain method of disposal • Some disposal methods presents public health and environmental contamination risks • Generator have capacity to pay for full cost of collection	Through HATAB and other tourism operation stakeholder organizations, local authority should facilitate for the establishment of tourism waste collection fund (TWCF). All tour operators in isolated areas beyond the capacity of the local authority and EHD should contribute to the fund, which will be used to pay for waste collection.

6.4.4 *Component 3: Waste treatment and disposal*

Objective(s)	Existing Situation	Issues/Assessment	Proposals
Reduce the quantity of waste for disposal through reuse and recycling	• Reuse and recycling are preferred options by the National Waste management Strategy because of their general environmental acceptability • Recycling is expensive when done by the local authority	• Large proportion of waste is putrescible other than the tradition recyclables • Limited market for recyclables and/or compost • Tourism operators are willing to separate waste at source	• Local authority should support the existing recycling initiatives by offering necessary incentives • Local authority should lease a centrally located piece of land in Maun to the Collect-A-Can agent for establishment

Objective(s)	Existing Situation	Issues/Assessment	Proposals
	• Currently there are small scale recycling initiatives by private sector for metal cans and used oil	• There is an established collection network in place for metal cans	of metal can recycling centre • The agent and local authority should jointly embark on a publicity programme to encourage waste generators to bring metal cans to the centre • The local authority should source a partner for the establish of a glass recycling centre
Minimize the toxicity of waste before final disposal though treatment by incineration (clinical and hazardous waste)	• There is currently only one operational incinerator in the entire ODRS • Some clinical waste is burnt in rudimentary incinerators • The Maun landfill is equipped with incinerator	• Poorly combusted clinical waste disposed of at disposal sites	• All clinical waste and hazardous waste need to be incinerated • To facilitate this, the local authority has to build an incinerator at Gumare primary hospital for the Okavango Sub-District
Dispose of waste safely to protect public health, environment and landscape	Open dumps	• Point sources of pollution if scared all over the place and have negative visual impact • Presents water resource and air contamination risk • Presents public health problems	• In the short-term (3-5) years minimize number of disposal sites and opt for a strategically located Okavango Sub-District dumpsite • Improve operational controls to limit impacts on air quality and water resources • In medium and long term (beyond the Strategy period), a sub-district sanitary landfill should be developed for Okavango Sub-District landfill
	Illegal dumps	• Opportunistic disposal options, usually as result of poor collection or inaccessible disposal sites • Usually difficult to police over a wide geographical area	• Improve and extend collection coverage • Build local authority capacity to enforce section 38 of the Waste Management Act where possible • The emphasis on combating illegal dumping should be on public education
	Landfills • Landfill at Maun to open soon for operation • No other landfill in the ODRS	• Relative environmentally safe • Expensive	• Provide adequate capacity for Maun landfill, equipment and human resource to ensure proper management

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6.4.5 Component 4: Liquid waste collection and treatment

Objective(s)	Existing Situation	Issues/Assessment	Proposals
Improve wastewater management systems to minimize their potential impact on the environment	• The predominant wastewater collection and treatment systems are conservatories and septic tank-soakaways • There is a limited capacity sewer system in Maun which experience frequent breakages • The sewer system in Gumare is expected to be operational by 2007	• Most the systems are old and require upgrading • Emptying is a problem in isolated areas and leads to overflows • There appear to be no standard construction of these facilities • Frequent breakages of Maun sewer network is not cost effective and leads over spillage and foul air	• Local authority should inspect all wastewater treatment facilities and make recommendation for renewal • Conservatories as wastewater collection systems should be phased out • The local authority should design a typical septic tank with specifications which allows for variation by number of users for standardization • All new construction of wastewater management systems should be approved by the local authority • Wastewater collection for isolated lodges and camps should be done through the TWCF • Upgrade Maun sewer network to increase capacity and spatial coverage
Improve effluent quality from wastewater systems to minimize their impact on the environment	• No monitoring of effluent quality from on-site and off-site wastewater treatment systems • Effluent quality varies greatly with some parameters with the desirable limits and others without from a single effluent source. • Effluent quality for wastewater treatment system used at Vumbura lodge is close to falling within the desirable standards for all parameters	• Local authority does not have capacity to monitor effluent quality • Some of the existing wastewater treatment options still pose some environmental risk • Septic tanks only provide primary treatment, the effluent quality may improve with the introduction of a secondary treatment option	• Install capacity within the Water and Wastewater Department to enable to carry out effluent quality monitoring on a regular basis • Pilot a septic tank and artificial wetland system as a wastewater treatment option for camps/lodges in the delta area with a capacity of more than 30 people and monitor effluent quality • In areas like Chiefs' Island, wastewater should be disposed off into interfluve areas where water is saline
Improve management of used oil to minimize its impact on the environment	• In majority of cases waste oil is stored for collection for recycling • Used oil spillages at source of generation are prevalent	• There is an opportunity to take advantage of the existing network of used oil collection for recycling • Some generators are not aware of the used oil collection system for recycling	• Local authority should hold a stakeholder meeting with used oil generators, to form linkages for used oil recycling • The meeting should brain storm of

Objective(s)	Existing Situation	Issues/Assessment	Proposals
			proper waste handling at the source of generation for the local authority to generate a leaflet for better used oil handling practices for the ODRS • Collection of used oil from isolated tourism operations should be done through the TWCF

6.4.6 *Component 5: Institutional and Logistical Capacity*

Objective(s)	Existing Situation	Issues/Assessment	Proposals
Improve institutional capacity of local authority departments charged with the responsibility of solid and liquid waste to enable them to discharge their mandate	• Solid waste is the responsibility of a section of the Environmental Health Department (EHD) • EHD is also responsible for wastewater from on-site systems • The head of the section is on the fourth tier of the EHD • Water and Wastewater Department (WWD) is responsible for management of wastewater from off-site systems • Wastewater is a section under WWD • The head of wastewater section is at 3rd tier of the WWD • Wastewater from on-site system is disposed of in treatment systems under the responsibility of WWD • EHD and WWD do not have full control over decisions and funding related to their responsibilities • Planning for waste management is done by the Engineering Department	• The large proportion of the EHD budget is for solid waste management • Solid waste section and wastewater section are headed by relatively junior officers in their departments, which means reduced decision making power • Responsibility for wastewater management are split across two departments of the same local authority • Time consuming organizational procedures result in low performance • Planning and operations activities are divided between different local authority departments	• EHD should be restructured to reflect that its main activity is solid waste management • Qualifications of departmental staff should have a solid waste management bias • All heads of sections should be elevated to 2nd tier of their departments (see proposed new structures) and be specialized in the sections they head. • EHD should be renamed Department of Solid Waste Management and Public Health • Management of wastewater from on-site systems should be the responsibility of WWD • Waste management departments should be given some level of autonomy in relation funding and budgeting • Planning and operational activities for waste managements should be under respective departments
Improve logistical capacity of local authority departments charged with the	• Maintenance Department is responsible for servicing waste management fleet	• Performance of waste collection fleet is low, because of low maintenance	• Attach qualified mechanics to waste management section(s)

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Objective(s)	Existing Situation	Issues/Assessment	Proposals
responsibility of solid and liquid waste to enable them to discharge their mandate	• Maintenance vehicle turnover is low • One collection vehicle for clinical waste	turnover • Clinical waste treatment facilities are in Maun and waste need to be transported there from all over the ODRS	• Purchase clinical waste vans (1 for Okavango, 2 for Ngami)

To further improve institutional and logistical capacity, the roles and responsibilities of the institutions, organizations and individuals should be clearly defined. Below is a proposal for the roles and responsibilities of the different stakeholders. Proposals for organizational reforms for the local authority waste management departments are discussed in Component 8.

Government Agencies	
National Government	National Government through the Department of Waste Management and Pollution Control should play its regulatory role as set out in the Waste Management Act of 1998. Government agencies should formulate policies to assist local authorities in improving and enhancing services for collection, treatment and disposal of waste. In particular, these policies should be aimed at building capacity at local authority level, to enable them to adequately carry out their mandate as specified in the Strategy and the Waste Management Act.
Local Authority Government	The North West District Council should ensure implementation of the Strategy and monitor performance of solid and liquid waste management departments. They should approve the necessary budget for implementation of the Strategy.
Local Authority Departments	Environmental Health and Water and Wastewater Departments will take the lead role in managing implementation of the Strategy. They should ensure that the budget for solid and liquid waste management is properly prepared inline with requirement of the Strategy. The two departments should ensure uptake of the Strategy by all stakeholders. A key will be encouraging stakeholder participation in improving standards of waste management.
Organization of Service Providers	
Environmental Health Department	Environmental Health Department should be renamed Department of Waste Management and Public Health in recognition of its primary responsibility of waste management. It will continue to be responsible for ensuring that effective waste management services are provided along with other public health responsibilities. The head of the department should have training that is waste management biased to enable him/her to carry out the duties of the local authority as specified by the Waste Management Act. Otherwise the department should ensure that their team has a senior officer who is trained at degree level in waste management or similar discipline. The department should be given greater autonomy in their operational and financial decision- making.
Water and Wastewater Department	The department will continue to be responsible for ensuring that effective wastewater management services are provided. For purposes of consistency, the responsibility of emptying conservatories and septic tanks should be taken away from the renamed Environmental Health Department, since the Water and Wastewater Department is responsible for the operation and maintenance of wastewater treatment and disposal infrastructure. The capacity of the department should be strengthened by creating a position for an engineer with wastewater engineering bias below the overall head of the department to head the wastewater management section. The department should have logistical capacity installed that will enable it to monitor effluent quality from point and non-point sources within the Okavango Delta Ramsar Site.
Private Sector	While the local authority has the overall responsibility for ensuring that the public is provided with waste management services, the existing public/private sector partnerships should be maintained. The private sector should fulfill their social responsibility by adhering to performance targets set by the local authority within agreed budgets.
Micro-Enterprises	The existing public/micro-enterprises partnerships should be maintained and strengthened. To improve performance and monitoring of these enterprises, their contracting and supervision should be devolved to community level organizations, either Village Health Committees (VHCs) or Village Development Committees (VDCs) or their equivalents. Devolving these responsibilities to community level organization will enable payments to be performance-based instead of the current practice where they are paid monthly, irrespective of performance.
Waste Generators	
Households	Households are responsible for ensuring that waste is made available for collection by the local authority or their nominated contractors. To facilitate this, households should acquire primary storage containers as of a standard specified by the local authority. Households should also construct

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	wastewater contained and primary treatment facilities to standard and specification approved by the local authority. They shall also pay charges for this service in accordance with a schedule of fees authorized by the North West District Council.
Tour operators **Commerce** **Institutions**	These generators are responsible for ensuring the proper disposal of wastes generated by their activities, and for paying appropriate costs of collecting, transporting, treating and disposing this waste. These generators may establish contracts with the local authority to provide this service or may choose to use other waste collection contractors. To facilitate collection, they must provide primary storage containers in accordance with collector specification. These generators should also ensure that the quality of effluent they discharge into the environment are of acceptable standard. They should foster linkages that assist reduce their unit costs of waste management, amongst this is TWCF.
Hospitals and Clinics	Hospitals and clinics should be responsible for ensuring that their waste is managed safely and effectively. Infectious and hazardous health care waste should be segregated, stored, and managed in a way that avoids health risks to staff and waste collection personnel. All health care waste should be incinerated.

6.4.7 *Component 6: Cost Recovery*

Objective(s)	Existing Situation	Issues/Assessment	Proposals
To ensure sustainability of waste management services by recovering part of operation and maintenance costs.	• Septic tank emptying fees in areas accessible to local authority collection, varying with distance of collection point • Fixed household solid waste collection fee charged on demand of service • Fixed commercial/institutional solid waste collection fees charged on demand of service • Sewerage connection and annual maintenance fees • Only few households pay service fees	• The basis for setting service fees at the current level is not clear • Service fees do not usually cover capital investment • Fees might be set at levels that are not affordable and presenting equity problems • The level at which fees are set could encourage fly tipping • The service are currently lower than those charged by private sector	• An effective cost recovery policy is essential and should be in place • Local authority should device means that should ensure that solid waste collection charges are paid by all households • Solid waste charges for households should be weighted depending on affordability • Variable charges of the quantity of solid waste should be charged based on the quantity of waste generated for commercial enterprises and institutions • EHD and WWD should be given some leverage to use revenue from service charges to augment their waste management recurrent budget

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6.4.8 Component 7: Public education and awareness

Objective(s)	Existing Situation	Issues/Assessment	Proposals
To inform stakeholders and public on key issues relating to waste management, to gain support for waste management initiatives and raise the overall profile of waste management within the community.	• Littering is prevalent and mainly attributed to lack public awareness of its impact • Illegal dumping is prevalent • Public not aware of some local recycling initiatives	• It usually takes time and demand a lot of resources to change ingrained habits • Education alone does not usually achieve desired results without appropriate incentives/disincentives	• Local authority should launch a public education and awareness programme (PE&AP) • Target groups for the programme should include local level institutions, decision makers, teachers, fishermen, health professionals, politicians • Key elements of the programme should include pilot projects, awareness of the need for waste avoidance and recycling, litter prevention, preventing waste disposal in rivers, burning of waste, phasing out of open dumping and penalties for littering • Funding for PE&AP should be sourced from local enterprises • Measurements of the successes of PE&AP should be evaluated

6.4.9 *Component 8: Strategy Implementation*

The Solid and Liquid Waste Management Strategy set out under Components 1 to 7 provides proposals for improving and developing waste management practices in the Okavango Delta Ramsar Site over the period 2006-2011. This Component 8 provides an Implementation Action Plan (IAP) which intends to turn the proposals into reality.

The key objectives for implementation of the Strategy are in consonant with the vision espoused in section 6.3.2 and are to:

- Increase investment;
- Improve service performance;
- Increase public awareness;
- Improve cost recovery; and
- Create stakeholder linkages

Implementation of the Solid and Liquid Waste Management Strategy will be in accordance with the detailed IAP set out under this component and shown in Table 6.1. The detailed IAP sets out the key areas of activity under Component 1 to 6, target completion dates and stakeholders to be involved.

An earlier observation was that the organizational procedures are an impediment to effective waste management and leads to low performance in some areas. The departments of Environmental Health and Water and Wastewater are not in full control over matters relating to decisions on finance, procurement and manpower relating to responsibilities allocated to them. To improve the overall situation, the structure shown in Figure 6.3 is proposed for both the Environmental Health and Water and Wastewater Departments. This proposed structure is expected to give the different waste management departments more autonomy, and minimize organizational procedures for service delivery.

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Table 6.1: Strategy Implementation Plan

Action required	Implementing Stakeholders	Strategy Periods					
		2006	2007	2008	2009	2010	2011
Develop a computerised waste information management system	EHD, WWD						
Develop by-laws and local rules and regulations	EHD, WWD						
Develop standard bin policy	EHD						
Develop prototype transfer stations for piloting	EHD						
Replicate transfer station after piloting to settlements with <3000 people	EHD						
Outsource primary collection to private collectors for settlements with >3000 people	EHD						
Outsource primary collection to micro-enterprises for settlements with <3000 people	EHD						
Assign performance monitoring of micro-enterprises to village level institutions	EHD, Village Institutions						
Provide only secondary collection for settlements with <3000 people	EHD						
Set collection performance targets and monitor quarterly	EHD						
Attach qualified mechanics permanently to waste management departments	EHD, WWD, Engineering						
Establish tourism waste collection fund	EHD, WWD, Tour operators						
Establish a recycling centre for metal cans	Collect-A-Can agent, EHD						
Source a partner to establish recycling centre for glass	EHD						
Purchase 3 additional clinical waste vans	EHD, Clinics						
Collect all clinical waste for incineration	EHD, Clinics						
Build an incinerator at Gumare Primary Hospital	EHD, Ministry of Health						
Establish a disposal site with operational controls in Okavango	EHD						
Design a prototype septic tank	WWD						
Inspect all wastewater treatment systems and recommend upgrading	WWD						
Phase out conservatories	WWD						
Monitor solid and liquid waste on a regular basis	WWD, EHD						
Upgrade Maun sewer network to increase capacity and spatial coverage	WWD, NWDC, Water Affairs						
Pilot septic tank and wetland systems for lodges/camps with >30 people	WWD, Lodges, Camps						
Pilot disposing of water into interfluve areas of the delta	WWD, lodges, Camps						
Hold a stakeholder meeting with used oil generators	WWD, EHD, Stakeholders						
Restructure local authority waste management departments	WWD, EHD, NWDC						
Develop a cost recovery policy	WWD, EHD						
Device mechanisms for ensuring that all household pay for waste collection	EHD						
Launch Public Education and Awareness Programme (PE& AP)	EHD, WWD, enlist NGOs						
Measure success of PE & AP	EHD, WWD		√	√	√	√	√
Evaluate Strategy		√	√	√	√	√	√

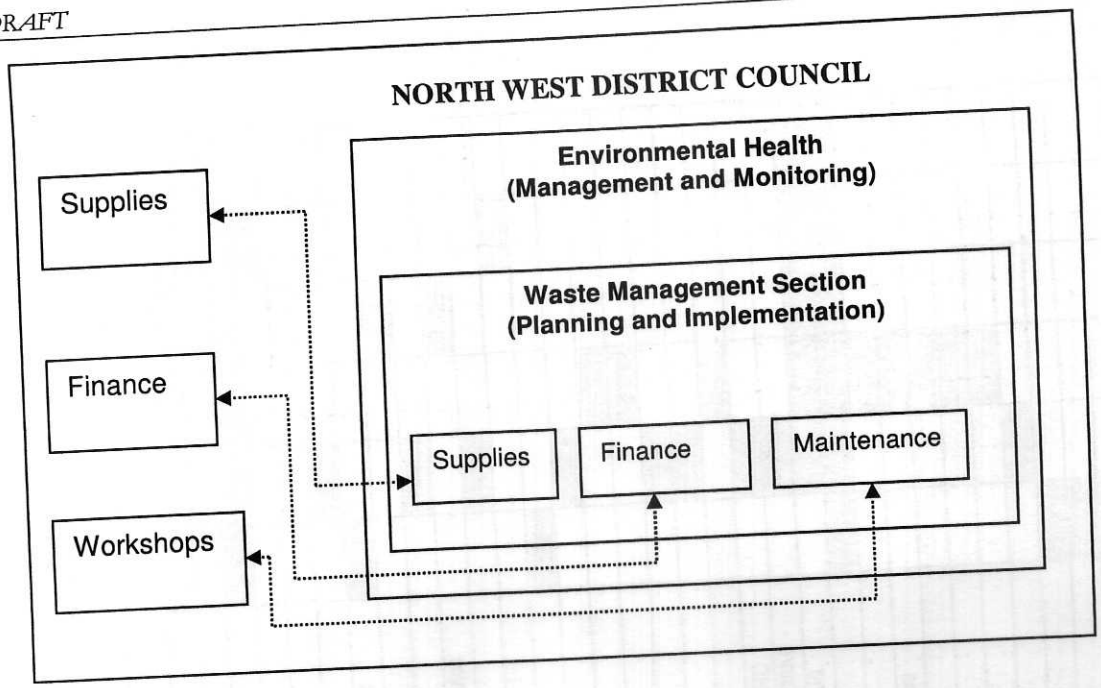

Figure 6.3: Proposed organizational structure

To facilitate the proposed changes in components 1-6, and the organizational structure in Figure 6.3, a framework for the organization of the waste management section in the Environmental Health Department and that of wastewater section of Water and Wastewater Department are shown in Figure 6.4 and Figure 6.5, respectively. The key proposal of the frameworks is that, the primary role of the heads of sections at district level would be to coordinate the activities of their respective sections in the two sub-districts. This proposal is based on the expectation that the heads section will be elevated to the second tier of their respective departments.

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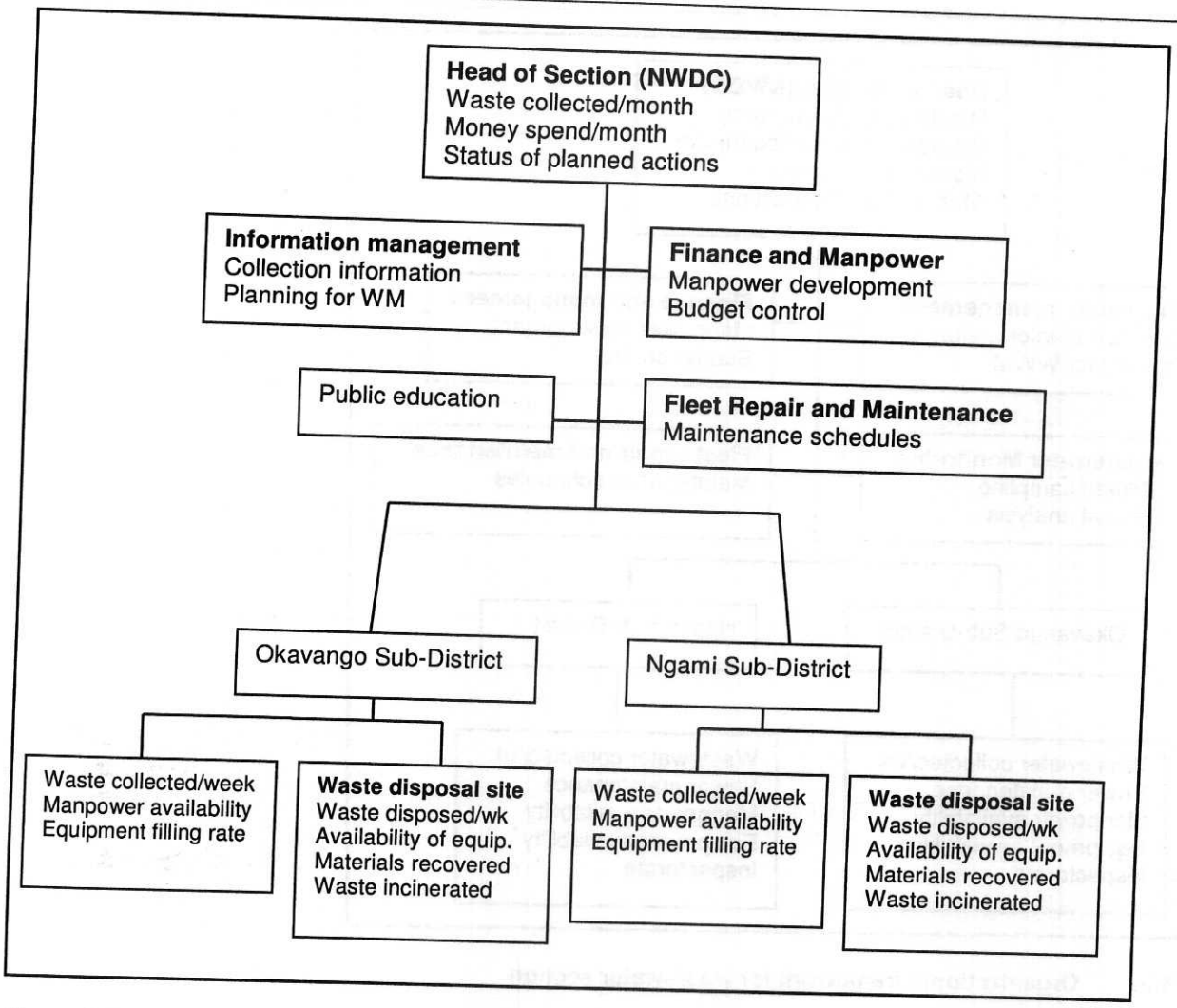

Figure 6.4: Organizational framework for waste management section

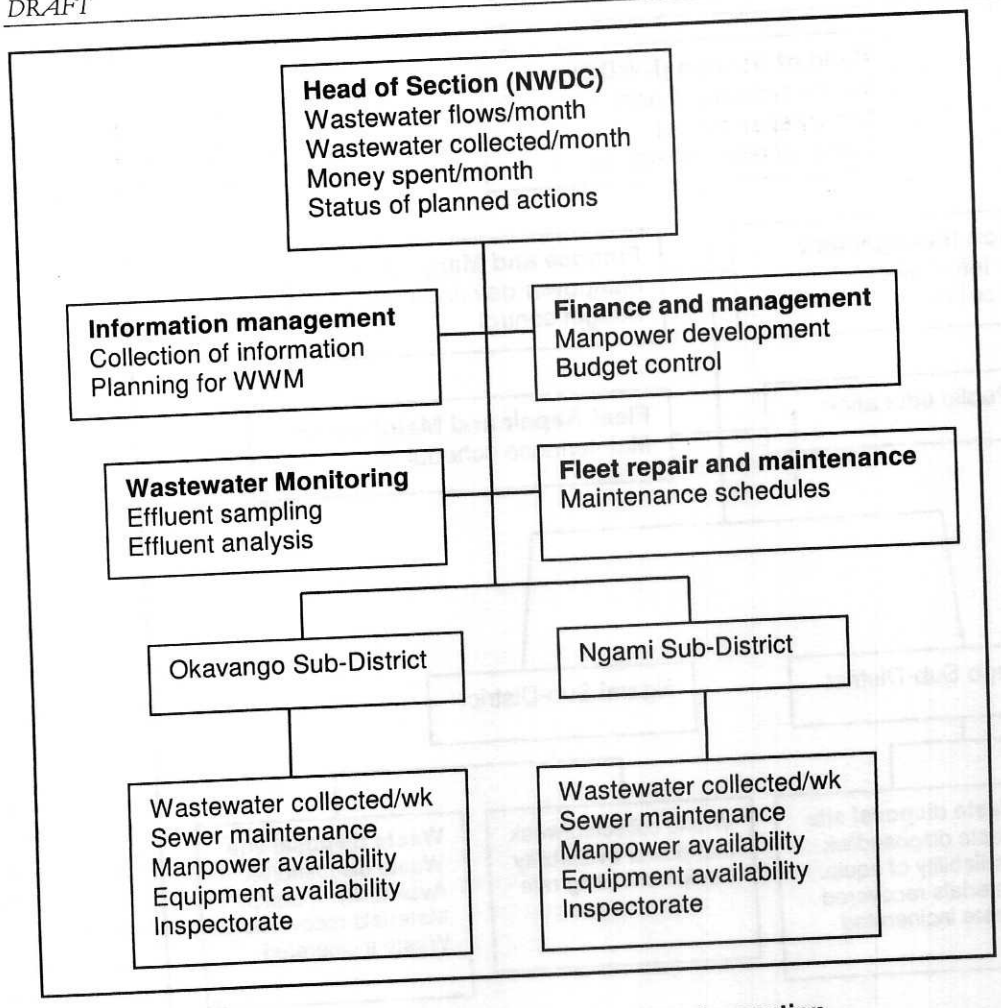

Figure 6.5: Organizational framework for wastewater section

In line with the frameworks shown in Figure 6.4 and Figure 6.5, the proposed organograms for the EHD and WWD are shown in Figure 6.6 and Figure 6.7 respectively. The organogram of the EHD is divided into two components of administration and planning, and implementation. The administration and planning component coordinates the activities of solid waste management for the entire district while implementation will be at sub-district level. The Principal Sanitation Officer will be the overall head of the EHD, while the solid waste management section will be headed by Senior Waste Management Officer. This implies that, there will be a mirror organizational structure for implementation at both Okavango and Ngami Sub-Districts, headed by Principal Technical Officer (Waste Management).

It was established in Section 4.4 that there are discrepancies between job requirement and actual staff qualifications at planning and implementation levels of the EHD. To close these discrepancies, it is proposed that the staff development paradigm show shift for equipping them with environmental health skills to environmental engineering and/or solid waste management skills. A typical environmental engineering programme from reputable universities will address the interaction of humans with their environments, and the planning, design, and control of systems for environmental quality and management. The discipline covers such areas as air and noise pollution, solid waste, potable water and wastewater.

Table 6.2 shows possible areas of training and/or proficiency required for each critical position proposed in the organogram of EHD to enable effective waste management. Provision of this training will sufficiently improve institution capacity to deliver on their mandate of managing solid waste.

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As alluded to earlier, a more appropriate in-depth training for water and wastewater management is Environmental Engineering, which addresses planning, design and control of systems for environmental quality management including potable and wastewater. Table 6.3 shows possible areas of training and/or proficiency required for each critical position proposed in the organogram of WWD to enable effective wastewater management. Provision of this training will sufficiently improve institution capacity to deliver on their mandate of managing wastewater.

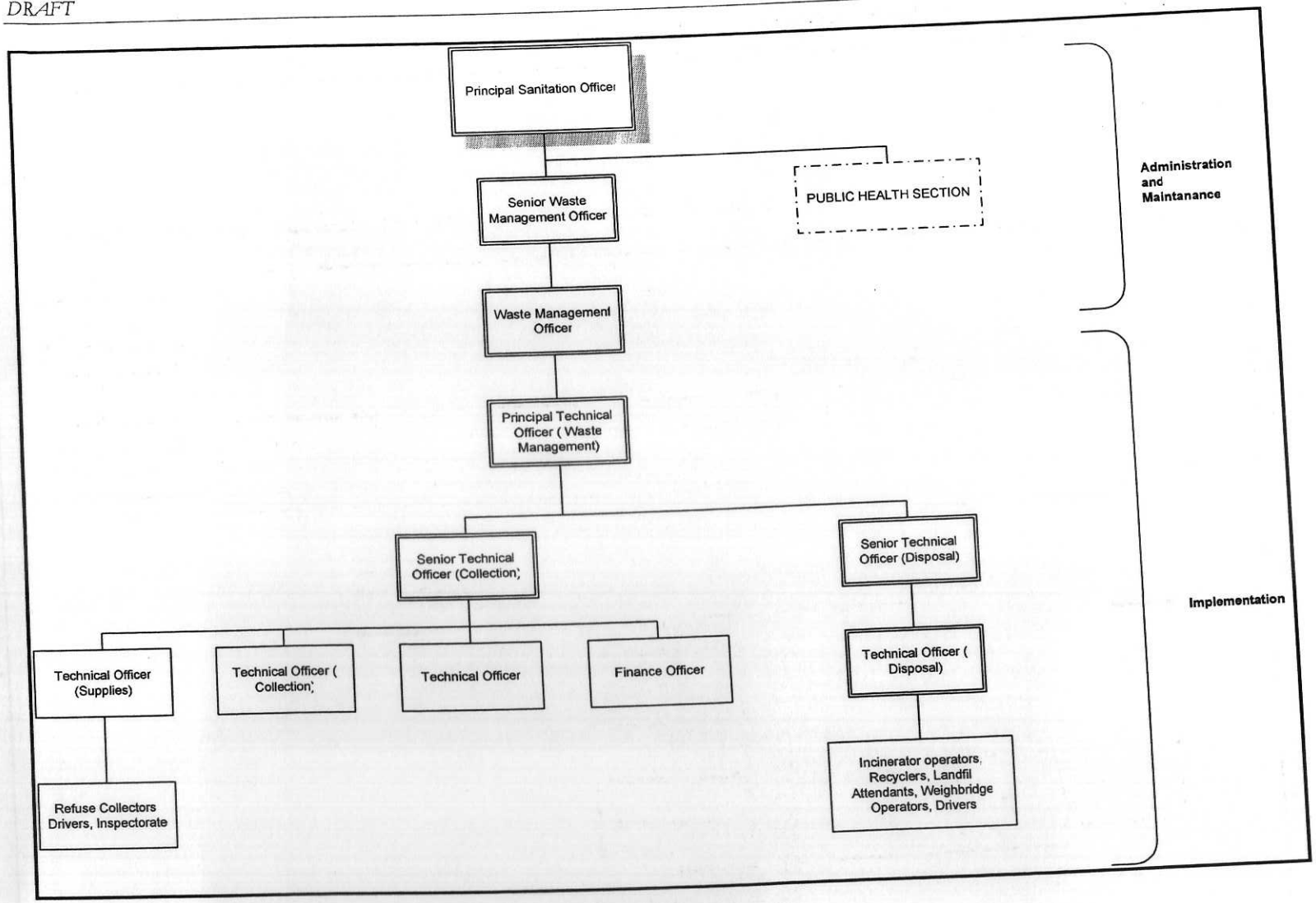

Figure 6.6: Proposed Organogram for Environmental Health Department

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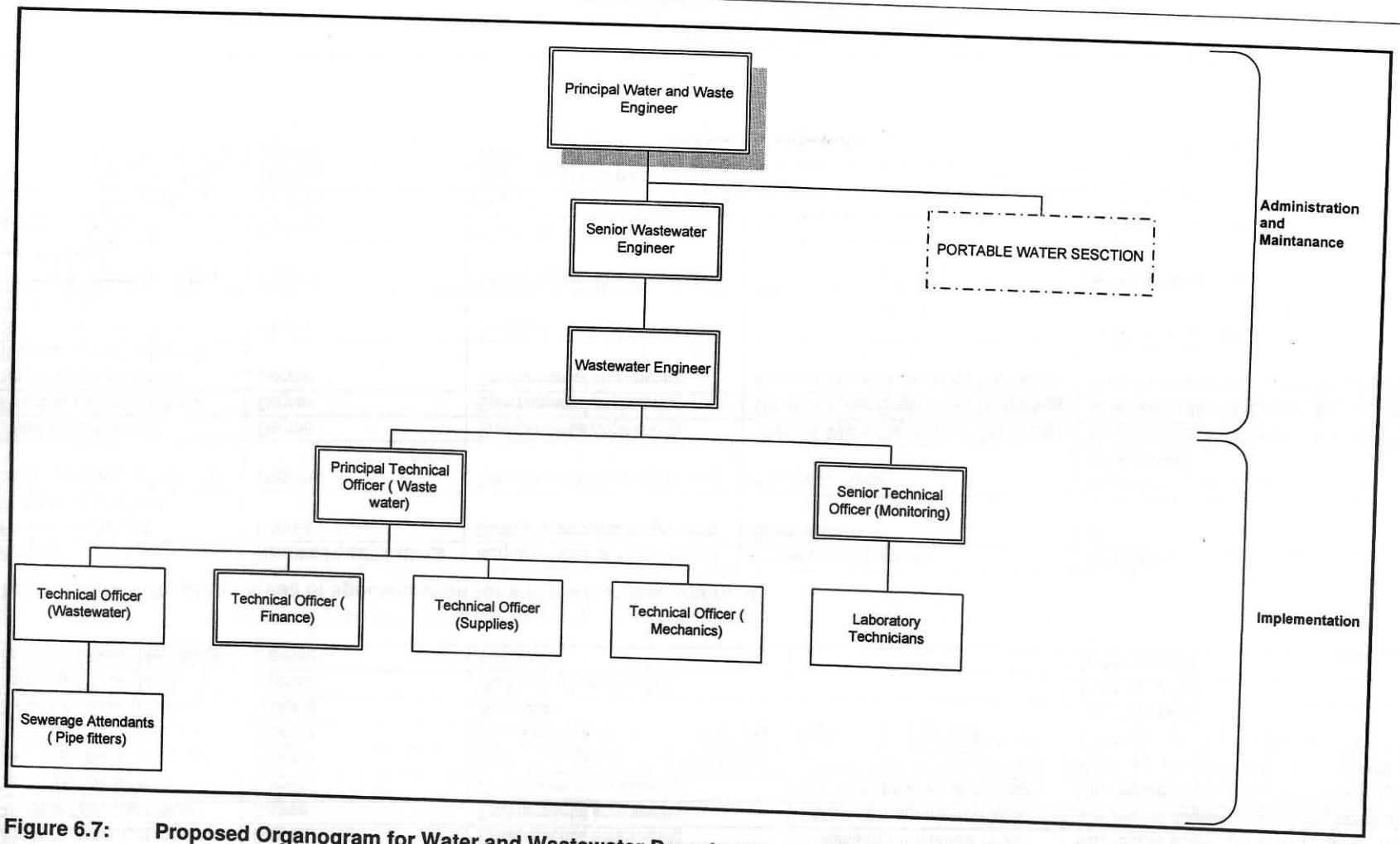

Figure 6.7: Proposed Organogram for Water and Wastewater Department

Table 6.2: Required areas of specialization for waste management

Position	Required qualifications	Required area of specialization	Current qualifications	Comments
Principal Sanitation Officer	Post-graduate diploma/degree	Environmental/Civil engineering/Environmental health	MSc. Environmental Health	Ok
Senior Waste Management Officer	Post-graduate diploma/degree	Environmental/Civil engineering + waste management	BSc. Environmental Health	May require post-graduate diploma/degree (waste management)
Waste management officer	Degree	Environmental engineering	Diploma Environmental Health	May require degree (Environ. Engineering)
Principal Technical Officer	Degree	Environmental engineering	Diploma Environmental Health	May require degree (Environ. Engineering)
Senior Technical Officer	Degree	Environmental engineering	Certificate Environmental Health	May require degree (Environ. Engineering)
Technical Officer (Collection)	Diploma	Waste management/Civil engineering	Certificate Environmental Health	May require diploma (waste management or equivalent)
Technical Officer (Disposal)	Diploma	Waste management/Civil Engineering	Certificate Environmental Health	May require diploma (waste management or equivalent)
Technical Officer (Finance)	Diploma	Accounts	-	To be seconded
Technical Officer (Supplies)	Diploma	Purchasing/Procurement	-	To be seconded
Technical Officer (Mechanics)	Diploma	Mechanics	-	To be seconded

Table 6.3: Required areas of specialization for wastewater management

Position	Required qualifications	Required area of specializtion	Current qualifications	Comments
Principal Water and Wastewater Engineer	Degree	Civil/Environmental engineering	BEng. (Civil)	ok
Senior Wastewater Engineer	Degree	Environmental/Civil engineering	BSc. (Mechanical)	May require post-graduate diploma/degree (Wastewater Engineering)
Wastewater Engineer	Degree	Environmental engineering	Diploma, Water Engineering Technology	May require degree (Environ. Engineering)
Principal Technical Officer	Degree	Environmental engineering	Diploma, Water Engineering Technology	May require degree (Environ. Engineering)
Senior Technical Officer (Collection and Treatment)	Degree	Environmental engineering	Diploma, Water Engineering Technology	May require degree (Environ. Engineering)
Senior Technical Officer (Monitoring)	Degree	Analytical Chemistry	-	Need to be recruited
Technical Officer (Collection and Treatment)	Diploma	Environmental/Civil Engineering	-	Need to be recruited
Laboratory technicians	Diploma	Chemistry	-	Need to be recruited
Technical Officer (Finance)	Diploma	Accounts	-	To be seconded
Technical Officer (Supplies)	Diploma	Purchasing/Procurement	--	To be seconded
Technical Officer (Mechanics)	Diploma	Mechanics	-	To be seconded

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6.5 Financial Implications of the Strategy

Some of the proposals in the action plan do not require capital investment. In cases where capital investment is required, estimates for such investment are provided in Table 6.4. The estimates provided in Table 6.4 do not account for inflation and depreciation and only serve as a guide on the magnitude of investment that might be required to realize the objectives of the strategy. One of the main recommendations of the strategy is organizational reform. However, costs estimates for organizational reform and institutional capacity building through training and re-deployment have not been carried out. It is expected that funding for the proposal in the strategy will come from regular developmental and operational budgets.

6.6 Strategy Review and Evaluation

It is proposed that for the first two years, the strategic intentions should be reviewed bi-annually and remedial action taken where there appears to be limited success. For subsequent years after the first two years, the strategic intentions should be reviewed annually. It is proposed that at the end of the strategy period, there must be a comprehensive evaluation of the strategy in terms of achieving its set objectives.

Table 6.4: Estimated costs of proposed actions

Action required	Implementing Stakeholders	Costs (000 Pula) over Strategy Periods					
		2006	2007	2008	2009	2010	2011
Develop a computerised waste information management system	EHD, WWD	50					
Develop by-laws and local rules and regulations	EHD, WWD	3					
Develop standard bin policy	EHD	-	10				
Develop prototype transfer stations for piloting	EHD			175			
Replicate transfer station after piloting to settlements with <3000 people	EHD			4 000	4 000	4 000	4 000
Outsource primary collection to private collectors for settlements with >3000 people	EHD			336	336	336	336
Outsource primary collection to micro-enterprises for settlements with <3000 people	EHD			42	42	42	42
Assign performance monitoring of micro-enterprises to village level institutions	EHD, Village Institutions			1 500	1 500	1 500	1 500
Provide only secondary collection for settlements with <3000 people	EHD	-					
Set collection performance targets and monitor quarterly	EHD	-					
Attach qualified mechanics permanently to waste management departments	EHD, WWD, Engineering						
Establish tourism waste collection fund	EHD, WWD, Tour operators		100	100	100	100	100
Establish a recycling centre for metal cans (Pilot first) see Appendix B	Collect-A-Can agent, EHD		LAND				
Source a partner to establish recycling centre for glass	EHD		LAND				
Purchase 3 additional clinical waste vans	EHD, Clinics		600				
Collect all clinical waste for incineration	EHD, Clinics		100	100	100	100	100
Build an incinerator at Gumare Primary Hospital	EHD, Ministry of Health			1 000			
Establish a disposal site with operational controls in Okavango (see Appendix C)	EHD			7 000	1 000	1 000	1 000
Design a prototype septic tank	WWD		5				
Inspect all wastewater treatment systems and recommend upgrading	WWD	50					
Phase out conservatories	WWD						
Monitor solid and liquid waste on a regular basis	WWD		500				
Upgrade Maun sewer network to increase capacity and spatial coverage	WWD, NWDC, Water Affairs				6 000		
Pilot septic tank and wetland systems for lodges/camps with >30 people (Appendix A)	WWD, Lodges, Camps		300				
Pilot disposing of water into interfluve areas of the delta	WWD, lodges, Camps		-				
Hold a stakeholder meeting with used oil generators	WWD, EHD, Stakeholders	2					
Restructure local authority waste management departments	WWD, EHD, NWDC	-					
Develop a cost recovery policy	WWD, EHD				3		
Device mechanisms for ensuring that all household pay for waste collection	EHD				3		
Launch Public Education and Awareness Programme (PE& AP)	EHD, WWD, enlist NGOs	10	5	5	5	5	5
Measure success of PE & AP	EHD, WWD						
Evaluate Strategy							
TOTALS		**113**	**1 615**	**14 258**	**13 089**	**7 083**	**7 083**

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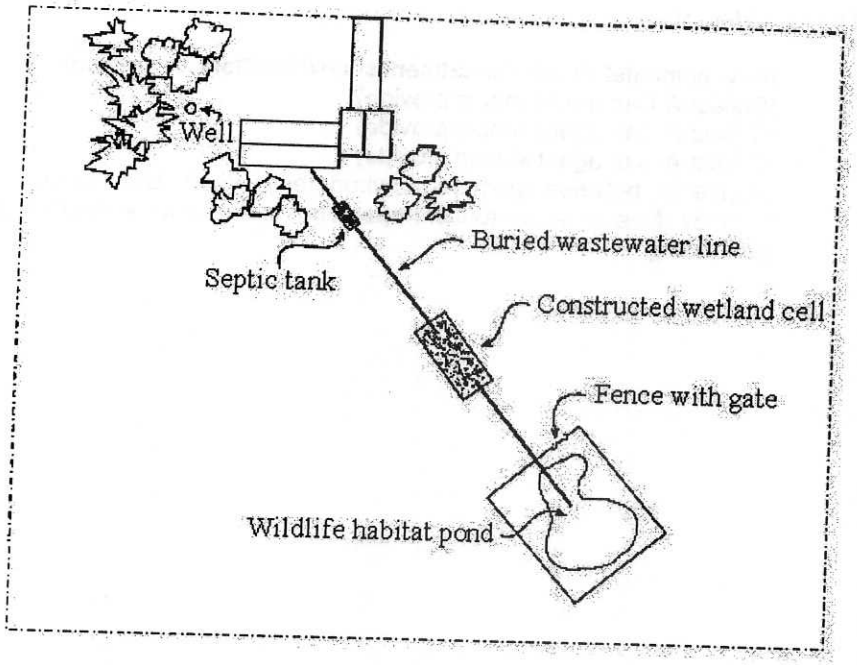
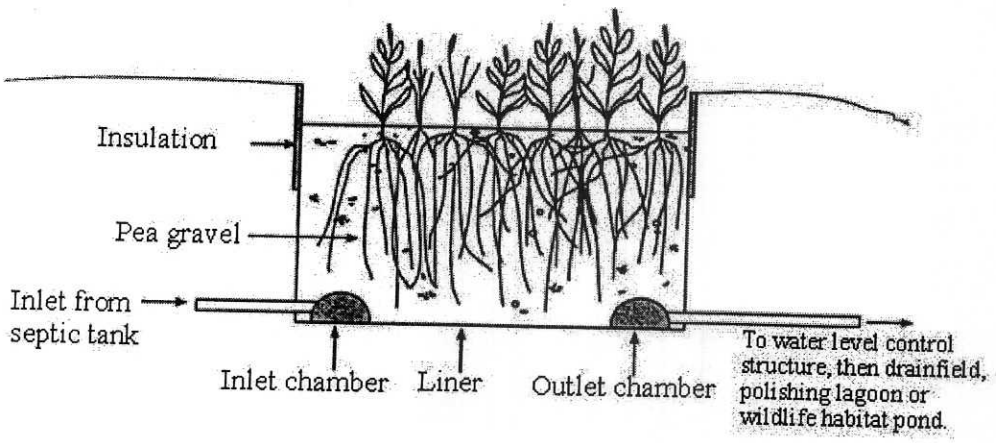
APPENDIX A: Proposed wastewater treatment pilot project: Septic tank/ constructed wetland coupled system

Studies have shown that septic coupled with constructed wetland as shown in the figure below can significantly reduce pollutant load in wastewater. It is proposed that such a system be piloted with wastewater generating facilities of more than 30 inhabitants. The nature of the pilot system should be to the design and specification of an engineer.





Source: Hygnstrom et al. (2002)

APPENDIX B: Proposed pilot project: Metal Can Recycling Centre

It was reported in section 4.1.7 that there is a steel beverage metal can recycling initiative by a Collect-A-Can agent in Maun. These activities are mainly targeting collection of such waste at pubs and disposal sites. In order to sustain and enhance these initiatives, it is proposed that a recycling centre be set up with the involvement of Collect-A-Can agent and the Environmental Health Department to intercept the cans before they reach disposal sites.

Project Requirements and stakeholder roles

Land	(Environmental Health Department should facilitate acquisition)
Metal can receptacles	(Collect-A-Can agent should provide)
Metal can crushers	(Collect-A-Can agent should provide)
Fencing for the land	(Collect-A-Can agent should provide)
Public education	(Joint effort between agent and Environmental Health Department)
Source separation	(Already done by some tourism operations but should be encouraged for all generators)

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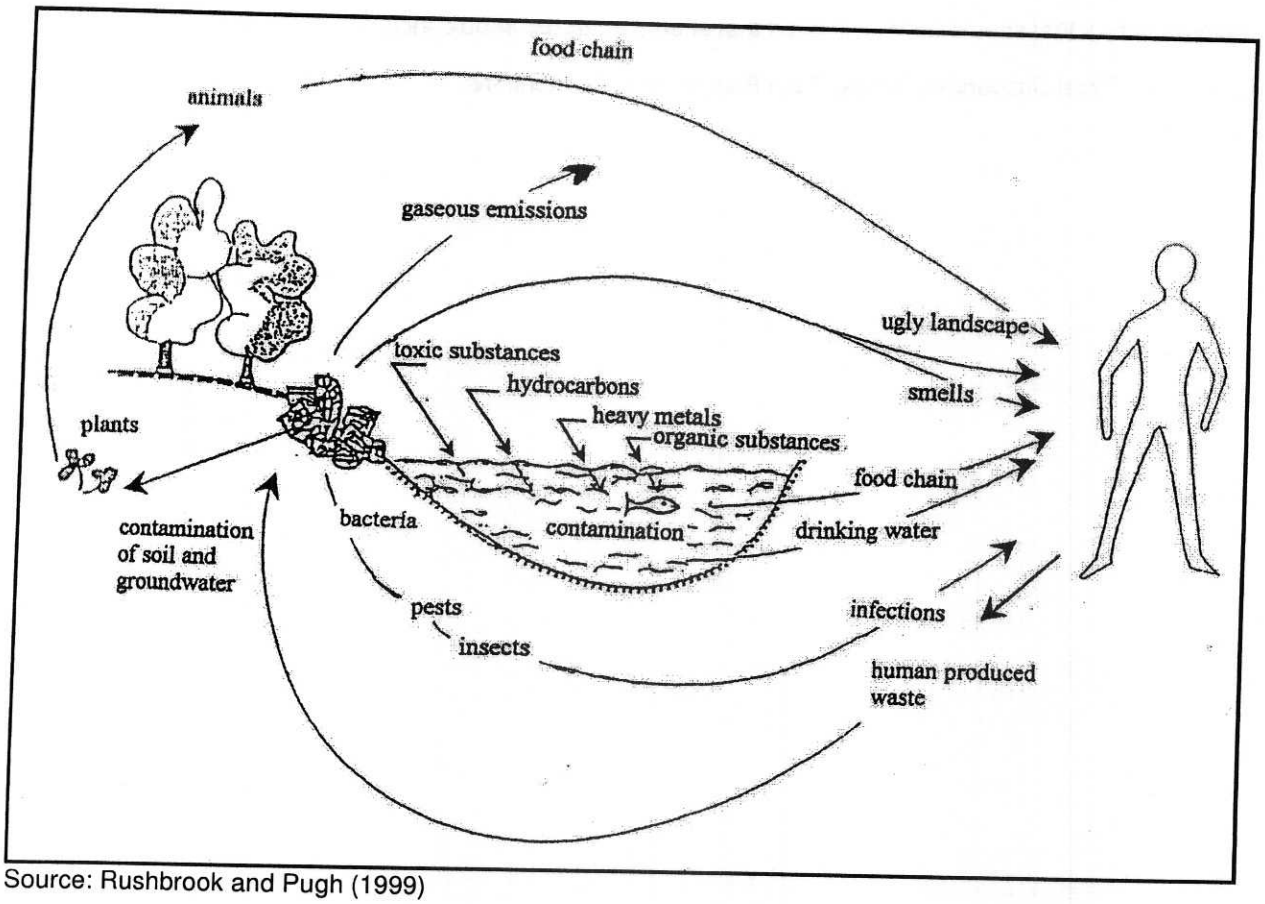
APPENDIX C: Open Dump with controls

The majority of waste disposal within the Okavango Delta Ramsar Site is through open dumping. The problems associated with open dumping are depicted in the figure below. Apart from that, several open dump sites present numerous point sources of pollution and are costly to rehabilitate. In order minimize these problems, it is recommended that a centrally located controlled dump be established for Okavango Sub-District. The required controls should include:

- Dividing the disposal site into manageable working areas
- Covering waste with soil, sand or any other convenient material
- Stopping fires
- Agreeing to rules of on-site work with waste pickers
- Developing a closure plan



Source: Rushbrook and Pugh (1999)

APPENDIX D: Monitoring effluent quality and contamination of surface and groundwater sources

It is proposed within the report that effluent quality information should be a component of waste information systems. This is an important aspect of monitoring possible changes in contaminant loading from effluent sources and their possible environmental impacts. It is proposed that effluent from selected wastewater treatment facilities, groundwater and surface water sources in their environs be sampled and analyzed twice in a year. The target wastewater generators should include:

- 1 lodge/camp using septic tank and soakaway system
- 1 institution using septic tank and soakaway system
- 1 commercial enterprise using septic tank and soakaway system
- 1 household using septic tank and soakaway system
- Travel path of houseboats

The parameters that should be investigated that should analyzed should include

BOD_5, COD, Total Suspended Solids, Total Phosphorus, Ammonia-N

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