FIELD REPORT

INTEGRATED ASSESSMENT OF HAZARDOUS WASTE MANAGEMENT IN BOTSWANA

WASH Field Report No. 421
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Prepared for the USAID Mission to Botswana
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by

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and
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RELATED WASH REPORTS

Market Survey of Solid Waste Management, Port-au-Prince, Haiti, September 10-28, 1990 (Volumes I and II). WASH Field Report 319. February 1991. Prepared by Philip Roark, Menajem Bessalel, David Dalmat, and Kevin Murray. (Available in English and French.)

Guidelines for Improving Wastewater and Solid Waste Management. WASH Technical Report 88. August 1993. Prepared by Richard N. Andrews, William B. Lord, Lawrence J. O'Toole, and L. Fernando Requena, with assistance from E. Brantly, P. Roark, and F. Rosensweig. (Available in English and Spanish.)

CONTENTS

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ACRONYMS

A.I.D.	United States Agency for International Development
BOCCIM	Botswana Confederation of Commerce Industry and Manpower
CHSD	Community Health Services Department
DCE	Department of Customs and Excise
DIA	Department of Industrial Affairs
DOM	Department of Mines
DTRP	Department of Town and Regional Planning
DWA	Department of Water Affairs
EIA	environmental impact assessment
ELO	Environmental Liaison Officer
FAP	Financial Assistance Program
GIS	geographic information system
HAP	hazardous air pollutant
HTW	hazardous and toxic wastes
kg	kilogram
l	liter
MCI	Ministry of Commerce and Industry
MFDP	Ministry of Finance and Development Planning
MLGLH	Ministry of Local Government, Lands, and Housing
MLHA	Ministry of Labor and Home Affairs
MMRWA	Ministry of Mineral Resources and Water Affairs
MOA	Ministry of Agriculture
MOH	Ministry of Health
MSDS	Material Safety Data Sheet
NCS	National Conservation Strategy

NCSA	National Conservation Strategy (Coordinating) Agency
NCSB	National Conservation Strategy Advisory Board
NDP	National Development Plan
NGO	nongovernmental organization
NWMP	National Water Master Plan
PCBs	Polychlorinated Biphenyls
POL	petroleum, oil, and lubricants
TSD	treatment, storage, and disposal
UNEP	United Nations Environment Program
VOC	volatile organic compounds
WASH	Water and Sanitation for Health Project
WHO	World Health Organization

EXECUTIVE SUMMARY

This report assesses hazardous waste management in Botswana, characterizes the country's policy and technical needs, and offers recommendations on establishing a hazardous waste management program. These recommendations are provided to the Botswana National Conservation Strategy (Coordinating) Agency (NCSA) and its reference group, for review and adoption.

For this study, hazardous wastes are defined as non-radioactive wastes that, by reason of their chemical reactivity or toxic, explosive, corrosive, or other characteristics, endanger health and the environment and are legally defined as hazardous in the state in which they are generated, transported, or disposed. (Batstone et al., 1989.) Medical waste is also covered by this study because hazardous waste is generated during a number of activities.

This study is designed to provide a qualitative assessment of the current situation as a basis for developing and prioritizing options for improving hazardous waste management. The analysis covers technical, policy, and institutional issues of public health, water quality, and environmental degradation. The report provides a framework for an ongoing strategy that may be implemented by the NCSA and its reference group. Primary users are anticipated to be the NCSA and other interested government entities.

Field work involved gathering data from several sources. Legislation, regulations, guidelines, and other policy statements were reviewed, as were reports from previous investigations. Interviews were conducted with representatives of most national departments and ministries responsible for hazardous and toxic waste (HTW) policy. Discussions were held with local officials in the nation's two largest settlements, Gaborone and Francistown. Site visits were made to a public hospital and selected private HTW generators in these cities. Review and feedback from the NCSA and its reference group on HTW was obtained at several stages in the project effort, via both meetings and written comments on draft reports.

Botswana has little reliable information on the quantity of hazardous waste generated. Primary HTW-generating activities include motor vehicle repair and maintenance, heavy equipment maintenance, paint manufacturing, pesticide use, mining activities, medical care, tanneries, dry cleaning operations, and timber treatment. HTW produced in these activities include waste oil, petroleum products, solvents, heavy metals, organochlorine pesticides, organophosphate pesticides, acids, and alkalis. Hazardous wastes are also produced by incineration of medical wastes and other wastes.

Only a small fraction of Botswana's hazardous waste receives safe treatment, storage, and disposal (TSD). Disposal of HTW with general wastes, co-disposal, is the rule. Among the few exceptions are isolated safe recycling programs undertaken with the assistance of manufacturers or distributors.

Waste oil is dumped in sewers, storm drains, on the ground, at the local dump, and on generators' own plots. In a few cases, such as the motor racing track in Gaborone, waste oil is sprayed on the ground for dust control. Chemical wastes are typically poured down the sewer or dumped at landfills. Medical waste is incinerated along with general wastes, and incinerator ash is hauled to landfills. In many cases, medical waste is directly landfilled without treatment.

The environmental or health effects of hazardous waste in Botswana are seldom documented. However, there is alarming evidence of water contamination by other pollutants and toxic upsets at sewage facilities. Anecdotal stories also allege damage to the environment and human and animal health.

Numerous national laws and regulations guide management of HTW. Water and air pollution, public health, local planning, and industrial licensing provisions constitute part of the policy framework, as does the National Conservation Strategy (NCS) and several policies under development. However, Botswana has no specific policy on HTW management. Present policy lacks provisions on importing and tracking HTW, recording quantities of HTW generated, designating acceptable disposal options, monitoring and enforcement, gathering statistics, offering incentives for HTW management, or providing HTW education.

The institutional setting for policy and its implementation is marked by considerable complexity. Administrative units involved include the National Conservation Strategy Advisory Board (NCSB) and NCSA, the Department of Water Affairs, the Community Health Services Department, the Department of Regional and Town Planning, the Department of Industrial Affairs, the Department of Mines, and the Factory Inspectorate within the Ministry of Labor and Home Affairs. The Ministries of Agriculture and Education also play significant roles. At the local level, the elected councils and their health inspectors are critical in setting and enforcing HTW policy. Parastatal organizations also influence development and generate waste, as do many private commercial and manufacturing organizations. Several government institutions receive and use general policy guidance on HTW management. However, overall management is hampered by policy gaps, limited resources, and a lack of coordination, especially during implementation.

This report recommends technical and policy changes for managing HTW. Policy recommendations address regulations, incentives, education and training, and institutional development. Highest priority recommendations include options to complete development of a hazardous waste management strategy. These recommendations are summarized as follows:

- Develop a specific HTW policy by the NCSA and its reference group in conformance with the NCS. Specifically, the policy should define and classify hazardous and toxic wastes; regulate their shipments; encourage pollution prevention and recycling; protect water quality; establish risk-based management; develop a detailed HTW management system; require interdepartmental coordination; include environmental criteria in development decision-making; and evaluate TSD technologies.
- Resolve coordination and fragmentation issues.

- Complete broader environmental policy, as outlined in the NCS.
- Prohibit importation of banned hazardous materials and HTW. At a minimum, a temporary provision should be adopted to prevent the dumping of prohibited waste, while a more flexible and appropriate provision can be developed.
- Designate NCSA to coordinate HTW policy and increase its personnel and financial resources accordingly.

Once HTW policy is established, attention can be paid to several more specific elements of HTW management. These include:

- Waste segregation
- Waste tracking
- Gathering information on HTW quantities and international guidelines
- Identifying and implementing safe storage
- Implementing guidelines from the DWA groundwater protection report (DWA, 1993c)
- Enhancing the effectiveness of regulatory agencies

The report's priority recommendations are the minimum requirements for improved HTW management. They preserve the current coordinating role of the NCSA and Advisory Board while enhancing the Agency's HTW management capacities regarding policy development, liaison, and information. Fully coordinated HTW management may require further enhancement of these measures, such as consolidated permitting. Effective HTW management may require measures such as consolidated permitting. If these efforts do not induce sufficient coordination, responsibility for HTW policy implementation may need to be consolidated in NCSA, another existing ministry, or an environmental ministry.

The report also proposes a number of options for technical, education, and coordination issues.

- Evaluate appropriate TSD options for use in Botswana.
- Provide incentives to waste generators who use or implement pollution prevention activities.
- Develop a placarding system for transport of hazardous materials.
- Certify commercial pesticide users.
- Improve laboratory analysis procedures.
- Provide training to emergency response officials.

Much of what needs to be done can be completed successfully through the use of internal personnel and financial resources. For some options, outside experts and financial assistance may be needed.

Prompt attention to HTW management can prevent Botswana from experiencing the serious environmental damage and public health problems that have plagued other developed (industrialized) countries.

Chapter 1

INTRODUCTION

1.1 Purpose

This report assesses hazardous waste management in Botswana, characterizes the country's policy and technical needs, offers recommendations on establishing a hazardous waste management program, and proposes a strategy to implement recommendations. These recommendations are provided to the Botswana National Conservation Strategy (Coordinating) Agency (NCSA) and its reference group, for review and adoption. While this report concentrates on the management of hazardous wastes, its finding and recommendations are generally applicable to overall environmental management in Botswana.

The Water and Sanitation for Health Project (WASH) undertook this assignment at the request of the NCSA through the United States Agency for International Development (A.I.D.).

1.2 Scope

This study assesses current hazardous waste practices and policy and offers suggestions for technical, policy, and institutional improvements. These recommendations are proposed for adoption by the NCSA, its reference group, and other Batswana officials.

The assessment was not designed to quantify hazardous waste generation or its impact nor was it intended to identify all possible options for hazardous waste management. Instead, the report presents an overview of the country's hazardous waste problem and provides a foundation of information along with the framework and rationale for comprehensive hazardous waste management. Field work was done primarily in Gaborone, the capital, but also in Francistown and Lobatse. Appendix A contains the complete scope of work for this study.

1.3 Approach

The hazardous waste situation in Botswana was examined using an integrated environmental assessment. As a consequence, this analysis considers both the hazardous and toxic wastes (HTW) generated and the institutions and policies that address waste removal and disposal. Using this broader approach, the report considers alternatives to HTW generation and recommends regulation of HTW imports, generation, treatment, storage, and disposal; public health efforts to minimize exposure; and resource management to safeguard valuable resources. The HTW analysis concentrates on risk reduction, pollution prevention, cost recovery and equity, appropriate technology, and the efficiency and effectiveness of HTW management.

Field work involved gathering information from several sources during June 1993. Legislation, regulations, guidelines, and other policy statements and plans were reviewed, as were reports from previous investigations. Data were also gathered from the Statistics Unit of the Department of Customs and Excise, the Department of Industrial Affairs, and the national telephone directory. Results of a survey by the Community Health Services Department (CHSD) on local handling of medical wastes were reviewed.

Team members also interviewed national government officials, local officials in Gaborone and Francistown, staff at a public hospital, and private HTW generators in Gaborone and Francistown, and Lobatse. Discussions were also held with managers of one company involved in recycling, plus a representative of the Botswana Confederation of Commerce Industry & Manpower (BOCCIM). Finally, the authors received feedback from the NCSA and its reference group at several stages during the project. The people contacted in this investigation are listed in Appendix B.

1.4 Country Profile

Botswana is a young country which attained self government in 1965 and became the independent Republic of Botswana on September 30, 1966. It has a unicameral legislature, the National Assembly. The House of Chiefs advises on matters of custom and tradition but has no legislative power. The country has an independent judiciary with a high court presided over by the chief justice. Botswana's capital is Gaborone.

The central government is administered through nine ministries. The civil service is headed by the permanent secretary to the president and each ministry is headed by a permanent secretary. The country has ten administrative districts and nine district councils. The central government is represented by the District Administrations. Gaborone has a city council; Francistown, Lobatse, Selebi-Phikwe, and Jwaneng have town councils. District Councils serve the remaining settlements. Much of the population of approximately 1.3 million is concentrated in the eastern region between Francistown and Lobatse.

The landlocked country straddles the Tropic of Capricorn and has a land area of approximately 582,000 square kilometers. Botswana is mostly flat; its elevation ranges between 500 meters and 1,200 meters. The climate is mainly arid or semi-arid. Rainfall averages 650 millimeters in the extreme northwest and less than 250 mm in the extreme southwest. Almost all rain falls between October and April in scattered showers and thunderstorms.

Northern Botswana is dominated by the Okavango River delta and plains. North-central Botswana consists of the Makgadikgadi Pans. The central-eastern region contains the Limpopo Valley system that includes the Limpopo River and the Shashe River and has more fertile soils than other regions. The rest of the country is covered by the thick sand layers of the Kalahari Desert. Average maximum temperatures range from 22° Centigrade (C) in July to 33° C in January. Average minimum temperature between June and August is 5° C.

Under Botswana's clear skies the sun shines an average of 8 to 10 hours per day. Evaporation rates in Botswana are high, ranging from 1.8 to 2.8 meters of surface water per year. Gaborone's climate is prone to inversions, cold air trapping warm air close to the ground.

Both surface water and groundwater resources serve the needs of the country. Surface water is concentrated in the thinly populated Chobe and Ngamiland Districts, site of the Okavango Delta and the Kwando, Chobe, and Linyanti rivers. These are the country's only perennial natural surface waters. Gaborone and Shashe have major dams that serve Gaborone, Francistown, and Selebi-Phikwe. Groundwater lies very deep beneath the Kgalagadi Desert. Its great depth inhibits recharge.

Water is located nearer the surface in geologic formations of calcrete, silicrete, and ferricete. Groundwater usually lies between 30 and 100 meters below ground surface in eastern Botswana. An ongoing project by the Department of Water Affairs (DWA) describes major aquifers, well fields, and dams, as part of an effort to define protection zones and guidelines for pollution prevention (DWA, 1993a, 1993b, 1993c).

The country is rich in mineral resources, including diamonds, gold, copper-nickel, soda ash, and coal. Diamond revenue sparked the economy's rapid development, growing infrastructure, and expanding government services. The rapid economic growth has also been assisted by the country's beef industry and a commercial sector. Substantial economic development continues, though fluctuations in revenue from external investment have affected recent budgets.

Chapter 2

GENERATORS, TREATMENT, DISPOSAL, AND IMPACT

The following sections provide an overview of Botswana's waste generation and waste disposal. Also discussed is the impact of hazardous waste on the country's environment and public health. Trends and potential impacts are also identified. The information-gathering process is described above in Section 1.3. The lack of a consistent definition of hazardous waste, as well as the differing levels of understanding about hazardous waste in general among interested parties, limits the amount and availability of information on hazardous waste. Specific data and information regarding the described activities are therefore supplemented by assumptions that are normally associated with the given activity.

Materials are typically designated as hazardous waste based on characteristics of the waste, the waste source, and specific waste listings. The characteristics that make wastes hazardous include: chemical reactivity, toxicity, explosivity, and corrosivity. Thus, the term hazardous waste includes "toxic" wastes. The common acronym for hazardous and toxic waste is HTW.

An *Ad Hoc* Working Group of Experts on the Environmentally Sound Management of Hazardous Wastes, convened under the auspices of the United Nations Environmental Program (UNEP) in December 1985, gave this definition of hazardous waste:

"Hazardous wastes means wastes other than radioactive wastes which by reason of the chemical reactivity or toxic, explosive, corrosive or other characteristics causing danger or likely to cause danger to health and the environment, whether alone or by coming into contact with other wastes, are legally defined as hazardous in the State in which they are generated or which they are disposed of or through which they are transported." (Batstone et al., 1989)

The definition includes solid, liquid, and gaseous wastes, sludges, or contaminated containers, and specifically excludes radioactive wastes and domestic wastes. HTW originates from a variety of industrial, agricultural, commercial, and transportation activities in both the public and private sectors.

Some medical wastes are considered hazardous wastes, although in general medical wastes usually are excluded. Medical wastes considered hazardous include some chemicals used in laboratories and for cleaning, as well as certain pharmaceuticals, such as anti-neoplastics that are used in cancer therapy, and other carcinogenic or toxic agents.

This study includes in its consideration of hazardous waste all the substances in the UNEP working group's definition, plus some medical waste and petroleum, oil, and lubricants (POL), particularly waste oil.

2.1 HTW Generators

Generators and potential generators of HTW were identified in both the public and private sectors. With the exception of mining activities, there is a limited industrialized sector in Botswana's economy. This results in relatively equal HTW generation by the public and private sectors. This is particularly true of waste oil and medical wastes. The HTW quantities presented in Section 2.1.2 are only estimates. No precise data were available for any of the wastes assessed.

2.1.1 Identification of HTW Generators

A variety of activities in Botswana produce HTW (see Table 1). A study conducted for the Department of Water Affairs (WLPU, 1990) identified the magnitude and sources of water pollution in Botswana. This study covered all waste types. While specific data on hazardous waste were limited, this report provides useful information.

Waste oil and other petroleum products are prevalent hazardous wastes in Botswana. These wastes are produced by vehicle and equipment repair, power generation, and the maintenance and manufacturing. Such activities generate waste oils and waste solvents. Diesel, leaded gasoline, and paraffin (kerosene) also contribute to hazardous waste generation through spills, tank leakage, and other accidental discharges. Previous inventories for storage of these products are included in other studies (WLPU, 1990). The continued use of leaded gas in the country further contributes to the toxicity of both the liquid waste and gaseous waste (vehicle exhaust).

Polychlorinated biphenyls (PCBs) were used in transformer oils until approximately five years ago. As a result, many transformers still contain PCBs.

Table 1

Identification of Hazardous Waste Generators

ACTIVITY	NUMBER OF FACILITIES[a]	WASTES
Agricultural Pesticide Use	multiple	outdated products, residues, and spills
Vector Control	multiple	outdated products, residues, and spills
Auto Repair Shops	25	waste oil, solvents, and other petroleum products
Battery Manufacturers	3	lead, acids, solvents, heavy metals
Botswana Defense Force	multiple[b]	waste oil, solvents, and other petroleum products
Botswana Vaccine Institute	1	laboratory chemicals and cleaning agents
Central Transport Agency	multiple[b]	waste oil, solvents, and other petroleum products
Chemical Distributors	11	outdated chemicals and chemical residues
Dry Cleaners	8	solvents (perchloroethylene)
Heavy Equipment Maintenance (private)	6	waste oil, solvents, and other petroleum products
Hospitals[c]	31	laboratory chemicals, cleaning agents, mercury, and products of incomplete combustion (heavy metals, furans, dioxins)
Public Medical Clinics[d]	multiple	laboratory chemicals, cleaning agents, mercury, and products of incomplete combustion (heavy metals, furans, dioxins)
Laboratories (not incl. hospitals)	3	solvents, acids, and heavy metals
Mining-Copper and Nickel[e, f]	1	acids and heavy metals
Mining-Gold[e, f]	1	cyanide and heavy metals
Mining-Coal	1	acids
Paint Manufacturing	2	solvents and lead
Pharmaceutical Manufacturing	3	organic chemicals

ACTIVITY	NUMBER OF FACILITIES[a]	WASTES
Photographic Laboratories	15	silver, acids, and solvents
Power Production	3	volatile organic compounds (VOCs), heavy metals, and acid
Printers	15	acids, solvents, inks, and dyes
Soap Manufacturing	1	acids
Tanning of Hides	2	acids, chromium, and solvents
Textile Manufacturing	2	dyes
Botswana Railways	multiple[b]	waste oil, solvents, and other petroleum products
Timber Treatment	2	insecticides
Households	multiple	pesticides, cleaning agents, and waste oil

Notes:
a. These estimates are based on data from the Department of Industrial Affairs (DIA) statistics, the Botswana telephone book, WPLU report (1990), the city of Gaborone (1993), interviews, and other sources. All published data are outdated and likely understate HTW generation.
b. The data cover all facilities of these government agencies and parastatals.
c. This figure includes government hospitals, totalling as of 1991 2 referral hospitals, 13 district hospitals, 13 primary hospitals, and 3 private hospitals.
d. This category includes 182 government clinics (1991 figures). Totals for private clinics were unavailable.
e. Several small mines are not included in this tally.
f. No wastewater is discharged directly; 80-100% is recycled.

Despite growth in industry and commerce, there is little manufacturing in Botswana. Most manufacturing consists of assembling imported parts, repackaging, and mixing base materials. For example, although Table 1 lists 11 chemical manufacturers and distributors, it is uncertain that any of these companies actually produce chemicals in Botswana. This study did not identify any facilities that produced chemicals in Botswana. As a result, hazardous waste generated by these companies comes from spills, disposal of outdated chemicals, and residues in used containers.

Pesticides used in commercial agriculture and vector control may also generate HTW released during spills, disposal of containers, and disposal of outdated or surplus chemicals. Only about 20 percent of Botswana's agriculture is commercial. The remainder is subsistence farming, where high costs probably restrict the use of pesticides. Table 2 lists the pesticides believed to be in current use. The list contains at least two pesticides, Chlordane and DDT, that are banned in the United States.

Table 2

Pesticides Currently Sold, Used, or Stored in Botswana

Insecticides:

Aldrin, Allethrin, Alphamethrin, Amitraz, Bendiocarb, BHC, Carbaryl, Carbofuran, Chlordane, Chlorophyrifos, Cyfluthrin, Cypermethrin, DDT, Demeton Methyl, Deltamethrin, Diazinon, Dichlorvos, Demeton-S-methyl Dimethoate, Diptrex, Endosulfan, Fenamiphos, Fenitrothion, Fenthion, Fenvalerate, Folithion, Malathion, Mevimphos, Methiocarb, Mercaptothion, Methamidophos, Methomyl, Mineral oils, Napthalene, Parathion, Permethrin, Pirimiphosmethyl, Phenthiote, Phostoxin, Terbufos, D, Tetramethrin, Tetramethrin, Trichlorfon

Fungicides:

Benomyl, Bupirimate, Brestan, Captan, Chlorothalonil, Cuprous Oxide, Copper Oxychloride, Dithane, Iprodione, Mancozeb, Mercaptothion, Pirimicarb, Propineb, Triadimefon, Triforine, Thiran Zineb

Herbicides:

2,4-D, Atrazine, Atrizene/Triazine (Gardomil), Basagram (Bentazon), Bromoxynil (Bentrol), Cycloxydim (Focus), Dicamba, Diuron, Fluazifop-butyl (Fusilade), Glyphosate (Roundup), Imazypar (Arsenal), Metolachlor (Dual), Paraquat (Gramoxone), MCPA, Triazine Metolachlor (Sorgomil), Trichlopyr, Trifluralin (Treflan), Terbuthylazine

Acaricides:

BHC, Toxaphene, Mevinphos, Amitraz, Propurgite, Ethylene dibromide

Molluscides:

Metaldehyde + Carbaryl

Nematodicides:

Feramiphos, Tebufos, Carbofuran, Ethylene dibromide

Rodenticides:

Brodifacoum, Zinc Sulphide, Ethylene Dibromide, Bromadiolone, Brodifacoum, Coumatetralyl, Wayfarin

Pesticides for public health use:

Pesticides used for public health are applied mainly to control vectors of malaria, primarily in the Okavango Region.

Note: All spellings [sic]

Sources: WLPU, 1990; Division of Plant Protection, 1992

Botswana has large quantities of pesticides supplied by donor agencies. These surpluses pose a storage and disposal challenge for the Ministry of Agriculture's (MOA) Division of Plant Protection.

Hazardous medical wastes include laboratory chemical wastes, cleaning agents, and mercury (from laboratories and medical monitoring equipment). All medical wastes except liquid chemicals are generally incinerated in poorly maintained incinerators or open pits. This incineration produces emissions of particulates, sulfur oxides, nitrogen oxides, heavy metals, hydrochloric acid, and other hazardous air pollutants. Incomplete burning of plastic also releases dioxins and furans, which are among the most toxic substances known. U.S. hospital incinerators, with and without air pollution control, have been shown to release high levels of hazardous air pollutants (HAP) and produce toxic ash. (U.S. EPA, 1988; Hagenmaier, et al. 1987). Medical laboratories also produce HTW that include heavy metals, solvents, and acids.

Mining of copper-nickel, gold, and coal also generate HTW. The high cost of water has prompted heavy use of recycled water in mining, reducing toxic wastewater discharges. Nevertheless, considerable HTW is generated. Gold mining's use of "Copperas" (Fe SO_4 . $7H_2O$) together with lime produces cyanide deposits (WLPU, 1990). Copper-nickel mining generates sulfates, heavy metals, and pyrates. Coal mining also produces ash containing heavy metals that may generate toxic leachates.

Asbestos is still used in building materials in Botswana, but is no longer being used in local manufacturing of building materials. Asbestos use and disposal are not regulated, and asbestos building materials are routinely imported from the Republic of South Africa, Botswana's primary source of imports.

Fossil-fuel power plants also produce heavy metals, volatile organic compounds (VOCs), and other toxic products of incomplete combustion.

While tires are not hazardous wastes, the burning of tires at landfills generates air pollutants, including HAPs.

Paint manufacturing uses petrochemical solvents and has high pollution potential in Botswana, according to a WLPU (1990) study. Tanneries in Francistown and Lobatse may release HTW from acids, heavy metal-based pigments, and solvents. The soap factory in Gaborone also may discharge hazardous alkaline wastewater. The soap factory discharges, however, are less significant in terms of HTW than they are in terms of conventional measures of biological oxygen demand and chemical oxygen demand.

Other generators of HTW include printers and photographic laboratories which use relatively small quantities of solvents, acid emulsions, and silver-coated films. Dry cleaning operations use large amounts of percloroethylene, a solvent. This solvent is toxic but less so than solvents (e.g., trichloroethylene) previously used in the industry.

Households generate HTW from auto maintenance and the use of pesticides and cleaning agents. Household HTW disposal is not usually regulated under formal management systems, but is instead addressed through public education programs.

Finally, as a result of the disposal practices described in Section 2.3, it is possible that sludge from municipal sewage treatment ponds contains heavy metals or other toxic materials.

2.1.2 Estimates of HTW Quantities

Virtually no information is readily available on the quantities of HTW generated in Botswana. As discussed in Section 2.3, HTW is seldom separated from other waste for special treatment or tracking. Waste loads can only be estimated from raw material use, production data, and import-export figures. In this assessment, statistical data from *The 1989 External Trade Statistics* (Department of Customs and Excise, 1992) are used. The magnitude of waste generated can also be inferred from prevailing industrial and manufacturing processes.

Table 3 shows 1989 data on imports of various hazardous materials. These customs statistics provide reasonable estimates of waste oil generation, as nearly all oils used for lubricating purposes become waste. Of the materials listed, petroleum products account for 7.758×10^6 liters of hazardous waste, the largest single source. These data probably underestimate the use of lubricating oil, since Botswana's imports of petroleum products have been increasing rapidly, approximately 95 percent between 1988 and 1989. Data for 1990-1992 will soon be available from the Department of Customs and Excise (DCE).

The largest paint manufacturer estimates that 200 to 400 liters of waste solvents are generated per month at the Gaborone plant. If this estimate is correct, the industry's total monthly waste solvent generation is approximately 1,000 liters.

Hazardous waste generation is proportionate to the level of activity in various industries. Thus, wastes from POL products are the most significant HTW, followed by wastes from medical facilities, dry cleaners, and pesticide use.

Quantity alone is not the critical factor in determining the risk or impact of waste. The degree of hazard and potential of exposure determine actual risk. Small quantities of highly toxic substances such as benzene can contaminate extremely large quantities of water. A single liter of a petroleum product can contaminate over one million liters of water.

2.2 Existing Treatment/Storage/Disposal Options

There are no hazardous waste treatment, storage, and disposal (TSD) options in Botswana. Disposal of HTW with general wastes, co-disposal, is the rule, except in a few cases where manufacturers or distributors have arranged safe recycling practices.

Waste oil is dumped in sewers, storm drains, on the ground, at the local dump, and on generators' own plots. In a few cases, such as at the motor racing track in Gaborone, waste oil is sprayed on the ground for dust control (Itshekeng, 1992). A local petroleum product distributor has initiated a waste-oil collection system for its customers. Still in its infancy, this program collects only a small percentage of the country's waste oil, and is economically marginal. The distributor, however, sees it as a marketing tool and a service to customers and

the country. The Gaborone Council is considering providing waste oil storage, but has no set plan or potential recycling firm yet identified.

Table 3

Imports of Hazardous or Potentially Hazardous Material

Material	Quantity
Lubricating Oils	7.758×10^6 liters
Lubricating Grease	2,628 kg
Benzene	6,301 liters
Toluene	2,198 liters
Xylene	2,241 liters
Ethylbenzene	75 kg
Hydraulic Brake Fluid	9,090 liters
Hydrochloric Acid	461,110 liters
Sulfuric Acid	299,025 kg
Cyanide	71,511 liters
Halogenated Hydrocarbons	45,555 kg
Photographic Emulsions	16,410 liters
Synthetic Tanning Substances	23,663 kg
Insecticides	332,489 kg
Fungicides	16,414 kg
Herbicides	24,220 kg

Source: Department of Customs and Excise, 1992

Waste chemicals are dumped in sewers, storm drains, or at local landfills, where waste sludges from industrial process settling tanks and sewage ponds are also dumped. Waste solvents from at least one paint manufacturer are used by the workers to control wood-eating ants at their home ranches.

General waste incinerators are used for a variety of wastes. These manually-operated batch incinerators are apparently incapable of reaching the temperatures or residence time necessary to achieve complete combustion. Moreover, no incinerators have air-pollution control equipment. The ash, often with visibly non-destructed material, is dumped in refuse landfills.

Wastewater recycling at all larger mines minimizes wastewater discharged from these activities. Gold mines recycle all wastewater, while the copper-nickel mine at Selebi-Phikwe recycles between 80 and 100 percent of its wastewater. (This high level of reuse reflects the high cost and scarcity of water.)

In one case, the Tsetse Control Program, pesticide users were able to return outdated and surplus pesticides to the manufacturer. This arrangement can be viable for buyers of large quantities of pesticides, who have greater leverage with suppliers. Growing awareness of global environmental concerns (and an interest in good public relations) is also making manufacturers more willing to accept returns of outdated pesticides and other chemical products.

Material substitution has occurred in Botswana as dry cleaners have followed the broader industry move to use perchloroethylene instead of the more toxic solvent used in years past. Other process improvements have helped reduce HTW in Botswana. For instance, pesticide use in the Tsetse Control Program has been reduced from 8×10^4 liters to just 300 liters through the use of pesticide-impregnated targets instead of aerial spraying.

A cement kiln proposed for Palapye is being considered as a means of incinerating used oil, some solvents, and, possibly, tires. This may be a feasible option. Modern cement kilns with state-of-the-art air pollution control technology are capable of achieving temperatures and retention time sufficient to incinerate these materials adequately. However, such incinerators must be properly operated and maintained to avoid HTW generation. Also, proper waste management must be employed to ensure that only suitable wastes are burned. Recent studies in the U.S. have revealed difficulties in maintaining safe emission levels with a number of incinerator and air pollution control equipment designs. Pre-siting risk assessment and proper waste management is needed to avoid adverse air quality and furnace damage.

2.3 Present Known/Suspected and Potential Impacts

Data are scarce on environmental or health damage caused by hazardous waste in Botswana. However, there are indications that the HTW problem is serious and getting worse.

Two previous studies (WLPU, 1990; DWA, 1993a, 1993b, 1993c) document degradation of surface water and groundwater from nitrates and bacterial contamination, which likely stems from pit latrines and sewage ponds. The presence of these contaminants in many boreholes indicates the potential for hazardous pollutant migration in these same areas.

Contamination of groundwater with leachate from poorly operated landfills is also suspected. An ongoing DWA project (DWA, 1993a, 1993b, 1993c) to define protection zones for major wellfields, aquifers, and dams has identified aquifers vulnerable to contamination because of high permeability and hydraulic conductivity. These vulnerable aquifers include some in the more developed region between Gaborone and Francistown.

Sewage ponds in Gaborone and Francistown do not achieve the treatment efficiency expected of such facilities (WLPU, 1990). Toxic shocks to the sewage oxidation ponds systems from receipt of trace heavy metals, halogenated solvents, other solvents, and acids have likely

affected treatment performance. The Francistown engineer has confirmed that such toxic shocks have occurred at the Francistown facilities. Such toxic shocks also are likely at the proposed activated sludge facility in Gaborone. Additional studies of effluent quality could provide useful information on the discharge of hazardous wastes to the sewer system.

Wastewater recycling at mines reduces or eliminates direct discharges to surface waters. Wastewater is discharged to the tailings dams and recycled back to the separation processes. Prior to the nearly complete recycling of wastewater at Selebi-Phikwe, elevated levels of heavy metals and sulfates were found in the surrounding Motloutse, Letlhakane, and Mathathane Rivers. The potential for tailings to leach from dams into groundwater has not been well studied but seems reasonably likely.

Serious degradation of surface water occurs when the tailings dams burst, as has occurred at all major dams in past years. Discharge of cyanide waste from the Monarch Mine from such a dam breakout contaminated a portion of the Tati River. As this event occurred during a drought period and the area was not fenced off, several cattle died from drinking the contaminated water.

Air pollution from inefficient incinerators, refuse burning, mine smelting, and power generation is visible. These emissions are not sampled for HAPs, but undoubtedly contain them. The volume of air pollution and the concentration of toxic constituents are increased through the burning of general wastes together with other wastes at medical facilities, refuse dumps, and other refuse-burning sites. In Gaborone, frequent thermal inversions increase the risk to human health from this air pollution.

The media have reported complaints about air pollution from residents of Selebi-Phikwe, the site of the copper-nickel mine operations.

Fish kills in the Okavango Delta caused by improper aerial spraying have demonstrated the environmental degradation that can occur because of poor use of pesticides.

Further industrialization, increased use of hazardous materials, and the continued lack of safe storage, treatment, and disposal may increase degradation of water and air quality.

2.4 Sorting and Ranking of Targets and Impacts

The sorting and ranking of targets (individuals or groups whose actions require modification) and impacts allow for the prioritization of intervention options. The targets identified above include a number of private and public sector generators of HTW. The impacts that should be prioritized include water quality degradation and air quality degradation. This environmental degradation affects public health and ecosystem health.

Protecting scarce water supplies is one of Botswana's most pressing concerns. Controlling waste oil and chemical discharges should therefore be priorities. Air pollution occurs in areas with large populations and can be partially addressed with low-cost modifications of waste management practices. Improvements in the sterilization of medical waste are also needed.

Finally, the country should establish separate collection, handling, and disposal for all hazardous wastes. All generators are targets for the initiation of waste segregation activities, with safe storage if necessary, as this facilitates waste quantification and minimizes immediate impacts. Small quantity generators of less hazardous materials such as photo shops and printers are of lower priority.

Chapter 3

THE PRESENT SITUATION: POLICIES AND INSTITUTIONS

The following sections describe the policies and institutions that influence HTW management in Botswana.

3.1 Policies

Although the Republic of Botswana has enacted several policies and regulations that bear indirectly on HTW management within the country. However, there is as yet no policy that specifically addresses the subject of HTW. However, hazardous and toxic wastes are a growing concern for several ministries and various local councils. The procedures now utilized for HTW management are often similar to those for waste management more generally. The results of this policy situation can be seen in many of the impacts summarized in Chapter 2.

3.1.1 Current Policies and Policies under Development

The most important policies affecting HTW management are listed in Table 4, along with the institutions primarily responsible for their implementation. Although not included in this list, National Development Plan 7 (1991-1997) also guides government HTW action and supports many policy goals discussed in this section.

The NCS, Government Paper No. 1 of 1990, establishes the importance of national policy on natural resource conservation and development for the Republic of Botswana; authorizes the creation of the NCSB and Agency; identifies major environmental issues; outlines a strategy for action; and sketches several "solution packages" for implementation. HTW are not specifically addressed. However, the strategy mandates specific steps to develop more comprehensive environmental policy. These include:

- A requirement for a new "NCS Act" specifying due regard for the environment by all government agencies
- Legislation that the NCSB and Agency have primary responsibility for developing
- A requirement for environmental impact assessments (EIAs) for all new development projects, with the NCSB and Agency to play key roles in implementation
- The designation of Environmental Liaison Officers (ELOs) within each of the central and local government ministries and departments.

Under current policy, the NCSA and Board are thus charged with coordinating the efforts of the government toward the goals of the strategy, but not with regulating environmental matters

directly or exercising line authority for operating programs. The NCS Act, the specifics of the EIA requirement, and the appointment of ELO officers are being completed.

Table 4

Significant Policies and Responsible Institutions

Policy and Legislation	Institution(s) Primarily Responsible
NCS Government Paper No. 1 (National Conservation Strategy)	NCSB and Agency
Water Act and regulations	Department of Water Affairs and Water Apportionment Board
National Water Master Plan	Department of Water Affairs and Water Apportionment Board
Town Councils (public sewer) regulations	Town councils
Atmospheric Pollution (Prevention) Act	Department of Mines
Public Health Act and regulations	Community Health Services Department
Town and Country Planning Act	Department of Town and Regional Planning
Industrial Development Act	Industrial Licensing Authority, Department of Industrial Affairs
Factories Act and regulations	Factory Inspectorate
Financial Assistance Policy	Ministry of Finance and Development Planning
Tax policy	Ministry of Finance and Development Planning

Policy on water pollution is stated primarily in the Water Act, which prohibits discharges that result in the "polluting or fouling of public water." A system of discharge permits is administered by the Water Apportionment Board. Monitoring is conducted by the DWA, which reports violations to the Board. DWA has issued several pollution control guidelines for specific aquifers or purposes. These include Guidelines for Water Pollution Control within the Ramotswa Aquifer (draft, 1987), Guidelines for Water Pollution Control in the Gaborone Dam Catchment Area (draft, 1987), Wastewater Re-Use and Discharge Guidelines (1988), Information Required from Pollution Industries, and Guidelines for Trade Effluent Agreements. These guidelines are not legally enforceable but aim to guide activities through information and persuasion.

National public sewer policy authorizes local councils to reach agreements with individual generators of industrial waste dischargers on enforceable limits on wastewater discharged into public sewers. Failure to comply bears the risk of disconnection from the sewer system. A few local councils are now seeking to develop such agreements. Local councils are also assisted in their planning by the Geological Survey, which provides information useful in land-use decisions regarding waste disposal and aquifers.

In recognition of the crucial need for water protection, the government has also developed a National Water Master Plan (NWMP) to establish water policy for the next 30 years. The plan recommends close monitoring of groundwater; greater use of alternative technologies to develop and conserve water; increased water recycling; and completion of EIAs for all new projects. A new and more comprehensive Water Act is also being proposed as part of the Master Plan. Formal ratification of the plan and the proposed Water Act will soon be before the Parliament.

Air pollution legislation charges the Department of Mines (DOM) with monitoring and enforcement. DOM now operates 19 monitoring stations. Ambient air quality objectives have been established for several "controlled areas" of the country, including the largest settlements. However, monitoring is aimed primarily at industry. For instance, Selebi-Phikwe, home of the nation's large copper-nickel mining operation, has more than half of the country's air-quality monitoring stations. In this region, the primary regulated pollutant is sulfur dioxide, which is of local and global environmental concern, but is not normally considered a HTW.

Policy on pollution from mining focuses primarily on air pollution. However, the Mines and Minerals Act does address water pollution with fencing requirements for water containing poisonous substances.

The Public Health Act of 1971 and associated regulations (1983) charge the Ministry of Health (MOH) with safeguarding public health in Botswana. Broad provisions of the legislation authorize the MOH to develop policies for controlling the spread of diseases, regulating sanitation, and controlling mosquitoes. As a result, the Community Health Services Department (CHSD) develops policy initiatives on waste management, including hospital waste management and vector control for implementation at the local level through councils and the health inspectors assigned by the central government. Local councils, in turn, can develop bylaws that deal with waste management (see, for instance, the Gaborone City Council [General] Bye-Laws).

The Town and Country Planning Act authorizes the Department of Town and Regional Planning (DTRP) of the Ministry of Local Government, Lands, and Housing (MLGLH) to work with local councils in their planning, including planning for waste management. The Act requires planning and consultation with affected parties before development in designated areas. It also requires consideration of these matters in local council decisions. Prior to the creation of the NCS, this department had primary responsibility for environmental affairs.

The Industrial Development Act has a less direct influence on HTW management. It requires annual licensing of businesses operating within Botswana, and includes a requirement that

applicants list all materials used in production processes and a consideration of whether licensing would be in the interests of the "public weal [that is, public interest] of Botswana." The Industrial Licensing Authority may refuse an application if a manufacturing facility is not located in a "suitable place for the industry" or if a manufacturing operation "would conflict with any approved or proposed town planning scheme or zoning area" (Industrial Development Act, Sections 5(b), 5(e), 5(f)).

The Factories Act requires inspection of industrial sites for the purpose of protecting workers' safety and health. Wastes are not a concern under the policy unless they pose a health threat to workers. Likewise, environmental or HTW risks are not considered in government's efforts to encourage business growth through subsidies (the Financial Assistance Policy, or FAP) and tax policy.

In short, while Botswana has adopted a number of policies with impacts on HTW, limitations can be noted. No policy specifically addresses HTW or promotes a systematic approach to the problem.

Some policies with implications for regulation of HTW are under development. The MOH is developing a draft waste management policy. The Ministry of Agriculture (MOA) has drafted legislation authorizing the safe TSD of pesticides, and the measure is being considered by Parliament. The DTRP has identified some HTW policy proposals. Moreover, in a particularly significant development, DWA has overseen a detailed investigation of groundwater conditions in the country and the development of a Groundwater Protection Strategy. The draft strategy classifies the 16 aquifers in the country according to their degree of vulnerability to contamination. Specific pollution control recommendations are included to help protect the aquifers, which constitute Botswana's main source of water.

3.1.2 Policy Gaps

As suggested in the preceding discussion, current policies and regulations in Botswana do not address several important aspects of HTW. These include:

- importation of HTW into Botswana
- a tracking system for HTW within the country
- a system for recording quantities of HTW generated
- regulations on acceptable HTW disposal options
- monitoring of discharges and their impact
- a procedure for gathering statistics on health effects from HTW
- incentives for encouraging appropriate HTW transport, storage, and disposal
- information and education on HTW issues

- coordination of HTW policy during implementation among the relevant departments and ministries.

Botswana has not taken a position on the two important international agreements on HTW imports: the Basel Convention, an international agreement developed in 1989 to control transboundary shipment of hazardous waste; and the Bamako Convention, a version developed for HTW transportation in Africa.

3.2 Institutions

The institutional setting important for HTW management is complex and highly differentiated. HTW management in Botswana is influenced by a large number of governmental, parastatal, private commercial and industrial, and nongovernmental organizations (NGOs).

3.2.1 Governmental Institutions

The national government agencies responsible for HTW in Botswana include the National Conservation Strategy Board and Agency; the Department of Water Affairs (within the Ministry of Mineral Resources and Water Affairs (MMRWA)); the Community Health Services Department; the Department of Town and Regional Planning; the Department of Industrial Affairs (DIA) (located in the Ministry of Commerce and Industry [MCI]); the Department of Mines; and the Factory Inspectorate within the Ministry of Labor and Home Affairs (MLHA). The role of these institutions was outlined in Section 3.1.1. Discussion here will concentrate on NCS.

The creation of the NCSB and accompanying secretariat Agency demonstrates Botswana's commitment to environmental protection and sustainable development. The Board itself includes representatives of several major ministries (MOA, MLGLH, Education, Ministry of Finance and Development Planning, MCI, and MMRWA), the University of Botswana, BOCCIM, NGOs, local districts, tribal administration, and the private sector. The MOH, however, is not included on the NCSB, despite its key role in environmental regulation.

The Agency assists the Board and operates with a small staff that is set to expand shortly. Board members are high-level appointees; therefore, the NCSB must rely on the NCSA for technical assistance.

The NCS institutional arrangement represents a choice by the government, at least for the present, to address environmental matters without creating a large ministry for this purpose. Its apparatus is designed to encourage policy coordination, and NCS representatives sit on interagency review committees at other ministries when major environmental issues arise. However, neither the Board nor its Agency are charged with, or equipped for, regulatory oversight of other national departments and ministries. NCS operations are located within the MLGLH at present. The Minister of MLGLH chairs the Board, which reports through that position to the cabinet.

In sum, the national institutions most involved in HTW are the NCSB and NCSA, DWA, CHSD, DTRP, and DOM.

Some other units of government have the potential to become involved in the development and implementation of HTW efforts. The Department of Agriculture (DOA) plays a role by its programs for administering pesticides to protect the nation's crops and cattle. Both the Division of Plant Protection and the Department of Animal Health and Production administer the use of these materials and thus can be major actors in addressing HTW issues as they arise in agriculture. Pesticide management for crop protection is clearly an important HTW issue in Botswana.

The Ministry of Education has been developing materials and films on environmental education for use in local schools. However, specific instruction on HTW has not yet been developed.

At the local level, the elected councils and their health inspectors can play a critical role in HTW management. The councils and their personnel are responsible for operating wastewater treatment facilities, handling the collection and disposal of other wastes, operating landfills, and—where possible—negotiating agreements with industries on enforceable standards. Together with the health inspectors assigned by MOH, councils are the institutions most active in day-to-day HTW management.

The most common form of coordination in this setting is through interministerial coordinating groups. Other advisory and coordinating bodies sometimes meet to share information and discuss common problems. An example of such meetings are MOH's Environmental Health Consultative Meetings, scheduled every few months for councils' environmental health officers. However, such mechanisms exist primarily for policy development and information exchange, not to coordinate policy implementation across jurisdictions.

Overall, it can be said that from the standpoint of HTW issues in Botswana, the institutional setting for policy and its implementation is marked by a high degree of fragmentation.

Numerous governmental institutions are also important waste generators in Botswana, as explained in Chapter 2.

3.2.2 Parastatals

In Botswana several parastatal institutions play significant roles in the HTW field. Some institutions influence the type, rate, and location of economic investment and industrial growth, as well as the procedures and policies that are used in development activities. The Botswana Development Corporation and the National Development Bank are important here. So too can be the donor agencies operating in Botswana, although these are obviously not Botswana parastatals. Some parastatal institutions, like the Botswana Railways, the Botswana Utilities Corporation, and the Botswana Power Corporation, are HTW generators.

3.2.3 Private Commercial and Manufacturing Organizations

As described in Chapter 2, private commercial and manufacturing firms are central to the HTW situation in Botswana. Private industry is represented by the general business association in Botswana, BOCCIM, on the NCSB. BOCCIM currently plays no role in dealing with HTW issues. However, in its information sharing role and its position on the NCSB it is situated to address a range of issues that relate to HTW. Although BOCCIM has organized a committee to encourage government deregulation of business in Botswana, it supports public education on waste disposal and "strict implementation of the laws governing waste disposal" (BOCCIM, 1991:36). In addition, some businesses in Botswana, such as hotels whose profitability depends on tourism, have initiated "green marketing" programs to support environmental causes within the country. The most important private institutions, then, are the large HTW generators, the fledgling recycling sector, and BOCCIM.

3.2.4 NGOs

Despite its relatively small population, Botswana has several NGOs dedicated to environmentalism or conservation. Although none is primarily concerned with HTW, some have an interest in the subject. Certain NGOs, like the Kalahari Conservation Society, have cooperated with local businesses in programs that promote environmental awareness. Time constraints precluded interviewing NGO representatives. While it may not be appropriate to include these organizations in the HTW reference group, their recommendations may be useful in developing HTW policy.

3.3 Implementation

Policy implementation in Botswana has distinctive characteristics which are described in this final section.

3.3.1 Overall Effectiveness

HTW-related policy in Botswana is often marked by energetic efforts on the part of skilled and dedicated government personnel. In many cases ministries are staffed with civil servants of talent who seek to utilize the policy tools at their disposal on behalf of the public interest.

However, because there is no explicit policy, and existing regulatory policies are relatively general, implementation efforts often involve staff utilizing broad interpretations of statutory and regulatory provisions to seek resolution of specific HTW threats. This pattern holds across numerous implementing units.

DWA staff make suggestions to point-source dischargers for reducing the most pressing pollution problems and identifying appropriate re-use of effluent. In the DOM, for instance, air pollution enforcers also informally encourage mining companies to address water pollution

problems when these can be identified. Formal action against violators can be initiated by written request to the Water Apportionment Board, but advice and encouragement are utilized as important supplements. The DTRP has been involved in isolated efforts to control transboundary shipments of HTW into Botswana. And, local health inspectors try to encourage better HTW management within their jurisdictions.

Nevertheless, all implementing institutions consider HTW management to be too limited. The slow progress is due to limitations in policy, resource and administrative constraints on implementing units, and a lack of coordination. Policy gaps, including the lack of appropriate guidelines and standards, are identified in Section 3.1.2. The other constraints are outlined below.

3.3.2 Resources and Administration

Botswana's revenues are relatively large primarily because of diamond operations. Nevertheless, government agencies responsible for environmental policy and HTW have faced serious resource constraints.

Shortages of funds and staff have limited the effectiveness of policy implementation. The DWA, for instance, has just three employees to monitor water pollution across the entire country. In addition, due to a lack of funds, there is no regular testing for heavy metals and other toxics in discharges. Budget constraints prevent DWA from equipping a local laboratory for a full testing program, and limit funds available for having samples tested abroad.

Another resource limitation restricting the degree and quality of implementation is the lack of appropriate and regularly-collected data to be used in making decisions, for instance about regulating. Departments and ministries often lack the information they need to make the implementation decisions with which they are charged. Some efforts have been made to rectify certain important information gaps. These include the aquifer investigation developed as part of the groundwater strategy effort; a computerized data base in the DWA containing information on sources, water quality, pollutants, and date of sampling; and a survey recently conducted by the CHSD on the disposal of medical wastes from hospitals and clinics. Some data gathering has thus begun to bear fruit and may become important in HTW management in the future. Nevertheless, at present the absence of HTW data limits implementation in many instances.

An additional constraint is the very limited HTW training available to government personnel. Without appropriate training, staff have difficulty identifying and managing the most serious risks, collaborating with other departments and ministries in a timely manner, and recommending appropriate HTW management strategies.

Even government personnel knowledgeable about their efforts at problem solving can be constrained by centralized controls, such as accounting reviews, that delay action.

3.3.3 Impediments to Coordination

Those responsible for HTW management in Botswana all agree that their efforts are seriously hampered by poor coordination between the institutions involved. While interministerial bodies can coordinate major policy development, they cannot tend to the implementation details.

Individual departments also lack timely access to data collected in other parts of the government. Thus, for instance, Department of Industrial Affairs licensing decisions are made independent of CHSD's health considerations or DWA's effluent guidelines. As a result, the permitting processes are perceived as burdensome by the private sector and contribute relatively little to policy goals.

Information gaps on HTW also appear between central government and local councils. The assignment of health inspectors to councils provides a channel of liaison, and other programs—like DTRP's efforts to assist council planning—offer possibilities for coordination. However, without an adequate flow of information, council decisions are sometimes made without the benefit of government data available elsewhere. For example, councils can purchase pesticides for mosquito control without consulting CHSD or the local health inspector.

Chapter 4

INSTITUTIONAL FRAMEWORK OPTIONS AND RECOMMENDATIONS

This chapter contains suggestions for modification in HTW practices and actions to be taken. They are presented in priority order, with the most urgent ones first, ending with options which might be considered for the future. The chapter also explains how Botswana could develop a comprehensive framework for HTW management.

The recommendations include both technical and policy options. Policy recommendations cover regulations, incentives, and education. Wherever possible, these policy recommendations also include suggestions as to which institutions should be responsible for their execution.

4.1 High Priorities for Hazardous Waste Management

Successful HTW management in Botswana requires official recognition and definition of the problem, adoption of comprehensive HTW policy, linking that policy with broader environmental management efforts, and establishing an HTW authority with overall responsibility for coordinating and implementing policy. Therefore, top priorities should be to:

- Establish a government-wide definition of hazardous and toxic materials and waste. This task can be done by the NCSA and its reference group on HTW. In the meantime, definitions of HTW can be drawn from standard references on the subject, such as Batstone, Smith, and Wilson, 1989, chapter two.
- Establish a hazardous waste classification system. A sample waste classification system is provided in Appendix C.
- Request NCSA and its reference group to develop a specific HTW policy that conforms with NCS. The policy should apply to government departments and ministries, parastatal institutions, and the private sector. At a minimum, the policy should:
  - Define HTW
  - State a position on transboundary shipments
  - Encourage pollution prevention and recycling
  - Protect water quality
  - Establish risk-based management
  - Promote a detailed HTW management system

- Require interministerial and interdepartmental coordination
- Include environmental criteria in development planning
- Encourage evaluation of TSD technologies.

- Develop and implement hazardous materials import restrictions, using Customs inspections for enforcement.
- Set deadlines for NCSA to:
  - Designate environmental liaison officers
  - Draft and forward the NCS Act to the cabinet and Parliament for enactment
  - Develop and enact EIA provisions
  - Consolidate environmental policies and regulations, as outlined in the U.N. Clearinghouse Mission Report and NCS.
- Designate NCSA as the coordinator of HTW policy. Designate one position or unit within NCSA to be responsible for developing and maintaining a database and reference library, chairing policy development efforts with the HTW reference group, managing HTW coordination with government ministries and local authorities, and assisting waste generators, ministries, and departments in minimizing and managing HTW.
- Provide NCS Agency with additional staff and funds for these HTW responsibilities.

These recommendations are minimal requirements for sound HTW management. They preserve the current coordinating role of the NCSA and Board, while enhancing the Agency's HTW management capacities in policy development, liaison, and information gathering. A complete hazardous waste management system should also include information gathering and monitoring so it should:

- Endorse and utilize information and guidelines from DWA's groundwater protection report and NWMP.
- Develop a manifest waste tracking system, to be implemented by NCSA.
- Develop a comprehensive HTW database and reference library. Information is urgently needed, in order of priority, on:
  - Pollutant sources, HTW quantities generated, and all generating activities, including materials used. A sample survey form is provided in Appendix D. Some industries may not track waste quantities. In such cases, quantities must be estimated from the raw materials and processes used. The WHO document *Management and Control of the Environment* (World Health Organization [WHO], 1986) provides an estimating approach that utilizes loading factors and production rates.

- Effluent characteristics
- International guidelines and disposal sites
- Treatment availability and recycling options

These data should be collected by the currently-responsible institution but stored for ready access by NCSA and other institutions.

- If the previous recommendation is not adopted, at minimum develop the improved database by maintaining central information at the NCS Agency as to source and availability of data in other departments and ministries rather than implementing physical consolidation of the information.

The following technical and waste management practices should also be adopted to improve regulation, handling, and storage of hazardous wastes:

- Require segregation of hazardous and non-hazardous waste in industry. This requirement should be enforced by MOH and local health inspectors.
- Require segregation of hazardous and general wastes at government departments and ministries, parastatals, the University of Botswana, and laboratories. Enforcement should be the responsibility of MOH and local health inspectors.
- Enhance the regulatory and enforcement capacities of DWA, DTRP, DOM, CHSD, and health inspectors through increased enforcement powers, staffing, and training resources.
- Establish government and industry cooperation in identifying safe storage sites for hazardous materials for which there are no suitable treatment or disposal options. This cooperation can be initiated by NCSA and its HTW reference group. Appendix E provides basic information on storage and compatibility of waste materials.

Most generators of medical waste are institutions already regulated by MOH and health inspectors at local councils. These regulators, hospitals, and clinics should:

- Require medical facilities to segregate and color code wastes into three categories: infectious wastes, general wastes, and hazardous wastes.
- Incinerate only infectious wastes, and evaluate more environmentally benign alternatives to infectious waste incineration. Possible alternatives include autoclave, grinding and sterilization, microwave, and advanced incineration (pyrolysis and vitrification).
- Establish centralized facilities for handling infectious wastes.

For pesticides, another important HTW source in Botswana, the country should:

- Establish a permanent committee of representatives from MOH and MOA to coordinate registration of pesticides and their distribution to government users. This committee should meet regularly, perhaps quarterly.
- Persuade donor agencies and pesticide manufacturers to accept returns of outdated or surplus pesticides.

Little is known about HTW in Botswana outside government agencies that manage the issue. Therefore, the government should initiate HTW education and training:

- Through schools, using curricula developed by the Ministry of Education and coordinated through NCSA
- Through training of government staff, coordinated by NCSA
- Through BOCCIM seminars that introduce HTW issues and promote "green" business practices and marketing techniques
- Through public education about household wastes.

Comprehensive HTW management may require further measures, such as the consolidated permitting recommended in this chapter. If these efforts do not produce sufficient improvement in HTW management, it may be necessary to consolidate line responsibility for HTW policy in NCSA, an existing ministry, or a new environment ministry.

4.2 Further Recommendations

Beyond these top-priority items, several additional options are recommended:

- Analyze appropriate treatment and disposal options with specific consideration of land treatment, biodegradation, advanced incineration, and processes that minimize transfer of wastes to other media. Disposal in controlled, properly designed and operated landfills may also be an option. Siting decisions of such facilities should address local geology, distance to population centers, and risks to human health. Special consideration should be given to protection of water resources. These decisions can be coordinated by the NCSA and the HTW reference group, in conjunction with local councils. Batstone, Smith, and Wilson (1989) provides basic information on many of these technologies. Newer technologies may also be appropriate for Botswana.
- Develop a consolidated permit system, overseen by the NCSA, through which individual departments coordinate their permitting programs with other departments. Consolidated permitting would allow better and earlier evaluation of environmental concerns and mitigation measures and can expedite permit processing.
- Establish incentives for minimizing waste, recycling, and using less toxic materials. These incentives should be developed by the relevant department or ministry, with

assistance from NCSA and the Ministry of Finance and Development Planning (MFDP). For example:

- Facilities that recycle waste oil could receive a tax credit or increased subsidies.
- Lower water rates could be charged to facilities that adopt significant water recycling.
- Facilities that replace toxic materials in their production processes with non-toxic or substantially less toxic materials could receive tax credits or increased subsidies.
- Facilities that pre-treat wastes to established guidelines could be charged lower sewer fees, subject to annual effluent inspections.

- Improve local abilities to test for heavy metals, volatile organic compounds, semi-volatile compounds, toxicity, and other hazardous materials. Strengthen and expand the testing capabilities of government laboratories, parastatal facilities, or the University of Botswana for joint utilization.
- Certify commercial applicators of pesticides for safe pesticide use, storage, transportation, and disposal. The MOA and MOH can implement this effort.
- After establishing safe disposal guidelines and certification, develop decentralized disposal management within relevant ministries to allow staff level management.
- Require placards on all commercial vehicles that carry hazardous materials. These placards should identify these materials and their essential characteristics (flammability, corrosivity, ignitability, toxicity, and explosivity).
- Train emergency response personnel in proper techniques for responding to hazardous material spills.

4.3 Additional Options

To enhance these initiatives, Botswana could:

- Have DCE record the type, quantity, and destination of imported hazardous material.
- Integrate the consolidated HTW database with the geographic information system (GIS) project being developed by DTRP.
- Improve data collection by:
  - Increasing the HTW data required for DIA licensing.
  - Increasing DWA's effluent monitoring, paid for by a fee charged to industry. Monitoring frequency should be based on potential environmental risk and facilities' past performance.

- Expanding groundwater testing by the Geological Survey Division of MMRWA in areas where HTW is generated over sensitive aquifers.

- Require hazardous product labeling in English and Setswana, administered by the Department of Commerce and Consumer Affairs. Hazardous products should also be shipped with material safety and data sheets (MSDS) that list ingredients, hazards and procedures for first aid, and emergency response, in the event of shipping or handling accidents. If product cannot be labeled in both languages, at a minimum the MSDS should be bilingual.

- Establish government-sponsored recycling of waste oil and solvents, and require participation by governmental and parastatal HTW generators.

- Consider replacing leaded gasoline with unleaded.

- Solicit manufacturers' assistance in disposing of outdated or surplus pesticides.

- Thoroughly evaluate cement kilns as a short-term and long-term disposal option. Other more environmentally-benign options may be more suitable and economical. Note that in more developed countries, incineration requires highly advanced air pollution or state-of-the-art incineration technology.

- Provide waste oil storage facilities where oil can be stored safely until it is recycled by a private company or industry group. Local councils can take responsibility for this effort.

- Initiate joint inspections in which one inspector can identify a wide range of waste-management problems covered by multiple agencies. This procedure involves providing inspectors with understanding of the basic requirements of other regulatory agencies and allows identification of critical waste management issues for investigation by the primary responsible agency.

- Consider coordinating regulatory standards with other countries in the Southern African Development Community countries. Include the Republic of South Africa in these efforts, in recognition of its economic, industrial, and technological standing. Charge the Ministry of External Affairs with pursuing this initiative.

- Add environmental criteria (to include HTW management improvement efforts) to government programs of financial support for economic development that are currently under review and revision, including FAP (training and labor subsidies) and the budget planning requirements of the Planning Officer Manual; add environmental/HTW criteria as well to the program of development grants from central government to councils.

- Establish an analysis unit in MFDP staffed with specialists on environmental policy to develop incentive-based policies to reward environmental performance.

4.4 Strategy for Development of HTW Management

The options above should be considered in the order presented. Much of what needs to be done can be completed using internal personnel and funds. For some options, external consultants and financial assistance may be beneficial.

NCSA is scheduled to receive additional staff. With the help of the new staff and the Reference Group ministries, NCSA should address:

- Developing hazardous waste policy
- Gathering information
- Coordinating HTW policy and implementation among government agencies
- Completing broader environmental initiatives by implementing the NCS Act, requiring environmental impact assessments, and appointing environmental liaison officers.

These tasks can realistically be completed within 12 to 18 months.

Immediate attention should be given to enforcing bans on imports of hazardous materials and HTW. At a minimum, a temporary provision should be adopted to prevent unwanted dumping of waste, until more flexible and appropriate measures can be developed.

Once the HTW policy foundation is established, attention can be paid to more specific matters. Among the tasks that can be accomplished internally are:

- Conducting inventories of hazardous waste generators and HTW produced
- Reviewing international guidelines on HTW and pesticide use, storage, transport, and disposal
- Implementing a pesticide safety program.

Tasks that may require external assistance include:

- Developing a transportation placarding system
- Training emergency response personnel
- Establishing incentive-based policy analysis and evaluation
- Evaluating detailed treatment and disposal options.

With prompt attention to HTW management issues, Botswana can avoid the serious environmental and public health problems other countries have suffered. Specifically, Botswana can avoid degradation of air quality and limited water supply, while attracting appropriate industrial and business investment for long-term growth and sustainable development. By acting now, Botswana can minimize the overall impact of hazardous waste on the economy and the environment through waste exchange, recycling, household waste collection, waste minimization, and proper waste disposal. Delay in taking action now may force adoption of costly command-and-control measures to mitigate environmental damage that is now preventable.

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Appendix A

SCOPE OF WORK

Botswana: Hazardous Waste Assessment

Background

Proper management of wastes, especially hazardous solid and liquid wastes, is an evolving concern in Botswana. As Botswana grows and develops there is a corresponding increase in the generation of hazardous wastes by industry, agriculture and individual households. Regulations, policy, and infrastructure for transport, treatment, and disposal of these wastes are generally underdeveloped.

The lack of a comprehensive policy for the management of hazardous waste products increases the risks associated with hazardous waste exposure for the human population as well as the environment. To alleviate these risks, Botswana is seeking assistance in the development of a comprehensive policy and/or legislation to regulate and monitor waste disposal practices in the country.

Botswana is in the unique position to take preemptive action to develop hazardous waste regulations, policy, infrastructure, and awareness programs for both industry and the general public to accommodate the anticipated increases in hazardous waste generation. Following the development of monitoring/regulatory tools the government will be in position to encourage innovative programs such as waste minimization, waste exchange programs, recycling, and household waste collection and disposal programs to minimize the overall impact of hazardous waste on the economy and the environment.

Improving waste management requires data gathering on waste sources and assessing the potential impacts of these wastes on health and the environment. Equally important is a consideration of existing and potential institutional capacities, plus review of the regulatory and policy tools that may offer feasible alternatives for improving conditions both for short-range problem solving and for longer-term, more systematic improvements. Some options are much more effective than others in improving conditions, while also meeting prevailing budget and institutional constraints.

It is understood that a study is currently underway in Botswana to identify/quantify imported hazardous materials. If possible, the following information should be included in the study prior to the start of WASH assistance.

- Identification of hazardous waste generators and their locations in Botswana
- Types and quantities of household wastes generated by indigenous population

- Identification of available infrastructure for transportation, treatment, and disposal of hazardous wastes
- Environmental and human impact of current and past disposal practices
- Quantitative inventory of pesticides and other agricultural products
- Quantitative inventory of petroleum products, petrochemical, other chemical feed stocks and other hazardous materials imported into the country
- Inventory and evaluation of waste produced and the treatment and disposal practices of the major industries and mines operating in Botswana
- Identify those policies, regulations and institutional entities currently coping with the management of hazardous wastes.

Objective

The objective of this task is to assess the hazardous waste problems in Botswana and provide preliminary recommendations to the government relating to institutional, policy, and technical options that will mitigate the negative impacts of the wastes. Emphasis will be placed on identifying health risk to humans, and their related ecosystem, through contamination of water supplies.

Tasks

(N.B. The assessment will largely take place in Gaborone, possibly including some additional areas which are readily accessible from the capital.)

1. Participate in a two-day team planning meeting at the WOC.
2. After arrival in-country, review sources of information and data in order to:
   - Identify significant hazardous waste generators
   - Inventory the quantities and types of hazardous wastes produced
   - Evaluate current treatment and disposal practices
   - Identify and quantify types of household waste generated
   - Identify water and other natural resources at risk from inappropriate waste treatment practices
   - Identify potential human and environmental health impacts of past and current disposal practices
   - Inventory pesticides and other agricultural imported products

- Inventory petroleum products, petrochemicals, chemical feed stocks and other imported hazardous materials.

3. In coordination with the technical analysis and risk assessment, conduct a review of the range of institutions important to the waste generation, management, and mitigation activities in Botswana. Identification of the institutions will be conducted with the consultation of a reference group including the NCS Agency, the Department of Water Affairs, the Department of Factory Inspectorate, the University of Botswana (Environmental Law and Department of Environment), Ministry of Local Government, Lands and Housing, and the A.I.D. The identification of important institutional actors will include consideration of nongovernmental organizations, industries, other businesses, and the informal sector.
4. Conduct site visits to observe waste generation and disposal practices for the major industries involved.
5. Identify priority institutions, either currently involved or potentially able to be involved, for use in waste management efforts to address the most pressing waste risks.
6. Identify any intra- and inter-institutional impediments to improved waste management.
7. Identify important inter-institutional links currently available or feasible for development to assist in the coordination of waste policy and management.
8. Conduct overview of most significant existing partial policies that influence waste generation, management, and mitigation.
9. Identify existing policies that may impose constraints on improved waste management.
10. Consider a range of policy tools, including regulatory, informational, organizational (assignment of responsibilities by institutions and sector), and incentive-based policies for their feasibility and effectiveness in Botswana. United States, World Health Organization, and the European Community hazardous waste regulations and policies will be evaluated for applicability and implementability in Botswana.
11. Review institutional and policy options with major institutional actors, including those listed above.
12. Develop recommendations organized as a priority list of options: institutional, policy, regulatory, and technological.
13. Review tentative recommendations with the major actors.
14. Produce revised recommendations in light of information from major actors.

Personnel/Level of Effort

WASH will send a two person consultative team consisting of a hazardous wastes specialist (approximately 26 person days of effort), as team leader, and an institutional and policy analyst (approximately 22 person days of effort). Skills required by WASH consultants consist of extensive knowledge of institutional development, knowledge of likely hazardous wastes encountered in Botswana, a firm background in hazardous waste management and assessment, and policy development experience related to waste management in developing countries. Additional resource persons may attend the team planning meeting to provide background information to the two primary consultants.

End Product

The team will prepare a report detailing its findings with recommendations to assist the government of Botswana in identifying the magnitude, extent, human health, and environmental impact of past and present industrial and domestic hazardous waste disposal practices, and approaches for development of regulations and guidelines for transportation, treatment and disposal of industrial wastes. Also included will be a set of recommendations regarding institutional, regulatory, and economic policy options that are most worthy of analysis and possible development to address the most pressing hazardous waste problems in Botswana. Options for improvement will be presented in approximate order of priority, so they can be used as a strategy for a phased execution. A draft copy of the report will be left with the implementing institutions on the departure of the WASH consulting team.

Schedule

Tentative schedule is as follows:

June 9/10	Team planning meeting at the WOC
June 11/12	Travel to Botswana
June 14	Meeting with the Reference Group and U.S. A.I.D.
June 15	Review of reports
June 16/17/18	Visits to involved institutions
June 19/21/22	Visits to industrial/other sites
June 23/24	Strategy development
June 25	Debriefing with Reference Group and USAID for further input
June 26/28	Report writing with access to major actors and institutions/submission of draft

June 29/30 Travel to DC

July 1 Debriefing at the WOC

Amendments to scope of work

At the team planning meeting on June 9/10, the scope of work was amended by consensus of the participants, as follows:

1. Addition to task 2 in scope of work:

   These items will be categorized and assessed in terms of the magnitude of issues and problems. Where quantification based on pre-existing information is available, it will be included.

2. Addition to task 3 in scope of work:

   Data gathering from all members of Reference Group will be sought, and from others as time permits.

3. Deletion from task 10 in scope of work:

   Remove last sentence.

Reference Group Guidance

Mr. Kagiso P. Keatimilwe of the NCSA and Mr. Thebe A. Pule of the Community Health Services Department will assist in coordinating, prioritizing, and scheduling appointments for this assignment.

Appendix B

PERSONS CONTACTED

U.S. Agency for International Development Mission to Botswana

Mr. Howard Handler, Mission Director
Mr. Ray Baum, Project Development Officer
Mr. Pushkar Brahmbatt, Assistant Project Development Officer
Ms. Peggy Manthe, Administrative Assistant
Mr. Robert McColaugh, Agricultural and Natural Resource Management Officer

National Conservation Strategy (Coordinating) Agency

Mr. Seeiso Liphuko, Executive Secretary
Mr. Kagiso P. Keatimilwe, Senior Natural Resources Officer

Ministry of Agriculture

Department of Animal Health and Production:

Dr. W.R. Wooff, Chief Tsetse Officer

Division of Plant Protection:

Mr. Fixen Mchive, Chief Plant Protection Officer

Ministry of Health

Community Health Services Department:

Mr. Thebe A. Pule, Chief Health Inspector
Mr. Clifford Matsoga, Principal Community Health Officer
Ms. Tuduetso Christos, Environmental Health Officer

Ministry of Commerce and Industry

Department of Industrial Affairs, Licensing Section:

Ms. Denise Bontle Gaboutloeloe, Principal Industrial Officer
Mr. Dumani Mbai, Industrial Assistant

Ministry of Mineral Resources and Water Affairs

Department of Water Affairs:

Pollution Control Section:

Ms. Oarabile Rankongwane, Pollution Control Engineer

Department of Mines:

Air Pollution Control Division:

Mr. C. Matale, Senior Air Pollution Inspector
Mr. M. Moffat, Technical Officer

Ministry of Labour and Home Affairs

Mr. D.M. Taolo, Acting Chief Inspector, Factory Inspectorate

Ministry of Local Government, Lands and Housing

Mr. Kodise Selotlegeng, Senior Public Health Engineer

Department of Town and Regional Planning:

Mr. David Modibetsane, Director
Ms. Esther Serati, Senior Planner

Ministry of Finance and Development Planning

Division of Economic Affairs:

Mr. Moagi Kenosi, seconded to Ministry of Local Government and Lands

Department of Customs and Excise:

Mr. C.P. Sechele, Director
Mr. Wazha Maunge, Assistance Director (Technical)
Mr. Frederick Sebatindira, Senior Statistician External Trade Statistics Unit

Gaborone City Council

Mr. Morgan Segokgo, Acting Chief Health Inspector
Mr. C. Velaiyutham, Chief Technical Officer for Sanitation Department

Princess Marina Hospital

Mr. M.M. Taukobong, Department of Electrical and Mechanical Services

Francistown Town Council

Mr. Ahmad H. Kombe, Chief Health Inspector
Mr. A.J. Gomani, Senior Health Inspector
Mr. J.J. Bernard, Town Engineer

Business Community

Gaborone:

Mr. E.M. Dewah, Deputy Director, Botswana Confederation of Commerce Industry & Manpower
Mr. P.K. Vyas, Chief Chemist; Kgalagadi Soap Industries, LTD.
Mr. H.K. (Raj) Patel, Managing Director, Plastech (Pty) Limited, Kgalagadi Plastics Industries (Pty) LTD
Mr. Nesh, Plastech (Pty) Limited, Kgalagadi Plastics Industries (Pty) LTD
Mr. Bill Hall, General Manager, Petrochem Botswana (PTY) Limited
Mr. Keith Lapham, Managing Director, Petrochem Botswana (PTY) Limited
Mr. Duncan Thela, Managing Director, Pulo Pharmaceuticals (PTY) LTD.
Ms. Heather Brodie - Brown, Hydrogeologist, Water Surveys Botswana(PTY) LTD.
Ms. Deborah McLaren, Environmental Scientist, Water Surveys Botswana (PTY) LTD.
Mr. Ian Murdock, General Manager, Dulux Botswana (PTY) LTD.

Francistown:

Mr. P.B. Staak, Technical Director, BGI Tanning Company (Pty) Ltd.
Mr. Edward Mukogo, Plant Superintendent, Monarch Mine
Mr. Denham Vickers, Manager, Monarch Mine

Appendix C

SAMPLE WASTE CLASSIFICATION SYSTEM

(Source: Batstone, Roger, et al., 1989)

ANNEX 2 - Waste Types for Proposed Classification Scheme

I INORGANIC WASTES

ACIDS AND ALKALIS

Waste Streams	Industry/Process	Industrial Groups
Acid		
Spent sulphuric acid	Galvanizing	D
Spent ferrous pickle liquor	Steel pickling	D
Acid strip solution	Metal finishing	D
Spent nitrating acid	Organic synthesis	F
Spent chromic acid	Anodising	D
Spent brightener for stainless steel	Metal finishing	D
Acid tars	Coking	C
Spent reagents	Pesticide manufacture	F
Alkalis		
Alkaline cleaning agents	Metal degreasing	D
Spent ammoniacal etchants	Electronics	G
Spent caustic baths	Metal finishing	D
Waste ammonia	Photocopying shops, chemical synthesis	F/L
Caustic sludge	Oil re-refining	F
Spent caustic	Oil refining	C
Ammonia still lime sludge	Coking operations/gas works	C

CYANIDE WASTES

Untreated rinse water	Electroplating	D
Spent electro-plating process solutions		D
Heat treatment wastes	Steel production	D
Spent concentrates and semi-concentrates	Hydrometallurgy	D
	Chemical synthesis	F
	Fumigation	L

HEAVY METAL SLUDGES AND SOLUTIONS

Lead sludges from diaphragm cell process	Chlorine production	F
Wastewater treatment sludge from the mercury cell process		
Brine purification muds from the mercury cell process		
Wastewater treatment sludges	Chrome pigments	F
	Wood preserving (1)	H
Surface impoundment dredged solids	Lead smelting (2)	D
Emission control sludge	Lead smelting (3)	D
Treatment process wastewater sludges	Zinc production	D
Acid plant blowdown		

Waste Streams	Industry/Process	Industrial Groups
Electrolic anode sleeves and sludges		
Cadmium plant leachate residue		
Lead sludges	Battery production	G
Sludge	Tin plating mill operations	D
	Galvanizing mill operations	
Acid plant blowdown slurry sludges	Copper production (2)	D
Wastewater treatment sludges	Copper rolling and drawing	D
Spent pickle liquor and sludge	Copper production	D
Zinc and other heavy metal sludges	Textiles industry	H
Emission control sludge	Production of steel in electric furnace (2)	D
Spent pickle liquor	Steel finishing operations	D
Untreated wastewater	Manufacture of explosives	F
Wastewater treatment sludges	Manufacture/processing of explosives	F
Mixed metal sludges	Paint production	F
	Ink formulation	F
Waste sludges	Photographic processing	F
Spent reagents	Electronics industry	G
Etching solutions/rinse waters	Plastic plating	G
Grinding and polishing residues	Metal finishing	D
Lead sludge	Glassmaking	E
ASBESTOS WASTES		
Asbestos powder	Preparation and processing of asbestos	E
Lagging materials	Power stations, industrial manufacturing, gasworks dockyards, hospitals and educational establishments	Various
Asbestos diaphragms	Chlorine production	F
SOLID RESIDUES N.O.S.		
Emission control dust	Production of steel in electric furnaces (2)	D
Dust and sludge	Ferromanganese furnaces	D
	Silicomanganese electric furnaces	D
	Ferrochrome electric furnaces	D
	Iron and steel foundries	D
Waste sand	Iron and steel foundries	D

Waste Streams	Industry/Process	Industry/ Group
Emission control dust	Lead smelting (3)	D
Blast furnace slag	Copper smelting (3)	D
Spent catalysts	Chemical synthesis	F
Solid residues	Rubber production	F
Spent activated carbon wastes	Manufacture of sulphuric acid, chemical synthesis	F
Scrap batteries	Miscellaneous sources	Various
Spent iron oxide	Gas purification/coking	C

Notes: (1) using chromated copper arsenate
(2) Primary
(3) Secondary

Appendix D

SAMPLE WASTE SURVEY FORM

(Source: Batstone, Roger, et al., 1989)

ANNEX 3A - A Typical Wastes Generation Questionnaire for Use as Part of a Waste Disposal Survey

Notes on the Waste Generation Questionnaire

This questionnaire is designed for use both in personal interviews and in a postal survey. It allows direct entry of the data into a computer for processing.

The questionnaire is designed to obtain information on a wide variety of waste types, primarily those produced by industry and commerce.

The first page comprises general information on the firm, its products or services and the number of employees. For computerization the firm is given a unique serial number and assigned to an MLH group (the minimum list heading which is a subdivision of the UK standard industrial classification) and a local authority area, which allows the information from the survey to be sub-divided on a geological basis.

Question 1 contains information on the types of waste produced. Part (A) distinguishes 10 broad waste types while Part (B) sub-divides industrial wastes into some 20 types. Both of these categorizations are based on those of the UK Department of the Environment (1976). It will be noted that an additional six waste categories are allowed under category (B), in order that the waste producer can describe this waste in his own words if he is un-sure as to which category it should come under. These wastes can then be re-classified by the survey team.

Questions 2 to 8 are answered for each type of waste separately. Typically, a firm might fill in four columns for, say, waste types I, IIIA, and VIII.

Question 2 categorizes each waste stream by its physical form: solid, semi-solid or liquid.

Questions 3 asks the producer to categorize his waste according to its hazardous properties. The quality of this information from postal returns is generally poor.

Questions 4 to 7 concern the quantity of waste. Most producers do not measure or weigh the waste quantities, so the aim of these questions is to enable an estimate of the volume to be derived from their size and the frequency with which they are emptied. In order to manipulate the information from the survey in tons, the computer program also requires the survey team to assign a typical waste density to each type of waste.

Question 8 concerns the treatment or disposal arrangements for each type of waste. In the particular area for which this questionnaire was designed, the predominant disposal methods are by landfill, operated either by the local authority or by a private contractor, or by the producer himself. For general use, other disposal options should be added to the list on the questionnaire.

Question 9 concerns by-products which are sold to other companies for recovery, recycling or reuse. Information is requested both on the type of waste and on the quantities.

Question 10 invites the respondent to provide any information on likely changes in the quantities or type of waste to be generated in the future.

WASTE DISPOSAL SURVEY
WASTE ARISING QUESTIONNAIRE

Name of firm

Products/Services

No. of employees

Address

Tel. No./Ext. No.

Name of contact **Position**

Date

OFFICE USE ONLY

Serial No. **Code**

MLH Group **L.A. Area**

Postal survey (Dates of despatch) **1.** **2.**

Interview (Personal) **Y/N on** **by whom**

Interview (Telephone) **Y/N on** **by**

NOTES:

1. **Waste type (classification)**
Please identify the types of waste produced by your premises by ticking one or more of the primary categories listed below:

a) Category	Waste Type	
I	Household and commercial (inc. waste from offices, shops, etc.)	____
II	Medical, surgical and veterinary wastes.	____
III	Industrial waste (see below for details)	____
IV	Mine and quarry waste	____
V	Radioactive waste	____
VI	Farm waste	____
VII	Construction and demolition waste	____
VIII	Sewage sludge, gully and cesspit emptyings	____
IX	Old cars, vehicles, etc.	____
X	Ash (from incinerators), etc..	____

If you have ticked category 'III' above, please specify the waste type produced by ticking one or more of the categories listed below:

b) Category	Waste Type	Examples	
A	Inorganic acid.....	(sulphur acid, etc.).....	____
B	Organic acids.....		____
C	Alkalis.....	(Ammonia, caustic, etc.)..	____
D	Toxic metal compounds..	(Lead, zinc compounds, etc.)	____
E	Non-toxic metal compounds	(Iron, etc.).....	____
F	Metals (elemental).....	(Mercury, aluminium).....	____
G	Metal oxides.....		____
H	Inorganic compounds....	(Cyanides, sulphides).....	____
J	Other inorganics.....	(Asbestos, slug, silt, etc.)	____
K	Organic compounds.....	(PCB's cleaning solvents, etc.)	____
L	Polymeric materials....	(Epoxy resin, latex rubber, etc.)	____
M	Fuel, oil and greases..	(Fats, waxes, kerosene, etc.)	____
N	Fine chemicals and biocides.....	(Pesticides, cosmetics, drugs, etc.)	____
P	Misc. chemicals wastes.....		____
Q	Filter materials, treatment sludge and contaminated rubbish.....		____
R	Interceptor waste, tars.	(From pits and traps, etc.)	____
S	Miscellaneous waste.....	(Soaps, paper, glass, etc.)	____
T	Animal and food waste...	(Slaughter and processing waste, etc.)	____

Please describe any industrial wastes not falling within the above waste types.

U _____
V _____
W _____
X _____
Y _____
Z _____

Please respond to the following questions for each waste category (and sub-category for industrial waste) ticked in question one (1). Should further space be needed, please photocopy relevant pages.

Waste category

_____ _____ _____ _____ _____

2. (a) What is the nature of the waste?

o solid	_____	_____	_____	_____	_____
o semi/solid	_____	_____	_____	_____	_____
o liquid	_____	_____	_____	_____	_____

(b) Do you have any information on the chemical composition of the waste (yes/no)?
If yes, please attach details on a separate sheet.

3. In your experience, is the waste:

o flammable	_____	_____	_____	_____	_____
o toxic	_____	_____	_____	_____	_____
o corrosive	_____	_____	_____	_____	_____
o odorous	_____	_____	_____	_____	_____
o non-hazardous	_____	_____	_____	_____	_____

4. Please state the numbers of units of each of the following types used for temporary waste storage:

o dustbin/sack	_____	_____	_____	_____	_____
o bulk bin	_____	_____	_____	_____	_____
o skip	_____	_____	_____	_____	_____
o tank	_____	_____	_____	_____	_____
o drum	_____	_____	_____	_____	_____
o other (specify)	_____	_____	_____	_____	_____

5. What is the size of each of the units described in (4) above?

o dustbin/ sack	_____	_____	_____	_____	_____
o bulk bin	_____	_____	_____	_____	_____
o skip	_____	_____	_____	_____	_____
o tank	_____	_____	_____	_____	_____
o drum	_____	_____	_____	_____	_____
o other (specify)	_____	_____	_____	_____	_____

NB. Please give approx. sizes in litres or m^3 (cubic metres).
For example standard dustbin = 70 litres, a standard paladin (industrial dustbin) = 950 litres ($0.95m^3$)

6. How often are the units emptied per week?

o dustbin/ sack	_____	_____	_____	_____	_____
o bulk bin	_____	_____	_____	_____	_____
o skip	_____	_____	_____	_____	_____
o tank	_____	_____	_____	_____	_____
o drum	_____	_____	_____	_____	_____
o other (specify)	_____	_____	_____	_____	_____

7. What is the weekly waste total calculated from 4-6 above (m^3)?

_____	_____	_____	_____	_____

8. What are your current disposal arrangements for each waste category?

o Local authority	_____	_____	_____	_____	_____
o Contractor (name)	_____	_____	_____	_____	_____
o Self (specify: e.g. burn, bury or transport else-where)	_____	_____	_____	_____	_____
o Other (specify)	_____	_____	_____	_____	_____

9. Does your company produce any 'waste' by-products which are sold to other companies (i.e., scrap, metal, plastics, paper, oil, solvents, tires)?

If yes, please specify:

_____
_____
_____

10. Are there likely to be any changes in the facilities operated by your company which are likely to increase or decrease the volumes of waste generated (i.e., due to an expansion or retraction programme) or alter the type of waste generated (due to a process change) in the foreseeable future?

If yes, please specify:

_____
_____
_____

Thank you for your cooperation.
Please return the above forms in the SAE provided at your earliest convenience.
Please do not hesitate to telephone for additional information or assistance to complete the above.

Source: Environmental Resources Limited (ERL). 1987.

Appendix E

WASTE COMPATIBILITY INFORMATION

(Source: Batstone, Roger, et al., 1989)

FIGURE 2-2

Compatibility of Selected Hazardous Wastes

1	Oxidising Mineral Acids	1										
2	Caustics	H	2									
3	Aromatic Hydrocarbons	H F		3								
4	Halogenated Organics	H F GT	H GF		4							
5	Metals	GF H F			H F	5						
6	Toxic Metals	S	S				6					
7	Sat Aliphatic Hydrocarbons	H F						7				
8	Phenols and Creols	H F							8			
9	Strong Oxidising Agents		H	H F		H F		H		9		
10	Strong Reducing Agents	H F GT			H GT				GF H	H F E	10	
11	Water and Mixtures containing Water	H			H E		S				GF GT	11
12	Water Reactive Substances	Extremely reactive, do not mix with any chemical or waste material										12

E	Explosive
F	Fire
GF	Flammable Gas
GT	Toxic Gas
H	Heat Generation
S	Solubilisation of Toxins