# R E P O R T

# FEASIBILITY STUDY INTO THE POSSIBLE REGIONALISATION OF HEALTH CARE RISK WASTE TREATMENT / DISPOSAL FACILITIES IN GAUTENG


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**NOVEMBER 2000**

**REPORT No. P99/024-03**

*PREPARED FOR:*


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## EXECUTIVE SUMMARY

Having identified a need for more co-ordinated and integrated Health Care Risk Waste (HCRW) management in Gauteng, the Gauteng Department of Agriculture, Conservation, Environment and Land Affairs (DACEL) prepared and issued Terms of Reference (ToR) to consultants during the latter half of 1999 for undertaking a Status Quo Study on HCRW management in Gauteng. This study was not only aimed at identifying and quantifying the various sources of HCRW in Gauteng, but it was also aimed at investigating and reporting on the available treatment/disposal facilities in the Province. The feasibility of regionalising HCRW treatment facilities were finally to be investigated in an attempt to come up with a broad strategy for the regionalisation of such facilities. Although siting scenario's for the proposed facilities were to be done, it was not required that specific sites be identified, as that was to form part of a follow-up project.

Having been successful in submitting a proposal to undertake the project, Kobus Otto & Associates Waste Management Consultants in Association with Environmental & Chemical Consultants, Executive Task Force, CSIR and Mabula Consulting Engineers were appointed. The appointment was to define and investigate the nature of HCRW and amount generated in Gauteng, status quo of HCRW treatment/disposal facilities, alternative HCRW treatment/disposal technologies, development of a customised module of the Environmental Information Management System (EIMS) in line with DACEL system to spatially represent the most prominent HCRW generators in Gauteng, as well as the existing HCRW treatment facilities. The final requirement was to undertake a waste transportation study that also considered the possible regionalisation of HCRW treatment facilities. The appointment was done according to the issued Terms of Reference (ToR).

The study started off with a literature review on HCRW practices implemented throughout the world, with particular emphasis on developing countries like South Africa, thus being able to identify shortcomings that may exist in present HCRW practices and to ensure that the recommendations made are in line with the relevant international standards.

With limited information available on potential generators of HCRW in Gauteng, the next step was to undertake an investigation that led to the identification of some 600 HCRW generators (community health centres, clinics and hospitals) that were subsequently classified as "major generators" and approximately 9,700 HCRW generators (medical doctors, veterinary surgeons, etc.) classified as "minor generators". To be able to make use of the survey data for extrapolation to facilities that were not surveyed, the potential generators were grouped into 5 different categories. Due to the limited impact that it was expected to have on the overall waste stream as well as the difficulty in obtaining such information, HCRW generated at private residences were not considered. Human corpses and animal carcasses were finally specifically excluded from the study.

Consultations with the personnel involved on various levels of HCRW management were then conducted during site visits to the Health Care Facilities. This was not only to obtain first-hand information on the conditions that exist at the generators, but also to do physical weighing of the HCRW stream at a selected number of facilities. Questionnaires, specially designed with the aid of research specialists to ensure that its appropriateness for the respective categories of HCRW sources, were used during the survey.

Resulting from the impact that the wide range of occupancy rates would have had on the HCRW generation rates, it was decided not to make use of a rate in kg/bed/day, but rather in kg/patient/day, which required that the bed occupancies be determined for the particular period over which the survey was conducted. For facilities where patients were not staying overnight, the HCRW generation rate in kg/patient or alternatively in kg/facility, was used for further extrapolation of the data.

It was found from the survey that the mass of HCRW generated ranges between 0,06 and 0,48 kg/patient/day for private clinics and between 0,002 and 0,05 kg/patient/day for public clinics. For hospitals, the mass of HCRW generated varies between 0,5 and 4,04 kg/patient/day for private hospitals and 0,23 and 2,43 kg/patient/day for public hospitals. Using statistical procedures, the total HCRW mass generated in Gauteng is estimated (with 95% confidence) not to be greater than 1 175 tons per month. It was also found that the approximately 600 “major” generators contribute about 89% and the approximately 9 700 “minor” generators about 11% of the total HCRW stream generated in Gauteng.

Although analysis of the waste composition did not form part of this study, it became evident that poor segregation of Health Care Waste (HCW) results in general waste not requiring incineration being disposed of with HCRW, and in HCRW being disposed of as general waste, which creates a health and safety risk to waste disposal site workers as well as the public at large. This particularly applies where there is poor access control at the waste disposal facility. The presence of polyvinyl chloride (PVC) in the waste stream in turn results in the emission of toxic fumes at the incinerators.

General observations made on the status of HCRW management at Gauteng Health Care Facilities indicated that the HCRW storage, collection and transportation in most instances does not meet the required standards and there are only limited awareness and education programmes on management of HCRW. Personnel responsible for awareness and education of the risks associated with HCRW and responsible management procedures were not conversant about their roles.

The investigation on the HCRW treatment facilities in Gauteng, (these are all incinerators) revealed that of the 70 incinerators located at 58 Health Care Facilities, only 58 (83%) are operational and only 25 (37%) are registered with the regulatory authorities. Only one of the incinerators is equipped with a scrubber, which appears to be mostly out of operation. Ash from the incinerators is in most instances disposed of as part of the domestic waste stream or alternatively mixed with the boiler ash, before being disposed of at general waste disposal sites. Whilst incineration is currently the only HCRW treatment method used in Gauteng (and, we understand, throughout South Africa), alternative technologies such as chemical disinfection, autoclaving and microwave technology could offer cost effective and environmentally acceptable solutions if fully developed.

As part of the project, a HCRW Incinerator Information Management System (IIMS) module was developed to form part of the existing Environmental Management System used by DACEL. This included a customised user-friendly module of the Environmental Impact Management System (EIMS) for accessing and maintaining the incinerator data in the form of maps, graphs and reports. Spatial representation of data on both the sources of HCRW generation as well as the treatment/disposal facilities was updated on DACEL's EIMS within a Geographical Information System (GIS). Future developments of the IIMS may require the addition of further components, as the need for capturing additional information becomes necessary. The current system allows for upgrading and development as DACEL's needs develop.

The study found that the current practice of incinerating HCRW "on site" at provincial hospitals is comparatively uneconomic. The cost of "on-site" incineration of HCRW, plus the costs associated with the use of third-party removal/incineration of HCRW from provincial hospitals by contractors, is estimated to be approximately R810,000 per month. Application of the numerical model developed as part of this study suggests that this monthly cost could be reduced to approximately R570,000 if two new facilities are brought into operation: one at or near the Greater Johannesburg Metropolitan Council's ("GJMC") Marie Louis landfill site in Roodepoort, and one at or near the GJMC's proposed Northern Works landfill site, north of Dainfern. A fleet of purpose-built vehicles would be used to transport the HCRW from hospitals to these facilities.

When applied to the total estimated HCRW stream emanating from both provincial hospitals and clinics, the model indicates that the optimal (i.e. minimum cost) configuration of incineration facilities (with or without gas-scrubbers) comprises three new facilities: one at or near the Marie-Louise landfill site (600kg/hour), one at or near Tambo Memorial Hospital (new 300kg/hour unit replaces existing) and one at or near the Pretoria Academic Hospital (new 300kg/hour unit replaces existing). This scenario remains optimal when the possible addition of 800 new beds at Pretoria Academic Hospital is taken into account.

A scenario substituting a new facility at or near the Pretoria Metro's Hatherley landfill site instead of the upgraded Pretoria Academic Hospital facility suggested above, indicates that there would be a cost-penalty of approximately 10% over the optimal scenario; this scenario is, however, relatively sensitive to increased transportation costs.

Various other siting scenarios were investigated, and the results summarised for easy reference. *Inter alia*, these scenarios indicate that the use of only one or two new/upgraded facilities, or the use of four or more facilities, results in increased costs.]

Having reference to a number of the best (i.e. least-cost) siting scenarios as determined in this study, a thorough investigation should be undertaken at and in the vicinity of the proposed siting locations to confirm the availability and suitability of sites for possible new facilities. Detailed feasibility studies should further be undertaken for the proposed new facilities. Detailed feasibility studies should further be undertaken for the proposed new facilities, and for the HCRW transport system to be used. Based on the outcome of such detailed studies, the financial model developed for this study should be used to confirm that the proposed regionalisation strategy remains the optimal solution.

Based on the observations made during the study, it is recommended that a detailed analysis of HCW composition from hospitals and clinics be conducted to quantify the potential for recycling and savings that are likely to be achieved through improved HCW segregation. This should be accompanied by the development of standardised policy guidelines and awareness training material on responsible handling of HCW, including segregation and possible recycling of same HCW at source. This material is ultimately to be included as part of formal training of new staff members and regular refresher courses for existing staff members.

Alternative ways of reducing the use of PVC in Health Care Facilities should also be explored in order to reduce the possible generation of toxic fumes during the incineration thereof, together with a study on the appropriateness of using alternative treatment/disposal technologies to incineration.

All new incinerators commissioned in Gauteng should be permitted to operate on condition that they comply with the DEAT 2009 emission guidelines, which may require that scrubbers be fitted. The current incinerators should be appropriately upgraded or phased out by 2009. It is further recommended that the DACEL EIMS be updated as new information on Health Care Facilities as well as HCRW generation and treatment facilities becomes available.

It is finally recommended that a regionalised approach be followed to the treatment/disposal of HCRW emanating from provincial hospitals and clinics in Gauteng. This recommendation is supported both by economic considerations, as well as by administrative considerations such as the ease of control/monitoring of the small number of facilities proposed, thus ensuring compliance with environmental regulations. The design-capacity of the regionalised facilities will, however, have to be carefully determined, taking into account factors such as the anticipated growth in the mass of HCRW generated, and whether the facilities should be sized also to cater for the HCRW generated by the private sector, particularly in view of the tighter regulatory environment envisaged in the future.

By making use of the proposed optimal facility scenario as a basis, a thorough investigation should be undertaken at and in the vicinity of the proposed siting locations to confirm the availability and suitability of sites for possible new facilities. Detailed feasibility studies should further be undertaken for the proposed new facilities, and for the HCRW transport system to be used. Based on the outcome of such detailed studies, the financial model developed for this study should be used to confirm that the proposed regionalisation strategy remains the optimal solution.

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## 1. INTRODUCTION

### 1.1 Background

Towards the end of 1999, the Gauteng Department of Agriculture, Conservation, Environment and Land Affairs (DACEL) issued Terms of Reference (ToR) for investigating the Feasibility of Regionalizing Health Care Risk Waste Treatment/Disposal for Provincial Hospitals in Gauteng.

During November 1999, Kobus Otto & Associates Waste Management Consultants, in association with Environmental & Chemical Consultants, Executive Task Force, CSIR and Mabula Consulting Engineers submitted a proposal (Report No. P99/024-01) in response to the DACEL's ToR. The proposal, which was subsequently approved, called for the confirmation or otherwise of the ToR. The revised ToR (Report No. P99/024-02) was submitted to DACEL.

### 1.2 Terms of Reference (ToR)

The revised ToR objectives for this project were to:

- Define health care waste (medical waste) and its components;
- Determine the current Health Care Risk Waste (HCRW) types and generation rates expressed in kg/bed and kg/patient;
- Explore different future scenarios on medical waste generation rates for Gauteng;
- Determine the number and location of Medical Waste Treatment Facilities, including their capacities, operational status, compliance to 1994 DEAT emissions guidelines as well as remaining lifespan;

- Capture both the sources of medical waste generation and existing HCRW Treatment Facilities on DACEL's Environmental Information Management System (EIMS), which is in the spatial representation form of a Geographic Information System (GIS);
- Determine the maintenance and operation costs of the existing HCRW treatment/disposal facilities based on current (2000 Emission Requirements) and future policy compliance (2009 Emission Requirements);
- Determine the feasibility of developing a regional HCRW treatment/disposal facility or facilities for Gauteng. This would be looked *at vis-à-vis* operating upgraded individual facilities;
- Investigate and recommend alternative siting scenario's for locating HCRW treatment/disposal facilities, considering both the environmental and the economic viability;
- Develop a broad HCRW (medical waste) collection and transportation strategy to meet the needs of various alternative sites for HCRW treatment/disposal facilities;
- Briefly evaluate opportunities for restricting the use of certain materials, such as PVC, that can lead to hazardous waste streams;
- Investigate and make recommendations on HCRW awareness; and
- Investigate potential need for HCRW movement across provincial borders.

The ToR also called for the presentation and production of a popularised and summarised version of the findings.

## 1.3 Approach and Methodology

### 1.3.1 Desktop study and consultations

The success of a study of this nature requires the co-operation of those who deal with HCRW in order for existing site conditions to be accurately recorded. A number of steps were taken to ensure maximum participation by parties involved in HCRW i.e.:

- Local and international literature was reviewed to identify the participants in HCRW, the current situation regarding generation and treatment facilities and the latest approaches in HCRW management;

- Site visits were made to do physical weighing of the HCRW stream generated at selected institutions, identify problems that may exist, collect the necessary statistical data and to acquaint the investigating team with prevailing conditions;
- The HCRW generation rates per patient were determined at the facilities where physical weighing was done to obtain the total Provincial HCRW generation rates by means of extrapolation;
- Consultations were held with various Provincial and National Departments as well as Private sector companies that deal with HCRW, in order to determine the most effective integrated approach;
- Different questionnaires were developed to be relevant to the various categories of HCRW generators, such that salient details required for the study were obtained from the respective HCRW generators.

### 1.3.2 Field surveys

**Purpose of the survey**

The aim of the survey was to:

- Obtain information concerning the HCRW generation rates by means of physical weighing that would ultimately determine the level of infrastructure required;
- Acquire the occupancy rates on the number of patients (past and present) that generate HCRW so as to be able to predict future trends and to be able to extrapolate the information to facilities that were not physically measured;
- Obtain first hand information regarding the standards for and conditions under which HCRW is managed;
- Determine the physical positions of the incinerators by means of a GPS device.

The information on the hospital occupancy rates was obtained by means of interviews together with completion of the relevant questionnaires. In other areas, questionnaires were sent to the respondents by means of a fax.

**Survey methodology**

The field survey *inter alia* involved the following activities:

- Collection and recording of statistical information related to the occupancy (past and present; and
- Collection and weighing (by using purpose made calibrated scales) of HRCW generation over an average period of five days from each HRCW generator. Where possible, the waste generation rates were recorded according to the source (ward or theatre in which it was generated). Where HCRW is not collected daily, surveys were limited to the day of collection. This information was later related to the occupancy rates for the period over which the HCRW was generated.
- Observations related to the way in which HCRW is managed at source, as well as the strategies followed with regards to the treatment/disposal thereof were made.

### 1.3.3 Limitation of the study

As it was not physically possible to measure HCRW masses at all potential sources, a "sampling" procedure had to be adopted. Although HCRW generation figures are internationally often expressed in kg/bed/day, a decision was taken rather to express the generation rates in terms of kg/patient/day, as the occupancy rate of some Health Care Institutions was way below their available capacities, whilst others exceeded full capacity.

With any "sampling" procedure there is the danger that the sampled values (in this case HCRW mass/patient/day or mass/patient treated in the case of clinics) give a misleading picture as to the values in the total population. This is particularly true when the sample size is small in relation to the population size. For example, if one wished to determine the average height of the pupils in a school having 1,000 pupils, but the researcher only had the time to measure a "sample" of say 50 pupils, it can be expected that the average height of the sample of 50 pupils would not be identical to the average height of ALL the pupils. In cases like this, one option is to resort to statistical techniques which, although it cannot predict the exact value for the average height of all the pupils, can predict with a given degree of confidence that this average will be between certain limits, for example: "the 90% confidence interval for the average height of the school pupils is 1.25 to 1.75 metres". From a confidence interval like this, other deductions can be made, viz. there is only a 10% (100% - 90%) likelihood that the actual average is outside the range stated and, further, there is only a 5% likelihood (10% / 2) that the actual average is less than 1.25 (the lower limit) or that it is greater than 1.75 (the upper limit).

In the case at hand, DACEL is essentially concerned with the upper limit of HCRW generation in the province, i.e. it would like to be confident that the capacity of existing or planned future HCRW incineration/destruction facilities is/will be adequate to treat the HCRW stream generated.

To assist with the interpretation and extrapolation of the HCRW generation data, statisticians from the University of the Witwatersrand were employed. They recommended that the "upper 90% confidence limit" be used in the extrapolation of the HCRW generation figures, which means that there is a 95% certainty that the actual mass of HCRW generated in Gauteng will not exceed the mass estimated in this study. (The statistical calculations are described in Annexure 3.3 and elsewhere in this report.).

With the exception of certain public institutions showing a zero increase in HRCW waste generated from 1995 to 2000, the HRCW waste generators did not have the necessary waste generation data for previous years which renders it impossible to predict future HRCW trends based on historical statistics. Some of the factors likely to have an effect on the HCRW generation rates are:

- The population growth rate (as projected from historical trends) will result in an increase in the rate at which HCRW is generated;
- The increase in AIDS-related illnesses could on the one hand result in an increase in the HCRW generation rates as more people fall ill, whilst it could in the worst case result in a negative growth in the population which will ultimately result in a reduction in HCRW generation figures;
- Improved HCRW awareness could result in better segregation of waste with a net reduction in the overall HCRW generation rates;
- A tendency towards the use of more disposable materials could result in an increase in the HCRW generation rates;
- Improved HCRW treatment standards may lead to higher treatment costs, which could result in a more dedicated effort being made by the generators to reduce their HCRW streams.

Due to the many variables that could have an effect in either direction on the projected growth of HCRW generation, it was not possible to predict a growth rate with any degree of certainty. As a sensitivity analysis proved that the outcome of the investigation was not significantly affected by the HCRW growth rate, it was finally decided to assume an average growth rate of 0% for the purpose of this investigation.

Other limitations included a delayed start to the project as a result of insufficient capacity building amongst the various stakeholders, a lack of information regarding potential HCRW generators which made it difficult to determine the required sample size as well as limited time available for the study when considering that the consultants had to do the physical weighing of HCRW at the generators.

### 1.4 Purpose and Scope of the Report

This report *inter alia* covers the following:

- The methodology adopted in conducting the study, as well as the limitations encountered;
- The status with regards to the number, types and locations of HCRW sources in Gauteng. The rates and mass of HCRW generated at the full spectrum of generators is covered;
- The status quo on the HCRW treatment facilities in terms of its location, ownership, types, sizes, capacity, condition and current operating costs;
- A visual perspective of the major HCRW generators as well as the treatment facilities by means of a customised module of the Environmental Information Management Systems (EIMS) for accessing and maintaining HCRW generators and treatment/disposal facility data captured on DACEL's EIMS;
- Recommendations on alternative siting scenarios for HCRW treatment facilities in Gauteng; and
- Conclusions reached with regard to the question of possible regionalisation of HCRW treatment/disposal facilities in Gauteng.

## 2. NATIONAL AND INTERNATIONAL REVIEW OF HEALTH CARE RISK WASTE MANAGEMENT

### 2.1 Background

- The term 'Medical Waste' or Health Care Risk Waste (HCRW) has various interpretations. In clinics and hospitals for example, it would be associated with sharps, used bandages etc. while pharmaceutical firms might refer it to expired or spoiled medicines in their retail or manufacturing process. The purpose of this chapter is to define and analyse the various components of Medical Waste or Health Care Risk Waste.

- Although this report will make use of the internationally accepted terminology, it is important that a link be created to the existing standards and requirements laid down in South Africa, i.e. the Minimum Requirements for the Classification, Handling and Disposal of Hazardous Waste [1] and the National Waste Management Strategy. For this reason the definition of hazardous waste in accordance with the Minimum Requirements will be discussed to define where HCRW will fit into this.

- This chapter therefore reviews the current practices of Medical or Health Care Risk Waste Management in South Africa, also covering the nature and definition of Medical or Health Care Risk Waste. The review is primarily based on literature studies and consultations with various role-players in the industry.

## 2.2 Nature and Definitions of Medical or Health Care Risk Waste

Medical or Health Care Waste can be separated into a number of categories that identify the major hazard characteristic or risk that they pose to human health and the environment. These categories are divided as follows: -

- Infectious;
- Chemical (includes pharmaceutical waste);
- Radioactive; and,
- General waste.

Each of these can be divided into subcategories in a number of ways. Often a specific hazard may be specified, e.g. sharps, that includes any waste that may puncture the skin and thus introduce infection, or alternatively the source or origin of the waste may be specified, e.g. pharmaceutical waste.

In South Africa, various attempts at legislating hazardous wastes have given rise to somewhat different approaches and definitions. In terms of the Minimum Requirements for the Classification, Handling and Disposal of Hazardous Waste [1] published by the Department of Water Affairs and Forestry, infectious waste, chemical waste and radioactive waste are all defined as ***Hazardous Waste*.** The United Nations and others have termed the hazardous wastes coming from health care facilities "*Health Care Risk Waste (HCRW)*" and GDACEL opted to use the latter term throughout this project.

### 2.2.1 The South African approach to the classification of Health Care Risk Waste (HCRW)

In South Africa, infectious waste is considered a sub-category of hazardous waste. The "Minimum Requirements for the Classification, Handling and Disposal of Hazardous Waste" (DWAF, 2nd edition, 1998) uses as a primary classification scheme the International Maritime Dangerous Goods (IMDG) Code, which has been published as SABS Code 0228**.** The code divides hazardous materials, in this case hazardous wastes, into 9 categories based on their hazardous characteristics, and even though HCRW may not fall under all of these, it is presented for the sake of more clarity.

- Class 1 : Explosives;
- Class 2 : Compressed Gases;
- Class 3 : Flammable Liquids;
- Class 4 : Flammable Solids;
- Class 5 : Oxidising Substances and Organic Peroxides;
- Class 6 : Toxic and Infectious Wastes, subdivided into
  - Class 6.1 : Toxic (poisonous) Wastes;
  - Class 6.2 : Infectious Wastes;
- Class 7 : Radioactive Wastes;
- Class 8 : Corrosive Wastes; and;
- Class 9 : Miscellaneous Dangerous Wastes.

Note that infectious waste is a subcategory of Class 6. Other wastes produced at the Health Care Facilities include Class 6, toxic materials such as pharmaceuticals, drugs and cytotoxic substances; flammable liquids such as ether, alcohol and many formulated products such as cough mixtures; radioactive substances, which are Class 7; and compressed gases, which are Class 2. Radioactive wastes and infectious wastes are generally managed separately from the other categories, which are all classified as chemical hazardous waste, whether they arise from a Health Care Facility or the chemical and petroleum industry.

### 2.2.2 Definition of hazardous waste

In order to compare the definition of HCRW with that of hazardous waste, the definition of hazardous waste, as outlined in the "Minimum Requirements for the Classification, Handling and Disposal of Hazardous Waste" (DWAF, 2nd edition, 1998) is:

'*Waste that may, by circumstances of use, quantity, concentration or inherent physical, chemical or infectious characteristics, cause ill-health or increase mortality in humans, fauna and flora, or adversely affect the environment when improperly treated, stored, transported or disposed of.*'

Note that the health care *infectious waste* stream is considered in this definition as a hazardous waste.

### 2.2.3 Definition of infectious waste

There are numerous definitions used for infectious waste and after considerable deliberation, a modified version of the definition used in the Minimum Requirements is recommended, which is subject to consultation before it will be finally accepted as the recognised definition

*'Infectious waste is that waste that contains or is suspected to contain pathogens, bacteria, viruses, parasites or fungi in sufficient concentration or quantity to cause disease in susceptible hosts. It includes any waste that is generated during diagnosis, treatment or immunisation of humans or animals; in research pertaining to this; in the manufacturing or testing of biological agents – including blood, blood products and contaminated blood products, cultures, pathological wastes, sharps, human and animal anatomical wastes and isolation wastes.'*

The definition is conservative and utilises the Precautionary Principal. Although much of the waste would not be hazardous, the risks posed by its potentially infectious nature are sufficient that it must be considered infectious unless proven otherwise. In South Africa, the waste is classified in terms of SABS Code 0228, "The Identification of Dangerous Substances and Goods" as Class 6.2: Infectious Substances.

Within the definition of infectious waste are two subcategories that are sometimes referred as follows: -

*Anatomical (Pathological) Waste is waste that consists of tissues, organs, body parts, foetuses and animal carcasses (excluding blood and body fluids, teeth, hair, etc.)*

The sub-category, anatomical waste, is useful since it is usually managed in different ways to other infectious wastes. In terms of the Human Tissue Act, human tissue must be incinerated and because of its generally offensive nature, technologies such as autoclaving and microwaving are not generally appropriate. In South Africa, religious customs, for example in the Muslim community, may require the burial of certain items of anatomical waste and this must be taken into account in the development of the procedures for anatomical waste management.

*Sharps are items that could cause cuts and puncture wounds and includes needles, hypodermic needles, scalpels and other blades.*

Sharps and in particular needles that give rise to "needle stick" injuries are a major health hazard in Health Care Facilities.

Infectious waste, such as old bandages, plasters, sanitary towels and babies nappies are often disposed with the general waste. In the United Kingdom this infectious or potentially infectious waste collected from households with the general waste stream is not considered a major problem, because it is generated from a "generally healthy population". The same approach is generally accepted in South Africa, since like other hazardous waste in general waste, it is usually catered for when the landfill sites are constructed and operated. The same approach cannot be followed in all hospitals.

However, when the potentially infectious waste is collected in increased volumes, such as *sanitary waste* from ladies toilets, in public areas such as large buildings, shopping malls and airports, then the risk becomes slightly greater. In South Africa, there are a number of companies rendering services that provide storage bins in toilets and a regular collection service. Often these wastes are disinfected with a "proprietary disinfectant", the bins cleaned and the waste disposed to landfill. There has been no real control over this practice, although the Department of Water Affairs and Forestry have requested each operator to assess their monitoring, treatment and disposal procedures.

### 2.2.4 Chemical Waste

The definition of chemical hazardous waste is given above under hazardous waste, if one excludes the infectious characteristic. Chemical hazardous waste includes any waste that has one or more of the following four characteristics:

- Corrosivity, pH $<6$ and pH $>12$
- Reactivity, (explosive, reacts with water, air or other wastes)
- Flammability, Flash Point $<61^{o}$C
- Toxicity (poisonous)

Toxicity is defined in terms of the following parameters:

- Acute toxicity to mammals ($LD_{50}$, );
- Ecotoxicity ($LC_{50}$, 96hr, fish);
- Chronic toxicity;
- Carcinogenicity,
- Mutagenicity;
- Teratogenicity;
- Biodegradability;
- Persistency;
- Bioaccumulation;
- Concentration; and;
- Assimilation capacity of the environment.

Using these parameters the Minimum Requirements, classifies chemical waste into five hazard groups i.e. (HG1, HG2, HG3, HG4, Non-toxic) as follows: -

*Extreme Hazard (Group 1)* is waste containing significant concentrations of extremely hazardous waste, including certain carcinogens and teratogens and infectious wastes.

*High Hazard (Group 2)* is waste with highly toxic constituents.

*Moderate Hazard (Group 3)* is waste, which is moderately toxic or which contains constituents that are potentially moderately harmful to human health or to the environment.

*Low Hazard (Group 4)* is waste that contains potentially harmful constituents in concentrations that would represent only a limited threat to human health or to the environment.

*Non-toxic - Hazard Rating Lower than Group 4* if the hazard rating falls below hazard rating 1 to 4, the waste can be considered as non-toxic (N/T) and be disposed of as a de-listed hazardous waste in a permitted general waste landfill.

Within the definition of chemical waste are a number of subcategories that are sometimes used as follows: -

*Genotoxic waste has mutagenic, teratogenic or carcinogenic properties.*

Note that genotoxic wastes, which include *cytotoxic (or antineoplastic)* drugs, are simply a sub-class of chemical waste and generally fall into the extreme hazard, HG1, and high hazard, HG2, groups.

*Pharmaceutical waste includes expired, unused, spilt and contaminated pharmaceutical products, drugs, vaccines and sera that are no longer needed.*

This category, which is simply an indication of the source of the waste, is not very useful since it implies to many people that the wastes are somehow different to chemical and other wastes. Whilst live vaccines and possibly sera must be managed as infectious waste, most pharmaceuticals contain one or more active chemical ingredients that are often toxic plus many other chemicals added to act as a carrier for the drug, to add flavour, etc. Almost all pharmaceuticals must be treated as a hazardous chemical waste. For example, the redundant or waste pharmaceuticals can include the following: -

- Active ingredients, many of which are highly toxic. For example, Warfarin is used to treat heart conditions but it is also a rat poison. In addition, a study on a list of 90 active ingredients used by a local pharmaceutical manufacturing company, found more than 70% to contain organochlorine or other organohalogens, hydrogen chloride and/or sulphur. All of these would generate acid gases on incineration.

- Flammable solvents, including chlorinated solvents such as chloroform, which is often a constituent of cough mixtures.
- Fillers, flavouring agents and preservatives, many of which could produce hazardous emissions in an incinerator that does not have a scrubber. An example is the use of mercury compounds as a preservative in some eye drops - although the concentration is very small.
- Packaging that can include PVC that will definitely give off considerable quantities of acid gases and can contain lead compounds. Packaging can also be labelled with dyes containing hazardous heavy metals such as Cd, although many packaging manufacturers have become aware of the problems with the combustion of these dyes and have stopped using them

*Compressed gases include gas cylinders, gas cartridges and aerosols.*

In general, gas cylinders are not a problem for the health facility as they are recovered by the suppliers, both because they are valuable and in terms of the duty of care. Compressed gases are SABS Code 0228, Class 2 wastes. Aerosols should be discarded only when empty and never included in the infectious waste stream, since they explode in an incinerator causing damage to the refractory lining and the rapid expansion of the gas gives a transient increase in the emission of particulates and other pollutants.

*Heavy Metal Wastes includes mercury from broken thermometers, blood pressure gauges and used batteries.*

Mercury and its compounds are an extreme hazard, HG1 and must be managed as a chemical hazardous waste.

### 2.2.5 Radioactive Waste from Health Care Facilities

Radioactive waste, which includes solid, liquid and gaseous wastes, contaminated with radioactive nuclides is generated in health care facilities in two forms, *unsealed* or open sources and *sealed* sources. Sealed sources are usually contained in equipment or as needles or seeds that may be re-used after sterilisation for other patients. The disposal procedures for sealed sources differ from those for unsealed sources. Sealed sources are usually disposed at the Atomic Energy Corporation's landfill site at Pelindaba or even re-exported to their country of origin.

Radioactive material is defined as any substance, which consists of or contains any radioactive nuclide whether natural or artificial and whose specific activity exceeds 74Bq/g (0.002µCi/g) of chemical elements and which has a total activity greater than 3.7kBq (0.1µCi).

The unsealed sources of radioactive material used in health care facilities usually results in low-level radioactive wastes (<1MBq), but waste in sealed sources may be of fairly high activity. In general, the low-level waste can be disposed with the normal infectious waste stream provided the appropriate controls are in place. However, the treatment of sealed or high level radioactive waste with the infectious waste stream must be avoided particularly when it is to be incinerated, since the ash and even the incinerator can end up being contaminated with unacceptable levels of radioactivity.

The definition of low-level waste is based on the concept of "Annual Limit on Intake" (ALI) and there are different ALI values published for ingestion and inhalation. The $ALI_{min}$ is the lesser of these two values for each radionuclide and a table of values has been published (Department of Health, Cape Town). For both solid and liquid waste the total activity supplied to the disposing facility, i.e. sewer, incinerator or even landfill cannot exceed 10 $ALI_{min}$ per month for each laboratory or corresponding entity and each release to the sewer or package containing solid waste must not exceed 1$ALI_{min.}$

## 2.3 Composition of the Health Care Infectious Waste

The composition of South African Health Care Risk Waste that is treated at the incinerators is not known. Poor separation at source means that considerable quantities of general waste end up in the HCRW stream and is thus incinerated at high cost. In the USA, the so-called "red bag" waste that is infectious has considerably different composition to the general waste produced at hospitals and the normal municipal waste stream as presented in ***Table 2.1*** below.

***Table 2.1:*** *Composition of infectious waste and hospital general waste according to Brown (1989)*, HL Brown, Thomas Jefferson University Hospital Waste Characterisation Study, Drexel University, 1989*

| **Material** | **Infectious Waste, %** | **General Waste, %** |
|---|---|---|
| Paper | 31.0 | 36.0 |
| Cardboard | 0.0 | 3.0 |
| Plastic | 29.0 | 20.0 |
| Rubber | 12.0 | 1.4 |
| Textiles | 5.0 | 2.1 |
| Food | 1.0 | 11.7 |
| Yard waste | 0.0 | 2.0 |
| Glass | 3.2 | 4.8 |
| Metals | 1.1 | 7.2 |
| Fluids | 17.7 | 9.9 |
| Misc. Organics | 0.0 | 1.9 |
| **TOTAL** | **100** | **100** |

Clearly, the major differences in the two waste streams reported in ***Table 2.1***, are the higher amounts of plastics, rubber and fluids and the very low amounts of food waste in the infectious waste stream compared to the hospital general waste. The higher amounts of plastic and rubber indicate that the waste has a higher calorific value compared to the general waste stream. In many countries, the amount of plastic in the medical waste and the use of disposable items have increased over the last 10 years and it is believed that South Africa is no exception, although there is no good data to support this. According to one South African medical supplier they have reported an increase in the sale of disposables including theatre gowns and bed sheets in South Africa in the last few years, with up to 10% per annum in the private hospitals, but only 3% per annum in the Provincial Hospitals.

As many as six different plastics are used in the waste stream i.e. polypropylene, polyvinyl chloride, polystyrene, polyethylene, polycarbonate and various mixed plastics. Only one, polyvinyl chloride (PVC), contains organochlorine and the amount found in an incinerator feed is closely related to the production of hydrogen chloride and may influence the emission of the extremely toxic chlorinated dioxins and furans. The major items that contain PVC are vinyl gloves, intravenous administration sets, syringes and needles. The amount of PVC items used will clearly depend on the type of hospital but figures of the order of 60g per bed per day have been published (A E S Green, ed. "Medical Waste Incineration and Pollution Prevention", Van Nostrand Reinhold, NY 1992).

The potential impact of the combustion of pure PVC, which is 56.7% by weight of chlorine, becomes clear when it is noted that 1kg would yield 583g of HCl or equivalent to the amount of acid in ~1.7 litres of pool acid. Most PVC items contain plasticisers and other ingredients and therefore the amount of chlorine is significantly lower; for example flexible items have a high plasticiser content and consist of ~36% PVC, whereas rigid items contain much less plasticiser, 54%-64%. In addition, some of the HCl reacts with alkalis in the waste stream and therefore does not necessarily get emitted through the stack. The major use for PVC is in the construction of blood bags because of the low cost of the material, its good mechanical behaviour and acceptable biocompatibility. There are substitute materials available for both the flexible and rigid PVC items used in hospitals (A E S Green, ed. "Medical Waste Incineration and Pollution Prevention", Van Nostrand Reinhold, NY 1992) but they are currently not generally available and are presumably more expensive. However, the presence of PVC does pose a significant environmental burden, if scrubbers are not fitted to the incinerators, which is the norm in South Africa. Scrubbers add significant capital and operational costs to incinerators and depending on the size of the incinerator, i.e. the economies of scale that can be achieved, the cost for incineration can increase substantially. The "incineration cost models" developed for this study, and described in paragraphs 6.3.1 and 6.4.2 below, suggest that the increase is only approximately R0.29 (50%) in the case of large (900kg/hr plus) new facilities; however, for existing (mostly small) facilities like Tambo Memorial and Pretoria Academic Hospital, the increase ranges from R0.54 to R0.61/kg.

It must be noted that location of incinerators away from residential and sensitive areas can greatly reduce the risk of impacting on health and safety but the acid gases are still released. Alternatives to the use of acid gas scrubbers, which can probably considered to be an "end-of-pipe" solution, include banning the use of PVC, except where no alternatives are available, and the use of alternative technologies for the sterilisation of the waste such as autoclaving or microwaving. Proper separation at source should also reduce the amount of PVC entering the waste stream.

## 2.4 Treatment Technologies for Infectious Waste

### 2.4.1 Minimum requirements

According to the "Minimum Requirements for the Classification, Handling and Disposal of Hazardous Waste", *sterilisation* is a minimum requirement before disposal of any residue in a permitted H landfill [1]. The Department of Water Affairs and Forestry have interpreted this, as requiring incineration of infectious waste before disposal of the ash to a hazardous waste landfill. The reason for this is that the infectious waste disposed, such as sharps, can be reused, even if sterile. As many sites still have pickers, disposal at these sites would be unacceptable. Furthermore, it is difficult to monitor the sterility of infectious waste arriving at a landfill site, if it remains in its original containers. It is well known that infectious waste is finding its way into the general waste stream in considerable quantities – at best, this results in disposal at permitted landfills, but frequently infectious waste ends up in informal landfills or dumped in the veld.

The definitions of sterilisation and disinfection given below are based on those published by the Centre for Disease Control in Atlanta, Georgia (Pruss, 1999): -

*Sterilisation* is a process that reduces the number of microorganisms by a factor of one million ($10^6$ or more than 99.9999% are killed).

*High-level disinfection* is when all microorganisms, with the exception of small numbers of bacterial spores, are killed.

*Intermediate Level* Disinfection is where Myocardium tuberculosis, most viruses and fungi are killed, but not necessarily bacterial spores.

*Low Level Disinfection* is where most bacteria, some viruses and some fungi are killed, but the complete absence of resistant microorganisms such as tubercle bacilli or bacterial spores cannot be relied on.

Note that although sterilisation implies the complete absence of any microorganisms, the definition allows the presence of small numbers of microorganisms. For disposal purposes, sterilisation is an ideal that should be achieved, if possible. However, there may be circumstances (like in emergency situations where due to unforeseen circumstances insufficient incinerator capacity is available or where the transport distance from remote rural areas make it impossible to have the HCRW incinerated) where disinfection or possibly even no treatment could be acceptable, before disposal, is done. This statement can be motivated as follows:

Even though in South Africa, incineration is still the method of choice for infectious waste, there are a number of new technologies that are available that compete with incineration and can be accepted provided they meet certain objectives specifically focussed at the South African environment and conditions. The final choice depends on many factors, but must as a minimum meet certain environmental, health and safety requirements. Issues that must be considered are:

- The sterilisation or disinfection efficiency;
- The waste should not be accessible for reuse;
- The potential impact of poor segregation of wastes, e.g. impact of chemical wastes, aerosols, etc;
- The ability to meet the requirements of the Occupational Health and Safety Act;
- The emergency procedures required, e.g. after a needle stick injury;
- Regulatory requirements, including an Environmental Impact Assessment with public scoping;
- Any gaseous emissions including fugitive emissions;
- Disposal of water, e.g. to sewer;
- The quantity of waste for treatment and the capacity of the system;
- The volume of waste and mass reduction;
- The residues after treatment – classification and disposal procedures;
- Infrastructure and operation and maintenance requirements;
- Training requirements;
- Available space;
- Location;
- Capital and operating costs – the technology should be cost effective; and;
- Public acceptability.

It is proposed that:

*"Any technology appropriate for South African conditions can be used, provided the operator/owner can demonstrate that it can meet all health, safety and environmental requirements including passing a full environmental impact assessment and public scoping study."*

Possible acceptable alternative technologies that can be used to treat all or part of the infectious waste stream include incineration, chemical disinfection, autoclaving and microwave technology and these have been considered in some detail in a previous report (GDACEL, "Background Study on Medical Waste Management", by Infotox, November 1998) and only a limited discussion is included below**.**

### 2.4.2 Alternative technologies to incineration

A number of alternative technologies are being investigated in South Africa – these include:

- Chemical Disinfection
- Autoclaving
- Microwaving
- Plasma Arc Destruction and
- Thermal Depolymerisation Technology

In Phase 2 of this GDACEL study, the plans include an evaluation of the treatment and disposal options available and their advantages and disadvantages. These must be considered in terms of both National and Provincial priorities.

# 3. STATUS QUO REPORT ON THE SOURCES OF HCRW IN GAUTENG

## 3.1 Objectives of the Chapter

Previously, planning for HCRW treatment/disposal facilities was hampered as a result of the limited data that was available on the actual volume/mass of HCRW that was generated at the various health care facilities. Reliable information on the volume/mass of HCRW generated is required by the authorities to effectively plan primary and secondary storage facilities, collection strategies, transportation, treatment and disposal alternatives that can be controlled and monitored throughout the life of the facilities. This information is further required to determine the viability of recycling initiatives. This would also help to attract the private sector to invest in HCRW infrastructure and would assist in finalising contractual arrangements between the collection contractors and the owners of health care facilities. Furthermore, this would help in the formulation, implementation and monitoring of HCRW policy.

The purpose of this chapter is to outline the status of HCRW generation in Gauteng. This information will in turn be used to make recommendations on the ways in which the HCRW stream is to be managed. This chapter covers the methodology used, sources of information as well as number and location of HCRW generators in Gauteng. The survey results on the volume/mass of waste generated per service area together with the combined effect on total HCRW are also covered.

## 3.2 Methodology Used

In order to identify all potential generators of HCRW as well as to obtain all the relevant information on such generators, a desktop study was undertaken. This study included literature studies as well as consultation with various governmental and non-governmental bodies that are recognised in the medical field.

On completion of the desktop study and consultations with authorities and organisations dealing with HCRW, all potential HCRW generators identified were categorised and questionnaires that were appropriate for each particular group were developed with the aid of market research specialists. This not only ensured that the data collected would be valid, reliable and relevant to the study, but it also resulted in the development of a questionnaire that was user-friendly for use during the survey, as well as during the data capturing phase.

The questionnaires were then distributed to the members of the Project Steering Committee for comments, approval and subsequent finalisation. The various types of questionnaires, specifically developed for each of the categories were then used to capture data during the survey. The questionnaires for the different groups are attached in ***Annexure 3.1.***

Statisticians from the University of the Witwatersrand were then employed to assist in determining the sample size for each of the health care institution categories to be surveyed, thus enabling the consultants to achieve a database that would be statistically representative.

Although the Project Brief indicated a number of potential sources of HCRW that were to be investigated, further investigations undertaken during the desktop study resulted in more potential sources being identified, which resulted in all sources of HCRW in Gauteng, with the exception of human bodies and animal carcasses, being included in the study. The complete HCRW stream was therefore identified and a scientifically selected number of facilities from each of the HCRW generating categories were then surveyed to have the generated waste masses quantified. It was important to cover the full spectrum of HCRW generators by first identifying all potential generators and then determining the contribution of each point source on the overall HCRW stream. The groups from which the sample size was determined were categorised as follows:

- Hospitals and clinics (Public as well as private);
- Medical Doctors, Veterinary Surgeons, Dentists, Medical Specialists;

- Old age homes, Mortuaries, Hospices;
- Pharmacies, Pharmaceutical Industries; and;
- Blood Banks, Pathology Laboratories.

The HCRW generated was weighed over periods ranging from one to seven days depending on the size of the facility under investigation (thus the volume of waste being generated) as well as the frequency at which HCRW was collected for treatment and disposal. HCRW containers (142 litre and 50 litre cardboard boxes with plastic liners; 85 litre plastic bags; 75, 50, 25 and 10 litre plastic buckets; 7,5 litre and 2,5 litre plastic sharps containers) were weighed to an accuracy of 10 grams on electronic platen scales. A total of 2 950 measurements were taken in the various health care institutions surveyed.

## 3.3 Sources of HCRW in Gauteng

Having identified all potential sources of HCRW in Gauteng, as well as the likely impact that each of these sources would have on the overall HCRW stream, the HCRW sources were divided into the major and minor sources as indicated below:

### 3.3.1 Major sources

The major HCRW generation sources were identified to be as follows:

- Provincial hospitals : Hospitals owned and operated by provincial government
- Military hospitals : Hospitals for the exclusive use by military personnel
- Mine hospitals : Hospitals for the exclusive use by mine employees
- Private hospitals : Hospitals owned solely by the private sector
- Provincial clinics : Clinics owned and operated by provincial government
- Industrial clinics : Clinics owned and operated by private industries
- Private clinics : Clinics owned and operated by the private sector[1]
- Municipal clinics : Clinics owned and operated by Local Councils
- Day clinics : Privately owned clinics with no overnight facilities
- Blood banks : Blood donor centres

***NOTE:*** *some confusion exists on exactly where the line is drawn between a private hospital and a private clinic. A definition of a private clinic could not be found. The problem arises where a facility would have a number of beds, do major operations, keep patients overnight but be called a Clinic e.g. Park Lane Clinic, etc.*

### 3.3.2 Minor sources

The minor HCRW generation sources were identified as follows: -

- Laboratories : Private and Public Pathology laboratories.
- Pharmaceutical Industries : Industries with the potential of generating HCRW
- Pharmacies : Private dentists and dental surgeries
- Dentists : Private and public pharmacies not forming part of hospitals or clinics
- Old age homes : Institutions catering for the aged as well as Frail care
- Hospices : Home for destitute and terminally ill
- Mortuaries : Forensic laboratory where corpses are temporarily stored
- Doctors : Qualified practitioners of medicine
- Specialists : Specialists in the field of medicine
- Allied practitioners : Podiatrists, acupuncturists, chiropractors, etc
- Veterinary hospitals : Hospital for the treatment of animals
- Veterinary surgeon : Veterinarian treating diseases and disorders to animals
- Psychiatric hospitals : Hospitals for the treatment of patients with mental disorders
- Rehabilitation centres : Patients recovering after illness, imprisonment or substance abuse
- Prisons : Places of custody or confinement
- Private homes : Places where private persons live

At that stage, based on the number of patients treated as well as the extent of the treatment, it was anticipated that the various types of Hospitals and Clinics would be the primary generators of HCRW and that most of the effort had to be focussed on those generators. Attention was however also given to less significant generators of HCRW in order to verify what their respective impacts would be on the overall HCRW stream. It is however to be noted that although minor HCRW generators have limited impact on the HCRW stream in terms of the mass of waste being generated, it is still important with regards to the risk that its waste creates for society. It is therefore important that HCRW from such generators be monitored. In view of the minute quantities of HCRW expected to emanate from private homes as well as the difficulty with which such information would be obtained, no further attention would be given to this source category in the present study.

### 3.4 Number of Sources Generating Health Care Risk Waste in Gauteng

The desktop study, literature review and consultation with various stakeholders including the authorities and the private sector resulted in the compilation of a list of potential HCRW generators in Gauteng. As a point of departure, a list of potential HCRW generators (in the form of an *Excel* file) was obtained from *Med Pages,* which is a publication presenting details on most health care institutions registered in South Africa. This database was initially compiled and is regularly updated by a private organisation. The list *inter alia* contained names, addresses, contact details and the respective sizes in terms of number of beds (where applicable) of a wide spectrum of health care institutions. This list was found to be reasonably accurate in most respects, but certain deficiencies became apparent. Firstly, some (public) institutions classified by *Med Pages* as hospitals were converted to Community Health Centres ("CHC's") and secondly, many (100-plus) public clinics were not reflected in the *Med Pages* database. The names of a number of health care facilities were also recently changed, which resulted in some confusion. The *Med Pages* database also included the number of beds available that was correlated with data provided by the DoH and where necessary verified when institutions were surveyed during the course of the study. In the case of public clinics the number of patients treated at the facility over a specified period of time was considered to be an objective measure of relative size (a calendar month in this instance).

For the public hospitals, the DoH classification system (i.e. "central, regional, district", etc.) was adopted, in order to group these hospitals appropriately. It was thus possible to produce a comprehensive listing, on which rates of HCRW generation (as measured and/or as extrapolated for use in the various cost models) could also be reflected. This listing appears as ***Annexure 3.2***. A summary showing total numbers of public and private hospitals, clinics, etc. according to category and area is presented in ***Table 3.1*** below.

*Table 3.1*: Hospitals & Clinics in Gauteng according to category and area (Data summarised from the listing in Annexure 3.2)

| **Service** | **Owner-ship** | **Category** | **East Rand incl. Midrand** | **Jhb** | **Pretoria & surrounds** | **Vaal Triangle** | **West Rand** | **Total** |
|---|---|---|---|---|---|---|---|---|
| Blood Trans-fusion | Public | | 6 | 8 | 7 | 2 | 3 | 26 |
| Clinics | Military | | | | | | | 24 |
| | NGO | | | 2 | | | | 2 |
| | Public | | 120 | 97 | 54 | 34 | 31 | 336 |
| | | Comm. Health Centres | 2 | 3 | 1 | 2 | | 8 |
| | | Marie Stopes | | 2 | 1 | | 1 | 4 |
| | | Dental | | 3 | 2 | | | 5 |
| | Private | | 8 | 15 | 9 | 3 | 5 | 40 |
| | | Day Surgery | 9 | 10 | 8 | 3 | 5 | 35 |
| | | Dental | 1 | | | | | 1 |
| | | Stepdown | | 3 | 5 | | | 8 |
| Hospitals | Military | | | | 1 | | | 1 |
| | Mining | | 2 | | 1 | | 6 | 9 |
| | Private | | 21 | 20 | 28 | 5 | 12 | 86 |
| | | Psychiatric | 5 | 6 | 2 | | 3 | 16 |
| | | Rehabilita-tion | 2 | 4 | 2 | | 1 | 9 |
| | Public | Central | | 1 | 2 | | 1 | 4 |
| | | Regional | 6 | 2 | 1 | 2 | 2 | 13 |
| | | District | 2 | 1 | 2 | 1 | | 6 |
| | | Psychiatric | | 1 | 1 | | 1 | 3 |
| | | Rehabilita -tion | | | 1 | | | 1 |
| | | Special | | 1 | | | | 1 |

Minor HCRW sources were grouped and classified as Medical Doctors and Dentists, Pathology Laboratories, Pharmaceutical Industries and associated Healthcare Professionals such as Veterinarians. The total number of minor HCRW sources, grouped by area, is presented in **Table 3.2** below.

***Table 3.2:*** Minor waste sources grouped by area

| Area | East Rand incl. Midrand | Jhb | Pretoria & surrounds | Vaal Triangle | West Rand | Total |
|---|---|---|---|---|---|---|
| **General Medical Practitioners** | 819 | 2 304 | 1 906 | 254 | 550 | 5833 |
| **Dentists** | 204 | 366 | 367 | 43 | 114 | 1 094 |
| **Physiotherapists** | 85 | 231 | 139 | 23 | 37 | 515 |
| **Retail Pharmacies** | 217 | 259 | 247 | 64 | 128 | 915 |
| **Hospital Pharmacies** | 13 | 16 | 17 | 6 | 9 | 61 |
| **Veterinarians** | 101 | 238 | 400 | 23 | 63 | 825 |
| **Pathology Laboratories** | 54 | 103 | 131 | 9 | 33 | 330 |
| **Pharmaceutical Companies** | 29 | 77 | 41 | 0 | 5 | 152 |
| **TOTAL** | 1 495 | 3 594 | 3 248 | 422 | 935 | 9 725 |

### 3.5 Location of HCRW Generating Sources in Gauteng

As a result of the magnitude of information to be included, only the large HCRW generators, i.e. hospitals and clinics (both public and private) are spatially presented on the Geographic Information System (GIS). Although not all clinics were expected to be significant generators of HCRW, it was felt that it would be useful to DACEL and to the DoH in particular to have the groundwork done for development of a comprehensive listing of these facilities. It was also decided that certain other (small) institutions would be spatially located, e.g. blood transfusion facilities, the Marie Stopes Termination of Pregnancy (TOP) clinics, etc. Locations of all hospitals, clinics (including Community Health Centres (CHC's)) and blood transfusion services are therefore as reflected on the Gauteng map presented in ***Figure 3.1*** below.

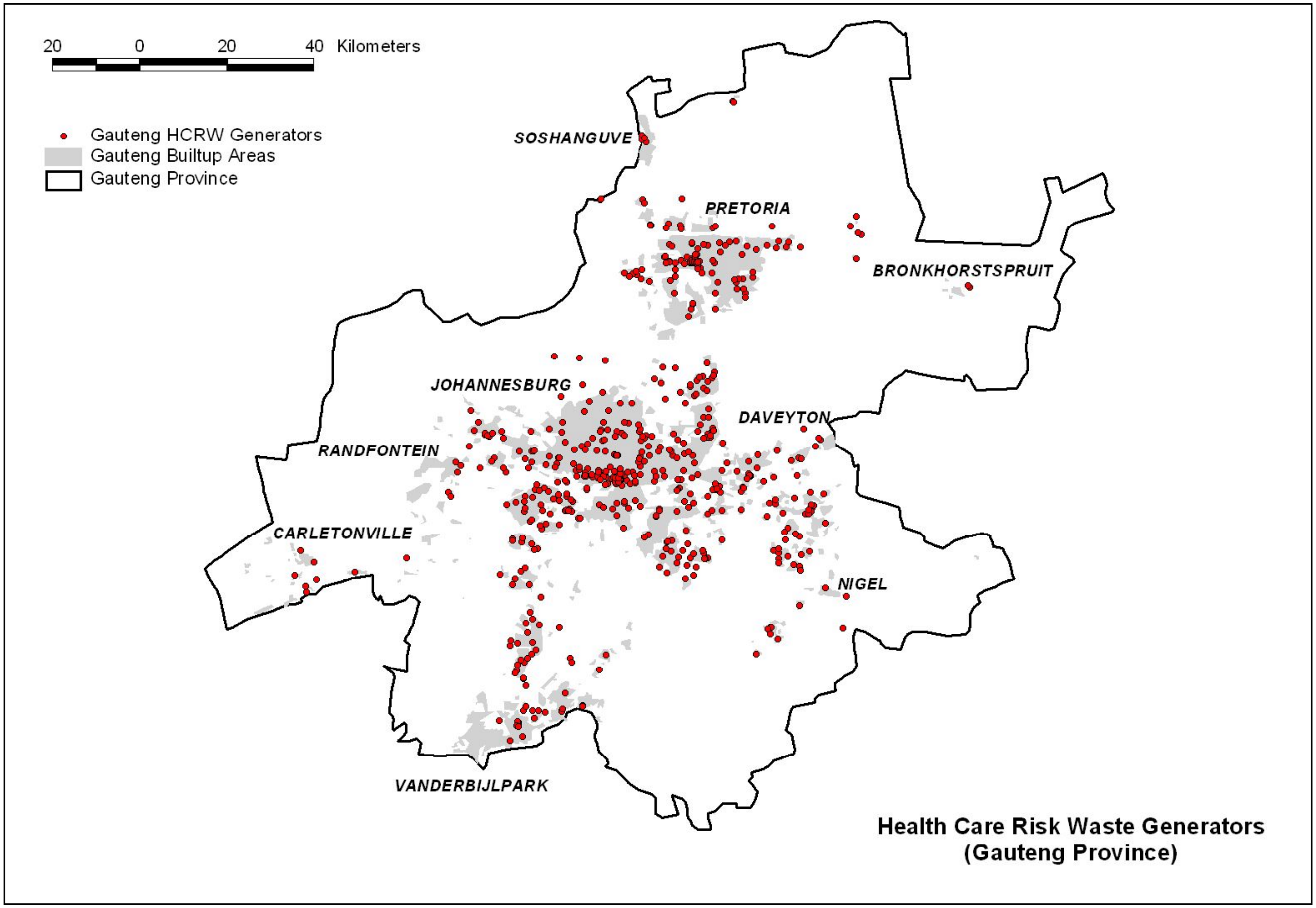


***Figure 3.1***: Location of major HCRW generators in Gauteng

To determine the coordinates of the various facilities that was not physically recorded by means of a GPS system, the *Map Studio "Map Master"* system was used. This system is in effect a computerised street-map system.

Once a health care facility was positioned on the "Map Master" system (using the best available information, viz. street address, suburb, zone, etc.) its longitude and latitude coordinates could be determined and recorded. The area covered by "Map Master", however, did not include the extreme southern and western parts of Gauteng and for those areas, longitude and latitude coordinates were scaled from the *Map Studio* 1:20,000 "Vaal Triangle" street map or the *Map Studio* 1:250,000 Gauteng Map. In cases where GPS readings of incinerator locations were taken during the course of the present study, the latter was used where the incinerator location coincided with that of the HCRW generator.

A problem experienced during this phase of the work resulted from the many name-changes in Provincial Hospitals and Clinics that were not yet reflected in the *Map Studio* data.

Due to the large numbers as well as its limited impact on the overall HCRW stream, no attempt was made to spatially locate the following sources on an individual basis: pathology laboratories, general medical practitioners, dentists, associated medical practitioners, pharmacies, veterinarians, pharmaceutical manufacturers, mortuaries and forensic laboratories.

## 3.6 Rates and Types of HCRW Generated per Service Area in Gauteng

### 3.6.1 Notes on survey procedures

It is important to record that the field staff doing the actual weighing were careful to avoid influencing the waste generators as to what was regarded as HCRW. In other words, all the waste regarded by the HCRW generators as being HCRW, was treated as such and weighed.

### 3.6.2 Hospitals

A total of 29 hospitals were surveyed. Where HCRW was not collected during weekends, weighing was only done during the week, ultimately arriving at a total waste generation mass per week. The total mass of HCRW recorded at any particular hospital was then divided by the number of days over which weighing was undertaken to establish an average daily HCRW generation mass. This daily average mass was then multiplied by 30.4 (taken as the average number of days per month) to arrive at a monthly equivalent HCRW generation mass. The monthly HCRW figures are reflected in ***Table 3.3*** below.

The HCRW generation data, as recorded during the survey, was then compared with average monthly HCRW generation figures for certain institutions, as obtained from a private HCRW Management Company. These figures were accumulated during the course of the execution of its HCRW collection, treatment and disposal contract with the Gauteng DoH. The figures obtained from the private HCRW Management Company, as weighed at their incinerators, are presented in ***Table 3.3*,** together with a "key" showing the type of service provided in each case, viz. Sharps only ("s"), sharps plus 142 litre containers ("s,l"), sharps plus 142 litre containers plus wet-waste containers (20 litres) ("s,l,w"), etc.

In order to set a norm for comparison of the HCRW generation in the various facilities, the number of patients treated in the hospital at the time of the survey was also obtained, with a view of relating the amount of HCRW generated to the number of patients treated. (In some instances the "occupancy" figure was not immediately available as certain hospitals recorded the number of admissions and discharges over a period of one month. Occupancy figures (or percentages of available beds occupied) could therefore in some instances only be obtained once the admission/discharge data was processed by the hospital administration, which often only takes place after month-end.

The 'Daily HCRW Mass per Patient' column in ***Table 3.3*** reflects the following: -

**Survey**

The Daily Mass of HCRW generated per patient, as calculated from the survey results (measured in kg).

**Group Average**

This is used in cases where more than one hospital was surveyed in any particular category, e.g. "private", "public: central", "public: district"' etc. (Calculation of the group average is reflected in ***Annexure 3.3***) The "Group Average" was determined by treating the HCRW generation figure (in kg/patient) for **each** institution for **each** day as **one** result, and then determining the average of all these results.

**Group Standard Error**

This is the Intra-group Standard Error of the survey results, as reflected in ***Annexure 3.3***.

**Model**

The Daily HCRW generation rate per patient, to be applied when extrapolation is done to obtain a representative HCRW generation figure for health care institutions that were not surveyed. This "model" generation rate has been taken at the "upper 90% confidence bound" (refer ***Annexure 3.3***), which as explained in Section 1.3.3 above, means that there is only a 5% risk that the actual HCRW generation rate for the group is underestimated.

Due to significantly varying occupancy rates, it was anticipated that the 'Daily HCRW mass per Patient' is intuitively the more correct metric than 'Daily HCRW mass per Bed' which appears from literature to be the more common metric. The 'Daily HCRW mass per Bed' has, however, also been calculated for comparative purposes for each of the hospitals surveyed, and is reflected in ***Table 3.3.***

**Table 3.3**

### 3.6.3 Clinics

For the purpose of this study, a "clinic" has been taken to be a health-care facility where patients are not accommodated overnight.

Fifteen clinics belonging to the private sector, local government as well as provincial government, were surveyed individually, and a further 12 clinics, referred to as the "Soweto Clinics", were surveyed as a group. This was as a result of the fact that a single contractor handles collection of HCRW from the Soweto clinics, and it was possible for the team to weigh such HCRW over a period of seven days. In addition to the clinics, two blood transfusion centres were surveyed. Details of the institutions surveyed are presented in ***Table 3.4*** below.

Estimated monthly HCRW masses at the private clinics surveyed varied from 25kg to 160kg. (This relatively wide range is to be expected, reflecting both differences in size and in services offered.) The **per-patient** generation rates ranged between 0,06kg and 0,48kg. (This range reflects differences in level of servicing.)

For public clinics, the per-patient daily generation range had a comparatively wider spread (viz. 0.002 to 0.05kg) but was in general lower than for private clinics. This is not surprising, given the fact that the level of servicing as well as the ability to perform surgical and other procedures, etc. is much higher at the private clinics.

In the case of the public clinics, approximate monthly patient numbers were obtained from the DoH. In respect of the "Soweto Clinics", the weighed HCRW masses and the patients/month figure produced a generation rate of 0.05kg/patient, which was considerably higher than generation rates for public clinics surveyed individually, as can be seen from ***Table 3.4***.

As with hospitals, clinics have been grouped, and 'Model' HCRW generation values have been statistically derived for the "Upper 90% confidence limit". In respect of the derivation of a model HCRW generation rate for private clinics, a "per institution" HCRW generation figure was used, rather than attempting to establish the number of patients treated over an average month. In part, this decision was taken as the clinics were reluctant to divulge patient numbers, and in part because it was felt that there would be no advantage in respect of the accuracy of the predictions if a "per patient" figure is used, given the relatively small contribution that these clinics make to the overall HCRW stream. The "per institution" figure for the highest group (day-surgery) was used for all private clinics except step-down facilities. This figure was also adjusted for sample size, in a similar way to the hospitals. The figure used was 135 kg/institution/month; for step-down facilities a figure of 20 kg/institution/month was used (as shown in ***Table 3.3***.).

**Table 3.4**

### 3.6.4 "Minor" HCRW Generators

In total, 58 surveys were undertaken covering general medical practitioners, dentists, pharmacies and other "minor" generators. A summary of these surveys is presented in ***Tables 3.5 a & b*** below.

***Table 3.5(a):*** Categories catered for by number & geographical location

| Category | Sample Size | HCRW Generation rate kg/month | | | Model (kg/month) | Notes |
|---|---|---|---|---|---|---|
| | | Maximum | Minimum | Average | | |
| Doctors (G.P.'s) | 15 | 10 | Nil | 3,5 | 3,5 | |
| Dentists | 1 | 2 | 2 | 2,0 | 2,0 | |
| Physiotherapists | 2 | 3 | 1 | 2,0 | 2,0 | Many spend some or all of their time in hospitals/ clinics |
| Pharmacies | 9 | 8 | 0.5 | 2,9 | 3,0 | |
| Pathology Laboratories | 2 | 68 | 28 | 48,0 | 50,0 | |
| Pharmaceutical Manufacturers | 1 | | | 400,0 | 300,0 | |
| Veterinarians | 9 | 50 | 0.5 | 9,4 | 5,0 | Larger vets surveyed had up to 4 individuals; the model figure is applied per individual. Carcasses were excluded. |

***Table 3.5 (b):*** Categories catered for in general terms only

| Category | Sample Size | HCRW Generation rate kg/month | | | Model | Notes |
|---|---|---|---|---|---|---|
| | | **Maximum** | **Minimum** | **Average** | | |
| Audiologists | 1 | | | Nil | | |
| Optometrists | 2 | Nil | Nil | Nil | | |
| Podiatrists | 2 | 5 | 5 | 5,0 | | Approx. 75 in province |
| Old Age Homes | 5 | 15 | Nil | 6,2 | | Approx. 200 in province. Waste generated varies with home size: largest surveyed had 300 residents |
| Hospices | 1 | | | 25,0 | | Only Approx. 10 in province |
| Prisons | 2 | 40 | 35 | 37,5 | | Small number in province |
| Onderstepoort Vet. Hospital. | 1 | | | 150,0 | | Unique |
| Industrial Clinic | 1 | | | 5,0 | | Est. 2,000 in province |
| Military Clinic | 1 | | | 15,0 | | Approx. 15 in province |
| SAP Forensic Laboratory. | 1 | | | Nil | | Unique |
| Mortuaries | 1 | | | Nil | | |
| SPCA | 1 | | | 1,0 | | Est. 100 in province |

**Estimated Total Mass of Medical Waste generated by the above: 13,000 Kg/month**

***Tables 3.5 (a) & (b)*** reflect sources which, although individually small, contribute significantly when considered together. These sources were, in turn, treated in two different ways: for the first group **(*Table 3.5 (a)*)**, which included general medical practitioners, dentists, physiotherapists, pharmacies, pathology laboratories, pharmaceutical manufacturers and veterinarians, the amount of HCRW emanating from these sources could be estimated by area, utilising the information contained in ***Table 3.2*** above.

For the second group ***(Table 3.5(b)),*** which included old-age homes, mortuaries, prisons, etc., the very small quantities generated (totalling an estimated 13,000kg/month) did not in the author's opinion justify any attempt to locate the sources spatially.

The resulting estimated HCRW generation figures are presented in ***Table 3.6*** below, showing a total mass of 93 230kg/month, estimated to emanate from these sources. To provide for possible omissions from the list, an adjustment of approximately 25% has been made to the totals. The adjusted overall total is 117 000kg.

***Table 3.6:*** Total estimated HCRW generation by minor sources (kg/month)

| Category | HCRW generation rate kg/month | Pretoria Area (kg/month) | Mid & East Rand (kg/month) | West Rand (kg/month) | Vaal (kg/month) | Jhb (kg/month) | TOTALS (kg/month) |
|---|---|---|---|---|---|---|---|
| **Doctors** | **3.5** | 6,670 | 2,870 | 1,930 | 890 | 8,060 | **20,420** |
| **Dentists** | **2.0** | 730 | 410 | 230 | 90 | 730 | **2,190** |
| **Physio-therapists** | **2.0** | 280 | 170 | 70 | 50 | 460 | **1,030** |
| **Retail** | **3.0** | 740 | 650 | 380 | 190 | 780 | **2,740** |
| **Hospital** | **10.0** | 170 | 130 | 90 | 60 | 160 | **610** |
| **Vets** | **5.0** | 2,000 | 510 | 320 | 120 | 1,190 | **4,140** |
| **Pathology Laboratories** | **50.0** | 6,550 | 2,700 | 1,650 | 450 | 5,150 | **16,500** |
| **Pharmaceutical Co.'s.** | **300.0** | 12,300 | 8,700 | 1,500 | 0 | 23,100 | **45,600** |
| **TOTALS** | | **29,440** | **16,140** | **6,170** | **1,850** | **39,630** | **93,230** |
| **Adjustment** | | 25% | 25% | 25% | 25% | 25% | **23,770** |
| **ADJ. TOTAL** | | **37,000** | **20,000** | **8,000** | **2,000** | **50,000** | **117,000** |

### 3.7 Survey Results

As mentioned above, the HCRW generation rates for the institutions surveyed have been presented in both kg/patient/day and kg/bed/day terms. Due to the large range of bed-occupancy figures encountered, the former measure is more appropriate than the latter. (The actual occupancy rates recorded during the survey ranged from 10% in the case of the Premier Hospital (mining), to in excess of 100% in the case of the Johannesburg Hospital.) However, it should be noted that the hospitals with low occupancy rates tend to be private/mining hospitals, which generate more HCRW on a kg/patient/day basis than the larger (typically public) hospitals. For this reason, the HCRW generation rates expressed on a kg/bed/day basis show a similar degree of variation (as measured by the standard deviation) to the generation rates expressed on a kg/patient/day basis. For this study the kg/patient/day rates will be used in the development of the Model (described in more detail in Paragraph 3.8 below), which seeks to estimate the overall rate of HCRW generation in Gauteng. The following points were deduced from the survey:

- The range of HCRW generation rates vary from a low of 0.001 kg/patient/day (Huis Herfsblaar Frail Care, Cullinan Rehabilitation Centre) to 4.04 kg/patient/day (Milpark Hospital).

- Taking public hospitals on their own, and excluding rehabilitation and psychiatric hospitals**,** which have low rates of generation, the range varies between 0.23 kg/patient/day (Kopanong) to 2.43 kg/patient/day (Pretoria Academic).

- Taken as groups, central hospitals showed an average generation rate of 1.23 kg/patient/day, district hospitals an average generation rate of 0.71 kg/patient/day and regional hospitals an average generation rate of 0.63 kg/patient/day.

- Amongst the central hospitals, Pretoria Academic is significantly higher than the other three hospitals.

- Amongst the regional hospitals, Helen Joseph is significantly higher than the other four hospitals surveyed.

- HCRW generation rates at private hospitals ranged from 0.50kg/patient/day to 4.04 kg/patient/day (Milpark).

## 3.8 HCRW Generation "Model" for Gauteng

The "Model" HCRW generation rates as derived and described above were applied to all institutions as listed in ***Annexure 3.2***, by category/type, in order to produce an estimated monthly HCRW mass for each institution.

In cases where monthly patient numbers at public clinics were not known, these were estimated, by region, based on data that had been received from DoH. The data and calculations are reflected in ***Table 3.7*** below. The patient numbers used in the model are: East Rand 3 300; Johannesburg 9 200; Midrand 7 700; Pretoria and surrounds 4 100; Vaal 3 400 and West Rand 4 500. The figure estimated for Community Health Centres is 9 600.

*Table 3.7* Patient Numbers: Public Clinics

| | Clinics | | | | | | |
|---|---|---|---|---|---|---|---|
| | East Rand | Jhb. | Midrand | Pretoria | Vaal | West Rand | C H C's |
| (Patient | 250 | 1,200 | 1,800 | 450 | 50 | 100 | 2,000 |
| numbers | 250 | 1,500 | 4,400 | 1,700 | 1,000 | 250 | 4,000 |
| per month | 350 | 1,700 | 5,100 | 2,000 | 1,100 | 700 | 4,900 |
| at various | 350 | 1,800 | 6,100 | 2,100 | 1,100 | 1,000 | 5,300 |
| clinics/CHC's | 350 | 1,800 | 7,600 | 2,150 | 1,300 | 1,500 | 8,000 |
| as provided | 450 | 1,800 | 9,900 | 2,200 | 1,300 | 1,600 | 15,000 |
| by the Dept | 500 | 2,000 | | 3,600 | 2,100 | 1,600 | |
| of Health) | 600 | 2,800 | | 5,290 | 2,100 | 1,700 | |
| | 700 | 5,600 | | 7,500 | 2,200 | 1,800 | |
| | 750 | 6,000 | | | 2,300 | 1,800 | |
| | 950 | 6,500 | | | 2,300 | 3,500 | |
| | 1,100 | 8,000 | | | 2,400 | 7,000 | |
| | 1,200 | 8,000 | | | 2,800 | 8,000 | |
| | 1,300 | 10,000 | | | 3,000 | 9,000 | |
| | 1,400 | 11,000 | | | 3,100 | 10,000 | |
| | 1,500 | 15,000 | | | 3,100 | | |
| | 1,600 | 17,000 | | | 3,200 | | |
| | 1,600 | 18,000 | | | 3,300 | | |
| | 1,600 | 19,000 | | | 3,400 | | |
| | 1,700 | | | | 3,500 | | |
| | 1,900 | | | | 3,500 | | |
| | 2,100 | | | | 3,500 | | |
| | 2,200 | | | | 4,300 | | |
| | 2,200 | | | | 4,400 | | |
| | 2,200 | | | | 4,700 | | |
| | 2,300 | | | | 6,600 | | |
| | 2,300 | | | | 8,400 | | |
| | 2,400 | | | | | | |
| | 2,500 | | | | | | |
| | 2,500 | | | | | | |
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| | 3,000 | | | | | | |
| | 3,000 | | | | | | |
| | 3,300 | | | | | | |
| | 3,400 | | | | | | |
| | 3,990 | | | | | | |
| | 4,000 | | | | | | |
| | 4,100 | | | | | | |
| | 4,100 | | | | | | |
| | 4,400 | | | | | | |
| | 4,400 | | | | | | |
| | 5,200 | | | | | | |
| | 5,200 | | | | | | |
| | 5,200 | | | | | | |
| | 5,200 | | | | | | |
| | 5,800 | | | | | | |
| | 6,600 | | | | | | |
| | 6,600 | | | | | | |
| | 7,000 | | | | | | |
| | 14,700 | | | | | | |
| **Average** | **2,853** | **7,300** | **5,817** | **2,999** | **2,965** | **3,303** | **6,533** |
| **Std. Dev.** | 2,400 | 6,116 | 2,778 | 2,157 | 1,743 | 3,390 | 4,582 |
| **N (obs.)** | 55 | 19 | 6 | 9 | 27 | 15 | 6 |
| **Conf. coeff. @ 90%** | 0.68 | 0.69 | 0.73 | 0.71 | 0.68 | 0.69 | 0.73 |
| **Model** | **3,100** | **8,300** | **6,700** | **3,500** | **3,200** | **3,900** | **8,000** |

The resulting estimated figures for HCRW generation at each facility are also reflected in ***Annexure 3.2***. These figures are utilized in the "Feasibility Study into The Possible Regionalisation of HCRW Facilities in Gauteng". (Chapter 6 below). However, for purposes of brevity, the estimated overall HCRW generation figures by type and category of institution are presented in ***Table 3.8*** below. As may be seen from this table, the estimated total HCRW generation figure for Gauteng is approximately 1 175 tons per month.

***Table 3.8***: Estimated HCRW Generation in Gauteng, by Type of Source and Area (kg/month)

| Service | Ownership | Category | East Rand incl. Mid Rand | Johan-nesburg | Pretoria & surrounds | Vaal Triangle | West Rand | Total | Group Totals |
|---|---|---|---|---|---|---|---|---|---|
| Blood Transfusion Services | Public | | 510 | 680 | 595 | 170 | 255 | 2,210 | **2,210** |
| Clinics | Public | | 32,640 | 69,120 | 16,850 | 8,470 | 9,750 | 136,830 | **143,290** |
| | | Comm. Health Centres | 1,200 | 2,160 | 770 | 1,330 | | 5,460 | |
| | | Marie Stopes | | 250 | 125 | | 125 | 500 | |
| | | Dental | | 300 | 200 | | | 500 | |
| | Private | | 1,080 | 2,025 | 1,215 | 405 | 675 | 5,400 | **10,445** |
| | | Day Surgery | 1,215 | 1,350 | 1,105 | 405 | 675 | 4,750 | |
| | | Dental | 135 | | | | | 135 | |
| | | Step-Down | | 60 | 100 | | | 160 | |
| Hospitals | Military | | | | 8,460 | | | 8,460 | **8,460** |
| | Mining | | 170 | | 170 | | 6,750 | 7,090 | **7,090** |
| | Private | | 109,803 | 80,326 | 131,060 | 24,170 | 86,150 | 431,509 | **443,249** |
| | | Psychiatric | 2,720 | 700 | 460 | | 7,750 | 11,630 | |
| | | Rehabilitation | 20 | 40 | 20 | | 30 | 110 | |
| | Public | Central | | 61,660 | 107,800 | | 76,360 | 245,820 | **427,790** |
| | | Regional | 61,090 | 24,190 | 24,140 | 26,110 | 19,760 | 155,290 | |
| | | District | 7,670 | 4,110 | 6,300 | 3,840 | | 21,920 | |
| | | Psychiatric | | 220 | 2,100 | | 1,320 | 3,640 | |
| | | Rehabilitation | | | 20 | | | 20 | |
| | | Special | | 1,100 | | | | 1,100 | |
| | **Totals:** | | 218,253 | 248,291 | 301,490 | 64,900 | 209,600 | 1,042,534 | |
| | **Minor waste sources:** (ref. Table 3.6) | | 20,000 | 50,000 | 37,000 | 2,000 | 8,000 | 117,000 | |
| | **Minor waste sources (general):** (ref. Table 3.5(b) ) | | | | | | | 13,000 | |
| | **Estimated Grand Total for province:** | | | | | | | **1,172,534** | kg/month |

## 3.9 General Observations from the on-site surveys

### 3.9.1 Intermediate storage area

It was obvious that the storage areas in some hospitals were given a high profile whilst in others it was almost totally ignored. The following is a summary of some of the findings with respect to onsite storage:

**Little Company of Mary**

HCRW is stored under roof in close proximity of the incinerator. Access to HCRW is not restricted and the storage area is not supervised.

**Pretoria West**

No dedicated storage area for HCRW. HCRW is stored in an open courtyard that is in some instances amongst general household waste. Red plastic bags normally used for the disposal of HCRW were noticed in a municipal container for household waste. HCRW is left unsupervised.

**Pretoria - East**

HCRW is stored in specially demarcated area. The area is locked and under roof. HCRW is under supervision until incinerated.

**Unitas**

HCRW is stored in a lockable storage room until collected by contractor.

**Garankuwa**

HCRW is stored in a specially demarcated area, although it cannot be locked. HCRW is left unattended.

**Tembisa**

HCRW is stored outside in an open courtyard. A temporary permit was granted to do incineration. According to the supervisor, the Tembisa Hospital was at the time of the survey receiving HCRW from Pretoria Academic Hospital for incineration.

**Mamelodi**

HCRW is stored under roof in an open space outside the maternity section. HCRW is left unsupervised for the contractor to collect. The gate cannot lock.

**Johannesburg General**

An area is demarcated for HCRW but the area is too small for the volumes generated. HCRW is stored outside the building in the car parking area until the contractor collects it. No roof is provided and the area is not supervised. The HCRW is exposed to all elements.

**Pretoria Academic**

A dilapidated building is used to store HCRW until it is collected by the contractor. This old building cannot be locked and the roof is not waterproof. HCRW is left unattended. The floor and walls of this building are in a state of disrepair and are therefore not washable.

At the orthopaedic and maternity sections the HCRW is stored in lockable rooms and kept under supervision.

**The Glynnwood**

HCRW is stored in a dedicated storeroom that is locked and properly supervised. This hospital uses red plastic bags for HCRW collection and the HCRW is daily incinerated on the premises, except during weekends when cardboard boxes are used to collect the HCRW. No waste is incinerated during weekends. A private contractor was appointed to collect the HCRW accumulated during weekends for safe offsite treatment and disposal on Mondays.

**Kalafong**

HCRW is stored in a specially demarcated area under roof, outside the hospital. The HCRW storage area cannot be locked and is left unsupervised. Access to the HCRW is unobstructed.

### 3.9.2 Collection and internal transportation

Internal transport of HCRW in different institutions ranges from a tractor-trailer systems and trolleys, to workers carrying the HCRW by hand to the intermediate storage areas. This equipment was generally in a good state of repair and was found to be suitable for the intended purpose. It was however found that the trolleys were in some instances overloaded resulting in some containers falling over the sides. This happened in a number of cases at the Johannesburg General Hospital where huge quantities of HCRW are collected and transported to the intermediate storage area, which inevitably led to some damage to the containers and in some cases spillage of the contents.

The issuing of protective clothing to workers involved with collection and handling of HCRW in the hospitals does not receive the required attention and the associated risks involved with transmitting diseases to the workers should be emphasized.

### 3.9.3 Ash from the Incinerators

Where incinerators are in use at the HCRW source, the ash from the incinerators is in all instances disposed of at a municipal landfill site. No special precautions are taken to treat and dispose of the ash to an H:H hazardous waste disposal site as prescribed by the "Minimum Requirements". The ash is deposited amongst the household waste; often mixed with boiler ash.

### 3.9.4 Radioactive Waste

A limited amount of radioactive material is used and where encountered it is disposed of in a controlled manner. The hospitals receive all their radioactive pharmaceuticals in injection form from private pharmaceutical companies. Each syringe is packed separately in lead containers and once used, is placed back in the container and covered with a bio hazardous seal before being returned to the supplier the following day for safe disposal. A hospital the size of The Glynnwood (289 beds) would use on average 250 radioactive syringes in any one month. Radioactive waste is not stored on site at the hospitals.

### 3.9.5 Human Tissue

Human tissue is treated in various ways by the hospitals. The personnel in hospitals are in some instances unaware of prescriptions on the way in which to handle, treat or dispose of human tissue. Human tissue is incinerated where incinerators are available. One hospital buries all human tissue with unidentified bodies, although the responsible person admits that this is not the desired option of disposing human tissue and that this method of disposing will be stopped. Outside waste management contractors such as Sanumed provide specially marked plastic, waterproof containers for disposal of e.g. placentas. In all instances proper records are kept of amputated human body parts. Human tissue is refrigerated until collected by outside contractors or in the event of downtime on onsite incinerators.

### 3.9.6 Mortuaries

No HCRW, including sharps, are generated in these facilities. All clothing not claimed by relatives is treated as “infected waste“ and is incinerated on the premises where the mortuary forms part of a hospital. Very few disposable products are used and body tissue that may have been removed is buried with the corpse. Water used for cleaning and disinfection of the premises is flushed into the municipal sewer system.

### 3.9.7 Blood Banks

At the Blood Transfusion Centres water that has been contaminated with blood is stored in 25lt plastic containers. These containers are collected by a contractor and transported to the Head Office of the Blood Transfusion Service for safe disposal. Water used for washing and disinfection of the premises is flushed into the municipal sewer system. At the two facilities surveyed, the estimated monthly HCRW mass was 30 and 50 kilograms, respectively

### 3.9.8 Containers

Different size biohazard cardboard boxes are used i.e. 142lt capacity (15kg dry waste) and 50lt capacity (15kg wet waste). Different size biohazard plastic buckets i.e. 85, 75, 50, 25, 10, 7.5, 5 and 2.5lt are used. Some institutions make use of red 85lt plastic bags for the disposal of HCRW. The main consideration for using plastic bags instead of boxes or buckets is financial. The 2.5lt container is most commonly used for the disposal of sharps. Unconventional containers, which pose a health and safety hazard i.e., empty 2lt plastic cooldrink bottles etc. were also used to collect sharps. This might be the reason for the spilled used sharps in most of the intermediate storage areas.

The colour of the plastic liner bags is not uniform and is in many instances also determined by financial considerations.

### 3.10 Trans-boundary Movement of HCRW.

The trans-boundary movement of HCRW into and out of Gauteng can be considered on two levels. Firstly, HCRW can originate from or be transported to other South African Provinces and particularly those that border Gauteng, i.e. Mpumalanga, Free State, Northern Province and the North West Province. In the past, some movement to Gauteng has occurred because of lack of treatment facilities within the neighbouring Provinces, although recent developments (particularly in the Free State and Northern Province) have resulted in lower amounts being transported to Gauteng for treatment. According to a large waste management company, the quantity of HCRW from outside Gauteng regularly treated at their facilities amounts to no more than 2% of the total volume handled by them. This equates to approximately 6 to 7 tons per month.

The recent HCRW crisis in Gauteng and the lack of facilities that one required to manage the HCRW generated lead to a build up of waste. Apart from some being landfilled, the crisis has been addressed by transporting HCRW for treatment to Kwa-Zulu-Natal and the Western Cape. Clearly, it is important that each Province manages its own HCRW and transport of HCRW over such long distances on a regular basis is not acceptable. It is, however, understood that the medium to long term policy of most Provinces is to manage their own waste streams. In the short term, until facilities can be made available, it is likely that limited disposal across Provincial borders will occur. Collaboration between Provinces in the long term is however considered important, as it would make economic sense to transport waste to the nearest facility, even if it is located within a different Province.

The trans-boundary movement of hazardous waste including HCRW between countries is managed within the requirements of the Basel Convention of which South Africa and many of its neighbours, such as Botswana, Zimbabwe and Swaziland are signatories. Many of the SADC countries are looking to South Africa to assist them with their hazardous waste management and importation of selected hazardous waste in terms of the Basel Convention is a possibility in the future. However, Gauteng does not border directly onto any of the SADC countries and importation of HCRW into Gauteng is considered unlikely. Some SADC countries, such as Botswana and Swaziland, are in the process of developing their own HCRW strategies. This is in the former case done with GTZ support and in the latter through technical and financial assistance from DANCED.

## 3.11 Training and Awareness

### 3.11.1 Introduction

The need for training and awareness programmes for both general and hazardous waste, which includes HCRW, was identified as a key issue during the development of the National Waste Management Strategy. There is clearly a lack of capacity at National, Provincial and Local level to implement and monitor HCRW at health care facilities. Training programmes for the authorities and health care workers are required and emphasis should be given to HCRW in waste awareness and education programmes. Management of HCRW is an integral part of hospital hygiene and infection control. HCRW should be considered as a reservoir of pathogenic microorganisms, which can cause contamination and give rise to infection. If HCRW is inappropriately managed, these microorganisms can be transmitted through direct contact, in the air, or by a variety of vectors. HCRW can contribute in this way to the risk of infections, putting the health conditions of hospitals at risk.

In South Africa, there have been a number of initiatives that lead to, at least, a portion of the infectious waste stream being managed in a reasonably acceptable manner. For example, guidelines for the disposal of waste materials within health care facilities that are based on a Canadian system were developed and published in 1993 by the SABS, (SABS 0248; 1993). In addition, systems for the handling and disposal of infectious waste have since 1990 been introduced by waste management companies, in collaboration with the Department of Environmental Affairs and Tourism, the Department of Health and the Department of Water Affairs and Forestry. Such handling, collection, treatment and disposal systems are based on many of the principles contained in SABS 0248 and those that have been in use in the USA and Europe. Although some of the HCRW stream is managed reasonably well, the regular presence of HCRW in the general waste stream (on permitted as well as non-permitted disposal sites and even discarded illegally), indicates that many facilities are managing their waste incorrectly which results in a considerable threat to human health. Currently, the SABS is in the process of updating their code of practice on the disposal of waste generated by health care facilities and a working committee has already been established. This offers a considerable opportunity for the development of appropriate guidelines that can be used as the basis for the development of training programmes.

### 3.11.2 Survey observations

During the survey it was apparent that training on HCRW management in the health care institutions is inadequate, which results in a lack of awareness and understanding of the correct management procedures and risks involved if the correct waste management procedures are not be adhered to. In most health care facilities training manuals on HCRW management were non-existent. Infection control personnel on the other hand, who often expressed the opinion that HCRW management is not given sufficient status in the curriculum, undertake training of hospital staff on HCRW management.

Insufficient training and awareness is not only resulting people's health and safety being put at risk, but it is also resulting in large volumes of HCRW being treated that may have been disposed of with the domestic waste. Poor segregation leads to HCRW being disposed of on general waste landfills in some instances, whilst also resulting in general waste is being incinerated in other instances.

A clear lack of motivation and awareness was evident. One of the observations made was that the provincial hospital staff is not aware of the cost implications of the HCRW treatment and is therefore not committed towards a reduction in the HCRW stream. The persons responsible for managing HCRW is often not familiar with the "cradle-to-grave" and "polluter pays" principles. The importance of appropriate training in the management of HCRW cannot be overemphasised, as this will not only result in safer and more responsible management for HCRW, but it will also bring some financial savings through a reduction in the HCRW stream that is to be treated.

On enquiry whether the institutions have training manuals or documents available that specifically deals with HCRW management, a wide variety of responses were received, and in particular from the persons handling the HCRW. The general feeling is however that even where the senior staff were aware of the manuals or documentation, this information was not passed on to the waste handlers.

The following documents can be considered to be relevant to the subject and could be used in training programs:

**Acts**

- The Health Act, 1977 (Act 63 of 1977).
- Occupational Health and Safety Act, 1993 (Act 85 of 1993).
- Medicines and Related Substances Control Act, 1965 (Act 101 of 1965).
- Human Tissue Act, 1983 (Act 56 of 1983).
- National Environmental Management Act, 1998 (Act 107 of 1998).
- Hazardous Substances Act, 1973 (Act 15 of 1973).
- Environmental Conservation Act, 1989 (Act 73 of 1989).
- Nuclear Energy Act, 1993 (Act 131 of 1993) (Repealed).
- National Nuclear Regulator Act, 1999 (Act 47 of 1999).
- Atmospheric Pollution Prevention Act, 1965 (Act 45 of 1965).

**Internal Policy Documents**

- Environmental Policy on Waste Disposal.
- CDC Standards.
- Netcare Infection Control Standards.
- Internal Circular 47 of 1997 – Medical.
- Presmed Infection Control Policy - G4.1.
- Health and Safety Policy 1.24 - Medical Waste Control.
- Infection Control Policy No 24 – Disposal of Medical Waste.
- Infection Control Policy No 33 – Disposal of Human Tissue.
- Infection Control Policy – How to deal with a blood spill.
- Health and Safety Policy - Recycling Policy.
- Health and Safety Policy – Hazardous Chemical Spill.
- SABS Code of Practice on Hazardous Substances Code 0228.
- SABS Code of Practice for the Handling and Disposal of Waste Materials within Health Care Facilities – SABS 0248:1993.

### 3.11.3 Lack of Motivation and Awareness at health care facilities

In a brief survey conducted on behalf of the NWMS (Baldwin and Ball, Proceedings WasteCon 2000, Somerset West, 2000, p432) considerable apathy and lack of awareness was found amongst the health care professionals regarding HCRW management. This of course does not serve to motivate the majority of staff who have to handle the HCRW. This lack of motivation and awareness at professional level also results in a failure to promote awareness and training programs to improve the situation, as well as the development of proper job descriptions for the people doing the work. At this level, most felt overwhelmed by the enormity of the task and were apathetic. Of the four people encountered during the NWMS study, who had had some training, only one was aware of the risks associated with HCRW management. On investigation, it was found that the training received was a "once off" training day comprising several lectures. Although there are Infection Control Committees in hospitals and clinics, there was insufficient emphasis on training in the management of HCRW. Since HCRW management training is not a priority, it follows that the standard of HCRW management leaves much to be desired. Cleaners and casual labourers, who were observed emptying colour-coded bags into black bags, had apparently never been trained or instructed regarding HCRW.

The proper training of workers who handle HCRW is essential and it has been noted that most of the HCRW waste management companies had training programmes for their staff and in one case for hospital staff. Workers at risk include health-care providers, hospital cleaners, maintenance workers, operators of waste treatment equipment, and all operators involved in waste handling and disposal within and outside health-care establishments.

### 3.11.4 Training programmes

All hospital personnel, including senior medical doctors, should be convinced of the need for a comprehensive HCRW management policy and the related training, and of its value for the health and safety of all This should ensure their collaboration in the implementation of such a policy.

Separate training activities should be designed for, and targeted to, four main categories of personnel:

- Hospital managers and administrative staff responsible for implementing regulations on HCRW management;
- Medical doctors;
- Nursing staff;
- Cleaners, porters, auxiliary staff, and waste handlers.

Since action is needed at management level, by those producing the waste, as well as by the waste handlers, training of all of these categories of personnel is equally important.

Medical doctors may be educated through senior staff workshops and general hospital staff through formal seminars. Training of the HCRW manager and regulators, could take place outside the hospital, at public health school or at Technikons and Universities.

Training programmes will clearly depend on the target group but could include:

- Information on, and justification for, all aspects of the HCRW policy;
- Information on the role and responsibilities of each hospital staff member in implementing the policy;
- Technical instructions relevant for the target group, on the application of HCRW management practices;
- The nature of HCRW and the potential risks it poses to human health and the environment;
- The procedures for the packaging, handling, storage and safe transport of the HCRW;
- The treatment of HCRW and the disposal of any residues;
- The value of immunization against viral hepatitis B and the importance of consistent use of personal protection equipment (PPE), i.e.;
    - Helmets, with or without visors - depending on the operation;
    - Face masks - depending on operation;
    - Eye protectors (safety goggles) - depending on operation;
    - Overalls (coveralls) - obligatory;
    - Industrial aprons - obligatory;
    - Leg protectors and/or industrial boots - obligatory;
    - Disposable gloves (medical staff) or heavy-duty gloves (waste workers) - obligatory;
- The need for basic personal hygiene to reduce the risks from handling HCRW;
- Convenient washing facilities (with warm water and soap) should be available for personnel involved in the handling of HCRW. This is of particular importance at storage and incineration facilities;

- The procedures that apply in the case of receiving a needle stick injury or coming into contact with infectious material. This should include the automatic provision of an AZT injection to guard against the possibility of contracting AIDS;
- The Emergency procedures required for a leakage or spillage that involves infectious material.

Periodic repetition of courses will provide refresher training and orientation for new employees as well as existing employees with new responsibilities; it will also update knowledge in line with policy changes. Follow-up training is instructive for trainers, indicating how much information has been retained by course participants and the likely need for future refresher courses.

The responsibility for all training related to the segregation, safe handling (i.e. collection, transport, storage, treatment and disposal) of HCRW should be given to the Infection Control Officer (ICO). He or she should ensure that staff at all levels is aware both of the HCRW management plan and policy and of their own responsibilities and obligations in this regard. A record should be kept of all training sessions, and the content of training programmes should be periodically reviewed and updated where necessary.

### 3.11.5 Public education and awareness on hazards linked to HCRW

Promotion of the appropriate handling and disposal of HCRW is important for the health of the community, and every member of the community should have the right to be informed about potential health hazards. The objectives of public education on HCRW should include the following:

- *Prevent exposure* to HCRW and related health hazards. This exposure may be voluntary, in the case of scavengers, or accidental, as a consequence of unsafe HCRW disposal methods;
- *Create awareness and foster responsibility* among patients and visitors to health-care institutions regarding hygiene and HCRW management;
- *Inform the public* about the risks involved with handling, transport and disposal of HCRW, focusing on people living or working in close proximity of, or visiting, health-care institutions, families of patients treated at home, and

scavengers on waste disposal sites.

The following methods can be considered for public education on the risks involved, waste segregation, or HCRW disposal practices:

- Poster exhibitions on HCRW issues, including the risks involved in scavenging discarded syringes and hypodermic needles;
- Education of patients and visitors, on the health-care facility's HCRW management policies;
- Informative poster exhibitions at strategic points in hospitals, such as waste bin locations, giving instructions on HCRW. Posters should be explicit, using diagrams and illustrations to convey the message to as broad an audience as possible. For maximum effectiveness, all information should be easily accessible for patients and visitors and should be displayed or communicated in an attractive manner that will hold people's attention;
- In the health-care establishment, waste containers should be easily accessible for patients and visitors and should be clearly marked with the waste category for which they are intended.

Growing awareness of health and environmental hazards has greatly increased public demand for information and guidance on these issues. Demand has intensified as the prevalence of HIV/AIDS and viral hepatitis B has risen. Health-care institutions should set an example to society by managing their waste in a manner designed to protect health and the environment.

# 4. STATUS QUO ON THE HEALTH CARE RISK WASTE TREATMENT / DISPOSAL FACILITIES

## 4.1 Background

An important component of the investigation into the Status Quo of the Health Care Risk Waste Management in Gauteng was to obtain information on the existing waste treatment facilities in the Province. The purpose of this chapter is to determine the:

- Location, types, sizes, capacity and condition of the existing facilities;

- Which facilities are owned by the public and private sectors;
- Operating costs for each facility, where available;
- Which facilities require upgrading or replacement in order to meet current and any future legislative requirements with the associated costs; and
- Spatial representation of the location of the incinerators.

Clearly, the information listed above is essential for Gauteng Province to plan for the future of HCW management. One of the key elements of the National Waste Management Strategy (NWMS) was integrated waste management planning which incorporates HCRW. A number of action plans were developed in the strategy and these included the following: -

- Regulations and guidelines for the compilation of waste management plans, covering *all types of waste*, was to be drafted by the Department of Environment Affairs and Tourism, in consultation with provincial government, and promulgated by the year 2000. Special consideration was to be given to waste management in rural and farming communities.

- For general waste, first generation plans will be compiled <u>by local government</u> in the year 2001, for submission in 2002. Final plans will be submitted and approved in 2003 and be implemented by 2006. Compilation of first generation integrated general waste management plans in the short-term is part of a phasing-in process.

- For hazardous waste (which includes HCRW), first generation plans will be compiled <u>by provincial government</u> in 2001, for submission in 2002. Final plans will be submitted and approved in 2003 and be implemented by 2006.

All I&APs involved in the development of the NWMS identified a number of high priority issues that should be investigated in the short term. The Action Plan on Waste Treatment and Disposal (Department of Environment Affairs and Tourism, 1999) identified certain aspects of the treatment and disposal of "medical waste" that required urgent attention. These were that:

- DEAT will develop guidelines for the safe management of HCW by 2001, which will include guidelines for the separation of waste at source into infectious waste that requires incineration (according to the Human Tissues Act) and non-hazardous HCW that can be disposed of by alternative methods;

- Revised air emission standards for waste incineration facilities will be developed by DEAT by December 2001. The revised air emission standards will consider international standards and South African conditions, and will be graded according to the size of the facilities and the type of waste incinerated;

- DEAT will undertake monitoring and auditing of all waste incineration facilities, to initiate enforcement of the revised air emission standards, from January 2002 onwards. Further enforcement action will be taken where necessary;

- A public awareness and education campaign, focusing on the hazards of HCW and the legal responsibilities of generators, will be developed by DEAT by December 2000 and implemented from 2001 onwards;

- Planning for a system of HCRW treatment plants will be completed by 2002. Additional treatment facilities will be established and operated thereafter, in accordance with this plan.

In order for Gauteng to meet its obligations and provide plans for hazardous waste management in the Province, including HCW, information is required on the waste generation and the treatment facilities available. This report gives the results of an investigation undertaken from March 2000 to May 2000, into the current treatment and disposal facilities for HCRW in Gauteng.

## 4.2 Investigation Methods

A questionnaire for capturing of data that is related to the operation and maintenance of incinerators to be investigated was drawn up on the basis of a survey document that was previously used by one of the consultants and the questionnaire presented in A Pruss et al., "Safe Management of Wastes from Health Care Activities", World Health Organisation, Geneva, 1999. The questionnaire was adapted during the initial stages of the survey in order to include issues of importance to South Africa. A copy of the questionnaire that was finally used is included as ***Annexure 4.1***.

The information required fell into three broad categories, i.e. Facility Information, Incinerator details and Information on HCRW Handling. Background information on each item in the questionnaire, the information obtained from the facilities and general comments are given below in Sections 4.3.1 to 4.3.3 below.

Initial information on the location or possible future location of incinerators was obtained from DACEL's database, from the Hospital and Nursing Yearbook of Southern Africa, 1999, from Mr C du Plooy of the Department of Environment Affairs and Tourism, and from Mr M Eksteen of the Gauteng Department of Transport and Public Works. (Because the list of private hospitals was very long, each hospital was telephonically interviewed to establish whether they had an incinerator on their premises. Only those that indicated that it was equipped with an incinerator were visited. During the study, information was received on the location of additional incinerators and these were added to the list.

## 4.3 Results of Survey

### 4.3.1 Facility information:

The facility information is summarised in ***Table 4.1*** and each column is discussed as follows: -

Table 4.1

**Name and type of facility**

The facilities were divided into Private Hospitals, Provincial Hospitals, Miscellaneous (Laboratories and Prisons) as well as Waste Service Companies. Details of the numbers in each category are included in ***Table 4.2***

***Table 4.2:*** Categories of Health Care Facilities

| Type of Institution | Number with Incinerators | Number of Incinerators | Number Operational | Registration Certificates |
|---|---|---|---|---|
| Private Hospitals | 14 | 14 | 13 | 5 |
| Provincial Hospitals | 32 | 38 | 28 | 11 |
| Miscellaneous* | 8 | 11 | 10 | 2 |
| Waste Service Companies* | 4 | 7 | 7 | 7 |
| TOTALS | 58 | 70 | 58 (83%) | 25 (37%) |

*This category includes the waste management companies and the Johannesburg Metro.

***Table 4.2*** shows that there are 58 institutions that have incineration facilities in Gauteng, the majority of these, 55%, are Provincial Hospitals with the next largest category being the Private Hospitals at 24%. The total number of incinerators identified was 70, as some institutions have more than one incinerator on the same site. These include some of the larger Provincial Hospitals, including Johannesburg, Photosong, Tambo Memorial and Tembisa Hospital, all of which have two incinerators. The waste management companies also tend to operate more than one incinerator; Envirocin has two small Furntec Units at their premises in Zandspruit, Randburg, whereas EnviroServ operates 4 incinerators, two of the TOXIC type at their premises in Roodepoort and two of the Macroburn type at Rietfontein, Germiston.

One of the difficulties that arose during the survey was that many of the hospitals had or were in the process of changing its names. As far as possible, the current or, where the name change has been ratified, the new name is included in the list.

**Addresses and contact details**

The town, the physical and postal addresses as well as the telephone and fax numbers for all the facilities are included in columns 2 to 6 of ***Table 4.1***. These were confirmed during the respective interviews and were correct at that time.

**Location – Latitude and longitude**

The latitudes and longitudes of some of the facilities were available at commencement of the project. Only where the co-ordinates were not included in GDACEL's list or where there was some uncertainty regarding the values, were readings taken. A Garmin 12 hand held GPS instrument was used. The values were confirmed by plotting the locations on a map and by comparison with the available *Map Studio* maps. A map indicating the location of the existing incinerators is presented in ***Figure 5.4*** of Chapter 5.

**Contact person and ownership of facility**

The contact details and for some private hospitals, the holding company details, are presented in ***Table 4.1;*** Columns 9 and 10.

**Type of facility and service required**

The type of institution presented in ***Table 4.1***, Column 11 is indicated by:

- H Hospital
- C Clinic
- RC Rehabilitation Centre
- LAB Laboratory
- P Prison
- WMS Waste Management Service

In addition, the type of service offered is indicated by:

- Me Medical
- Ma Maternity
- WR Welfare Retirement Village
- I Incineration Service

**Number of beds and occupancy rate**

Most hospitals and clinics interviewed were well aware of the number of beds, which varied from as low as 43 at the Bronkhorstspruit Private Hospital to 1 804 at the Ga-Rankuwa Hospital in Pretoria. However, only three of the facilities interviewed had any idea of the occupancy rate, a figure that is important if the elected procedure of determining the mass of waste generated per patient per day is to be used.

**Date of survey and interviewers**

The date of the survey presented in ***Table 4.1***, Column 13, is that of the first visit by the interviewer. In some instances, the facility was visited more than once or contacted by phone in order to verify certain information.

### 4.3.2 Incinerator details:

**Treatment and disposal method**

The approach to the treatment and disposal of the infectious waste stream is presented in ***Table 4.3***, Columns 2 and 3. Many health care facilities use their own incinerators together with an external contractor for the management of the infectious waste. Three scenarios were encountered:

- All infectious waste is removed by a contractor.
- Only human tissue and/or sharps are incinerated on site.
- All infectious waste is incinerated on site.

The type of waste incinerated is indicated in Column 3 as:
mw = medical waste (HCRW)
ht = human tissue
- gw = general waste

lab waste = biologically contaminated laboratory waste

Envirocin is a specialised company that cremates animal carcasses. Hillbrow hospital on the other hand, reports that it uses its incinerator occasionally for incinerating drugs that are confiscated by the police. It should be noted that this practice is unacceptable from an environmental standpoint as most drugs, except dagga (which is a plant material), are chemical formulations that should only be destroyed in an incinerator designed for chemical hazardous waste.

Some health care institutions have closed down their incinerators, resulting in all HCRW being removed by an external contractor. Johannesburg General Hospital uses its incinerator for human tissue as well as for general waste. However, it became apparent from interviews that practices at many institutions vary considerably during the year. For example, at the end of the financial year, when funds are low, some facilities resort to using their own facilities, as they cannot afford to pay for the external service.

**Make and size of incinerators**

The make and size of each incinerator is presented in ***Table 4.3***. Note that some facilities have more than one incinerator on site, resulting in the 58 health care facilities having 70 incinerators. (See ***Table 4.2)***

There are seven makes of incinerators still in use in Gauteng, some of which are outdated and some that is no longer available, namely:

- **TOXIC** (Thermal Oxidation Incineration Company) is manufactured by Johnson Thermal Engineering, Randburg and is a modern "controlled air" type incinerator;

- **Lucifer, SA Incinerator Company** and **Mitchell Monk** incinerators are very similar and use the original Los Angeles design. They are "excess air" incinerators. Lucifer are very old units and are no longer available, but many are still in use;

- **Safex** has also been discontinued. The units were originally supplied as coal burning units but were later converted to diesel or gas;

- **Macroburn** also developed from the old Lucifer units of LA design, but has been modernised and many design improvements were made. Although the latest units have much better control over the combustion air, it is still the "excess air" type;

- **Furntec** is a recent entry into the market and is a “starved” or “controlled air” type incinerator.

The model identification numbers given in ***Table 4.3*****,** Column 3 give the capacity of the incinerator according to the manufacturer. The model number of the Lucifer, SA Incinerator, Mitchell Monk and Safex incinerators refer to the mass ***in pounds*** of General Waste that they can incinerate in one hour. Therefore, an LA 100 can incinerate 100 lb (pounds) of general waste. The older Macroburn incinerators also referred to pounds, but the numbers were later converted to kilograms so that a Macroburn 500 can incinerate 500 kg of general waste. The Furntech and TOXIC incinerators also refer to the mass of general waste that can be incinerated in kilograms per hour.

However, it should be noted that the actual mass of HCRW that can be incinerated usually differs considerably from the capacities claimed by the manufacturers as discussed in Section 3.3.

**Permit/Registration Certificate status**

Only 24 of the incinerators have registration certificates (of which some are temporary) and although many of the operators indicated that they were applying for registration, the actual status is uncertain.

**Type of incinerator: excess air or controlled air**

The incinerators are predominately of excess air type, with only 5 of the 70 incinerators being the more modern controlled air type. The latter are all operated by waste management companies.

Table 4.3

The types of incinerators were discussed in detail in a previous report prepared for GDACEL: "Background Study on Medical Waste Management", by Infotox, November 1998 as part of the Danced Capacity Building Project. The more modern excess air incinerators in use in South Africa are Multi-chamber Incinerators equipped with both primary and secondary combustion chambers. Many of the older excess air incinerators however cannot reach temperatures above 800°C in the primary chamber and often work at temperatures considerably lower than that. The advantages and disadvantages of this type of incinerators are listed in ***Table 4.4***.

***Table 4.4*** Advantages and disadvantages of Multi-Chamber ("Excess Air") Incinerators*

| Advantages | Disadvantages |
|---|---|
| a) Relatively inexpensive<br>b) Physically compact | a) Require very high excess air levels,<br>b) Unable to comply with regulations without pollution control equipment, especially particulate emission standards,<br>c) High fuel use in order to maintain the required high temperatures in the primary and secondary chambers,<br>d) Expensive to retrofit air pollution control equipment,<br>e) Difficult to control combustion air levels and rate of combustion,<br>f) Limited to batch operation unless some form of air control added,<br>g) Regular incidents of poor combustion, smoke and release of hazardous substances,<br>h) Ash removal manual, leading to potential exposure to dust. |

*Adapted from GDACEL, "Background Study on Medical Waste Management", by Infotox, November 1998

Note that the emissions from the incinerators are dependant on the quality of the in-put waste. The presence of PVC in the HCRW streams results in the permitted levels of HCl in the gas almost always being exceeded. However, the excess air incinerators do emit considerably more particulates that the controlled air type, which means that they often cannot even meet South Africa's generous standard of 180 $mg/Nm^3$ for particulates.

The advantages and disadvantages of the controlled air type of incinerator are listed in ***Table 4.5.***

***Table 4.5***: Advantages and Disadvantages of "Controlled Air" Incinerators*

| Advantages | Disadvantages |
|---|---|
| a) Reduction of waste volumes without excess quantities of supplementary fuel,<br>b) High thermal efficiency due to relatively low air requirements,<br>c) Lower fuel costs,<br>d) Uncontrolled air emissions can be low,<br>e) Converts carbonaceous solids to gases that are more easily combusted,<br>f) Limited particulate emissions,<br>g) Can burn waste with a minimum amount of processing,<br>h) Capital costs modest compared to performance. | a) May have incomplete combustion of carbonaceous material in ash,<br>b) Needs regular maintenance to remove clinker and scale build-up on refractory surfaces,<br>c) Difficult to control operating parameters, if the waste type varies,<br>d) If the primary chamber temperature is too high because of the waste characteristics or poor operating practices, metal emissions may be high. |

*Adapted from GDACEL, "Background Study on Medical Waste Management", by Infotox, November 1998

Generally, the controlled air type is more effective and efficient, particularly when a larger capacity is required. Note that the latest incinerators installed by both waste management companies are the controlled air type.

**Operational status**

The number of incinerators actually operational was estimated at 58, i.e. 83% of the total, (see ***Table 4.2***). The reasons for some not being operational ranged from old and inoperable (such as that at Cullinan Rehabilitation Hospital), to those at Tambo Memorial and Tembisa Hospitals that have only recently been installed, but did not comply with the EIA requirements. As described below and is evident from the comments by the investigator given in ***Table 4.3***, the actual status of many of the incinerators is extremely poor.

**Installation date**

The date installed was in most instances difficult to obtain, as there has been a turnover of staff and often nobody was able to provide the information. Therefore, some dates in ***Table 4.3*** are no more than educated guesses. Note that the installation dates vary from about 1967 to 1999, with the controlled air incinerators being installed from 1996 onwards.

**Condition**

Condition of the incinerators is given as:

- **G = good:** Indicating that the steel shell, burners, chimney and refractory appear from a limited inspection to be in a reasonable condition. If classed as good, however, it does not necessarily indicate that the unit can be upgraded to meet the Department of Environmental Affairs and Tourism's emission guidelines.
- **NR = needs repair:** One or more of the above-mentioned items needs repair.
- **N/O = not operating:** For the reason given in the comments section, ***Table 4.3.***
- **B = bad:** the incinerator is in bad state of repair and probably not repairable.

The incinerators at 32 of the 58 facilities identified were described as being in a good state of repair.

**Fuel used and fuel usage**

The type of fuel used is indicated in Column 12 and the amount used, if known, in Column 13. The most common fuel used is diesel, although there are four that are gas fired and three that are still using coal. The new Toxic 350, operated by the Johannesburg Metropolitan Council is gas fired. The figures vary widely for fuel used and this is a reflection of: -

- Uncertainty in the figures – many operators do not have accurate records of the volume of fuel used;

- The considerable variation in the utilisation of burners. For example, at Ga-Rankuwa Hospital, the burners were not even running during the visit;

- The type and quality of the waste being burnt;

- The type of incinerator. For example, the Macroburn's are excess air incinerators and utilise ~0.25 litres/kg of waste, whereas the controlled air Toxic incinerators utilise ~0.1 litres/kg of waste. Note that at the current price of diesel the controlled air incinerators are therefore considerably more cost effective in this regard. Assuming the price of diesel to be R3.00 a litre, the fuel cost for the excess air incinerator works out to be R750 per ton whereas for the controlled air incinerators the cost is R300 per ton.

**Operating hours/month**

The estimated operating hours per month for the incinerators are given in Column 13 of ***Table 4.3***. In many instances, it was very difficult to establish these times, as some units are only used when human tissue or other health care waste was available for treatment. Note that the times vary considerably with the Carletonville and Kutsong Hospitals recording only operating 8 hrs per month whereas one of the waste management companies operate their incinerators for 400 hours per month.

**Scrubber fitted**

Of the 70 incinerators, only the Johannesburg Metropolitan Council's incinerator is fitted with a scrubber. However, the scrubber is not operational for most of the time. At the time of the visit by the investigating team for instance, the scrubber had been disconnected because of corrosion problems in the connection pipe from the incinerator.

The gas emissions from all health care waste incinerators in South Africa cannot meet the Department of Environmental Affairs and Tourism's requirements in terms of the Atmospheric Pollution Control Act. The HCRW stream in South Africa includes significant amounts of PVC and other chlorine containing compounds and therefore the emissions of HCl are generally well above the limit of 30 ppm, currently set by the Department of Environmental Affairs and Tourism. In addition, the current limit for particulates of 180mg/Nm$^3$ is high compared to international limits, which fall in the range 10 to ~30mg/Nm$^3$. The addition of scrubbers could reduce the acid gases and particulates to more acceptable levels and this may have to be introduced in the future. However, it is estimated that the costs for incineration would increase by a minimum of 50%. It is argued by many that South Africa cannot afford this cost, although many others believe that the environment cannot and should not be required to accept the pollution load. The argument is, however, more complex since various factors such as location of the incinerator, the stack height and the potential low volumes of waste incinerated mean that incinerators not meeting the emission standards may still have a low impact on human health and the environment. It is further recognised that if one operator is required to install a scrubber and not the other, then the former would clearly be at a considerable commercial disadvantage. An application to operate an incinerator without a scrubber requires a full multi-pathway health risk assessment to prove that the impact is acceptable before the Department of Environmental Affairs and Tourism will grant a permit. The burden of proof is therefore on the operator/owner of the incinerator.

**Feed mechanism**

Only five of the existing incinerators, those of Sanumed (EnviroServ) and the Johannesburg Metropolitan Council, have mechanical feeding systems. In these incinerators, the feed rate is determined by the temperature in the primary chamber as well as the maximum feed rate set by the operator. These parameters are generally specified by the incinerator manufacturer but have also been determined by the CSIR during studies carried out for one of the waste management companies.

The guidelines for Class 2B incinerators set in Schedule 39 of the Atmospheric Pollution Prevention Act (Act 45 of 1965) state that:

"Controlled hygienic (preferably mechanical or automatic) feeding methods should be used which will not affect the air supply and temperatures in the primary and secondary chambers of the incinerator."

Waste should not be fed into the incinerator under the following circumstances:

- At start-up or until the minimum combustion temperatures have been reached;
- Whenever the minimum combustion temperatures are not maintained;
- In the case of a batch loader, whenever the previous charge has not been combusted completely; and
- If addition of waste would exceed the design specifications of the incinerator.

Note that the feeding of the waste without allowing a large intake of air through an open door is extremely important, since opening of the door can lead to generation of excess smoke and presumably the emission of other pollutants. With a mechanical feeder an airlock or other control system is used to minimise ingress of air.

**Chimney height and position**

Schedule 39 of the aforesaid Act requires that "the incinerator chimney should have a minimum height of 9 m above ground level and clear the highest point of the building by not less than 6 m for flat roofs, and 3 m for pitch roofs. The topography and height of adjacent buildings within a distance of approximately five times the chimney height should be taken into account."

An assessment of these factors was made by the investigator and in 8 cases (see ***Table 4.3***, Column 16), the chimney height was adjudged as being too low, although in general all incinerators were considered to be located adequately with regard to adjacent buildings, Column 17. In two instances, the emissions are lead into an existing boiler stack, one of which is 82 metres high.

In order to obtain good dispersion, the gas exit velocity should be at least 10 m per second, according to the guidelines. The investigators were however unable to judge whether the incinerators comply with this requirement.

**Primary burner temperatures**

Schedule 39 of the Atmospheric Pollution Prevention Act (Act 45 of 1965), gives the following guidelines for the primary chamber:

"The primary chamber should be equipped with a burner(s) burning gas or low sulphur liquid fuel. The primary air supply is to be controlled efficiently."

The guidelines do not specify the primary combustion zone temperature but for efficient combustion, temperatures above ~850$^{o}$C are recommended. Temperatures recorded in the primary chambers at most institution were well below this, with temperatures as low as 200$^{o}$C being recorded. However, the investigator noted that the measured temperature probably had no relationship to the actual temperature in either the waste body or gas because of the poor location and/or maintenance of the thermocouple. It should be noted that temperatures in excess of 600$^{o}$C are required if the sterilisation of the waste is to be guaranteed.

**Secondary burner temperatures**

Schedule 39 of the Atmospheric Pollution Prevention Act (Act 45 of 1965), gives the following the guidelines for the secondary chamber: -

- "The secondary chamber should be fitted with a secondary burner, burning gas or low sulphur liquid fuel, or other suitable fuel.

- The secondary air supply is to be controlled efficiently.

- A residence time of two seconds is specified to allow sufficient flame contact of the gases in the combustion zone.

- The gas temperature as measured against the inside wall in the secondary chamber should not be lower than 1100 degrees centigrade, if materials containing 1 percent or more of halogens are incinerated. In cases where halogens are present at concentrations from below 1 percent, the temperature may be reduced to 850 degrees centigrade. Those cytotoxic materials should be combusted at an after burner temperature of lower than 1000 degrees centigrade. The oxygen level of emitted gas should be not less than 11 percent."

Note that the requirements are set in order to minimise the emission of organic compounds and in particular the extremely toxic dioxins. The percentage of halogen in the South African HCRW stream is unknown, but from emission tests that have been done and the concentrations of HCl detected, it is likely that the percentage halogens reaches and exceeds 1%, at least in some instances.

Column 19 of ***Table 4.3*** gives, where known, the temperature of the secondary chamber and information on the status of the secondary burner. This data is also summarised in ***Table 4.6.***

***Table 4.6:*** Summary of the status of the secondary burners

| Requirement | Number of Incinerators meeting requirement |
|---|---|
| Temperature ? 1100$^{o}$C | 5 |
| Temperature ? 850$^{o}$C but < 1100$^{o}$C | 12 |
| Temperature < 850$^{o}$C | 10 |
| Not Measuring | 5 |
| Not Operating/in use | 10 |
| Not Fitted | 15 |

Only five incinerators, i.e. those operated by Sanumed (EnviroServ) and the Johannesburg Metropolitan Council had temperatures ? 1100$^{o}$C in the secondary chambers and another 12 were possibly adequate in terms of the guidelines in that they were recording temperatures of between 850 and 1100$^{o}$C. However, ten facilities were recording secondary chamber temperatures below the required minimum of 850$^{o}$C. Five operators were not measuring the secondary temperature and fifteen of the incinerators were not even fitted with secondary chambers.

### 4.3.3 Operations and Waste Handling

Information on the quantity of HCRW treated, the number of operators and the HCRW handling and storage procedures at the incinerator facilities is presented in ***Table 4.7.***

**Table 4.7**

**Operators: Number, qualifications and number of shifts**

Columns 2,3 and 4 of ***Table 4.7*** provide information on the number of operators per shift, the number of shifts per week and the minimum qualifications of operators.

The number of operators per shift varies from one at most facilities with up to eight at the Johannesburg Metropolitan Council's Incinerator. Comparison of the number of operators with the operating hours and tonnage of waste handled (Columns 7 and 8 of Table 4.7) shows some correlation. However, for the smaller units, some of which only operate for eight hours per week or month, the operator presumably has other duties. Some institutions seem to be grossly overstaffed; for example the Johan Heyns Hospital that has four operators on a single shift and yet only treats 0,7 tons of waste per month, whereas one waste management company operates with two operators on each shift and handles 165 and 295 tons of HCRW per month at their facilities in Rietfontein and Roodepoort respectively.

Where qualifications are required for employment, the private hospitals and waste management companies require at least a formal grade 10 education. However, the Provincial Hospitals do not set a minimum entrance qualification but only rely on in-service training. In South Africa, there are many people with low formal qualifications that will, through in-service training and experience, work at a much higher level. However, successful operation of a modern incinerator requires a good understanding of the operating parameters in order to minimise the pollution potential and it appears that the quality of the staff used as operators and the training they receive may not be adequate in many hospitals. Larger incinerators, in particular, are sophisticated pieces of equipment that work at extreme high temperatures to attain good combustion efficiency. The low temperatures recorded in the secondary chambers and the general neglect of the equipment at some facilities is indicative of poor management control and a lack of understanding of the correct operating requirements amongst staff.

**Tonnage of waste treated per month**

The tonnage of waste that the facilities claimed to treat per month is included in Column 5 of ***Table 4.7.*** Many facilities did not have any records on the amount of HCRW treated and some staff members guessed the amount. In order to properly manage the waste generated, the waste should be weighed prior to incineration. Most facilities did not have scales and only the waste management companies routinely weighed the waste received at their incinerators. Once the theoretical maximum amounts were estimated from the incinerator capacities (see Maximum Theoretical Capacity), a follow up call was made to the various facilities in order to verify the amounts claimed since, for many, the amounts did not correlate well. See Section 4.3.4, below for further discussion of this issue.

**Maximum theoretical capacity of incinerators**

The actual maximum capacity of an incinerator depends not only on its design but also on the calorific value of the waste. Macroburn have used as a standard the concept of General Refuse Equivalent (GRE) to determine the capacity of its incinerators. The burning rate of waste in an incinerator varies according to the characteristics of the waste. The variation is taken into account by comparing the waste with "general waste" which is defined as follows:

- Calorific value 4600k Cal/kg.
- Moisture 15% max.
- Density 160kg/$m^3$
- Ash 5% approx.

Dry loose office waste that does not have excessive quantities of food, plastics or densely packed paper is typical of "general waste". The ratio between the weight of general waste and the weight of a particular waste that an incinerator can burn in a given period of time is called the General Refuse Equivalent

***Table 4.8:*** Proposed GRE factors for Health Care Risk Waste.

| **Type of Waste** | **GRE** |
|---|---|
| Sorted boxed HCRW | 2.0 |
| Hospitals : General | 1,30 |
| Hospitals : Maternity | 1,40 |
| Hospitals : Teaching | 1,50 |
| Nurses homes | 1,20 |
| Old age homes | 1,25 |
| Out Patients | 1,25 |

Actual capacity = GRE capacity / GRE factor

For example, if an incinerator can incinerate 100 kg GRE waste/hour, it will only be able to incinerate

100/2 = 50 kg/h sorted boxed health care risk waste (GRE=2),

100/1,3 = 77 kg/h general hospital waste (GRE+1,3) or,

100/1,4 = 71 kg/h maternity hospital waste (GRE=1,4).

Note that EnviroServ have had both the Macroburn and Toxic incinerators evaluated by the CSIR in order to get maximum burning capacity with the best environmental performance, i.e. lowest emissions. This does not mean that the incinerators can meet the emission standards since these require < 30ppm HCl and with the input waste containing PVC, it is not possible to achieve without scrubbers. The following data was obtained:

**Macroburn Incinerators:** A Macroburn 500 has a theoretical capacity for sorted and boxed infectious waste of 250 kg per hour, i.e. a GRE factor of 2 according to the manufacturer. In practice, the maximum capacity when operating efficiently is closer to 200 kg per hour, i.e. a GRE of 2.5. This is probably due to the practice of burning sharps together with the sorted infectious waste as this will result in a GRE of more than 2. The rated value in kilograms quoted by the manufacturer has thus been divided by 2.5 to get the estimated capacity per hour.

**Toxic Incinerators:** The TOXIC 350 has been found to burn approximately 350 kg of waste per hour, which is identical to the manufacturers contention that the model number reflects the amount of waste that can be incinerated per hour.

**Other Incinerators:** Since the other types of incinerators installed in South Africa, i.e. Lucifer, South Africa Incinerator Co, Mitchell Monk, etc, are excess air incinerators that are similar to the Macroburns, it was decided to apply the same GRE factor of 2.5 to determine the theoretical maximum capacity for the infectious waste stream. However, the model numbers of these incinerators reflect the capacity in pounds; a model 100 burns 100 pounds or 45.45 kg of general refuse an hour. The capacity for mixed HCRW, i.e. sorted waste and sharps, is therefore given as 45.45/2.5 = 18.2kg/hr.

All incinerators in use in Gauteng are of the intermittent operations type; a period is regularly required during the operation for de-ashing of the incinerator. For example, one commercial operation feeds the incinerators for 16 hours a day and uses the remaining eight hours for complete combustion of the remaining waste and for thorough cleaning out of any accumulated ash. Thus, a Macroburn 500 burns 16 x 200 = 3200kg/day and the Toxic 350 burns 16 x 350 = 5600kg/day. The incinerator is used only six days a week with the seventh day being used for maintenance. With 365 days per annum or an average 4.35 weeks per month, the amount of HCRW that can be incinerated in an average month is:

- Macroburn 500: 3200 x 6 x 4.35 = 83520kg = 83.5 ton per month
- Toxic 350: 4960 x 6 x 4.35 = 129500kg = 129.5 tons per month

Using the same assumptions for the other incinerators, the amount of HCRW that can be incinerated is:

- Lucifer 100: 290 x 6 x 4.35 = 7570kg = 7.57 tons per month

***Note :*** The above calculations assume no downtime other than the weekly day for maintenance.

**Ash**

In Column 8 of ***Table 4.7***, the method of disposal of the ash generated at the incinerator is indicated. ***Table 4.9*** gives the breakdown of the ash disposal methods used for the various incinerators:

***Table 4.9:*** Disposal method for ash

| Method | Number | Percentage of Total |
|---|---|---|
| With the General Waste (GW) | 21 | 38.9 |
| To General Waste Landfill (GWL) | 2 | 3.6 |
| With the Boiler Ash (BA) | 28 | 51.9 |
| To a Hazardous Waste Landfill (HazW) | 3 | 5.6 |
| TOTAL | 54 | 100 |

Of the 54 facilities that provided information on the disposal methods used for the incinerator ash, 21 or 38.9% simply mixed the ash with the general waste; 2 disposed of it as a separate waste stream to a general waste landfill and 28 or 51.9% mixed it with the boiler ash, which presumably is also disposed to general waste landfills. Note that many of the incinerators at hospitals are operated by the maintenance staff also responsible for the boilers. This probably accounts for the frequent mixing of the two ash streams. Only one facility, the Rietfontein Incinerator operated by EnviroServ, disposed of the ash at a hazardous waste landfill. Incinerator ash, including that from an infectious waste incinerator, is internationally considered to be a hazardous waste. In South Africa, the Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste, published by the Department of Water Affairs and Forestry, requires that (because of the presence of heavy metals) incinerator ash be considered as a hazardous waste. There are, however, procedures in the Minimum Requirements that can be used to demonstrate that such ash can delist as a hazardous waste or that, because of the small quantity generated and the low load it presents to a landfill, it can be accepted onto a permitted $GLB^+$ waste disposal site. Recent tests have indicated that incinerator ash generated in the excess air and controlled air incinerators leaches considerable amounts of lead, manganese and other heavy metals and is therefore classified as a hazardous waste. Incinerator ash accepted at the Holfontein H:H landfill is normally treated with lime or soda ash to reduce the leachability of the heavy metals before being co-disposed. From the above it is evident that incinerator ash disposal, particularly without treatment, as part of the general waste stream or with boiler ash, is not acceptable, unless proven through the procedures outlined in the Minimum Requirements, that it can be safely disposed of at a permitted general waste disposal facility.

Disposal of the incinerator ash with boiler ash is of particular concern, since the relatively small amounts of incinerator ash effectively renders the total boiler ash waste stream potentially hazardous. In addition to this, boiler ash is often used at landfills as daily cover material and there is a possibility that needles may not have been properly destroyed and that landfill staff could get needle stick injuries.

The quality of the incinerator ash at many facilities was poor with cool drink cans, bottles and other items that should be disposed of as general waste, being present. Unburnt carbon and even charred paper in some ash loads, was strong evidence of poor operating practices.

It should be noted that the ash from incinerators that burn radioactive waste either deliberately or inadvertently, must be checked periodically to ensure that it does not classify as radioactive waste that have to be disposed of at a dedicated radioactive waste disposal site. Only one facility surveyed was aware of the requirements by the Department of Health, Cape Town and forwarded samples of ash for analysis every three months, as required. Note that the permit holder of the treatment facility has a "duty of care" to ensure that any waste such as the ash, is disposed of correctly. This also includes ash that is derived from multiple HCRW generators.

**Separation at source and handling**

All the incinerator facilities indicated as "int = internal", Column 9 of ***Table 4.7***,handle the HCRW within the hospitals themselves and no external waste management contractor is used to collect the waste – a practice that is common in the USA and Europe. All operators insisted that sound separation at source was practiced at their health care facilities. However, it was clear from observations of HCRW being collected and incinerated as well as from interviews with waste management companies, that separation at source was not carried out well. The presence of general waste such as cool drink cans, hazardous waste such as bottles of solvents, aerosols that can explode in the incinerator and sharps in the boxed infectious waste stream is common. Separation at source is essential to ensure that only the required infectious waste is incinerated at high cost and that compounds or products are not present that can damage the incinerator or potentially impact on the health and safety of the waste management staff.

**Occupational health and safety programme**

The handling and treatment of infectious waste by incineration represents a fairly high-risk occupation with the opportunity for needle stick injuries and contamination by the infectious waste handled being high. A strictly controlled and well-managed occupational health and safety programme is therefore essential. This should include entry and exit medical examinations as well as medical examinations for the staff.

It is a requirement of the Occupational Health and Safety Act that approved programmes for the management of the risks posed by hazardous waste to staff and the general population are in place. This should include well-documented procedures and a regular health-monitoring programme. Emergency procedures should *inter alia* be in place, for instance when staff obtained a needle stick injury or accidentally become contaminated with blood from the HCRW. At one waste management company, the procedure requires an immediate visit to the physician for an examination and an AZT injection against AIDS. All staff are further vaccinated against Hepatitis B and C.

From ***Table 4.7***, it can be seen that only 23 percent of the facilities stated that they had an Occupational Health and Safety programme. All the provincial hospitals and the incinerators at "other institutions" such as the prisons indicated that they had no occupational health and safety programme in place. Presumably, some form of infection control programme is in place in the hospitals in terms of the requirements of the Health Act.

It is however clear that the apparent situation observed during this limited study cannot be allowed to continue. The facilities that do not have an Occupational Health and Safety programme in place are probably placing their workers at risk and, therefore, could be liable to prosecution in terms of the Occupational Health and Safety Act.

**Needle stick injuries**

Needle stick injuries are an important occupational hazard when operating an infectious waste incinerator. Column 12 of ***Table 4.7*** indicates that only 5 of the facilities stated that they experienced needle stick injuries; some indicated that they had no injuries, whereas 26 facilities didn't know. Poor HCW separation at source often leads to needles being disposed in the ordinary plastic bags or the cardboard boxes and one facility indicated that, because of this practice, needle stick injuries occurred once or even twice a month. The literature (Pruss et al, Safe management of Wastes from Health Care Activities", WHO, 1999) indicates that up to 8 percent of needle stick injuries result in the worker being infected by hepatitis B or C, unless precautions have been taken such as a regular vaccination programme for the staff.

**Containers used – General infectious waste and sharps**

Most of the general infectious waste is collected in plastic bags or in plastic lined cardboard boxes. According to the investigators, both red and black plastic bags were used. In the previous investigation (Department of Environment Affairs and Tourism "Background Document of the Management of Health Care Waste", March

2000) hospital staff were even observed transferring the waste from the normal red plastic bags into black plastic bags, which are used for general waste.

For sharps, almost all facilities used puncture proof polypropylene plastic containers. However, some of the containers used were observed to be inadequate, since they were over full, lids were not fitted properly, etc.

**Storage and access control**

The storage facilities for the infectious waste were generally found to be adequate at most of the medical facilities. The HCW was stored in the plastic bags or in the boxes. In the private hospitals, access was generally restricted to the operator. However, in the provincial hospitals, access was not restricted and during the study the investigators found that they could gain access to the storage areas and the incinerators without any restriction. Clearly, only authorised personnel should have access to the waste storage and treatment areas.

**Costs for treatment**

Only the private waste management companies that provide an incineration service knew the costs of incineration of the HCRW. EnviroServ and Envirocin both indicated incineration cost to be in the region of R1.00 per kg. The Johannesburg Metro facility stated that they charged 0.55c per kg to incinerate the HCRW, but it is understood that this figure does not include the recovery of the capital cost of the incinerator, which is written off at the time of purchase.

**Support for regionalized facilities**

There was general support for the concept of regional HCRW treatment facilities, although most respondents qualified their support and indicated that it must be cost effective.

### 4.3.4 Quantities of waste incinerated

***Table 4.10***, which is reproduced from ***Table 4.1*** of the report "The Development of a Medical Waste Incinerator Information System (IIMS), Developed for the Gauteng Department of Agriculture, Conservation, Environment and Land Affairs", August

2000, calculates some data based on the theoretical total incinerator capacities that were calculated under Maximum Theoretical Capacity of Incinerators referred to in Section 4.3.3 above. The theoretical mass of infectious waste that could be incinerated at the facility has been calculated from the total hours reported by the operators multiplied by the theoretical maximum capacity per hour. This figure is then compared with the actual reported mass of infectious waste incinerated and the discrepancy between the theoretical and actual figures is presented in the last column. Note that most incinerators are being used at much lower capacities than its theoretical capacity as shown by the negative figures in the last column. Possible reasons for this phenomenon include:

- Low loading rates, which probably arise simply because of the small amounts of HCRW that need to be treated at some incinerators;
- Low combustion temperatures, which combined with low fuel usage, will result in slow combustion;
- Poor segregation resulting in some HCRW entering the general waste stream;
- Excess capacity due to the trend to make use of private waste management companies, at least for a portion of the HCRW stream;
- Poor condition of some incinerators including poor maintenance;
- Poorly trained operators.

Two facilities indicate that they are accepting much more waste than what can theoretically be incinerated. The EnviroServ facilities at Rietfontein, Germiston and in Roodepoort reported a combined excess of 52 tons per month. Note that the date of the survey was early April 2000, when the company was still appointed for the Gauteng Provincial Hospital Tender. The excess HCRW was taken up in a number of ways; which included transporting thereof to incinerators in other Provinces, using the Johannesburg Metropolitan Council's incinerator when available and by obtaining special permission from the Department of Water Affairs and Forestry to landfill HCRW at the Holfontein H:H Landfill. The Johan Heynes Hospital, Sebokeng and Sizwe Rietfontein, apparently also incinerate more HCRW than the theoretical capacity. This could be due to a number of reasons:

- Poor estimates of the HCRW mass incinerated;
- The operational hours are underestimated; or
- The waste is not completely combusted.

Many operators did not know the mass of waste being incinerated and the presence of carbon and other unburnt material was observed in the ash from certain incinerators.

The data suggests that there may be sufficient capacity for the apparent excess of infectious waste that needs treatment, although it is to be noted that many of the incinerators are in poor condition and would require considerable capital investment for upgrading.  Such an investment may not be warranted in the short term, if more centralised facilities are envisaged in the longer term. A few incinerators could, however, take up some of the shortfall. For example, the four new Monk LA350 incinerators at Tambo Memorial and Tembisa Hospital could accept a total of 105.6 tons per month, if operated at full capacity.  (See Maximum Theoretical Capacity of Incinerators in Section 4.3.3.)

***Table 4.10.*** Theoretical incinerator capacities and masses incinerated against recorded weights incinerated per month.

| Name of Hospital/Clinic | Unit | Make of Incinerator | Size | Total Capacity (kg/hr) | Unit Capacity (kg/hr) | Operational hours (hrs/month) | Theoretical Mass (kg/month) | Recorded Mass (kg/month) | Discre-pancy (kg/month) |
|---|---|---|---|---|---|---|---|---|---|
| Actonville Hospital | | SA Incin LA150 | 150 | 27 | | 75 | 2 025 | 400 | -1 625 |
| Anglogold Health Western Deep Levels | | Lucifer LA150 | 150 | 27 | | 170 | 4 590 | 750 | -3 840 |
| Arwyp Medical Centre | | SA Incin LA50 | 50 | 9 | | 150 | 1 350 | | |
| Boksburg Prison | | M Monk LA50 | 50 | 9 | | 44 | 396 | 150 | -246 |
| Bronkhorstspruit Hospital | | SA Incin LA50 | 50 | 9 | | 75 | 675 | 500 | -175 |
| Carletonville | | Lucifer LA150 | 150 | 27 | | 8 | 216 | 235 | 19 |
| Carstenhof | | SA Incin LA100 | 100 | 18 | | 200 | 3 600 | 1 500 | -2 100 |
| Coronation Hospital | | Sinderator 120 | 120 | 22 | | 180 | 3 960 | | -3 960 |
| Cullinan Rehabilitation | | SA Incin LA50 | 50 | 9 | | | | | |
| Discovery | | M Monk LA150 | 150 | 27 | | 120 | 3 240 | 1 500 | -1 740 |
| Dr.Yusaf Dadoo Hospital | | SA Incin LA150 | 150 | 27 | | | | | |
| Edenvale General | | SA Incin LA150 | 150 | 27 | | 180 | 4 860 | 540 | -4 320 |
| EnviroServ Rietfontein | Unit 1 | Macroburn 500 | 500 | 400 | 200 | 400 | 160 000 | 165 000 | 5 000 |
| | Unit 2 | Macroburn 500 | 500 | | 200 | | | | |
| EnviroServ Roodepoort | Unit 1 | Toxic 350 | 350 | 620 | 350 | 400 | 248 000 | 295 000 | **47 000** |
| | Unit 2 | Toxic 350 | 350 | | 350 | | | | |
| ERPM Hospital | | Lucifer LA150 | 150 | | | | | | |
| Far East Rand | | M Monk LA150 | 150 | 27 | | 120 | 3 240 | 5 000 | **1 760** |
| Forensic Science Labs | | SA Incin LA150 | 150 | 27 | | 25 | 675 | | -675 |
| Ga-Rankuwa | Unit 1 | SA Incin 450LA | 450 | 164 | 82 | | | 9 000 | |

| Name of Hospital/Clinic | Unit | Make of Incinerator | Size | Total Capacity (kg/hr) | Unit Capacity (kg/hr) | Operational hours (hrs/month) | Theoretical Mass (kg/month) | Recorded Mass (kg/month) | Discre-pancy (kg/month) |
|---|---|---|---|---|---|---|---|---|---|
| | Unit 2 | SA Incin 450LA | 450 | | 82 | | | | |
| Germiston | | Lucifer LA150 | 150 | 27 | | 120 | 3 240 | 1 000 | -2 240 |
| Glynnwood Hospital | | Lucifer LA150 | 150 | 27 | | 120 | 3 240 | 3 000 | -240 |
| H.A. Grove | | Lucifer LA450 | 450 | 82 | | 32 | 2 624 | | -2 624 |
| Heidelberg | | Lucifer LA150 | 150 | 27 | | 120 | 3 240 | 250 | -2 990 |
| Helen Joseph | | M Monk 200 | 200 | 36 | | 180 | 6 480 | 5 550 | -930 |
| Hillbrow | | Macroburn 200 | 200 | 36 | | | | | |
| JHB City Incinerator | | Toxic 350 | 350 | 350 | | 240 | 84 000 | 80 000 | -4 000 |
| Johannesburg Hospital | Unit 1 | Sinderator 120 | 120 | 44 | 22 | 200 | | | |
| | Unit 2 | Sinderator 120 | 120 | | 22 | | | | |
| Jonan Heyns | | Lucifer LA100 | 100 | 18 | | 180 | 3 240 | 700 | -2 540 |
| Kalafong | | Safex Burnall 100 | 100 | 18 | | 60 | 1 080 | 2 400 | **1 320** |
| Khutsong Public Hospital | | M Monk LA350 | 350 | 64 | | 8 | 512 | 132 | -380 |
| Kopanong | | Lucifer LA150 | 150 | 27 | | 360 | 9 720 | 1 800 | -7 920 |
| Laudium Hospital | | Lucifer LA100 | 100 | 18 | | | | 1 800 | |
| Leeuwkop Prison | Unit 1 | M Monk 250 | 250 | 109 | 45 | 140 | 15 260 | | |
| | Unit 2 | M Monk LA350 | 350 | | 64 | | | | |
| Lenmed Clinic | | SA Incin LA100 | 100 | 18 | | 150 | 2 700 | 3 000 | 300 |
| Leratong | | M Monk LA350 | 350 | 64 | | 180 | 11 520 | 2 300 | -9 220 |
| Leslie Williams Memorial Hospital | | SA Incin LA250 | 250 | 45 | | 100 | 4 500 | 3 000 | -1 500 |
| Little Company of Mary | | SA Incin LA100 | 100 | 18 | | 300 | 5 400 | | |
| Mamelodi | | M Monk LA100 | 100 | 18 | | 120 | 2 160 | 1 800 | -360 |

| Name of Hospital/Clinic | Unit | Make of Incinerator | Size | Total Capacity (kg/hr) | Unit Capacity (kg/hr) | Operational hours (hrs/month) | Theoretical Mass (kg/month) | Recorded Mass (kg/month) | Discre-pancy (kg/month) |
|---|---|---|---|---|---|---|---|---|---|
| Naledi Nkanyezi Hospital | | SA Incin LA150 | 150 | 27 | | 120 | 3 240 | | -3 240 |
| Natalspruit Hospital | | Lucifer LA100 | 100 | 18 | | 120 | 2 160 | 990 | -1 170 |
| National Institute Virology | Unit 1 | M Monk LA350 | 350 | 204 | 102 | 100 | 20 400 | | -20 400 |
| | Unit 2 | Macro | 350 | | 102 | | | | |
| Nigel Hospital | | Safex Burnall 100 | 100 | 18 | | 120 | 2 160 | 50 | -2 110 |
| Onderstepoort Biol Prod | Unit 1 | Macroburn LA450 | 450 | 360 | 180 | 120 | 43 200 | | -43 200 |
| | Unit 2 | Macroburn LA450 | 450 | | 180 | | | | |
| Pholosong Hospital | Unit 1 | SA Incin 450LA | 450 | 164 | 82 | 180 | 29 520 | 200 | -29 320 |
| | Unit 2 | SA Incin 450LA | 450 | | 82 | | | | |
| Pretoria Academic | Unit 1 | Lucifer LA450 | 450 | 164 | 82 | 30 | 4 920 | 4 500 | -420 |
| | Unit 2 | Lucifer LA450 | 450 | | 82 | | | | |
| Pretoria East Hospital | | SA Incin LA250 | 250 | 45 | | 90 | 4 050 | 1 600 | -2 450 |
| Pretoria West | | Safex Burnall 100 | 100 | 18 | | 240 | 4 320 | 200 | -4 120 |
| Protechnic Lab | | SA Incin 450LA | 450 | 82 | | | | 20 000 | |
| Rand Aid Association | | Macroburn 100B | 100 | 18 | | 42 | 756 | | -756 |
| Sebokeng | | Lucifer LA150 | 150 | 27 | | 300 | 8 100 | 10 000 | 1 900 |
| Sizwe Rietfontein | | Lucifer LA150 | 150 | 27 | | 300 | 8 100 | 10 000 | 1 900 |
| Soshanguwe Clinic 3 | | M Monk LA100 | 100 | 18 | | 600 | 10 800 | 1 260 | -9 540 |
| South Rand Hospital | | SA Incin | 200 | 36 | | 300 | 10 800 | 540 | -10 260 |

| Name of Hospital/Clinic | Unit | Make of Incinerator | Size | Total Capacity (kg/hr) | Unit Capacity (kg/hr) | Operational hours (hrs/month) | Theoretical Mass (kg/month) | Recorded Mass (kg/month) | Discre-pancy (kg/month) |
|---|---|---|---|---|---|---|---|---|---|
| | | LA200 | | | | | | | |
| Sterkfontein Hospital | | SA Incin LA150 | 150 | 27 | | 24 | 648 | | -648 |
| Tambo Memorial | Unit 1 | M Monk LA350 | 350 | 128 | 64 | | | 400 | |
| | Unit 2 | M Monk LA350 | 350 | | 64 | | | | |
| Tembisa Hospital | Unit 1 | M Monk LA350 | 350 | 128 | 64 | | | 500 | |
| | Unit 2 | M Monk LA350 | 350 | | 64 | | | | |
| Univ Pretoria Pathology | | Macroburn LA450 | 450 | 180 | | 150 | 27 000 | | |
| Vaal Med | | SA Incin LA150 | 150 | 27 | | 210 | 5 670 | 3 000 | -2 670 |
| TOTALS | | | | 3 265 | | 6 992 | 813 587 | 637 747 | 150844 |
| Envirocin | Unit 1 | FURNTEC | 100 | 80 | 40 | 200 | 16 000 | 10 000 | -6 000 |
| | Unit 2 | FURNTEC | 100 | | 40 | | | | |

# 5. DEVELOPMENT OF A HEALTH CARE RISK WASTE INCINERATOR INFORMATION SYSTEM (IIMS) FOR GAUTENG DEPARTMENT OF AGRICULTURE, CONSERVATION, ENVIRONMENT AND LAND AFFAIRS (DACEL)

## 5.1 Background

The purpose of this chapter is to outline the development of a:

- Health Care Risk Waste (HCRW) Incinerator Information Management System (IIMS) module as part of the existing Environmental Management System of the Gauteng Department of Agriculture, Conservation, Environment and Land Affairs (DACEL);
- Customised user-friendly module of the EIMS for accessing and maintaining the incinerator data in the form of maps, graphs and reports;
- Spatial representation of both the sources of HCRW generation and treatment/disposal facilities on DACEL's EIMS within a Geographical Information System (GIS). The key issues to be considered were:
  - GPS readings and/or address Geocoding of the HCRW treatment facilities to spatially reference the sites;
  - Design and development of the attribute database.

A total of 70 incinerator units were captured in the IIMS, from 58 incinerator facilities throughout the Gauteng Province. Of these, 9 incinerators are not currently operational. The only information which could be captured within the IIMS, included:

- General facility information, e.g. Name, location, operation status, registration number;
- Incinerator details, e.g. Incinerator type, fuel type, incinerator capacity, scrubber information, burner temperatures, waste types incinerated; and
- Information and handling, e.g. Packaging material, mass incinerated. This field allows for the recording of detailed information, which was not captured during the Phase 1 project, but which will form part of the information requirements under the National Waste Management Strategy. Such information includes monthly reporting on needle stick injuries, downtime, mass incinerated and operational hours.

A comparison of theoretical incinerator capacity, based on incinerator unit information, against calculated mass incinerated (operation hours multiplied by recorded mass), shows a number of discrepancies in recording. In many instances, recorded mass incinerated far out-weight theoretical incinerator capacities, as shown in ***Table 4.10***. In most cases however, the recorded mass incinerated are below the theoretical capacities, suggesting available spare capacity at these incinerators. Such information will need to be verified by DACEL staff during future data captures.

## 5.2 Incinerator Information Management System (IIMS)

The HCRW Incinerator Information Management System (IIMS) has been developed for the Gauteng Provincial Government to aid in the effective management, updating, representation and reporting of HCRW Incinerator Facilities throughout the Gauteng Province. The system was developed to capture specifically HCRW incinerator information, although additional incinerator and waste types may be added to the system.

The IIMS has been designed to link to, compliment and form part of the existing Environmental Information Management System (EIMS) already implemented at the Department of Agriculture, Conservation, Environment and Land Affairs (DACEL). As such it incorporates the same database format, the same look and feel and the same user functionality as the three administration components already linked to the EIMS, namely the EIA Administration System, the Waste Information Management System and the Environmental Complaints Register. The IIMS however does incorporate an upgrade in reporting functionality from within the administration component. This is due to the fact that the other components to the EIMS are very reliant on the GIS system for reporting and graphing of information gathered. It was felt during the course of the development of the IIMS that the system should be an effective management tool with GIS support and representation as opposed to a data capture tool with GIS reporting. This reduces the training necessary for managers and system administrators using the IIMS.

The IIMS uses the latest in Microsoft's Data Access technology to communicate with a centralized Access database over the DACEL network. This database is accessible from any workstation within the department and as such, the IIMS Administration and GIS components may be installed at any node of the network. All users authorised and connected to the system will see updates and changes made by other users.

The IIMS is in effect an addition to the EIMS system already operational within the Department. However, the IIMS has been designed in such a way that it may be installed on any stand-alone computer as well as on any network as it is not dependant on any of the EIMS features to function.

A summary of the IIMS is given in ***Annexure 5.1***, a training manual developed for DACEL staff involved in capturing information into the IIMS. Screen captures are included in this manual, which shows the design and layout, graphing, data capture and reporting.

## 5.3 Geographical Information System

Based on the information captured within the IIMS, all incinerator units were captured in a Geographical Information System (GIS). This included both HCRW generators and HCRW incinerators. All spatial coverages were developed within ArcView 3.1.

The GIS system links via Open Database Connectivity (ODBC) to this common data store in order to access spatial information for each incinerator facility (latitude and longitude) and display the facility as an on-screen icon. The icon is colour co-ordinated depending on the registration status of the facility. In this manner the users to the EIMS will be able to view the entire Gauteng region with all captured provincial incinerator facilities.

Spatial coverages of HCRW generators and incinerator facilities is given in ***Figures 5.1-5.5*** as follows:

***Figure 5.1***: All captured HCRW generators. As expected, generators cluster around built up areas.

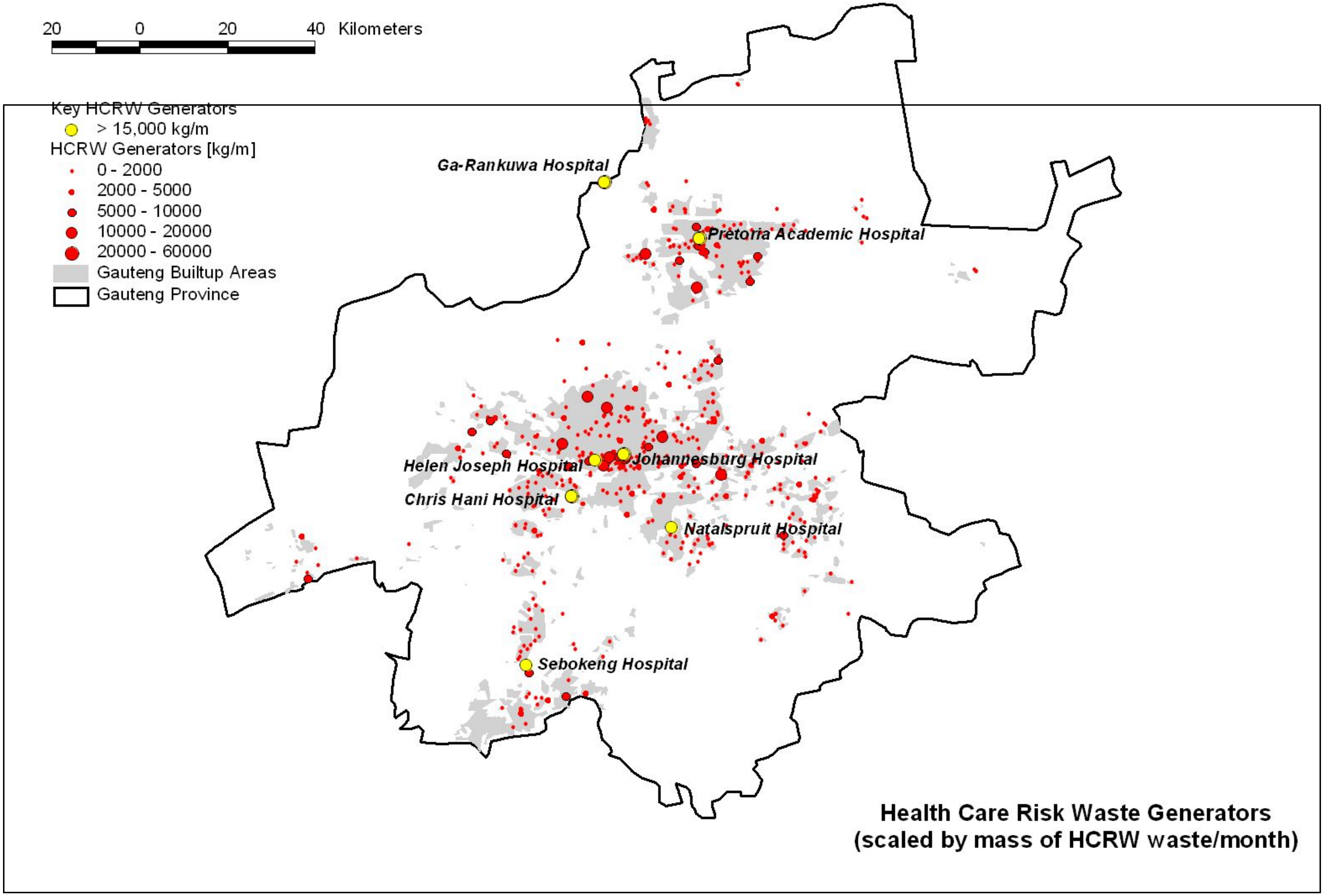


Figure 5.2: HCRW generators scaled by mass of HCRW generated (kg). Large generators, such as Johannesburg Hospital, Chris Hani (Baragwanath) Hospital and Pretoria Academic Hospital are evident.

Figure 5.3: HCRW generators, coded by service, i.e. Blood Transfusion Services, Clinics, Community Health Centres, and Hospitals.

Figure 5.4: Location of HCRW incinerators

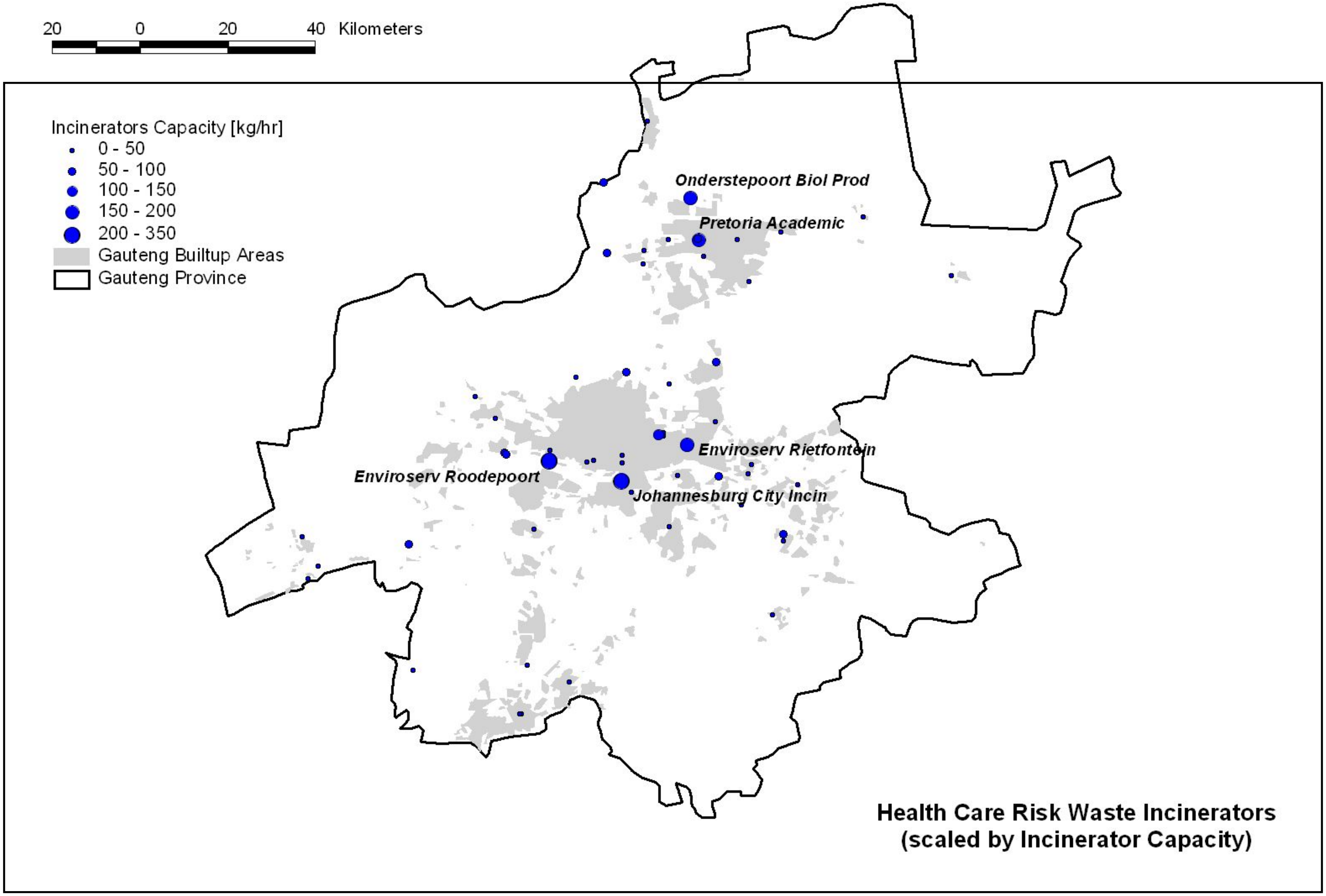


Figure 5.5: HCRW incinerator capacity, scaled by theoretical capacity, based on incinerator unit type.

### 5.4 Data Accuracy

Data captured within the IIMS is based upon information supplied by incinerator operators during interviews and through questionnaires. The data currently stored within the IIMS should be treated with caution as much of the data was not readily available from operators and has been captured for the first time. This data should be reviewed, verified and updated with more accurate information as it becomes available.

Many of the incinerator's spatial positioning, is based upon information obtained from DACEL. This information was checked and verified where possible against HCRW generator information, as in many instances the incinerator units correspond with waste generators, e.g. hospitals. As new information becomes available from incinerator operators, the positioning of incinerators should be verified.

GIS coverages prepared of HCRW generators, was based on information obtained from directories of medical services. Coordinates of these generators were obtained from street addresses and where this was not possible, from postal code areas. The accuracy of these coordinates needs to be verified and updated by either DACEL or Department of Health.

### 5.5 Installation and Training

DACEL staff were given the opportunity to review the draft IIMS on a number of occasions, during which time, modifications and corrections were made to the system. The final version of the IIMS, version 2000.1 was installed within DACEL during the week of the 7-11 August 2000. Training of DACEL staff on the use and operation of the IIMS was conducted as per the training manual.

## 6. FEASIBILITY STUDY INTO THE REGIONALISATION OF HEALTH CARE RISK WASTE FACILITIES IN GAUTENG

### 6.1 Introduction

As indicated in Chapter 4 titled "Status Quo on the Medical Waste Treatment Facilities" of this report, the majority of HCRW incinerators in Gauteng are owned and operated by Provincial Hospitals. Other priorities have delayed the upgrading/replacement of these units, as required to meet the emission standards laid down by DEAT in 1994 for various scheduled processes, including HCRW incineration. Full compliance with the emission standards is required by the year 2002.

During the 1998-1999 budget cycle, the first two incineration facilities were upgraded, viz. those at Tambo Memorial and Tembisa Hospitals. The Gauteng Department of Transport and Public Works has now presented a programme that envisages the replacement/installation of incinerators at all Provincial Hospitals by 2009, requiring an extension of DEAT's original deadline by 7 years.

GDACEL in turn has embarked on a process to develop a HCW strategy for Gauteng. This process includes a feasibility study into the possibility of the regionalisation of HCRW treatment/disposal facilities in the province. This approach is in line with the National Waste Management Strategy (NWMS) as sound HCRW management has been identified by the NWMS as being a priority concern.

The feasibility study described in this chapter focussed on determining the financial feasibility or otherwise of regionalisation of HCRW incineration in the province, with specific regard to HCRW generated by Provincial Hospitals.

## 6.2 Problem Definition

The estimated current rate of HCRW generation by provincial hospitals has been discussed in Chapter 3 : Status Quo Report on the Sources of HCRW in Gauteng, which forms part of the present study. Currently, this HCRW is either (a) incinerated on-site at the hospital concerned, (b) removed by a waste management contractor and incinerated at a third-party incineration facility, or (c) regrettably, dumped illegally. In certain cases, a combination of (a) and (b) occurs. An estimate of current overall monthly cost associated with the destruction of HCRW generated in Gauteng provincial health care facilities, is presented in Section 6.3 below.

The current study sought to establish whether the overall cost referred to above could be reduced by "regionalizing" incineration of HCRW, i.e. by utilising a number of new (or upgraded/expanded existing) incineration facilities, as a departure from the current practice of undertaking on-site incineration at the majority of provincial hospitals.

In order to establish whether overall costs incurred by HCRW treatment/disposal of provincial health care facilities could be reduced, it was necessary to "model" various scenarios and compare the results. For this purpose, a numerical model was developed which is described in Section 6.4 of this Chapter.

## 6.3 Current Incineration Costs for Provincial Hospitals

As referred to elsewhere in this report, information on costs associated with the operation of incinerators at provincial hospitals were generally not available, or not known to the persons interviewed. In addition, there is a very real risk that costs obtained through canvassing incinerator users produces results which are not comparable, i.e. not all costs are included in all cases, and costs ("overhead" costs in particular) are treated in different ways. For this reason, it was decided that it would be prudent to develop an independent cost-model for incinerators, which would ensure that all installations were treated in a consistent manner. The same cost model could then also be used for "new" installations, as discussed below during the investigation into possible regionalisation of HCRW treatment/disposal operations.

### 6.3.1 Incineration Cost Model

Costs associated with incineration can be divided into two main classes**: Fixed** (Monthly) **Overhead Costs** and **Variable Costs**.

**Fixed** (Monthly) **Overhead Costs** are costs that are/would be incurred, irrespective of the extent of usage of the incinerator(s). Components of this cost include the depreciation of the capital cost of the installation, a portion of the maintenance cost of the incinerator itself, the annual electricity connection fee, a portion of the electricity consumption costs, and the salaries/wages of the staff associated with the incinerator (whether directly, as in the case of operators, labourers, etc., or indirectly, i.e. supervisors, administrative and financial personnel, etc.).

**Variable** costs are costs associated with actual operation of the incinerator. Chief among these is the fuel (usually diesel oil) cost, the electricity consumption cost, the costs associated with the removal and disposal of ash, as well as a portion of the maintenance cost of the installation, and in particular the incinerator(s). (The more the incinerator is used, the more maintenance is required, in the form of burner nozzles, thermocouples, refractory linings, etc.).

A typical model is presented below as Table 6.1, which is for the Tembisa Hospital incinerator. It should be noted that all costs are current (Year 2000) costs. A brief explanation of the model is set out below, in which the rationale and assumptions made are explained/noted. (For ease of reference, paragraph numbers below match the section numbers in the table.)

1. **Property (land) costs**: In all cases dealing with **existing installations**, the acquisition cost has been taken as **nil**.

2. **Development costs:** Reasonable assumptions have been made regarding the building size (which has been related to incineration capacity in all cases) and infrastructure development costs. The same per $m^2$ costs have been applied in all cases. Note that no cost has been associated with diesel storage tanks, as these are typically installed by the fuel supplier, who levies a surcharge on each litre of diesel sold in order to recoup the equipment/installation costs.

3. **Incinerator:** Make and model are given, together with the number of units installed. Operating hours per day is a variable in the model, i.e. can be increased or decreased as required (see below). Installed cost of the incinerator(s) has been determined using current *Macroburn* and *Toxic* pricing. For other makes of incinerators, comparable *Macroburn* pricing has been used. (This pricing has been determined according to relative HCRW kg/hr treatment capacity.) Rated power (in kW) has been set as a function of HCRW treatment capacity (2.0 + 0.016 x capacity) kW, as has diesel usage (7.0 + 0.14 x capacity) lit/hr. (This applies to all incinerators except the Toxic; fuel usage on the Toxic 350 is approximately 19 lit/hr.) Diesel usage figures have been established by taking manufacturer's claimed figures, corroborated with actual usage figures as recorded and kindly made available by Sanumed. No separate allowance has been made for fuel usage during warming-up of the incinerator. Where incinerators are coal-fired, equivalent diesel-firing costs were used; where gas-firing is used, 90% of the equivalent diesel-firing costs were applied. Annual maintenance costs associated with the incinerator have been taken as 12% of the installed capital cost: this percentage was derived using actual maintenance costs as kindly made available by Sanumed. This percentage is high in comparison with conventional plant and equipment, and reflects the harsh conditions under which the equipment operates.

4. **Scrubbers:** This section has been included to cater for new installations (see below). No costs have been reflected in the case of existing installations, as none of the incinerators installed at provincial hospitals currently have scrubbers installed.

5. **Sundry Equipment:** Self-explanatory.

6. **Power & Consumables Cost:** In this section, total electricity usage (kWh) and fuel usage (lit) are extended at representative rates (R0.1838/kWh – Eskom Small Business rate; and R 2.95/lit – "bulk" diesel user rate, incl. 5c/lit surcharge for storage facilities). The apportionment of these and other costs into "Fixed Overheads" and "Variable Costs" is also reflected in the two columns, which commence to the right of Section 6. The assumption has been made that 5% of the electricity cost, and 50% of the maintenance and "miscellaneous services" costs (e.g. ash-removal, etc.) are "fixed", with the remaining percentage "variable".

7. **Depreciation and Cost of Capital:** The "original capital cost (excluding land) at time of installation" is estimated by deflating the 2000 cost by 8% p.a. over the installed life of the facility. Annual depreciation is then determined using the "original capital cost" and an "economic life" of 20 years. Interest Cost has been taken as nil for all existing facilities.

8. **Personnel Costs:** Reasonable assumptions have been made regarding the personnel required to operate, load and clean the facility; an allowance has also been made, where justified by the size of the facility, for supervision and administration personnel costs. Personnel costs have been treated as "fixed".

The model output consists of a "Fixed Overhead/month" figure, (rounded to the nearest R'000) and a variable cost, expressed in R/kg of HCRW incinerated. The figures for Tembisa are R 12 000 and R 0.87/kg, respectively. The total "**cost per kilogram**" figure for Tembisa is R 1.32.

**Table 6.1: Incinerator Cost Model**

| No. | Item | | | | | | Est. Fixed Overheads | Est. Variable costs | |
|---|---|---|---|---|---|---|---|---|---|
| | Incinerator Designation: | | **46** | Place: | **Tembisa** | | | | |
| | Existing / New / Upgraded | | **Existing** | Name: | **Tembisa Hosp.** | | | | |
| 1 | **Property Parameters: (all costs exclude VAT)** | | | | | | | | |
| | Site Area | | 0 | square metres | | | | | |
| | Estimated Land Cost | | R 200 | /m2 | **R 0** | | | | |
| 2 | **Development Costs:** | | **m2** | **Cost/m2** | **Amount** | | | | |
| | Earthworks, roads & drainage | | 500 | R 100 | 50,000 | | | | |
| | Building | | 75 | R 2,500 | 187,500 | | | | |
| | Electrical: Switchgear & Reticulation | | | | | | | | |
| | | KVA required: | 25 | | 50,000 | | | | |
| | Diesel storage tanks & equipment | | 40,000 | litres | 0 | | | | |
| | Fire-fighting & emergency equipment | | | | 15,000 | | | | |
| | Environmental Impact Assessment | | | | 0 | | | | |
| | Total development costs | | | | **R 302,500** | | | | |
| 3 | **Incinerator:** | | | | | | | | |
| | Make & Model: ***M Monk LA350*** | | | No. of units: | 2 | | | | |
| | Operating hours per day: | | | | 8 | | | | |
| | | | | **Per Unit** | **Total** | | | | |
| | Capacity: | | kgs/hour | 64 | 128 | | | | |
| | | | kgs/day | 512 | 1,024 | | | | |
| | Rated Power | | kw | 3 | 6 | | | | |
| | Daily Power consumption: | | kwh | 27 | 53 | | | | |
| | Diesel consumption | | lit/hr | 16 | 32 | | | | |
| | Diesel consumption | | lit/day | 128 | 256 | | | | |
| | Installed cost: | | | R 250,000 | **R 500,000** | | | | |
| | Estimated annual maintenance cost: | | | 12.00% | R 60,000 | | | | |
| 4 | **Gas Scrubbers:** | | | | | | | | |
| | Make & Model: ***n/a*** | | | No. of units: | 0 | | | | |
| 5 | **Sundry Equipment:** | | | | | | | | |
| | Office & Washroom furniture | | | | 2,000 | | | | |
| | Computer | | | | 5,000 | | | | |
| | Store | | | | 3,000 | | | | |
| | Coldroom | | | | 0 | | | | |
| | Ash skips | | | | 0 | | | | |
| | Total Sundry Equipment cost: | | | | **R 10,000** | | | | |
| | Estimated annual maintenance cost: | | | 10.00% | R 1,000 | | | | |
| | **Total Capital Cost:** | | | | **R 812,500** | | | | |
| | Estimated total annual maintenance cost: | | | | R 61,000 | | | | |
| 6 | **Power & Consumables** | | | | | | | | |
| | Working days per annum: | 300 | | | | | | | |
| | **Annual usage & cost:** | **Quantity** | **Unit** | **Unit Cost** | **Total Cost** | | | | |
| | Incinerators: | | | | | | | | |
| | Electricity | 16,000 | kwh | R 0.18 | 2,900 | | **R 580** | **R 2,320** | |
| | Diesel | 76,800 | lit | R 2.95 | 226,560 | | | **R 226,560** | |
| | Other | | | | 0 | | | | |
| | Scrubbers: | | | | | | | | |
| | Electricity | 0 | kwh | R 0.18 | 0 | | | **0** | |
| | Water | 0 | lit | R 0.00 | 0 | | | **0** | |
| | Lime | 0 | kg | | 0 | | | **0** | |
| | Sundry consumables: | | | | | | | | |
| | Clothing | | | | 2,500 | | **R 2,500** | | |
| | Other | | | | 2,500 | | **R 2,500** | | |
| | Water | | | | 4,000 | | **R 4,000** | | |
| | Misc. services: ash removal, etc. | | | | 10,000 | | **R 5,000** | **R 5,000** | |
| | Annual Eskom connection cost: | | | | 1,800 | | **R 1,800** | | |
| | **Total Annual Power & Consumables Cost** | | | | **R 250,260** | | | | |
| | Total annual maintenance cost | | | | **R 61,000** | | **R 30,500** | **R 30,500** | |
| 7 | **Depreciation & Interest on Capital** | | | | | | | | |
| | Est. original Capital cost (excl. land) at time of installation: | | 1 | R 752,000 | | | | | |
| | Depreciation on orig. capital cost (excl. land) over | | 20 | years | **R 37,600** | per year | **R 37,600** | | |
| | Interest on capital cost @ | | 0% | | **R 0** | | **R 0** | | |
| | | | | | **R 348,860** | | | | |
| | | Number | Annual Cost | Amount | | | | | |
| 8 | **Personnel costs** | 0 | R 150,000 | R 0 | | | | | |
| | | 0 | R 80,000 | R 0 | | | | | |
| | | 0.2 | R 50,000 | R 10,000 | | | | | |
| | | 2 | 24000 | 48000 | | | | | |
| | | | | | **R 58,000** | | **R 58,000** | | |
| | **Total annual cost** | | | | **R 406,860** | | | | |
| | **Capacity:** | | | | | | | | |
| | **hours/day** / **days/week** | **weeks/yr** | | | | | | | |
| | 8 / 6 | 50 | 307,200 | kgs/yr | **1.3244** | **Rand/kg** | | | |
| | | | 25,600 | kgs/mon | | | | | |
| | | | | | | | **R 142,480** | **R 264,380** | **R 406,860** |
| | | | | | | **Per month** | **R 12,000** | | |
| | | | | | | | **Annual capacity (kgs):** | **307,200** | |
| | | | | | | | **Variable cost/kg:** | **R 0.87** | |

Models were produced for each provincial hospital / community health centre installation. In each case, the operating hours/day for the incinerator was set at a figure that would allow all, or as much as possible, of the HCRW generated at the hospital to be incinerated on site. (The maximum working hours/day was limited to 16, i.e. two 8-hour shifts.) The number of personnel required to operate/load the incinerator was gauged from the number of shifts and the mass of HCRW to be handled. These models are attached as Annexure 6.1.

•

The estimated Fixed Monthly Overhead and Variable costs for each of the provincial hospital incinerators, as obtained directly from the models described above, are presented in ***Table 6.2*** below. This table also reflects the estimated total HCRW generation figure for the hospital as determined in accordance with Paragraph 3.8 in Chapter 3.

From this table, it can be seen that the estimated total HCRW produced by the provincial hospitals (including the 5 Community Health Centres also having incinerators) is 432 000 kg/month. Of this, a total of 272 700 kg/month could be incinerated on-site, and the remaining 159 300 kg/month would have to be removed and incinerated elsewhere. The estimated total cost of the on-site incineration is R519 000 per month, and for the removal/incineration by contractors, R291 000 per month. (In both cases, these amounts **exclude** the cost of the HCRW containers. In the case of removal/incineration by contractors, where the cost of supplying the container is typically included in the overall price charged, this has necessitated the deduction of the cost of the container: the calculation to effect this is shown in the note at the bottom of ***Table 6.2***.)

Table 6.2

The total monthly HCRW removal/destruction cost is therefore approximately **R810 000**.

This figure may be considered as the "**base-line cost**", with which alternative scenarios, as described below, can be compared.

As can also be seen from ***Table 6.2***, the incineration **capacity** of the provincial hospitals plus CHC's (based on 16 hours/day x 6 days/week x 50 weeks/year – equivalent to 400 hours/month) is 592 000 kgs/month, i.e. approximately 137% of the estimated 432 000 kg/month generated.

From the above it is evident that although the Gauteng Provincial Hospitals **collectively** have sufficient capacity to cater for treatment/disposal of the HCRW being generated, the cost of onsite incineration is high, due to the low volumes being treated at numerous facilities, each of which has comparatively high fixed costs.

## 6.4 Development of Numerical Model for comparison of HCRW incineration scenarios

The possible regionalized treatment of HCRW falls into a broad category of so-called "allocation" problems, wherein it is sought to "allocate" a resource, commodity, product, etc. (in this case HCRW) such that a number of criteria are satisfied, and subject to certain "constraints". In the case at hand:

(a) All the HCRW needs to be allocated to and treated at an incineration facility;
(b) The maximum capacity of the incineration facility/facilities cannot be exceeded; and
(c) The overall cost (i.e. transport plus incineration) must be minimised.

While the problem as stated above lends itself to solution using the techniques of linear programming ("LP"), it was felt that this method was less than ideal in relation to the HCRW problem for two reasons, viz.

(a) it is cumbersome to manage when both the number of incineration facilities in operation, and their location, would require many changes during investigation of various scenarios; and

(b) it is abstract, i.e. does not offer a visual context within which scenarios can be developed, tested and changed.

For this reason, it was decided to expand on a computer program developed originally in Denmark, which facilitated on-screen representation of all HCRW sources (hospitals) and incineration facilities, and also allowed the latter to be easily moved from place to place on-screen. From the screen positions, the program automatically calculates all point-to-point distances, as required for cost computations. The visual context has been further enhanced by the addition of a longitude/latitude grid, and by incorporation of the Gauteng provincial boundary.

### 6.4.1 Model Logic

The logic used to establish the overall cost associated with a given scenario is as follows:

(i) The program computes the distance from each hospital to each incineration facility (only facilities with capacities > 0 are included in the computation; by setting a capacity = 0, the facility can in effect be "switched off")

(ii) The program computes the transportation cost (per kg HCRW) from each hospital to each incineration facility. (The derivation of the per-kilometre transportation cost is described in Paragraph 6.4.3 below.)

(iii) The program computes the incineration cost (per kg of HCRW) at each incineration facility. This per kg cost is calculated as the sum of the **Variable** cost per kg* and the **Fixed Monthly Overhead Cost*** divided by the monthly incinerator capacity. (In cases where the total mass of waste allocated to a facility is less than the capacity, this results in an understatement of the cost per kg, and therefore of the overall cost. For this reason, successive iterations of the model are run, reducing the capacity at the incineration facility/facilities until the actual mass allocated closely matches the capacity in each case. It was decided not to automate this process, as it could potentially lead to instability of the model. In practice, a small number of iterations is sufficient to achieve a solution, particularly when the number of incineration facilities is small.

The computation of these costs is described in Section 6.4.2 below.

(iv) From (ii) and (iii) the program computes the total cost (per kg of HCRW) to transport the waste from each hospital to each incineration facility and incinerate it.

(v) The program then allocates waste, utilising the familiar "container-packing" algorithm, viz. the hospitals are dealt with in order of volume of HCRW generated, with the largest "blocks" of HCRW being allocated to the least-cost facility; smaller "blocks" are allocated later, and the smallest "blocks" last. (This algorithm, although efficient in terms of the computational effort required, will generally not produce the absolute least-cost solution; for example, it can lead to anomalies in the model results, with small "blocks" being routed to relatively remote facilities. These anomalies do not, however, compromise the principles of the model but rather provide opportunities for greater refinement of the actual waste allocation in practice, through the use of, say, the LP techniques referred to above. (Comparative tests, which we performed to confirm the accuracy of the model, indicated that results were always within 5% of the least-cost solution, as determined through LP, and were often within 2%. Absolute least-cost solutions are, however, seldom totally applicable/practical in real-life.)

Application of, and output from, the Model is presented in Paragraph 6.5 below.

### 6.4.2 Incineration Cost Model

The development and application of this model has been dealt with in Section 6.3.1 above. However, as there are certain additional /different considerations in the case of "new" incinerators, certain relevant aspects of the model are described below.

An important additional component of the **Fixed Overhead Cost**, when evaluating potential new facilities, is the "cost of capital", usually determined as the interest that would have to be paid on the capital necessary to purchase the land and develop the facility. In the particular case of a new incineration facility, an Environmental Impact Assessment ("EIA") is required and the cost of this is treated as a capital cost (as with other investigative/consulting costs). These costs are amortised over the economic life of the facility (assumed in this case to be 20 years.)

If new facilities are required to have gas-scrubbers installed, both the capital cost and the **Variable Costs** need to reflect this.

A typical model is presented below as ***Table 6.3***, which is for a potential new incinerator (with gas-scrubbers) located in Roodepoort. A brief explanation of the model is set out below, in which the (additional) assumptions made are explained/noted. (As before, paragraph numbers below match the section numbers in the table.)

1. **Property (land) size and cost:** A site size of 4,000 $m^2$ has been chosen. This is probably larger than actually required, notwithstanding the relatively large capacity envisaged (900 kg/hr HCRW). The land acquisition cost has been based on a price of R 200/$m^2$ , which is conservative for industrial land in this area.

2. **Development costs:** The cost of the EIA has been estimated at R200 000 in all cases. This figure has also been used in the case of the Tambo Memorial and Tembisa Hospitals, where new incinerators have been installed but have not yet officially been put into operation.

3. **Incinerators:** As before.

4. **Scrubbers:** A "wet scrubber" option has been chosen, as opposed to a considerably more expensive ceramic ("dry") filter. The estimated capital cost (for a 900 kg/hour HCRW installation) is R 2,8 million. Installed power required is approximately 55kW (the majority of which is required by the powerful fan).

5. **Sundry Equipment:** Self-explanatory.

6. **Power & Consumables Cost:** Incinerators: as before;
   Scrubbers: approximately 30 kg of "sorbent" is consumed per hour, at a cost of R 2.00 per kg, and the residual wet waste (approx 60 kg/hour) requires removal and safe disposal. Electricity consumption figures for the scrubbers are more than double those for the incinerators, due to the fan.

(For smaller and larger scrubber installations, the above (capital and running-cost) estimates have been used as a reference, appropriately adjusted to account for size differences.)

7. **Depreciation and Cost of Capital**: Annual depreciation (on buildings, infrastructure and equipment) is determined on a straight-line basis, using an economic life of 20 years.

   The Interest Cost has been based on an interest rate of 12% for all new facilities; the total capital cost (i.e. including the purchase price of the land) has been used in the calculation.

8. **Personnel Costs:** Reasonable assumptions have been made regarding the personnel required to operate, load and clean the facility; additional personnel (one per shift) have been allowed for operation of the gas-scrubbers (where installed) in larger installations.

As before, the Incinerator Model output consists of a "Fixed Overhead/month" figure, (rounded to the nearest R'000) and a variable cost, expressed in R/kg of HCRW incinerated. The figures for the example shown in ***Table 6.3*** are R185 000 and R0.52/kg, respectively.

Models were produced for each proposed new facility. In most cases, new facilities were operated on at least a two-shift basis, which is considered reasonable in view of the high capital cost of the installations. The number of personnel required to operate/load the incinerator was gauged from the number of shifts and the mass of HCRW to be handled. These models are attached as ***Annexure 6.2***.

***Table 6.3*** : New Incinerator Cost Model

Table 6.3 p2

### 6.4.3 Transportation cost model

In order to establish representative costs for road transportation of HCRW, a Transportation Cost Model was developed.

The first step was to identify suitable vehicles for this purpose. *Messrs McCarthy Toyota Trucks, Midrand* were approached, who kindly provided recommendations and costs based on the requirements indicated, viz:

(a) Vehicles were to have bodies designed to accommodate the maximum number of 142 L HCRW containers (plastic-lined cardboard boxes with overall dimensions approx. 45 cm x 45 cm x 70 cm high.);

(b) It would be necessary for the vehicles to transport containers safely, whether the vehicle was full or partially full. For this reason, and to obviate the need to stack boxes on top of one another, a shelf having a retaining lip would be provided at a suitable height;

(c) A central or offset passage would be provided to allow access for loading/unloading and securing of the boxes. Access would be via a single rear door. The coachwork should allow for easy internal cleaning/disinfecting, and be of corrosion-resistant material;

(d) The chassis was to be fixed, i.e. non-articulated, to provide for maximum manoeuvrability in confined spaces;

(e) Also for reasons of manoeuvrability, overall size and road speed, only vehicles having a payload up to 5-tons would be considered.

Messrs *McCarthy Toyota Trucks* recommended consideration of two “Dyna” chassis-cab models, viz. the 4-093, having a payload of approx 1.5 tons, and the 7-094 (with a chassis-extension to 6m) having a payload of approx. 4 tons. Details of each of these vehicles, together with capital and operational costs, etc., are presented in ***Table 6.4*** below, being the Transportation Cost Model. A brief explanation of the model is set out below, in which the rationale and assumptions made are explained/noted. (For ease of reference, paragraph numbers below match the section numbers in the table.)

1. **Vehicle parameters:** *Self-explanatory. Note that the maximum number of 142L HCRW containers that can be transported by the two vehicle sizes is 42 and 108, respectively.*

2. **Costs:** These are divided into annual fixed costs and per kilometre costs. Vehicles are depreciated over 5 years, at which time a "salvage value" is recovered. Reasonable assumptions are made regarding tyre replacement and diesel; consumption consistent with "urban cycle" type operation.

3. **Crew costs:** A driver and one helper is assumed.

4. **Costs applicable to model:** In order to translate the fixed and variable costs as referred to above into "per kg (of HCRW) per km" transportation costs, as required for use in the regionalisation model, assumptions have to be made in respect of the amount of HCRW that each vehicle could transport in a given period. This in turn depends on (i) the number of loads that the vehicle can transport in one day, (ii) the average "round-trip" distance, and (iii) the mass that the vehicle transports per load. The assumptions that have been made in this regard are reflected in the table.

Importantly, it should be noted that the numerical model assigns transportation costs in accordance with the one-way, straight-line distance between hospital and incinerator. This means that two further steps are required, viz.:

(a) Transportation costs must be expressed in this "one-way" format. To achieve this, the formula used is: one-way transportation cost (Rand per kg-km) = total annual cost of ownership and operation ÷ (average load mass x kms travelled per year ÷ 2). These costs are R0.0287 per kg-km for the Dyna 4-093 and R0.0142 per kg-km for the Dyna 7-094 respectively, based on the assumptions set out above.

(b) A correction must be made to allow for the fact that straight-line distances between two points are **less than the road distances.** The correction applied here is 25%, i.e. the road distance between two points is taken to be 25% more than the straight-line distance. The one-way transportation costs, as referred to in (a) above, increase to R 0.0359 per kg-km and R 0.0178 per kg-km respectively, when based on one-way straight-line distances.

Further, it is necessary to make a decision on which of the two vehicles would be used. Although the larger Dyna (Model 7-094) is more cost-effective than the smaller Model, there may be other considerations (such as the need to also service clinics, which typically only generate small quantities of HCRW). This suggest the use of a "mixed" fleet, comprised of both vehicle models described above, and indeed other sizes of vehicle.

For purposes of this study, and to allow simulation wherein the HCRW generated by both hospitals and clinics is treated on a regionalized basis (see Sections 6.5.2 and 6.5.3 below) without necessitating a change to the transportation cost, we have assumed that HCRW will be transported by the two sizes of vehicles considered above in the ratio 2:1, i.e. twice as much waste (by mass) will be transported in the larger vehicles as in the smaller vehicles, over any given period. The one-way transportation cost associated with this "mixed" fleet is therefore ( ⅔ x R0.0178 + ⅓ x R0.0359) = R0.0238 per kg-km, say R0.024 per kg-km.

***Table 6.4*** : Cost Model : Transportation

## 6.5 Application of the Model

The first model that runs (Section 6.5.1 below) are solely to provide a **comparison with the current practice of incinerating waste on-site** at many of the provincial hospitals. These scenarios **would not be applied in practice**, as (i) any new strategy for HCRW treatment and disposal **must include waste generated at provincial clinics as well**, and (ii) it will almost certainly be necessary to provide gas-scrubbers when new incineration facilities are commissioned.

More "practical" scenarios, involving the incineration of both hospital and clinic waste, appear in Sections 6.5.2 and 6.5.3 below.

During **all** the model runs described below, it was only attempted to determine whether one, two or many new facilities, with or without the simultaneous use of existing facilities, would offer the most economical solution. Incinerators have therefore been "sized" (i) according to the estimated current rate of HCRW generation, and (ii) without allowing for "spare" capacity. Although allowances would have to be made for both of these factors in any practical design, its omission here has little or no effect on the **principles** established. If necessary however, the alternative scenarios could be re-evaluated at design stage, having made the appropriate (quantitative) adjustments.

Where new facilities are proposed, it was generally decided to locate these at or near existing landfill sites. The rationale for this is explained in Section 6.7 at the end of this chapter.

### 6.5.1 Investigation of various scenarios *without gas scrubbers*

(Total mass of HCRW to be incinerated per month: 432 000 kg.)

**Scenario 1, One (new) incineration facility, sited such that overall HCRW transportation and incineration costs are minimised**

Features of this scenario are:

- All existing incinerators at provincial hospitals are "switched off";
- All HCRW is transported to a single facility, comprising of 3 x 300 kg/hr incinerators, operational for 24 hrs/day, 6 days/week.

Results may be summarised as follows:

- Estimated overall monthly cost is **R580 000**;

- Optimum siting (i.e. resulting in lowest overall cost) is in vicinity of the Johannesburg Hospital.

**Scenario 2, One (new) incineration facility, sited in vicinity of existing Marie-Louise landfill (Greater Johannesburg Metropolitan Council) in Roodepoort**

Features of this scenario are identical to the previous scenario, with the facility moved to a more suitable location. The resulting estimated overall monthly cost is **R630 000**, i.e. 9% higher than the previous scenario.

**Scenario 3, Two new incineration facilities: one sited in vicinity of existing Marie-Louise landfill (Roodepoort), and one in the vicinity of the GJMC's "Northern Works" site (at Diepsloot, north of Dainfern)**

Features of this scenario are:

- As for previous scenarios, all existing incinerators at provincial hospitals are "switched off";
- HCRW transported to two new facilities: At Roodepoort (2 x 300 kg/hr incinerators, operational for 24 hrs/day, 6 days/week) and at Northern Works (one 300 kg/hr incinerator, operational for 24 hrs/day, 6 days/week.

Results may be summarised as follows:

- Estimated overall monthly cost is **R570 000**;
- Overall cost is therefore marginally lower than for a single facility at Roodepoort.

**Scenario 4, One new incineration facility, sited in vicinity of existing Marie-Louise landfill; full utilisation of existing incinerators at Tambo Memorial and Tembisa Hospitals**

Features of this scenario are:

- HCRW is transported to a new facility at Roodepoort (2 x 300 kg/hr incinerators, operational for 24 hrs/day, 6 days/week) as well as to the existing incinerators at Tambo Memorial (16* hrs/day, 6 days/week) and Tembisa Hospital(16* hrs/day, 6 days/week).

- It is understood that DACEL will require automatic feeders on these units, and allowance was therefore made for the additional capital cost (estimated at R60 000 per incinerator). DACEL would further prefer the incinerators to operate 24 hours per day, which would require mechanical de-ashing. Although it is possible to 'retro-fit' mechanical de-ashing equipment to the units, (a) the cost will be high (of the order of R120 000 per incinerator) and (b) the manufacturers may be unwilling to guarantee the modification. In view of this, the assumption was made that the units will operate for only 16 hours/day, to allow for manual de-ashing.

EIA costs for Tambo Memorial and Tembisa Hospitals (estimated at R200 000 each) have been included in the calculations.

Results may be summarised as follows:

- Estimated overall monthly cost is **R650 000**;
- This is more expensive than all the other options.

For each of the above scenarios, a "sensitivity analysis" has been performed: Each scenario has been re-evaluated, having **doubled** the transportation costs (R per kg per km). This tests the sensitivity of the scenarios to the transportation costs used in the model and can be expected to have a higher influence on the more "centralized" scenarios, i.e. ones having fewer incineration facilities with longer transport distances.

Results for all the above scenarios are tabulated in ***Table 6.5*** below to facilitate comparison:

*Table 6.5:* Comparison of various scenarios without gas scrubbers

| Facility/facilities | Scenario 1 | Scenario 2 | Scenario 3 | Scenario 4 |
|---|---|---|---|---|
| New 900 kg/hr facility at optimum location | ▲ | | | |
| New 900 kg/hr facility at/near Marie Louise (Roodepoort) | | ▲ | | |
| New 600 kg/hr facility at/near Marie Louise (Roodepoort) | | | ▲ | ▲ |
| New 300 kg/hr facility at Northern Works | | | ▲ | |
| Existing Tambo Memorial Hospital 64 kg/hr facility | | | | ▲ |
| Existing Tembisa Hospital 64 kg/hr facility | | | | ▲ |
| Estimated total monthly transportation + incineration cost | **R580 000** | **R630 000** | **R570 000** | **R650 000** |
| ***Sensitivity Comparison: Model Transportation costs increased by 100 %:* Total Monthly Cost** | **R890 000** | **R980 000** | **R820 000** | **R920 000** |

**Conclusions drawn from investigation of various scenarios *without gas-scrubbers* for provincial hospitals only**

Some valuable conclusions can be drawn from the above, viz,:

- Each of the above scenarios (setting aside the results based on doubled transportation costs) is more economical than the existing arrangement of on-site incineration plus third-party contractor removal/disposal. This would still pertain even if a substantial "profit element" were added, i.e. if incineration facilities were owned/operated on a commercial basis by a private contractor;
- The most economical arrangement consists of two new facilities, viz. a 600 kg/hour facility at or near the Marie Louise landfill in Roodepoort and a 300 kg/hour facility at Northern Works;
- Under sensitivity analysis conditions, the above scenario (viz. two new facilities) remains the most economical.

While the above scenarios offer valuable comparisons with the current situation *vis á vis* HCRW derived from provincial hospitals, **they do not represent practical solutions** in that any evaluation of the potential economic advantage of provincial regionalisation **needs to cater for HCRW derived from all provincial health-care institutions**, viz. hospitals, community health centres and clinics. The scenarios investigated below therefore cater for HCRW derived from all provincial institutions.

### 6.5.2 Investigation of various scenarios both with and without gas scrubbers, and including HCRW from BOTH provincial hospitals AND provincial clinics

(Total mass of HCRW to be incinerated per month: 573 000 kg)

Of the approximately 25 scenarios investigated, 15 are listed in ***Table 6.6*** below. These scenarios reflect the total monthly cost associated with the operation of up to four **new** incineration facilities, and up to three **existing** facilities (Tambo Memorial, Tembisa and Pretoria Academic). Scenarios were also investigated involving the replacement of existing incinerators at Tambo Memorial, Tembisa and Pretoria Academic with new 300 kg per hour facilities at these locations.

In all cases that involves **existing** incinerators, the cost were included of up-grading the units to allow for automatic feed. However, for the reasons mentioned in Paragraph 5.5.1 above, no allowance was made for mechanical de-ashing at these facilities; thus only allowing for these units to operate sixteen hours per day, six days per week.

In all cases involving **new** facilities, or **new incinerators** at existing facilities, allowance was made to operate the facilities for 24 hours per day, six days per week, as mechanical de-ashing will be required on all such facilities.

The cost of EIA's has been allowed for in all instances.

In addition to the locations considered in the scenarios described in Paragraph 6.5.1, the following were also considered: "**Alpha Quarries**", off the Old Pretoria Road, near the Jukskei River in Midrand (as a possible alternative to the Northern Works); **Hatherley**, the existing landfill site of the Greater Pretoria Metro Council, to the east of Mamelodi; and **Platkop**, the existing landfill site of the Eastern Gauteng Services Council, off the N3 highway on the R550 to Kliprivier.

As before, the sensitivity of each of the scenarios were tested by doubling transportation costs (R per kg per km). This tested the sensitivity of the scenarios to the transportation costs used in the model, and can be expected to have a higher influence on the more “centralized” scenarios, i.e. ones having fewer incineration facilities with longer transport distances.

Finally, the scenarios have been “ranked” from the one with the lowest to the one with the highest monthly cost.

Allow 1 page for Table 6.6 please.

**Conclusions drawn from investigations of various scenario's *with and without gas scrubbers* for ALL provincial health institutions**

As new facilities that are to be developed will almost certainly have to have gas scrubbers incorporated, the focus was in particular on the results/costs making provision for scrubbers (printed in red in ***Table 6.6***).

Conclusions that can be drawn from the results are:

- Scenarios A, B, C and D are the lowest, second lowest, etc. in terms of the total monthly cost, and **remain** the lowest under the sensitivity-analysis conditions;
- Each of the above scenarios embodies a 600 kg per hour facility at/near the Marie Louise landfill;
- Each of the above scenarios involves a total of three facilities: In scenarios A and B all the facilities are new, and in scenarios C and D two out of the three facilities are new;
- Monthly costs are much higher if only one (new) facility is involved (scenario L), or if four or more (new) facilities are involved (scenario O);
- With two new facilities only (scenario E), costs are only marginally higher than for scenario D. However, under the sensitivity analysis, the increase is more marked;
- There is little difference in cost between the use of the Northern Works and Alpha Quarries (scenario E, cf. scenario F).

### 6.5.3 Investigation of various scenarios both with and without gas scrubbers, and including HCRW from BOTH provincial hospitals AND provincial clinics with provision made for additional waste generated by proposed extension of 800 new beds at Pretoria Academic Hospital.

(Total mass of HCRW to be incinerated per month: 613 000 kg)

**(Note:** The DoH requested that the implications associated with the possible addition of 600-800 beds at Pretoria Academic Hospital should be considered, in order to ascertain whether this altered the choice of a least-cost HCRW incineration solution for Gauteng.)

As in Paragraph 6.5.2 above, a number of scenarios were investigated, of which 13 are listed in ***Table 6.7*** below. Note that the same nomenclature as before has been used for the various scenarios (viz. “A”, “B”, etc.). However, two scenarios, C* and D*, although similar to the previous C and D scenarios, require increased capacity at Marie Louise landfill.

The scenarios have once again been “ranked” from lowest to highest total monthly cost.

Allow 1 page for Table 6.7 please.

**Conclusions drawn from investigation of various scenarios both *with and without gas scrubbers* for ALL provincial health institutions including extension of Pretoria Academic Hospital**.

As stated before, new facilities developed will almost certainly have to have gas scrubbers incorporated and the focus is therefore on the results/costs making provision for this (printed in red in ***Table 6.7***)

Conclusions that can be drawn from the results are:

- Scenarios A and B remain the lowest and second lowest in terms of total monthly cost, and **remain** the lowest under the sensitivity-analysis conditions; scenarios C* and D* have dropped down considerably in the rankings;
- Each of the above scenarios embodies a 600 kg per hour facility at/near the Marie Louise landfill;
- Each of the above scenarios involves a total of **three new facilities. I**n scenario A these are located at Marie Louise, Tambo Memorial and Pretoria Academic, and in scenario B these are located at Marie Louise, Tembisa and Pretoria Academic respectively.

## 6.6 Conclusions

The following conclusions may be drawn from the above:

a) The current practice of incinerating HCRW "on site" at provincial hospitals is comparatively uneconomic. The estimated cost of "on-site" incineration, plus the costs associated with the use of third-party removal/incineration by waste management contractors, is R810 000 per month. Application of the numerical model developed as part of this study suggests that the total monthly cost could be reduced to approximately R630 000 if **one new** 900 kg/hour facility was brought into operation at or near the Marie-Louise landfill site in Roodepoort, and a fleet of purpose-built vehicles was used to transport the HCRW from hospitals to this facility. The most economical arrangement (total monthly cost approximately R570 000) consists of **two new** facilities, viz. a 600 kg/hour facility at or near the Marie Louise landfill in Roodepoort and a 300 kg/hour facility at Northern Works landfill.

b) **When applied to the total estimated HCRW emanating from both provincial hospitals and clinics**, the model indicates that the optimal (i.e. minimum cost) configuration of incineration facilities (with or without gas-scrubbers) comprises **three new facilities,** or **two new facilities** together with retention of **existing (but upgraded) facilities** at Tambo Memorial and Pretoria Academic Hospitals. Monthly costs increase if only one new facility is introduced, or if more than three new facilities are introduced.

c) **When applied to the total estimated HCRW emanating from both provincial hospitals and clinics, and taking into account the proposed addition of 800 new beds at Pretoria Academic Hospital**, the model indicates that the optimal configuration (with or without gas-scrubbers) comprises **three new facilities,** i.e. at Marie-Louise, Tambo Memorial and Pretoria Academic, **or** at Marie-Louise, Tembisa and Pretoria Academic, respectively.

d) Sensitivity analyses, performed to test the "stability" of the optimal scenarios, as described in (b) and (c) above, through doubled transportation costs, confirm the triple new-facility scenario to be the most economical choice.

### 6.7 Investigation into alternative sites for locating the medical waste treatment/disposal facilities, considering both the environmental and the economic viability.

The siting of an incinerator or incineration facility is without doubt the most important aspect of the planning for health care waste management. In terms of the EIA regulations, the developer is required to submit a pre-scoping document and to identify a number of sites (preferably three or more) that could be appropriate for locating an incinerator. A matrix comparing the relative merits of the selected sites should be drawn up and the preferred site motivated in terms of the selection criteria. The issues that must be considered are in many ways similar to those used for siting a landfill, and embrace:

***Economic Criteria:***

a) Distance of site from waste sources;
b) Site access – roads may have to be constructed;
c) Visibility of site – there may be a screening cost;
d) Land availability – competitive uses may increase costs of acquisition;
e) Availability of services – electricity, water, sewage etc.

***Environmental and Health and Safety Criteria:***

a) Presence of sensitive ground or surface water resources;
b) Topography of the site and surroundings, e.g. valleys where temperature inversion could occur should be avoided;
c) Land zoning – land zoned industrial is preferred;
d) Sensitivity of receiving environment – an existing landfill or derelict mining land would be preferable;
e) Quality of soil – low permeability soils would reduce pollution potential from spills, ash, etc.;
f) Impact on public healthy and safety.

***Public Acceptance Criteria:***

a) Distance to residents or other incompatible land use – a distance of 1km is preferred, although such distance should finally be determined by means of air dispersion models;
b) Prevailing wind direction – the treatment facility should be located downwind of any residential areas;
c) Visibility;
d) Access – roads that pass through residential or other sensitive areas should be avoided;
e) Displacement of inhabitants.

**Existing Landfill Sites**

Many of the above criteria are satisfied by existing landfill sites, and certain landfills have therefore been considered “in principle” as potential incinerator sites. In particular:

**Marie-Louise** (Roodepoort): This facility is close to the “centre of gravity” of HCRW generation in the province, as discussed in Section 6.5.1above. It is also very accessible by road whilst being suitably far from residential areas.

**Northern Works** (Diepsloot): Not as desirable as Marie-Louise, but it is economically viable as an adjunct to Marie-Louise, catering for HCRW generated in the Greater Pretoria area, and northern Gauteng in general.

**Platkop** (Suikerbosrand): This facility is very accessible by road, and sufficiently far from residential areas (and built-up areas in general) to be of interest. From an economic point of view, it is too far south in the province;

**Weltevreden** (Brakpan): Similar to Platkop, in the sense that it is suitable in principle, but too far east to be economically suitable;

**Simmer & Jack** (Germiston): Suitable economically, but it may be too close to residential/built-up areas.

**Hatherley** (East of Pretoria): Environmentally suitable, but too far north-east to be economically suitable.

**Existing Incinerator installations at Provincial Hospitals**

For obvious reasons, hospitals are not environmentally sound locations for the siting of incinerators. However, we have considered the use of the existing incinerators at Pretoria Academic Hospital which is in good condition, and also the recently-replaced incinerators at Tambo Memorial and Tembisa hospitals in our economic feasibilities. These facilities could be usefully included in a regionalized HCRW incineration plan, burning both 'own' waste, and waste from other provincial institutions. It may, however, not be economically viable to retro-fit gas-scrubbers to these units, but this would have to be established after a technical investigation.

Although increasing the incineration capacity at Tambo Memorial and Pretoria Academic Hospitals (to say 300kg/hr) is very attractive economically (because of their spatial locations), this may not be desirable for environmental reasons. This being the case, alternative sites within reasonable proximity should be sought.

## 7. CONCLUSIONS

- It is concluded that: -

- Medical waste, referred to by the United Nations and others as Health Care Risk Waste (HCRW), emanate from health care facilities and can be divided into infectious-, chemical-, radioactive- and general categories that identify the major hazards or risk it pose to human health and the environment. Infectious waste is further sub-divided into anatomical (pathological) waste and sharps. Chemical waste is determined by the extent of one or more of the following factors: corrosivity, reactivity, flammability and toxicity. Radioactive waste includes solid, liquid and gaseous waste contaminated with radioactive material. General waste finds itself in the HCRW stream as a result of poor segregation at source

- In South Africa the classification of waste generated from health care facilities has been linked to the legislation of hazardous waste in general. In terms of legislation, infectious, chemical and radioactive waste from health care facilities are all defined and listed under hazardous waste as Class 6 out of 9 classes. This approach is based on International Maritime Dangerous Goods (IMDG) (published as SABS Code 0228) which has been adopted as a code of practice in the country.

- While the categories of HCRW are known in South Africa, its composition is unknown. Experience from other countries (e.g. USA) indicates that although the infectious hospital waste is different from the general waste, there are considerable quantities of general waste that could be found in infectious wastes. This results in an artificial increase in tonnage of HRCW that costs more to dispose of per ton than the general waste.

- The presence of general waste in the infectious waste stream can be attributed to poor sorting of waste at source by health care workers.

- The composition of infectious (hospital) waste includes all components that could be found in the general waste stream with the exception of yard waste and building rubble. Such components are paper, rubber, textiles, food, glass, metals, plastics and fluids. Some of the components such as plastics, and in particular the Polyvinyl Chloride (PVC) type (which is estimated at 60g per bed), could be found in vinyl gloves, intravenous administration sets, syringes and needles. It contains chemical compounds that, when incinerated, will result in the emission of toxic gases which pose significant environmental pollution and health risks.

- The environmental burdens caused by incineration of PVC can be minimised by equipping incinerators with scrubbers, which is presently with the exception of one incinerator, not done in South Africa. The fitting of scrubbers is however likely to result in a significant increase in incineration costs. Another strategy would be to reduce the use of PVC in the medical industry. However, this would be a long term strategy and difficulties have been experienced introducing this in Europe.

- While incineration is currently the only method of HCRW treatment/disposal in South Africa, alternative technologies such as chemical disinfection, autoclaving and microwave technology could offer cost effective and environmentally sound solutions if fully developed.

- The major HCRW generators in Gauteng are community health centres, clinics and hospitals. The major HCRW generators contribute about 89% by mass of the total HCRW stream, with the remainder being generated by minor generators.

- Although the minor HRCW generators have a limited impact on the total HCRW stream, they are still important with regards to the risk that its HCRW creates for society.

- Currently there is a total of approximately 600 "major" HCRW generators, and a total of approximately 9 700 "minor" HCRW generators located in Gauteng. (This excludes private residences.)

- The amount of HCRW generated per service area in kg/patient/day range between 0,06kg to 0,48kg for private clinics, 0,002kg to 0,5kg for public clinics, 0,5kg to 4,04kg for private hospitals and 0,23kg to 2,43kg for public hospitals. Based on the "Upper 90% confidence limit", a total of 1 175 tons of HRCW is generated in Gauteng per month.

- The current HCRW management stages that include segregation, containerisation, storage, collection, transportation and treatment/disposal are not standardised throughout all health care facilities and practices are in many instances far below the required norm.

- There are currently only limited awareness and education programmes on the risk associated with HRCW as well as correct management and handling procedures. Personnel responsible for education are in some instances not fully aware of their duties and responsibilities.

- Since payment for collection, treatment and disposal of HCRW is presently based on volume, financial losses are incurred by health care facilities not filling containers to full capacity.

- A total of 70 incinerators in Gauteng are located in 58 health care facilities consisting of private and public hospitals, laboratories, prisons and waste management companies.

- Of the 70 incinerators in Gauteng, 58 (83%) are operational and only 25 (37%) are registered, of which some are only temporary registrations.

- There are seven types of incinerators installed in Gauteng, with different makes and sizes of which some have been discontinued.

- Of the 70 incinerators in Gauteng, only one incinerator is equipped with a scrubber, which is currently not working.

- The capital and operational cost for an incinerator, as estimated by two commercial operators, is approximately R1,00 per kg.

- The IIMS has been developed according to the Terms of Reference as set out in this report. The IIMS is currently operational within DACEL offices.

- The current IIMS should be seen as the first step in developing an Incinerator Information System which encompasses more than just HCRW incinerators. Future developments of the IIMS are expected to add additional components, as the need for capturing additional information becomes necessary. The current system allows for easy upgrading and development as the requirements of DACEL develop.

- The current practice of incinerating HCRW "on site" at provincial hospitals is comparatively uneconomic. The estimated current cost of "on-site" incineration, plus the costs associated with the use of third-party removal/incineration by contractors, is R810,000 per month. Application of the numerical model developed as part of this study suggests that the monthly cost could be reduced to approximately R570,000 if two new facilities are brought into operation: one at or near the Greater Johannesburg Metropolitan Council's ("GJMC") Marie Louise landfill site in Roodepoort, and one at or near the GJMC's proposed Northern Works landfill site, north of Dainfern. A fleet of purpose-built vehicles would be used to transport the HCRW from hospitals to these facilities.

- When applied to the total estimated HCRW emanating from **both provincial hospitals and clinics**, the model indicates that the optimal (i.e. minimum cost) configuration of incineration facilities (with or without gas-scrubbers) comprises **three new/upgraded facilities**: one at or near the Marie Louise landfill site (600kg/hour), one at or near Tambo Memorial Hospital (new 300kg/hour unit replaces existing) and one at or near the Pretoria Academic Hospital (new 300kg/hour unit replaces existing). This scenario remains optimal when the possible addition of 800 new beds at Pretoria Academic Hospital is taken into account.

- Sensitivity analyses, performed to test the "stability" of the optimal scenario, as described above, through doubled transportation costs, confirm the dual new-facility scenario to be the most economical choice.

- A scenario substituting a new facility at or near the Pretoria Metro's Hatherley landfill site in place of the upgraded Pretoria Academic Hospital facility suggested above, indicates that there would be a cost-penalty of approximately 10% over the optimal scenario, this scenario is, however, relatively sensitive to increased transportation costs.

- If it is decided that increasing the size of incineration facilities at Provincial Hospitals is undesirable, and no suitable sites can be identified within reasonable proximity of Pretoria Academic and Tambo Memorial Hospitals, an alternative would be to establish two new facilities: one at or near the Marie Louis landfill site (600kg/hr) and one at or near the proposed Northern Works landfill (300kg/hr). This scenarios is, however, comparatively sensitive to increased transport costs.

- Having reference to a number of the best (i.e. 'least-cost') siting scenarios as determined in this study, a thorough investigation should be undertaken at and in the vicinity of the proposed locations to confirm the availability and suitability of sites for possible new facilities. Detailed feasibility studies should further be undertaken for the proposed new facilities, and for the HCRW transport systems to be used. Based on the outcome of such detailed studies, the financial model developed for this study should be used to confirm that the proposed regionalisation strategy remains the optimal solution.

- In summary, the "economies of scale" that can be achieved through the regionalised incineration of HCRW emanating from provincial hospitals and clinics are substantial, and should be exploited.

## 8. RECOMMENDATIONS

It is recommended that:

- DACEL adopt the use of the international terminology of Health Care Waste (HCW), consisting of Health Care Risk Waste (HCRW) and Health Care General Waste (HCGW) in its policies, planning and operations when defining waste emanating from health care facilities.

- Detailed composition investigations on HCW emanating from hospitals and clinics be conducted to quantify the potential for savings that could be accrued through proper segregation as well as recycling.

- An awareness and education campaign be implemented to reduce the HCRW management costs by reducing the HCRW stream through effective segregation.

- Guidelines on responsible handling and management of HCRW during segregation, containerisation, storage, collection, transport treatment and disposal be established, standardised and enforced. This should include written procedures on responsible HCRW management as well as the way in which Occupational Health and Safety matters should be addressed by workers engaged in HCRW handling.

- During induction of newly appointed staff, the safe handling and segregation of HCRW be addressed in detail, with ongoing refresher courses being presented. This should include a training program for all personnel handling HCRW.

- Personal Protective Clothing with disinfection and disposal measures, where applicable, be provided to workers involved in HCRW handling and disposal and that the risks of transmitting diseases to the workers be emphasised.

- The principle of duty of care be promoted with generators of HCRW.

- A strategy on assessing ways of minimising the use of PVC be developed. Proponents should be encouraged to assess the appropriateness and cost effectiveness of chemical disinfection, autoclaving and microwave technology to the South African health care situation as alternatives to incineration.

- No new incinerators be permitted to operate without being equipped with scrubbers and complying with the 2009 DEAT emission requirements. The current incinerators not suitable for upgrading should be phased out by the year 2009.

- All institutions generating HCRW comply with the latest revisions of the SABS Code of Practice – Handling and Disposal of Waste Materials within Health Care Facilities. (SABS 0248)

- Compliance with guidelines and codes regarding the responsible handling and storage of HCRW be monitored by means of auditing programmes to be implemented at all parties involved in HCRW management.

- Containers used for HCRW be filled to capacity in all instances, without putting the safety and health of workers at risk, since payment for collection, treatment and disposal is based on volume.

- The accepted measurement system be changed from volume to mass measurement, thus resulting in more accurate data recording by all HCRW generators.

- Containers be marked in such a way that a HCRW tracking system be introduced that will ensure safe disposal of all HCRW generated.

- A regionalised approach be adopted for the treatment and disposal of HCRW emanating from provincial hospitals and clinics.

- The design-capacity of the regionalised facilities be carefully determined, taking into account:
  - The anticipated growth in the mass of HCRW generated over the design life of the facilities;
  - Whether the facilities should be sized to also cater for the HCRW generated by the private sector, particularly in view of the stricter regulatory environment envisaged for the future.

- By making use of the proposed optimal facility scenario as a basis, a thorough investigation should be undertaken at and in the vicinity of the proposed siting locations to confirm the availability and suitability of sites for possible new facilities.

- Firm costings be prepared for the proposed new facilities, as well as for the vehicles to be used for transporting the HCRW. Based on these costs, the model developed during this study should be used to confirm that the proposed solution remains optimal.

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**ANNEXURE 4. 1: Sample Incinerator Survey Form:Health Care Risk Waste Incinerator Survey**

| |
|---|
| Name Of Health Care Facility: …………………………………………...... |
| Physical Address: ..………………………………………………………. |
| Postal Address:…………………………………………………………………. |
| Tel No: (………) ………………… Fax No: (………) …...………..…. |
| Coordinates: X .......................... Y............................................... |
| Date of Survey: ......................... |
| Interviewer: ...................................................................................... |
| Contact Person: ..................................................................................... |
| Ownership: Private / Government / NGO / Church/Mine/Other |

**A: Type of health care facility:**

Hospital: ...... Clinic: ...... Laboratory: ...... Doctor: ......

Dentist: ...... Aids Care: ...... Hospice: ...... Mortuary: ......

Prison: ...... Vetinary Clinic: ...... Day Clinic: ......

Other:........................ (please indicate type of facility).

**B: Number of beds: ............... Occupancy rate:...................%**

**C: Services generating health care risk waste:**

Medical: ........... Maternity: ........... Surgical: ...........

Casualty: ........... ICU: ........... Theatres: ...........

Oncology Unit: ........... Outpatient Clinic: ........... Dialysis unit::........

Laboratories: ........... Pathology: ........... Blood Bank: .........

Pharmacy: ........... Other (please name) .......................................……......

**D: Current health care risk waste treatment/disposal methods:**

Own Incinerator: ................ (Y/N)

External Incinerator: ................ (Y/N)

*If an external incinerator – who is the owner?* ..............................…………......

Landfill: ................ (Y/N)

Other: ................ (Y/N)

*If other method used please describe*:..............................................……………....

**E: If own incinerator is used, please provide the following information (if you have more than one incinerator please provide details of the other unit(s) on a separate sheet):**

Make: ....................................………………………......................................................

Size: .......................kg/h

Is it registered with the Department of Environmental Affairs and Tourism? .............. (Y/N)

If so, please give the certificate number: ……...........

Type of incinerator:

*Excess air (e.g. LA type retort):* ................ (Y/N).

*Controlled air (e.g. Toxic):* ................ (Y/N)

Date installed: ………...............

Condition of incinerator:

*Good* ...............…(Y/N)

*Needs repair* ...............…(Y/N)

*Bad* ................…(Y/N)

*Not Operational* ...............….(Y/N)

Oil/fuel consumption ........ litres/month

Operational Hours ........ hours/month

Downtime ........ hours/month

Equipped with scrubber? ................ (Y/N)

Type of feeding?

*Manual:* ................ (Y/N)

*Mechanical:* ................ (Y/N)

Stack height: ............... metres

Is it equipped with:

*A primary burner?* ................ (Y/N)

*A secondary burner?* ................ (Y/N)

Operating temperatures:

*Primary* …......... $^{o}C$

*Secondary* …......... $^{o}C$

Used for incinerating:

*Health care risk waste only* ................ (Y/N)

*General waste* ................ (Y/N)

*Hazardous waste* ................ (Y/N)

*(e.g. drugs, lab. waste)*

Location of Incinerator:

*Suitably located to minimise environmental pollution?* ............... (Y/N)

*Suitably housed to prevent a local nuisance?* ................ (Y/N)

Operators:

*How Many:* ................

*Educational Standard:* ................

*Number of Shifts* ................

How is the Incinerator Ash Disposed?:

On-site: ................ (Y/N)

With the General Waste: ................ (Y/N)

Hazardous Waste Landfill: ................ (Y/N)

**F: Packaging and Handling of Health care risk waste:**

Who handles your health care risk waste?

Internal Staff: ............... (Y/N)

Waste Management Company: ............... (Y/N)

**Do you separate health care risk waste:**

From general waste ................ (Y/N)

From chemical hazardous waste: ................ (Y/N)

Sharps from other infectious waste: ................ (Y/N)

Have the waste handling staff experienced any needle stick injuries over the last five years? ................ (Y/N)

**Are sharps stored/collected in:**

Old bottles or containers? ................ (Y/N)

Special puncture proof containers? ................ (Y/N)

Other? ................ (Y/N)

**Is the non-sharp health care risk waste stored/collected in:**

Plastic Bags: ................ (Y/N)

Cardboard Boxes (with liner): ................ (Y/N)

Plastic bins: ................ (Y/N)

Other: ................ (Y/N)

**G: What are your current treatment/disposal costs?**

Sharps R............../kg

Other Infectious Waste R............../kg

**H: The Province is considering the need for Regionalised Health care risk waste Treatment Facilities:**

Does this have your support? ................ (Y/N)

Would your Hospital/Clinic use such a facility? ................ (Y/N)

## Annexure 3.3

### Summary of Results

Each sample measure is either the average waste per person for all the measurements on a given hospital, or alternatively the average waste per person on a particular day. The results are presented first for the scenario where there is one measurement per institution and then for the situation where there is one measurement per day.

As we discussed telephonically all waste has been pooled (i.e. no distinction by container size) and the number of days is assumed to be the whole period from the first day through to the last day, even if no waste was collected on the days in between.

For each day there are two tables. The following information is provided.

| Column | Description |
|---|---|
| **Table 1** | |
| Region | Region |
| Average Waste Per Patient (Kg) | This is the estimate of the mean waste per patient. It is the same for both approaches. |
| Estimated Variance | This is the estimate of the variance of the waste used by each patient based on the variance of the means. It is quite poorly estimated due to the few samples. |
| Total Patients | This is the total number of patient days over the period of investigation for the particular region. |
| Total Waste (Kg) | This is the total waste disposed by the given region over the period of investigation. |
| No of Samples | This reflects in the first instance the number of institutions in the region and in the second the total number of days in the survey, across the regions. |
| **Table 2** | |
| Region | As above |
| Average Waste Per Patient (Kg) | As above |
| Standard Error | This is the estimated variance of the estimate of the mean waste disposed by each individual. |
| No of Samples | As above |
| L90, U90 | These are respectively the lower and upper bounds for a 90% confidence interval on the estimated mean waste per person. Thus given the above data we can be 90% sure that the real value of the "Average Waste Per Patient" lies between L90 and U90. |
| L95, U95 | As above, but a 95% confidence interval. |

For regions where there is only one institution no estimate of variance can be obtained when only one observation is calculated for each region. As such no results are presented for these regions in the section below.

**One measurement per institution.**

**Table 1:** Estimates of Parameters by District.

| Region | Average Waste Per Patient (Kg) | Estimated Variance | Total Patients | Total Waste (Kg) | No of Samples |
|---|---|---|---|---|---|
| Central | 1.23 | 2845.88 | 18211 | 22413.58 | 4 |
| District | 0.71 | 1.50 | 592 | 422.70 | 2 |
| Private | 1.57 | 1114.67 | 5842 | 9157.57 | 7 |
| Regional | 0.63 | 451.05 | 11021 | 6912.30 | 4 |

**Table 2: Confidence Intervals for the Mean Parameter.**

| Region | Average Waste Per Patient (Kg) | Standard Error | No of Samples | L90 | U90 | L95 | U95 |
|---|---|---|---|---|---|---|---|
| Central | 1.23 | 0.395 | 4 | 0.30 | 2.16 | -0.03 | 2.49 |
| District | 0.71 | 0.050 | 2 | 0.40 | 1.03 | 0.07 | 1.35 |
| Private | 1.57 | 0.437 | 7 | 0.72 | 2.42 | 0.50 | 2.64 |
| Regional | 0.63 | 0.202 | 4 | 0.15 | 1.10 | -0.02 | 1.27 |

**One measurement per day.**

**Table 3: Estimates of Parameters by District.**

| Region | Average Waste Per Patient (Kg) | Estimated Variance | Total Patients | Total Waste (Kg) | No of Samples |
|---|---|---|---|---|---|
| Central | 1.23 | 639.07 | 18211 | 22413.58 | 16 |
| District | 0.71 | 5.61 | 592 | 422.70 | 8 |
| Military | 0.90 | 50.42 | 975 | 880.25 | 5 |
| Private | 1.57 | 365.33 | 5842 | 9157.57 | 43 |
| Regional | 0.63 | 127.84 | 11021 | 6912.30 | 19 |
| Soweto Clinics | 0.05 | 2.24 | 14880 | 729.35 | 4 |

**Table 4: Confidence Intervals for the Mean Parameter.**

| Region | Average Waste Per Patient (Kg) | Standard Error | No of Samples | L90 | U90 | L95 | U95 |
|---|---|---|---|---|---|---|---|
| Central | 1.23 | 0.187 | 16 | 0.90 | 1.56 | 0.83 | 1.63 |
| District | 0.71 | 0.097 | 8 | 0.53 | 0.90 | 0.48 | 0.94 |
| Military | 0.90 | 0.227 | 5 | 0.42 | 1.39 | 0.27 | 1.53 |
| Private | 1.57 | 0.250 | 43 | 1.15 | 1.99 | 1.06 | 2.07 |
| Regional | 0.63 | 0.108 | 19 | 0.44 | 0.81 | 0.40 | 0.85 |
| Soweto Clinics | 0.05 | 0.012 | 4 | 0.02 | 0.08 | 0.01 | 0.09 |

**The impact of variance estimation.**

In the situations where there are only a few samples to estimate the variance, this estimate of the variance may be very poor. This is accounted for in the confidence intervals making then very wide, when there are few samples. To demonstrate the impact of this inaccuracy of estimates I have recalculated the confidence intervals assuming that the variances were known. The aim of this analysis is to indicate that dramatic improvements in these estimates could be obtained by adding more samples to the dataset. The means are probably much more accurate than is suggested by the confidence intervals above, but we don't have good estimates of the variances to determine these intervals.

| Variance | | | | Estimated | | | | Known | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Region | Average Waste Per Patient (Kg) | Standard Error | No of Samples | L90 | U90 | L95 | U95 | L90 | U90 | L95 | U95 |
| Central | 1.23 | 0.40 | 4.00 | 0.30 | 2.16 | -0.03 | 2.49 | 0.46 | 2.01 | 0.21 | 2.25 |
| District | 0.71 | 0.05 | 2.00 | 0.40 | 1.03 | 0.07 | 1.35 | 0.62 | 0.81 | 0.58 | 0.84 |
| Private | 1.57 | 0.44 | 7.00 | 0.72 | 2.42 | 0.50 | 2.64 | 0.71 | 2.42 | 0.44 | 2.69 |
| Regional | 0.63 | 0.20 | 4.00 | 0.15 | 1.10 | -0.02 | 1.27 | 0.23 | 1.02 | 0.11 | 1.15 |

| Variance | | | | Estimated | | | | Known | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Region | Average Waste Per Patient (Kg) | Standard Error | No of Samples | L90 | U90 | L95 | U95 | L90 | U90 | L95 | U95 |
| | 1.23 | 0.19 | 16.00 | 0.90 | 1.56 | 0.83 | 1.63 | 0.86 | 1.60 | 0.75 | 1.71 |
| District | 0.71 | 0.10 | 8.00 | 0.53 | 0.90 | 0.48 | 0.94 | 0.52 | 0.90 | 0.46 | 0.97 |
| Military | 0.90 | 0.23 | 5.00 | 0.42 | 1.39 | 0.27 | 1.53 | 0.46 | 1.35 | 0.32 | 1.49 |
| Private | 1.57 | 0.25 | 43.00 | 1.15 | 1.99 | 1.06 | 2.07 | 1.08 | 2.06 | 0.92 | 2.21 |
| Regional | 0.63 | 0.11 | 19.00 | 0.44 | 0.81 | 0.40 | 0.85 | 0.42 | 0.84 | 0.35 | 0.91 |
| Soweto Clinics | 0.05 | 0.01 | 4.00 | 0.02 | 0.08 | 0.01 | 0.09 | 0.02 | 0.07 | 0.02 | 0.08 |

**Approach to calculating the estimates of waste per person.**

The data obtained gives the number of individuals at a hospital on a given day (or over a given period of time) and the amount of waste disposed for that period. From this information it is simple to derive an estimate for the average waste per person per day, by dividing the total waste by the total number of patient days (i.e. the sum of patients over each day in the period of interest.)

Now assume that the amount of waste consumed by each patient on a given day is a random variable denoted by $X_i$. Further assume that all the $X_i$ are independently distributed with mean μ and variance $\sigma^2$. Then each estimated mean as described above is a random variable denoted $\bar{X}_{n_i}$, which is the sample mean of a random sample of $n_i$ random variables $X_i$ as described above. Since we do not have values for the variables $X_i$ the mean values form the sample items.

As such we have a sample $\bar{X}_{n_1}, \bar{X}_{n_2}, \ldots, \bar{X}_{n_p}$. Assuming that the $n_i$ are sufficiently large the central limit theorem ensures that each item follows a normal distribution with mean μ and variance $\sigma^2 / n_i$

Then it can be shown that the maximum likelihood estimates for the parameters μ and $\sigma^2$ are given by

$$\hat{\mu} = \frac{\sum_i n_i \bar{X}_{n_i}}{\sum_i n_i} \text{ and}$$

$$\hat{\sigma}^2 = \frac{1}{p} \sum_{i=1}^{p} n_i \left(\bar{X}_{n_i} - \hat{\mu}\right)^2 .$$

As usual the MLE is used in the unbiased form giving the unbiased estimate of $\sigma^2$ as

$$\hat{\sigma}^2 = \frac{1}{p-1} \sum_{i=1}^{p} n_i \left(\bar{X}_{n_i} - \hat{\mu}\right)^2 .$$

Now the variance of the estimate of μ is given by

$VAR[\hat{\mu}] = \frac{\sigma^2}{?_i \; n_i}$ and the estimate $\hat{\mu}$ is unbiased. As such the statistic $\frac{\hat{\mu} - \mu}{\hat{\sigma}}$ follows a $t$ distribution with $p$-1 degrees of freedom. (1- α)% Confidence intervals for $\hat{\mu}$ can be obtained from the equation $\mu \; ? \; \hat{\mu} \; ? \; \frac{\hat{\sigma}^2}{?_i \; n_i} t_{p-1,1-\alpha/2}$, where $t_{p-1,1-\alpha/2}$ is the $1-\frac{\alpha}{2}$ percentile of the t distribution with $p$-1 degrees of freedom.