SAINT LUCIA

Government of Saint Lucia

Medical Waste and Other Bio-Hazardous Wastes Management Plan

Prepared for: Saint Lucia Solid Waste Management Authority
Document of the Saint Lucia National Emergency Response Plan

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Cap Pt.
Pigeon I.
Rodney Bay
Gros Islet
CASTRIES
Grande Cul de Sac Bay
Babonneau
Anse la Raye
Roseau
La Caye
Canaries
Dennery
Mt. Gimie
Praslin
Soufrière
Micoud
Canelles
St. Lucia I.
Choiseul
Laborie
Hewanorra Int'l. Airport
Vieux Fort
Maria Is.

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1.0 INTRODUCTION

In September, 2000, GPEC International Ltd. (GPEC), through discussions with various Saint Lucian Government officials, including personnel from Saint Lucia Solid Waste Management Authority (SLSWMA), became aware of the need to for hazardous waste management strategies to deal with various hazardous waste streams that were currently threatening human health and the environment of Saint Lucia. The hazardous waste streams were identified as follows:

- Bio-hazardous (Medical) waste streams;
- Biological/chemical hazardous wastes (including pesticides, condemned meats, and quarantined foods);and,
- Industrial hazardous wastes (including asbestos and waste oils).

With joint funding from GPEC and the Canadian International Development Agency's Industrial Cooperation Program (CIDA INC), GPEC proposes to develop and aid in the implementation of various hazardous waste management strategies to address the current hazardous waste management needs in Saint Lucia for the above noted hazardous wastes.

This waste management plan describes in detail the minimum requirements for the safe handling, transportation, treatment, and disposal of bio-hazardous wastes being generated in Saint Lucia. The bio-hazardous waste management plan provided in this document address wastes generated in the healthcare industry (e.g. hospitals, medical laboratories, health clinics, doctors and dentist offices, veterinary, and funeral parlors) as well as condemned meats and quarantined foodstuff. These different types of waste streams were grouped together due to the nature of the waste, their risks to human health, and their method of treatment and disposal. A discussion on the general risks associated with bio-hazardous wastes generated during healthcare activities is provided in Appendix A.

1.1 Need for Bio-Hazardous Waste Management Strategies in Saint Lucia

In general, the types of bio-hazardous wastes being generated in the various Saint Lucian healthcare facilities (including health clinics, hospitals, medical laboratories, doctor and dentistry facilities), veterinarian facilities, and funeral parlor facilities include sharps, pathological and anatomical wastes, human blood and bodily fluids (including soaked materials such as dressings), microbiological wastes, pharmaceutical wastes, general refuse, and liquid wastes (both hazardous and non-hazardous). Based on the findings of a recent waste generation survey, the hospitals in Saint Lucia have a medical hazardous waste generation rate of approximately 1 kg/bed/day, and a general refuse waste generation rate of approximately 1.8 kg/bed/day. These rates were based on an occupancy rate of 50%. In addition, the total hazardous medical waste being generated for all healthcare facilities, including hospitals, health clinics, dental and doctor facilities, and veterinary facilities, was estimated to be approximately 300 kg/day (or 110 tonne per year). Currently, waste generated by funeral parlors are not treated as bio-hazardous wastes, and thus waste generation rates were not determined. However, bio-hazardous waste being generated at funeral parlors is only a concern when the person being prepared for burial purposes if known to be infectious.

Based on site visits, discussions with healthcare officials, and review of relevant documents and reports, it was revealed that, in general, the hospitals and health clinics have various waste management strategies in place in order to limit human exposure to hazardous medical waste streams. Most hospital facilities have a two bag system in place. Black bags are being used for general refuse, and red bags are being used for hazardous (infectious) medical waste. In addition, sharps are collected separate from the rest of the waste streams in designated rigid containers, however it is not uncommon for sharps to be disposed with the other bio-hazardous red bag wastes. Some anatomical wastes such as placenta, are either buried on-site or disposed via the hospitals septic sewage system, while other pathological wastes are burned. Liquid wastes are disposed in the hospitals sewage system. In addition, some liquid wastes which are suspected of being infectious are disposed down the drain with a liquid bleach solution.

Waste segregation activities varies between the 34 health clinics in Saint Lucia. Some health clinics segregate hazardous and non-hazardous solid waste in red and black bags respectively, and also segregate sharps into empty bleach bottles. Other clinics only segregate the sharps while mixing together all other solid waste streams.

It is a common practice at hospitals and health clinics for black and red bags being intermixed such that red bags are used for non-hazardous wastes, and black bags are used for hazardous wastes. In addition, no cold store facilities are available for the long term storage of medical waste at many of the healthcare facilities on the island. Thus, stockpiled medical waste is typically stored at warm ambient temperatures and high humidity.

Hospital staff responsible for handling of medical waste are supplied with personal protective equipment including disposal gloves, and gowns. However, it is common for staff to handle medical waste without the use of gloves or gowns. This illustrates the lack of appreciation personnel have for the true health risks associated with the handling and disposal of medical wastes.

Disposal practices vary across the island. Typically most bio-hazardous waste is burned in open fires or burned in non-functional, rudimentary incinerator. Other disposal practices include landfilling with municipal solid wastes, and burying waste on-site, at the healthcare facilities.

Currently there are no formal medical waste management training programs available in Saint Lucia, however some limited training is provided to staff handling medical waste. In addition, hospitals have appointed Infections Control Officers to inform staff of the dangers associated with the handling of bio-hazardous wastes. The Ministry of Health provides some information sessions to health clinic staff in order to inform them of the potential dangers associated with the handling of hazardous medical wastes.

While there is some level of understanding of the hazards associated with bio-hazardous wastes being generated in Saint Lucia, the lack of appreciation by waste handlers for the risks associated with these wastes and the current poor bio-hazardous waste management practices are putting Saint Lucian's at risk of potentially developing a disease or infection, or causing personal injury.

In Saint Lucia there are currently no specific regulations or legislation concerning the handling, transportation and disposal of medical wastes. However, existing legislation, which indirectly regulates the disposal of medical waste, include: the Public Health Act; the Litter Act; Employees (Occupational Health and Safety) Act; Saint Lucia Solid Waste Management Act; and the Standards Act. In addition, since Saint Lucia is a member of the Basel Convention, the handling, transportation and disposal of medical waste would also need to be consistent with convention guidelines.

The bio-hazardous wastes not generated during regular healthcare activities which require special care can be classified into two waste streams:

1. Condemned meats: which include quantities of fish, meat, and poultry deemed by government officials (Ministry of Health) as not meeting national health requirements. Sources of these materials include incoming shipments at ports, abattoirs, packaging facilities, and grocery stores.

2. Quarantined foods: which include plant (produce) material deemed by government officials (Ministry of Agriculture) as representing a risk to agriculture and/or national ecosystem. The primary source for these materials are incoming passengers at air and seaports.

Previous studies by SLSWMA have estimated that approximately 1.2 tonne/week (or approximately 63 tonnes/yr) of condemned meat is generated in Saint Lucia, while approximately 200 kg/week (or 10 tonnes/yr) of quarantined food is generated in the country. Based on condemned food inventory records maintained by the Ministry of Health, from November 1996 to December 1997, Saint Lucia generated approximately 165 tonnes of condemned food stuff which included approximately 64 tonnes of condemned meat and fish material.

Currently, once foods are condemned or quarantined in Saint Lucia, Ministry of Health Environmental Health Officers (EHO) oversee the disposal of these biological hazardous wastes. Typically, the wastes are stored in the packaging or containers in which they have arrived at the ports in Saint Lucia. Quarantined foods are collected by port officials and stored on-site prior to being disposed in a landfill. No separate or designated storage bins or areas are reportedly available for the storage of these bio-hazardous food wastes. The condemned foods are handled by the consignee or owner's representatives, as directed by EHO. Quarantined foods are handled by port officials under the direction of EHO's. Currently there are no handling procedures or guidelines in-place and thus handling practices vary based on the EHO's direction.

In addition, there are no guidelines for the transportation of bio-hazardous food wastes, thus waste handling and transportation practices vary between waste haulers, amount of waste being disposed and the location of the final disposal site. Previously, condemned meats and quarantined foods were disposed via pig farming by certified pig farmers which used these wastes as feed for their pigs. However, this practice is reportedly no longer practiced as concerns were raised by the Ministry of Agriculture. Thus, these wastes are currently being landfilled. This practice of landfilling is also not a preferred option by the Ministry of Agriculture but is viewed as an interim solution until a proper disposal facility is established.

1.2 Limitations

This report was prepared by GPEC International Ltd. (GPEC), expressly for SLSWMA. The findings and conclusions presented in this document are based solely upon the scope of services described in GPEC's proposal (dated July 27, 2000), and are governed by the time and budgetary constraints imposed by this document.

This waste management document has been developed based on the information provided to GPEC by SLSWMA, and the various hospital and Ministry of Health personnel interviewed during GPEC's site visit in Saint Lucia. In addition, this document is based on the observations made during GPEC's site visits to hospitals and health clinics, the current waste management practices in Saint Lucia, and current international best-practice waste management strategies. This waste management plan has been developed specifically for use by Saint Lucians in order for them to deal with their current concerns associated with the handling and disposal of medical waste, quarantined food and condemned meats. This waste management document has been developed in the Saint Lucian context and is intended to provide safe, sustainable, efficient, affordable and culturally acceptable methods for the handling and disposal of bio-hazardous wastes being generated in Saint Lucia. The material in this report reflects GPEC's best judgement in light of the information available to GPEC at the time of preparation. Any use which a third party makes of any part of this report, or any reliance on or decisions to be made based on this report, are the responsibility of such third parties. GPEC accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions taken based on this report. This report may discuss certain relevant environmental laws, regulations and guidelines associated with the hazardous waste management. Although strong efforts were made to consider current relevant laws, regulations and guidelines, this report is not meant to provide legal advice or interpretation. The user should seek legal advice and review as to the applicable laws and their implications as required.

2.0 MEDICAL WASTE MANAGEMENT PLAN

Bio-hazardous waste management systems, regulations and technologies in North America have developed significantly over the last twenty (20) years and are currently considered to be some of the most thorough and complete in the world. These various standards address numerous aspects of the environmental concerns related to the treatment and disposal of bio-hazardous wastes. These concerns are focussed on three (3) major areas:

1. Handling and transportation of bio-hazardous waste;

2. Treatment and disposal of bio-hazardous waste; and,

3. Minimisation of emissions into the atmosphere, and aquatic and terrestrial domains.

GPEC has adopted proven North American standards and developed a customized bio-hazardous waste management system that is specific to address the current concerns in Saint Lucia for hospitals, health clinics, doctor and dentist practices, veterinarian facilities and other bio-hazardous waste generators in Saint Lucia.

2.1 In-house Bio-hazardous Waste Management

The purpose of any waste management program is to provide protection to human health and the environment from the hazards posed directly or indirectly by the wastes being generated. A proper management program will ensure that the wastes are handled in accordance with accepted procedures from the point of generation through to its ultimate disposal or destruction.

In order to implement GPEC's proposed centralized bio-hazardous waste treatment and disposal facility in Saint Lucia, a proper bio-hazardous waste management system must first be established. GPEC's proposed bio-hazardous waste management system is similar to North American standards and will include following elements:

- Designation;

- Segregation;

- Packaging/labelling;
- In-house waste movement;
- Storage;
- Contingency planning and spill control/response; and,
- Staff training.

2.1.1 Waste Designation

The first step in safely managing bio-hazardous waste is to specify which wastes are to be deemed infectious and/or hazardous, in accordance with the known standards. For the purposes of this bio-hazardous waste management plan, the following waste streams are defined:

Isolation bed wastes (highly infectious waste): Consists of wastes generated by hospitalised patients who are isolated to protect others from communicable diseases.

Pathological/Anatomical wastes : Consists of tissues, organs, anatomical parts, and body fluids that are removed during surgery, obstetrical procedures, autopsy, and laboratory procedures.

Microbiological/Laboratory bio-hazardous wastes: Consists of laboratory cultures, stocks or specimens of microorganisms, live or attenuated vaccines, serums, human or animal cell cultures used in research, and laboratory materials (such as culture dishes and other devices used to transfer, inoculate, and mix cultures) that have come in contact with the above wastes. In addition, this category includes any discarded laboratory waste which has come in contact with pathogenic organisms and which has not been rendered noninfectious by autoclaving or other sterilisation techniques.

Human blood and body fluid wastes: Consists of all human blood, semi-liquid blood and blood products, which should all be managed as infectious wastes. This class of wastes also includes items contaminated with blood or blood products that would release liquid or semi-liquid blood if compressed, body fluids visibly contaminated with blood, and body fluids removed in the course of surgery, treatment (e.g. waste being discarded from renal dialysis), autopsy, embalming or for diagnosis, excluding urine and faeces.

Animal wastes: Consists of contaminated carcasses, body parts, body fluids, tissues, organs, blood, and bedding of animals that were intentionally exposed to pathogens in research, in the production of biologicals, or in the *in vivo* testing of pharmaceuticals.

Contaminated sharps: Sharps include needles, needles attached to syringes, and blades; or broken glass or other materials which are capable of causing punctures or cuts and which have come into contact with human blood or body fluid or in contact with animal blood or animal body fluid.

Cytotoxic wastes: Cytotoxic drugs possess a specific destructive action designed specifically to destroy certain cells, including antineoplastic drugs which selectively kill dividing cells. Waste cytotoxic drugs includes leftover or unused cytotoxic drugs as well as syringes, tubing, IV bags, tissues, needles, gloves and any other items which may have come into contact with a cytotoxic drug.

Pharmaceutical wastes: All prescription drugs (excluding cytotoxic drugs) and narcotics which have expired, perished or deemed unusable for its intended use.

Quarantine foodstuff: Include plant (produce) material deemed by government officials (Saint Lucia Ministry of Agriculture) as representing a risk to agriculture and/or the island's ecosystem. The primary source for these materials is via incoming passengers at air and seaports.

Condemned Meats: Include quantities of fish, meat, and poultry deemed by government officials (Saint Lucia Ministry of Health) as not meeting national health requirements. Sources of these materials include abattoirs, packaging facilities, grocery stores, and incoming shipments at ports throughout the island.

General wastes: General refuse is considered non-infectious and non-hazardous and includes office waste, food waste, hospital maintenance waste (excluding chemicals, dry-wall, boards) as well as non-infectious, non-anatomical waste from patient care areas (i.e. disposable diapers, pads, gloves, trays, catheters/bags (empty) and casts).

Hazardous wastes: Hazardous wastes (as defined by the Government of Saint Lucia and/or as classified under Workplace Hazardous Materials Information System [WHMIS]) generated during regular health care activities, which are not infectious but require special handling, storage, transportation and disposal based on the physical and chemical properties of the waste. Some examples of these hazardous wastes include solvents, cleaning detergents, pesticides, mercury, pressurised cylinders.

Those wastes which do not specifically match any of the above described waste classes will be evaluated, on an individual basis, with regards to their potential to cause disease, and will be handled accordingly. Such wastes include those determined by the generator to require careful handling such as other bio-hazardous wastes as well as waste which has come into contact with a human or animal being treated for or suspected to be infected with one or more of the infectious agents listed in Appendix B).

2.1.2 Waste Segregation

Bio-hazardous waste should be separated from the general waste stream, at the point of generation, to assure that these wastes will be properly handled and disposed. Segregation also assists in reducing overall bio-hazardous waste treatment and disposal costs and permits facilities to effectively divert those materials that are recyclable. If bio-hazardous waste is mixed with general refuse, then the total waste stream would be considered infectious and require special treatment and handling. The most efficient means of segregating bio-hazardous waste is to provide separate, distinct containers at the points of generation throughout each generator facility (e.g. hospitals, health clinics, doctors offices, dentists etc.).

2.1.3 Waste Packaging and Labelling

Generators should undertake the necessary steps to ensure that bio-hazardous waste is not placed in with other general wastes. Bio-hazardous waste should be packaged in such a way as to protect personnel handling the waste, and the public, from possible injury and exposure to infectious agents within the waste. The integrity of the packaging should be maintained from the point of origin to the point of treatment. In addition, the packaging should deter rodents and vermin which can be vectors in disease transmission.

A colour-coded system should be implemented for segregating and packaging bio-hazardous wastes. It is suggested that the following colour-coded format be used:

(a) Red -- for bio-hazardous waste which is being transported to an off-site treatment facility;

(b) Yellow/Orange -- for bio-hazardous waste which is being autoclaved on-site prior to being placed with the red bag wastes and transported to an off-site treatment facility;

(c) White – Disposable leak-proof containers for cytotoxic and pharmaceutical wastes; or,

(d) Black – for general refuse or solid waste which is being transported off-site to a landfill facility for final disposal and non-infectious hazardous wastes which require special handling and disposal (labelled and stored in accordance to WHMIS).

Table 2-1 details the types of wastes generated, their suggested packaging and available treatment. Waste containers should be classified as reusable or single-use/disposable. Reusable waste containers should be made of metal or rigid plastic and able to withstand exposure to common cleaning agents. They should be colour-coded according to the type of waste for which they are intended and labelled with the bio-hazard symbol. All re-usable containers used for transporting waste from generators to the treatment facility should be marked with a container ID number for tracking purposes. An inventory record should be maintained of the number of containers utilised and their respective location. Reusable containers should be inspected for holes or leaks each time they are emptied, as well as the condition of colour-coding and labelling. Holes and leaks must be repaired or the waste is to be container replaced. Reusable containers must be cleaned regularly to prevent the accumulation of bio-hazardous wastes and odours. Containers are to be cleaned as soon as possible if waste materials leak or spill within the containers. The generating facility's infection control officer, and/or other appointed person(s) should be consulted about the frequency and the type of cleaning agent to be used.

Single-use containers should be classified as one of the following types: sharps container; waste-holding plastic bag; disposable leak-proof container; or cardboard container. These contains are for single use only and need to be labelled with the bio-hazard symbol as well as written warning of "Infectious Wastes or Bio-Hazardous", as illustrated in Figure 2-1. Similarly, single-use containers used for storing cytotoxic wastes, should be clearly labelled with the international symbol for cytotoxic materials, as illustrated in Figure 2-2.

Table 2-1: Summary of the types, packaging and treatment of bio-hazardous wastes.

Waste Type	Waste Packaging	Treatment
Isolation bed wastes	Yellow bags (pretreatment)* Red bags	Steam sterilization or incineration
Pathological/anatomical wastes	Red bags	Steam sterilization or incineration
Microbiological/laboratory bio-hazard wastes	Yellow/orange bags (pretreatment)* Red bags (final treatment)	Steam sterilization or incineration
Human blood and body fluid wastes	Red bags or red leak-proof containers	Steam sterilization or incineration
Animal wastes	Red bags	Steam sterilization or incineration
Contaminated sharps	Plastic puncture-proof containers	Steam sterilization or incineration
Cytotoxic wastes	White disposable leak-proof containers	Incineration
Pharmaceutical wastes	White disposable leak-proof containers	Incineration
Quarantine foodstuff	Red bags or red leak-proof containers	Steam sterilization or incineration
Condemned meats	Red bags or red leak-proof containers	Steam sterilization or incineration
General wastes	Black bags	Landfill
Hazardous wastes	Packaged according to WHMIS (i.e. according to the material, quantity and characteristics of the waste)	Disposed appropriately

Note: This table summarizes the proposed waste packaging plan for the various types of bio-hazardous wastes being generated in Saint Lucia, which is based on current international best-practice waste management strategies.

* Generators equipped with an autoclave unit should autoclave all microbiological wastes (including isolation wastes) prior to their disposal with red bag wastes.

As noted in Table 2-1, sharps should be placed directly into impervious, rigid and puncture resistant containers to eliminate the hazard of physical injury. Suitable container materials for sharps include metal, rigid plastic, wood and heavy cardboard; the containers should be compatible with the selected treatment processes and dedicated specifically for that purpose. In addition, sharps containers should be relatively small for easy of transport. Examples of sharps generated during healthcare activities, and appropriate sharps containers are illustrated in Figure 2-3. The sharps container should have a lid which cannot be removed once it has been permanently closed. Sharp containers should be marked with the universal bio-hazard symbol and sealed before handling. Once sealed, sharps containers should be removed for the source and replaced with a new empty container. The full sharps container should be placed into a red bio-hazardous bag during collection and on-site transport, as outlined below, in Section 2.1.4. It may be useful to users if sharps containers have the following features:

- A fill line;
- Features permitting simplified movement and handling of filled containers before disposal;
- Means by which unauthorised individuals are prevented from removing items from the container or from removing the container itself;
- A design that allows stacking, to decrease storage space; and
- Features that allow the sharps container to be attached to medication and/or treatment carts.

Sharps containers should be conveniently located close to the point of use to reduce the likelihood of injury from sharps being carried significant distances for the purpose of disposal. Sharps containers should not be filled to more than three-quarters of their usable volume in order to prevent injuries due to overfilling. Sharps should never be forcibly pushed into the container. Generators of sharps should be strongly discouraged from including disinfecting solutions or chemicals in sharps containers; the use of chemicals or disinfectants does not eliminate the biological and physical hazards associated with sharps, and additional treatment is still required.

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Figure 2-1: International bio-hazardous waste symbol, to be used for labelling containers with bio-hazardous wastes.

Figure 2-2: International cytotoxic symbol, to be used for labelling containers with cytotoxic wastes.

Figure 2-3:Examples of sharps (Top left image), and different types of sharps containers.

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Solid or semi-solid wastes such as pathological wastes, animal carcasses, and laboratory wastes may be placed in plastic bag lined containers. The critical characteristic of any plastic waste-holding bag is that it be sturdy enough to resist puncture under conditions of use and to the point of disposal. Each facility should fully test and evaluate their bags under actual conditions of use. Plastic bags must also be colour-coded and marked with the universal bio-hazard label (as illustrated in Figure 2-1). Examples of red bags and plastic containers used for collecting bio-hazardous waste, at the point of generation (i.e. source), are illustrated in Figures 2-4, 2-5, and 2-6.

Specimens of blood and body fluid wastes must be placed in red bags inside leak-proof containers labelled with a bio-hazard label. If leakage is possible from a primary container, then secondary leak-proof containers shall be used. These containers must also be labelled with the bio-hazard warning. Depending in the container size used to collected the blood and body fluid specimens, relatively small containers of liquid wastes (e.g. less than 50 ml), equipped with a leak-proof cap, can be disposed with the red bags.

Microbiological/laboratory bio-hazard wastes and highly infectious wastes should be collected in yellow/orange bags and treated on-site, if available, using an autoclave prior to mixing with the red bag wastes. If autoclave units are not available, than these wastes should be double bagged with the red bio-hazardous bags. Once pretreatment has been completed, these waste are reclassified as red bag wastes. Examples of typical yellow/orange bags are illustrated in Figure 2-7.

All non-infectious wastes, such as general hospital refuse, should packaged within regular black bags. No special labelling is required on these bags. Uncontaminated broken glass should be placed in puncture-proof containers in order to minimize the potential for causing injury to waste handling personnel. The containers should be clearly labelled "Broken Glass" and located in an area which is easily accessible. An example of a broken glass container is provided in Figure 2-8.

Cytotoxic and pharmaceutical wastes are to be packaged in separate white disposable leak-proof containers. The containers housing cytotoxic wastes should be marked with the universal Cytotoxic symbol, as illustrated in Figure 2-2 and sealed before handling. The pharmaceutical waste container should be labelled with a bio-hazardous symbol and clearly written ***"Pharmaceutical Wastes"***. All containers should be sealed before handling.

A supply of fresh collection bags and/or containers should be readily available at all locations where waste is generated. An inventory of these bags and containers should be maintained in sufficient supply in order to ensure that appropriate bio-hazardous waste collection containers are always available.

Cardboard containers can also be used for bio-hazard waste. However, the cardboard containers must be: colour-coded and labelled with the bio-hazard symbol; rigid; closeable; leak-resistant (i.e. lined with an impervious material); and capable of being permanently sealed. If cardboard boxes are to be used, then cardboard boxes which contain recycled fibres is encouraged.

Wastes should not be allowed to accumulate at the point of generation (i.e. source). A routine program for waste collection should be established as part a health-care facility's waste management plan. In the case when bio-hazardous waste containers become full, and have not been collected or will not be collected for some time by housekeeping personnel, then housekeeping should be notified that the immediate collection of the full containers is required.

In general, prior to on-site movement of bio-hazardous waste, the waste should be packaged in containers which are rigid, leak-resistant, impervious to moisture, and of sufficient strength to avoid tearing or bursting under normal conditions when being handled. Packaging types may vary with the specific type of bio-hazardous waste thus appropriate means to move the waste in-house are required (as discussed below).

Figure 2-4:Examples of a typical bio-hazardous waste disposable red bags.

Figure 2-5:Examples of bio-hazardous waste bag holders.

Figure 2-6:Examples of different plastic containers used for collecting bio-hazardous wastes.

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Figure 2-7: An example of a microbiological, disposable orange bag, designed to withstand autoclaving treatment.

Figure 2-8: An example of a broken glass disposable container used for collecting uncontaminated broken glass.

2.1.4 In-house Waste Movement

Housekeeping staff should collect all other bio-hazardous waste throughout a facility on a daily basis in order to prevent the accumulation of bio-hazardous wastes. The bio-hazardous waste is to be stored in a designated storage area. Handling of bio-hazardous waste should be done in a careful manner and in accordance with known safety guidelines (detailed in Section 3.6). Operators should wear protective apparel when handling bio-hazardous waste containers (detailed in Section 3.6). Housekeeping workers responsible for collecting and transporting waste should:

- Collect waste daily;
- No bags should be removed unless labelled; and,
- Bags should be immediately replaced with a bag of the same type.

Special care should be taken when handling or transferring plastic bags containing bio-hazardous waste in order to prevent tearing or opening. Personnel protective equipment should be used and an adequate spill response kit should be readily available. Details for Personnel protection equipment and spill response are provided in Sections 3.6 and 3.6 respectively. In general, plastic bags should not be transported or loaded using mechanical means such as chutes or dumbwaiters. Safe bio-hazardous waste plastic bag handling procedures include loading bags to a rigid cart by hand, and transporting the cart, or box, directly to the storage and/or treatment facility, to minimize the possibility of waste handlers incurring injuries while handling.

Single plastic bags may effectively contain bio-hazardous wastes. Additional packaging should be used to preserve the integrity of the bags and to ensure containment of the waste. One suitable practice for additional packaging includes double-bagging the sealed plastic bag with another bag which is subsequently sealed. Another suitable practice is to place the single-bagged waste within a rigid or semi-rigid container such as a bucket, box or carton.

When transporting packaged bio-hazardous waste, secondary containment is recommended. Typically, reusable carts or rigid cardboard boxes should be used to transport bio-hazardous waste within the facility. Red bags or sharps containers can be placed within the cart or box for ease of handling. Sharps containers should be covered with secure lids during transport and storage. Examples of reusable carts and boxes are illustrated in Figures 2-9 and 2-10. These carts should be designed to prevent spills, and made of materials able to withstand exposure to common cleaning agents. The bio-hazard symbol should be clearly displayed on these carts. The carts should be disinfected frequently to prevent odours and as soon as possible if waste materials leak or spill in the carts. Carts should be thoroughly cleaned before any maintenance work is performed on them. Carts used to transport infectious waste should not be used for other material prior to decontamination. For safe transportation of bio-hazardous waste, wheeled carts, trolleys or dollies should be used. The carts should be:

- Easy to load and unload;
- No sharp edges that could damage waste bags or containers during loading and unloading;
- Easy to clean; and,
- Preferable to have locking lids and locking wheels.

In instances where the waste generators produce smaller or reduced quantities of waste, smaller portable tote boxes (as illustrated in Figure 2-10) may be used instead of the larger bulkier carts, for the in-house transportation of bio-hazardous waste.

The handling and transportation of waste containers should be minimized to reduce the likelihood of exposure to the waste. When transferring waste from the source container (bag and rigid containers) to the portable re-usable carts (or boxes), the bio-hazardous container should first be inspected in order to insure no spillage of bio-hazardous waste has occurred or will occur during transferring activities. If spillage is suspected than proper spill clean equipment and procedures should be followed. The waste handler should cautiously and carefully close bags by tying a knot in the opening or securing the draw string. In the case of plastic disposable containers, the lids should be placed secured. Once the bag or container is closed and the waste secured, the waste can subsequently be transferred into the portable cart or box. Figure 2-11 illustrates the action of transferring bio-hazardous waste from bags to a portable waste collection bin. Wastes should be moved through the facility in such a manner as to prevent unnecessary exposure to staff and others. Specific routes must be planned throughout the facility to minimize the passage of loaded carts through patient care and other clean areas.
Because of the risk of dispersing potentially infectious agents, bio-hazardous waste should not be compacted prior to treatment. This applies to any means of destroying the integrity of the packaging prior to treatment.

Housekeeping staff should collect general refuse (black bag wastes) throughout the facility on a daily basis and place it into the municipal garbage storage bin. However, the collection and transport of general refuge waste should be carried out separately from that of bio-hazardous wastes.

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Figure 2-9: Examples of re-usable bio-hazardous waste containers used for in-house waste movement.

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Figure 2-10: An example of a re-usable bio-hazardous waste tote box.

Figure 2-11: Typical in-house bio-hazardous waste transferring activities.

2.1.5 Bio-hazardous Waste Storage

The storage time of bio-hazardous waste should be minimized. Four (4) factors are to be considered when storing bio-hazardous waste:

- The integrity of the packaging;
- Storage temperature;
- Duration of storage; and,
- The characteristics of storage area.

The integrity of the packaging should be maintained during storage, and care should also be taken in arranging the bio-hazardous waste packages while in storage. All means to avoid spillage should be employed. Stacking and piling of bio-hazardous waste containers should be avoided. Carts should not be overloaded at any time during storage. Appropriate personnel protective equipment and spill response equipment should be available in the storage room.

The storage area should be a specifically designated area. The on-site storage facility should be large enough to accommodate maximum daily waste generation rates. The storage facility should be physically separate from food preparation or supply areas of the healthcare facility. Storage temperature and duration of storage should be considered. The risk of disease transmission increases as storage temperatures and/or duration increase. As temperature increases, the rate of microbial growth and putrefaction also increase. This results in the unpleasant odours typically associated with wastes containing decaying organic matter. Human anatomical and animal anatomical waste should be stored for a maximum of 4 days at temperatures below 4°C. Where proper storage facilities are not available, bio-hazardous wastes should not be stored for more than 24 hours at ambient temperatures.

The universal biological hazard symbol should be posted on the door to the storage room and protected from deterioration by rodents, vermin and weather. Outdoor bio-hazardous waste storage areas should be locked to prevent unauthorized access, and access should be limited to authorized employees only. These outdoor storage facilities should also have a sign clearly indicating the presence of bio-hazardous wastes.

Floors, walls, and ceilings of storage areas must be thoroughly cleaned in accordance with the facility's established procedures. These procedures should, as a minimum, include daily wiping of the floors with disinfectants and cleaning products. These procedures should be prepared in consultation with the facility's infection control officer and/or other appointed person(s).

If the facility generates only sharps, waste storage areas need not be refrigerated. All non-infectious hazardous wastes should be stored in accordance to WHMIS guidelines as outlined in Section 3.8 of this waste management document.

2.1.6 Contingency Planning and Spill Control/Response

A contingency plan is included to provide for emergency situations. It is important that these measures be selected in a timely manner so that they can be implemented quickly when needed.

As previously mentioned, during the handling of bio-hazardous waste, staff should wear appropriate personal protective equipment (PPE), as outlined in Section 3.6 of this management plan. Similarly when cleaning-up an accidental spill, staff should wear appropriate PPE to prevent direct exposure to the potentially infectious agents when cleaning up spills. Details procedures to follow in the event of a bio-hazardous waste spill is provided in Section 3.7 of this waste management plan.

In general, any spill of dry infectious waste should be immediately placed in an appropriate infectious waste container using appropriate tools (such as a shovel, or dust pan). The area should subsequently be mopped using a disinfectant. During the spill of infectious liquid wastes or wet wastes, disinfectant should be applied immediately and allowed to react for a sufficient of time. The waste should then be mopped and the area cleaned. Any accidents with sharps and other bio-hazardous wastes should be reported to the appointed Infection Control Officer following the report format outlined in Section 3.4 of this waste management document. Furthermore, any persons who sustain needle-sticks or other sharps injury should report the incident immediately to the Infection Control Officer, and seek appropriate medical attention. Such incidences should be recorded on an employee file and the health of the employee monitored as directed by a doctor. During spillage of cytotoxic materials, the area should be cornered off and absorbent material placed on the spill to absorb any free liquid. All solid wastes and absorbent material used to soak up the waste should then be placed in appropriate bio-hazardous waste bags or containers and handled accordingly. The area should then be mopped with water and detergent.

Contingency plans must be prepared for storing refrigerated bio-hazardous waste if excess waste is produced, or if either refrigeration, or treatment facilities, or equipment become inoperative (e.g. identify additional storage area and identify alternative treatment).

2.2 Transportation Of Medical Waste

Several key factors are needed in order to safely and effectively transport medical waste from a generator's facility to an off-site final waste treatment facility. These factors include:

- Packaging and labelling;
- Vehicle transportation requirements;
- Manifesting & waste tracking;
- Handling of waste (loading of vehicles);
- Driver training;
- Transportation contingency planning; and,
- Scheduled waste collection.

The following subsections outline the minimum requirements for transporting medical waste off-site.

2.2.1 Packaging and Labelling

Waste generators (consignor) are to ensure that all bio-hazardous waste being transported is properly packaged within the re-usable waste transportation containers (e.g. wheeled tote bins, or tote boxes) and labelled, as outlined above in Section 2.1.3, in order for safe handling and transportation. All bio-hazardous waste prepared for transport ***must be packaged appropriately to prevent crushing during transportation.***

Before any waste is loaded onto the bio-hazardous waste transport vehicle, the packaged wastes should be inspected for leaks, broken or ruptured containers, and improper waste packaging (e.g. waste is exposed), if the waste is not properly packaged, then the waste generator must properly package the waste.

2.2.2 Vehicle Requirement

Vehicles used to transport bio-hazardous waste must not be used to transport mixed cargoes of wastes and other goods, including food or other goods for human consumption. Instead, vehicles selected for the transport of biomedical waste should be dedicated for this purpose. In addition, all vehicles used for the transport of medical waste should be appropriately placarded, as discussed above.

All vehicles used to transport bio-hazardous wastes must have sufficient storage compartments designed to efficiently maintain a protective barrier between the contained waste and the driver and general public. The storage compartment should, as a minimum,:

- Be constructed of materials with a suitable surface finish to enable cleaning and disinfection;
- Have a sealed, leak-proof floor with a liquid-retaining lip at the doorway;
- Have no windows or ventilation openings;
- Have locking doors;
- Be equipped with an interior light; and,
- Have the universal bio-hazardous or infectious waste symbol prominently displayed on the outside of the storage compartment.

The storage compartment should be locked at all times that the bio-hazardous waste transportation vehicle is being operated or contains any waste.

As a policy, bio-hazardous waste should be dropped-off daily at the treatment facility and unloaded for proper and safe storage. However, in general, bio-hazardous waste can be stored in the vehicle for up to one day in tropical climates. However, if the bio-hazardous waste is going to be stored in the vehicle compartment for more than one day, then the storage compartment must be refrigerated. The compartment would have to be insulated and the internal temperature maintained at 4 ^{o}C or less while the waste is being stored in the vehicle. ***Given the relatively high ambient temperatures in Saint Lucia, storage compartments should be refrigerated and storage of bio-hazardous waste in the vehicles kept to a minimum.***

All vehicles should be properly cleaned with a disinfecting agent after bio-hazardous waste has been off-load and prior to loading clean empty waste bins (which are to be transported to the various bio-hazardous generators). Regular cleaning will prevent staining and odours from building-up in the storage compartment. Thorough cleaning once-a-day should be sufficient, however, additional cleaning will be required in the event of a spill.

In order to prevent breakdowns and accidents, the vehicles must be properly maintained, thus regular maintenance and repairs should be scheduled and records of all maintenance work kept for each vehicle.

All vehicles should be equipped with a communications device, such as a two way radio or cellular telephone, in order to be able to keep in contact with the treatment facility. In the event of a spill, immediate notice can be given to the treatment facility and other appropriate authorities.

All vehicles used for transporting medical waste must be placarded (equipped with a sign), clearly visible to other vehicle operators, and clearly indicating the contents of the waste being transported. Placards should be placed on the sides and the back of the vehicle, and clear from any obstructions. The placards should have the universal bio-hazardous or infectious waste symbol according to the United Nations dangerous goods classification system. Placards should be as follows:

- **Minimum Size:** 100 mm X 100 mm (3.9" x 3.9")
- **Colour:** Symbol (three crescents superimposed on a circle), numbers, text, and border line must be black on a white background.
- **Text:** Bottom half of the label should bear the inscription ***"INFECTIOUS SUBSTANCE — In case of damage or leakage immediately notify public health authority."***
- **Symbol:**

D.

2.2.3 Manifesting and Waste Tracking

At the time of bio-hazardous waste collection, each waste load from the generator must be manifested in order to track the bio-hazardous waste being generated. A typical manifest form is provided in Appendix C. Manifest forms should be divided into three sections including:

- Consignor (Generator) information;
- Carrier information (waste hauler); and,
- Consignee (treatment and final disposal facility) information.

The ***consignor*** information required as a minimum should include, but not be limited to, the following:

- Name, complete address and telephone number of the consignor;
- Name of person (and signature) assigned by the consignor to hand-over the waste to the waste hauler;
- Description of containers (e.g. re-usable containers, disposable containers, double bagged waste etc.), and number of bio-hazardous wastes containers being collected;
- In the case of re-usable containers, the Bio-Hazardous Container ID Number (which is affixed to the container) should be recorded;
- Comment on the condition of the containers if they are in a poor state, and thus potentially inappropriate for transportation of waste, at the time of waste collection; and,
- The time and date when the waste was picked-up by the carrier.

The ***carrier*** information required on the waste manifest should include but not be limited to:

- Carrier company name, complete address, and telephone number;
- Vehicle ID number (as assigned by the carrier company) or the vehicle's license plate;
- Driver's name and signature; and,

- Number of re-usable waste containers dropped-off at the generator facility (including a list of Bio-Hazardous Container ID Numbers).

The ***consignee*** or treatment and final disposal facility information required on the waste disposal facility includes:

- The name, complete address and telephone number of the Consignee facility;
- The time and date when the waste is received at the facility;
- The total weight of waste received;
- The time and date when the waste is treated;
- The name and signature of the Treatment Facility Manager;
- The time and date when the treated waste is disposed in the landfill; and,
- The name and signature of authorized landfill personnel.

When the shipment of bio-hazardous waste arrives at the waste treatment facility the consignee must inspect the waste to ensure there are no discrepancies in the manifest. If discrepancies exist, then such discrepancies should be noted and appropriate action taken (if any is required) including the notification of the waste generator and/or the appropriate government authority.

In general, a total of four copies of each manifest should be maintained for record keeping and tracking purposes. At the time when the waste is collected, a copy of the waste manifest is left with the generator. The remaining three copies are returned to the treatment facility. Once the waste has been off-loaded from the vehicles at the treatment facility, the Consignee should inspect the waste prior to accepting the waste. Once the waste is accepted, the Consignee signs the waste manifest and gives a copy to the carrier. The remaining two copies are kept by the Consignee. Once the waste has be treated and disposed, the Consignee fill-in the remaining information on the waste manifest forms and mails a copy of the waste manifest back to the Consignor, as well as retaining a copy at the facility. Waste manifests should be kept on-site in a safe area for easy access and made available, upon request, to the government authority responsible for monitoring bio-hazardous waste treatment and disposal activities.

2.2.4 Waste Handling Practices

When loading vehicles, bio-hazardous waste ***MUST NOT*** to be tipped into vehicle. In addition, during loading activities, outer containers ***MUST NOT*** be damaged. Thus, care must be taken when loading bio-hazardous waste onto the vehicle. For ease, and safe loading, vehicles should be equipped with a hoist (or lift) system, of sufficient load bearing capacity, to be able to lift waste from the ground onto the vehicle. Bio-hazardous waste containers equipped with wheels can be easily wheeled on the lift of the vehicle and subsequently into the vehicle's storage compartment. However, for cases when bio-hazardous waste containers are not equipped with wheels, a dolly should be used in order to wheel the waste onto the lift and into the vehicle's storage compartment, thereby limiting handling and lifting activities.

When picking-up waste filled bio-hazardous waste containers, waste haulers should drop-off empty cleaned re-usable bio-hazardous waste containers in order to replace the containers being transported off-site.

2.2.5 Driver Training

Drivers of vehicles transporting bio-hazardous waste must have a valid drivers licence to operate the waste vehicles used, and must be trained in transporting bio-hazardous waste with periodical follow-up training should be provided to drivers. The training should cover the following areas:

- Operation and basic maintenance of all vehicles and equipment the driver may use;
- Proper loading, unloading, and cleaning procedures;
- Minimum requirements, as set out in this management plan, for proper packaging, labelling, documenting, and waste classification;
- The nature and characteristics of the waste being transported (including personal and community health risks associated with the waste);
- Emergency response procedures, including what to do in the event of an accident or spill, and reporting requirements;
- First Aid; and,
- Protocol in filling out and administration of waste manifest forms.

Upon successful completion of the training program, drivers should be issued with a certificate. In addition, a list of trained drivers should be maintained with the vehicle manager or treatment facility and made available to authorities, upon request. In addition, drivers who have not received a certificate of training must not operate a bio-hazardous waste transportation vehicle.

2.2.6 Transportation Contingency Planning

The waste carrier must have appropriate contingency plans in-place in the event of an accidental spill of bio-hazardous waste, or in the event of a vehicle accident. Proper spill containment, absorbent and collection equipment, and disinfectants, should be on the vehicle at all times when bio-hazardous waste is stored in the vehicle. Detailed procedures in the event of a spill are provided in Section 3.7 of this management plan.

In general, once an accident or a spill has occurred, the immediate area should be blocked off and the spill contained, in order to prevent exposure to bio-hazardous waste by others. Appropriate authorities are to be contacted including the police department, fire department, SLSWMA and/or Ministry of Health, and the treatment facility. People requiring medical addition should be administered first aid until help from the proper authorities arrive.

If during a spill, the vehicle is no longer functional, another vehicle should be dispatched by the treatment facility to collect all bio-hazardous waste spilt and present in the disabled vehicle. However, if the vehicle is still operable, then the driver should commence clean-up activities, and re-package all released wastes (as discussed below). The bio-hazardous waste treatment facility should also dispatch personnel to aid in the cleanup as needed.

With the use of proper personal protective clothing (including gowns, double gloves, eye protection, respiratory protection), as outlined in Section 3.6 of this management plan, and appropriate equipment (such as shovels, adsorbent pads etc.), the driver should re-package all wastes, taking extreme care in handling the waste. Absorbent materials should be used for absorbing or soaking any liquid wastes which may have been released. The soaked absorbent materials are to be subsequently double bagged and placed into bio-hazardous waste containers. Once all waste has been repackaged and loaded onto the vehicle, the area must be disinfected using appropriate disinfectants. Refer to Section 3.6.2 for a summary of different types of disinfectants and their associated characteristics.

All drivers should be trained in containing and collecting all waste materials in the event of an accidental spill.

An accident report must be generated once the spill has been clean-up and the waste is in a secure location. The accident report should include but not be limited to:

- The time and place of the accident or spill;
- The name and phone number of the person reporting the incident;
- The type and amount of material spilled;
- A brief description of what happened and the status of the situation at the time of the report;
- Description of clean activities undertaken, parties involved, and fate of spilt waste;
- The name of the driver if different then the person reporting; and,
- The name(s) of consignors whose waste was spilled.

A copy of the written accident report must be provided to the responsible government department. Detailed procedures for reporting is provided in Section 3.4 of this waste management program.

2.2.7 Scheduled Waste Collection

Research has indicated that some of the bio-hazardous waste generators in Saint Lucia do not generate significant quantities of bio-hazardous waste in a single day, while others generate relatively large quantities of bio-hazardous wastes. This research is based on discussions with various informed persons (including SLSWMA personnel, hospital and health clinic personnel, and Ministry of Health personnel) and the findings of the review of various relevant medical waste documents and reports, GPEC's site visits to various hospitals, hospital laboratories and health clinics, and the recent medical waste survey (which included various hospitals, hospital laboratories, health clinics, and dental, doctor and veterinary practices) conducted by SLSWMA.

Accordingly, bio-hazardous waste should be collected daily from the larger bio-hazardous waste generators, and every other day from the smaller bio-hazardous waste generators. In addition, the route taken by the waste haulers should be charted in such a way as to minimize the distance travelled as well as provide a means of tracking vehicles during the transportation of bio-hazardous waste. Figure 2-12 illustrates the relative location of each of the medical bio-hazardous waste generator facilities in Saint Lucia.

Given the quantity of waste being generated, the type of packaging required for transporting bio-hazardous wastes, the relative location of the different bio-hazardous waste generators, and the vehicle accessibility to the different generators, a minimum of two vehicles should be dedicated for the collection and transportation of bio-hazardous wastes. These vehicles could also be dispatched to the various air and seaports for the collection of quarantined foods as well as being dispatched to the various condemned meat generators on an as needed basis.

Figure 2-12: Locations of Hospitals and Health Clinics in Saint Lucia.

2.3 Bio-Hazardous Waste Treatment Technologies

2.3.1 Operating Criteria for Bio-Hazardous Wastes Treatment Technologies

The purpose for treating bio-hazardous waste is to eliminate or minimize the risk of disease and/or infection due to the presence of pathogens within the waste. Thus, bio-hazardous waste treatment technologies must demonstrate the ability to render the waste innocuous (or non-infectious, as defined below) while concomitantly minimizing the threat of other adverse health effects associated with exposure to bio-hazardous wastes. In order to demonstrate, and monitor, the effectiveness of bio-hazardous waste treatment technologies treatment indicators, including chemical, and biological, are typically employed.

Chemical indicators typically only indicate the attainment of temperature within a treatment process. They do not indicate the duration for which the temperature was achieved. For this reason, chemical indicators are not recommended. Biological indicators are typically more reliable since they consist of live microbes that can be used as a bench mark for all microbes in the waste in order to demonstrate the technologies' microbe destruction (or inactivation) efficiency. Accordingly, biological indicators such as *Bacillus Stearothermophilus* spores or *Bacillus Subtilis* spores can be used for demonstrating and monitoring the effectiveness of bio-hazardous waste treatment technology (CCME 1992, MOE 1994).

It is generally accepted internationally that:

> *"The treated bio-hazardous waste can be considered non-infectious after 6 log kill (or 99.9999% reduction/inactivation) of the spores of* ***Bacillus Stearothermophilus*** *or* ***Bacillus Subtilis*** *is achieved"*

Thus waste treatment technologies must demonstrate their ability to achieve 6 log kill. This can be done using the following Bacillus Subtilis and Bacillus Stearothermophilus tests (WHO, 1999):

- Dried test spores are placed in a thermally resistant and steam-permeable container near the centre of the waste load and the apparatus is operated under normal conditions.

- At the end of the cycle, the test organisms are removed from the load; within 24 hours, test discs or strips should be aseptically inoculated in 5.0 ml soybean-casein digest broth medium and incubated for at least 48 hours, at 30°C for Bacillus Subtilis, and at 55°C for Bacillus Stearothermophilus.

- The media should then be examined for turbidity as a sign of bacterial growth; any growth should be subcultured onto appropriate media to identify the organism either as the test microorganism or as an environmental contaminant.

It is important to note that the biological indicators (such as Bacillus Stearothermophilus spores or Bacillus Subtilis spores) should have an initial nominal population in excess of 10^6 (or 1 million), in order to determine if 6 log kill has been achieved. In addition, all tests should be conducted in multiple replicates in order to determine the reproducibility of the testing conducted.

As part of the commissioning process for the selected bio-hazardous waste treatment technology, the initial waste streams being treated should be tested pre-treatment and post treatment in order to demonstrate that 6 log kill can be achieved. The operating conditions used to achieve the desired destruction efficiency would than be set as minimum operating conditions for that technology in order to ensure that 6 log kill is achieved for each batch of waste treated.

Other operating criteria to consider when evaluating different treatment technologies include:

- Proven ability to effectively treat all bio-hazardous waste streams;
- Percentage of volume reduction achievable;
- Ability to render the waste non-recognizable;
- Generation of secondary emissions (such as air emissions);
- Waste handling requirements;
- Level of technical expertise required to operate and maintain the equipment; and,
- Capital and operational costs associated with the technology.

For bio-hazardous waste treatment technologies which generate air emissions, the incinerator technology must be able to achieve typical air quality guidelines as summarized in the following tables.

Table 2-2: Emission guidelines for new "hospitals/medical/infectious waste" incinerators, constructed after June 1996 (US EPA, 1997).

Pollutant	Small Incinerator (91 kg/hr)	Medium Incinerator (91 - 227 kg/hr)	Large Incinerator (227 kg/hr)
Particulate matter	115 mg/m^3	69 mg/m^3	
Carbon monoxide (CO)	40 ppmv	40 ppmv	
Dioxins/furans	125 ng/m^3 total CCD/CDF or TEQ 2.3 ng/m^3 TEQ	125 ng/m^3 total CCD/CDF or TEQ 2.3 ng/m^3 TEQ	125 ng/m^3 total CCD/CDF or TEQ 2.3 ng/m^3 TEQ
Hydrogen chloride (HCl)	100 ppmv or 93% reduction	100 ppmv or 93% reduction	100ppmv or 93% reduction
Sulfur dioxide (SO2)	55 ppmv	55 ppmv	55 ppmv
Nitrogen oxides	250 ppmv	250 ppmv	250 ppmv

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Lead	1.2 mg/m^3 or 70% reduction	1.2 mg/m^3 or 70% reduction	1.2 mg/m^3 or 70% reduction
Cadmium	0.16 mg/m^3 or 65% reduction	0.16 mg/m^3 or 65% reduction	0.16 mg/m^3 or 65% reduction
Mercury	0.55 mg/m^3 or 85% reduction	0.55 mg/m^3 or 85% reduction	0.55 mg/m^3 or 85% reduction

ppmv : parts per million in volume
CDD: polychlorinated dibenzo-p-dioxins
CDF: polychlorinated dibenzofurans
TEQ: 2,3,7,8 - tetrachlorinated dibenzo-p-dioxin toxic equivalent based on the 1989 international toxic equivalency factors

Table 2-3: Standards for incinerator emissions in the European Union (WHO, 1999).

Emission	Daily Average (mg/m^3)*	Hourly Average (mg/m^3)*	4-hour Average (mg/m^3)*
Total dust	5	10	-
Total organic carbon	5	10	-
Chlorine compounds	5	10	-
Fluorine compounds	1	2	-
Sulfur oxides as SO_2	25	50	-
Nitrogen oxides as NO_2	100	200	-
Carbon monoxide	50	100	-
Mercury	-	-	0.05
Cadmium and Thallium	-	-	0.05
Lead, chromium, copper, and manganese	-	-	0.5
Nickel and arsenic	-	-	0.5
Antimony, cobalt, vanadium and tin	-	-	0.5
Dioxins and furans	-	-	0.1
Oxygen content	At least 6% at any moment		

* Measurements made at standard temperature and pressure.

2.3.2 Review of Available Bio-Hazardous Waste Treatment Technologies

The objective of any bio-hazardous waste treatment technology is to eliminate the threat of disease and/or infection thereby rendering the waste innocuous while concomitantly minimizing the threat of adverse health effects associated with exposure to bio-hazardous wastes. To achieve this objective, various bio-hazardous waste treatment technologies (as outlined below) have been developed to either destroy or inactivate the disease causing pathogens such that the waste no longer poses a of disease and/or infection. While several technologies have been developed and are still being developed for treating bio-hazardous wastes, incineration, steam sterilization (also referred to as autoclaving), and to a limited extent, chemical disinfection are considered the three most frequently used technologies in the world. The following is a list of some of the more common bio-hazardous waste treatment technologies currently available:

- Incineration
- Steam sterilization (autoclaving)
- Chemical disinfection
- Low temperature infrared disinfection
- Thermal inactivation
- Gas/vapour sterilization
- Irradiation sterilization
- Plasma torch
- Pyrolysis

- Microwave disinfection

A discussion on the various bio-hazardous waste treatment technologies listed above is provided in Appendix E. In addition, examples of some typical bio-hazardous waste treatment technologies are provide on the following pages in Figures 2-13 to 2-16.

Figure 2-13: Typical Incinerator for treating bio-hazardous waste.

Figure 2-14: Typical autoclave for treating bio-hazardous waste.

Figure 2-15: Typical microwave for treating bio-hazardous waste.

Figure 2-16: Example of an irradiation plant for treating bio-hazardous waste.

2.3.3 Recommended Treatment Technologies

Different bio-hazardous waste treatment technologies are currently available and being employed in Saint Lucia. However, none of these technologies likely come close to meeting current World Health Organization (WHO) or North American standards of effectiveness in the destruction of pathogens. To promote the safe destruction of bio-hazardous wastes in Saint Lucia and meet WHO and/or North American standards, GPEC has selected two treatment technologies for consideration in Saint Lucia based on the following:

- Observations made by GPEC during site visits made to several healthcare facilities in Saint Lucia;
- The findings of the bio-hazardous waste generation survey conducted by SLSWMA;
- Previous bio-hazardous waste investigations conducted in Saint Lucia;
- Discussions with various government officials, and other informed persons;
- Current regulations existing in Saint Lucia;
- Costs associated with the various treatment technologies;
- Efficiency of the treatment technology to achieve 99.9999% destruction (i.e. 6 log kill) of *Bacillus Stearothermophilius* or *Bacillus Subtilis* spores;
- Level of expertise required to operate the different treatment technologies; and,
- Availability of space at the proposed treatment facility site.

The two treatment technologies include fixed hearth incineration and steam sterilization (or autoclaving). A comparison of these two technologies is provided in Section 5.0 of this waste management plan.

2.4 Summary Bio-Hazardous Waste Management Plan

A summary of the bio-hazardous waste management plan developed for Saint Lucia to address the different bio-hazardous waste generators identified on the island, including medical waste generators (e.g. hospitals, health clinics, dentist and doctor offices, veterinary facilities, funeral parlours), quarantined foodstuff generators (e.g. port authority), and condemned meats (e.g. as identified by the Ministry of Health and Ministry of Agriculture), is summarized in Figures 2-17 to 2-20. These figures are provided on the following pages.

Figure 2-17: Saint Lucia Bio-Hazardous Waste Management Plan for Hospitals, Medical Laboratories, and Health Clinics.

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Figure 2-18: Saint Lucia Bio-Hazardous Waste Management Plan for Doctor/Dentist Offices, Veterinary Facilities, and Funeral Parlours.

Figure 2-19: Saint Lucia Bio-Hazardous Waste Management Plan for Generators of Quarantine Foodstuff and Condemned Meats.

D.

Figure 2-20: Saint Lucia Bio-Hazardous Waste Management Plan for the Transportation and Treatment of Bio-Hazardous Wastes.

3.0 Operation of a Bio-Hazardous Waste Management Plan

In addition to the various bio-hazardous waste components discussed in Section 2.0 of this waste management plan, additional components are required for the effective implementation and operation of the bio-hazardous waste management plan. These components include:

- Selection of a waste management team (e.g. Infectious Control Officers, and Inspection Officers);
- Employee training programs;
- On-going monitoring and infraction reporting;
- Accident and incident reporting;
- Follow-up monitoring activities;
- Occupational health and safety guidelines;
- Emergency response procedures; and,
- Hazardous waste classification (WHMIS).

The following subsections provide detailed discussions on these additional bio-hazardous waste management components.

3.1 Waste Management Team

On a national level an infectious waste management plan cannot be effective unless it is fully implemented. A waste management team should be established at each facility and the roles and responsibilities of all staff members involved in waste management activities need to be identified.

For the large waste generating facilities such as the hospitals, the waste management team should include the following:

- Hospital Administrator (Chair of the waste management team);

- Infectious Control Officer;
- Senior Nursing Officer;
- Waste Management Officer;
- Chief Pharmacist;
- Purchasing Officer; and,
- Laboratory Manager.

Provided below are some of the roles and responsibilities associated with the different waste management team members:

The Hospital Administrator will act as the designated contact with the Ministry of Health and will establish the waste management team. The Hospital Administrator will select an Infectious Control Officer who is to supervise and coordinate the bio-hazardous waste management plan. The Hospital Administrator will allocate adequate resources to efficiently operate the management plan (including the provision of personnel training) and coordinate the regular review of the management plan.

The Infectious Control Officer will report to the Hospital Administrator and will facilitate communication amongst the management team members. The Infectious Control Officer will ensure that all supplies required to carry out the management plan are held in stores. The Infectious Control Officer will supervise:

- The timely collection and replacement of waste containers within the facility;
- The in-house movement of waste generated on an on-going basis; and,
- The operation of the waste storage areas.

In addition to monitoring of the waste management practices, the Infectious Control Officer should also be responsible for providing training to all persons involved in the handling of bio-hazardous wastes, respond to questions or concerns raised by the Hospital Administrator and other waste handling personnel, ensure the proper selection of bio-hazardous bags, containers, and other waste collection supplies, ensure that waste manifests are properly recorded and maintained, conduct routine inspections of different components of the waste management plan, make recommendations on improving the management of bio-hazardous wastes, oversee the implementation of corrective actions required as a result of an accident, or incident, conduct follow-up activities, and maintain detailed records concerning the different aspects of the bio-hazardous waste management plan. Furthermore, the Infectious Control Officer will track the quantity and types of wastes being generated.

The Senior Nursing Officer will report to the Infectious Control Officer and ensure that nursing personnel, medical assistants and ancillary staff receive training as stipulated by the plan and that proper waste segregation activities are performed.

The Waste Management Officer will report to the Infectious Control Officer and consult with the Infectious Control Officer on an ongoing basis regarding all concerns with respect to the management plan. The Waste Management Officer should be responsible for overseeing daily waste management practices, and thus will be the primary person for waste handling personnel to report to. The Waste Management Officer should ensure that staff have appropriate personal protective equipment, wastes are being handled, and transported in a safe manner, report any accidents or incidences to the Infectious Control Officer, ensure waste handling personnel are aware of the risks associated with handling bio-hazardous waste, make recommendations, as necessary, to the Infectious Control Officer for improving bio-hazardous waste management practices, review recommendations with Infectious Control Officer prior to the implementation of any recommendations, and oversee the implementation of recommended actions.

The Chief Pharmacist will report to the Infectious Control Officer and ensure that all staff involved in pharmaceutical waste handling receive training as stipulated by the waste management plan. The Chief Pharmacist will supervise all activities associated with the proper management of pharmaceutical wastes being generated.

The Purchasing Officer will report to the Infectious Control Officer and will ensure that are enough quantities of materials readily available required to support the management plan. The Purchasing Officer will also seek out opportunities to reduce the waste generated through product substitution and consider opportunities to replace halogenated plastic disposable items with non-halogenated equivalents. In addition, the Purchasing Officer will also seek out opportunities to reduce the costs associated with the required supplies by continually updating the list of available supplies in order to get the best prices for all supplies purchased.

The Laboratory Manager will report to the Infectious Control Officer and ensure that all staff involved in laboratory waste handling receive training as stipulated by the bio-hazardous waste management plan. The Laboratory Manager will supervise all activities associated with the proper management of laboratory wastes being generated.

Since smaller bio-hazardous waste generators, such as health clinics, doctors and dental offices, funeral parlours and veterinary facilities, are staffed, administered and structured differently from larger hospitals, the management plan must reflect these differences:

- Health clinics should be administered by the Ministry of Health. Thus the Ministry of Health should designate an off-site Infectious Control Officer for routine monitoring and training of health clinic personnel. The clinics should designate a Waste Management Officer and Senior Nursing Officer who will be located on-site and will administer the waste management plan as indicated above. Waste Management Officers and Senior Nursing Officers would report regularly to the Infectious Control Officer.

- Doctors and dental offices, and funeral parlours should be administered by the Ministry of Health. Thus the Ministry of Health should designate an off-site infectious Control Officer. While veterinary facilities should be administered by the Ministry of Health and the Ministry of Agriculture (as appropriate). Depending on the number and location of waste generators, off-site Infectious Control Officers should be designated for monitoring and training as needed. Depending on the size of the waste generator, as a minimum a Waste Management Officer should be appointed and any additional support staff (as needed) in order to administer the waste management plan on-site and ensure that the waste management plan is effectively implemented on-site as well as ensuring that all waste handling personnel are appropriately trained. The Waste Management Officer will regularly report to the Infectious Control Officer.

- Quarantine foodstuff bio-hazardous waste management should be administered on-site by the Saint Lucia Air and Sea Port Authority (SLAPSA) through the designation of an on-site Waste Management Officer. This person will be responsible to ensure that the waste management plan is effectively implemented on-site, as well as ensuring all waste handling personnel are appropriately training. The Ministry of Health and/or Ministry of Agriculture in conjunction with SLSWMA should designate off-site Infectious Control Officers to monitor and train SLASPA personnel in the management of bio-hazardous wastes. The Waste Management officer will regularly report to the Infectious Control Officer while overseeing all on-site waste management activities.

- Condemned meats bio-hazardous waste management should be administered by the Ministry of Health and/or the Ministry of Agriculture (as applicable)in conjunction with SLSWMA. An on-site Waste Management Officer should be designated to monitor and oversee all waste management activities and ensure all waste handling personnel are appropriately handled. The Waste Management Officer would report to off-site Infectious Control Officers designated by the Ministry of Health or Ministry of Agriculture.

3.2 Employee Training

Facilities which generate bio-hazardous waste should provide its employees with bio-hazardous waste management training. This training should include an explanation of the bio-hazardous waste management plan and the assignment of roles and responsibilities for the implementation of the plan. Such training is important for all employees who either generate or handle bio-hazardous waste regardless of their role (i.e. supervisor or supervised) or type of work (i.e. technical, scientific, housekeeping or maintenance). Staff training should be required when:

- The Bio-hazardous Waste Management Plan is first developed and instituted;
- New employees are hired;
- Annual refresher training to up-date and maintain skills; and,
- Whenever bio-hazardous waste management practices are changed.

The infection control officer or inspection officer should be responsible for all training related to the segregation, collection, storage, and disposal of bio-hazardous waste. He or she should ensure that staff at all levels are aware both of the bio-hazardous waste 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 programs should be periodically reviewed and updated where necessary.

Continuing education is also an important component of the training process. Refresher training will help maintain personnel awareness of the potential hazards posed by bio-hazardous waste. Follow-up training is useful for trainers, indicating how much information has been retained by course participants and the likely need for future refresher courses. Staff training will also serve to reinforce waste management policies and procedures that are detailed in the bio-hazardous waste management plan.

A training package should be suitable for various types of bio-hazardous waste generator establishments, including hospitals, health clinics, medical laboratories, doctor/dentist offices, veterinary facilities, and those facilities who generate condemned meats and quarantined foodstuff. The training package should address the similar aspects of the waste management plan as well as the specific particulars associated with the different waste generators.

The package should be liberally illustrated with drawings, diagrams, photographs, slides, or overhead transparencies. These should reflect the environments in which trainees work and provide examples of measures that have been (or will be) implemented. Where it is likely that waste handlers and other workers have limited reading abilities, all procedures should be carefully represented in diagrams and photographs.

3.3 On-Going Monitoring and Infraction Reporting

A monitoring program should be implemented as part of the bio-hazardous waste management plan in order to ensure that proper waste management practices are followed. The monitoring program should include all aspects of the bio-hazardous waste management plan from its generation, to its final disposal. The monitoring program would include the monitoring of:

- Equipment used to contain the different waste types;
- Waste handling practices and personal protective equipment used;
- Waste segregation activities;
- Movement of bio-hazardous waste throughout the facility;
- Waste storage facility;
- Packaging and labeling practices by waste handlers;
- Treatment/disposal of bio-hazardous waste streams;
- Waste transportation activities; and,

- The implementation of recommendations concerning the management of bio-hazardous waste.

Infractions to the Bio-hazardous Waste Management Plan should be taken seriously. Personnel who breach the infectious waste management plan should be so advised, and should be asked to clarify why the breach occurred. Minor breaches due to poor judgement or lack of understanding of the infectious waste management plan should be led to reaffirmation of the plan and may result in further safety training. The Infectious Control Officer should evaluate whether the breach should be noted on the employee's record and whether any other disciplinary action should be taken. Breaches due to gross misconduct or flagrant continuous actions should be followed by a disciplinary review. Disciplinary actions that should be considered include: a warning and note on the employee's record, extensive safety protocol retraining, being put on probation, a limited suspension without pay, and dismissal.

In addition to the above monitoring program, the efficiency of the selected bio-hazardous treatment technology must also be monitored in order to ensure that the waste effectively being treated and safely disposed.
As detailed above in Section 2.3.1 of this waste management plan, as part of the commissioning process of the bio-hazardous waste treatment technology, the initial waste streams being treated should be tested pre-treatment and post treatment in order to demonstrate that 6 log kill of the biological indicators (such as Bacillus Stearothermophilus spores or Bacillus Subtilis spores) can be achieved. The operating conditions used to achieve the desired destruction efficiency would than be set as minimum operating conditions for that technology in order to ensure that 6 log kill is achieved for each batch of waste treated. Subsequent to this initial testing, quarter-annual testing should be conducted for the first year of operation, and semi-annual testing for subsequent years. However, if deemed necessary by the governing authorities or the Infectious Control Officer or the Inspection Officer, more frequent testing can be conducted. All test results should be maintained by the treatment facility and available for review upon request.

3.4 Accident and Incident Reporting

All accidents and incidents need to be investigated and an accident investigation is not complete until a report is prepared and submitted to management. Unlike accidents, incidents do not necessarily result in actual or observable injury, illness, death, or property damage but should still be included in the accident report. The information obtained from such reporting can be extremely useful in identifying and mitigating problems before they result in actual personal or property damage. To be an effective tool, an accident report should be clear and concise. An example of an accident report can be found in Appendix D. The purpose of the investigation is to prevent future accidents or incidents from occurring.

Injuries and illnesses that require reporting include those injuries and illnesses occurring on the job which result in any of the following:

- Lost work time;
- Restrictions in performing job duties;
- Requirement for first aid or outside medical attention; and,
- Permanent physical bodily damages, or death.

Examples of reportable injuries and illnesses include, but are not limited to, heat exhaustion from working in hot environments, strained back muscles from moving equipment, etc.

Other incidents requiring reporting include those incidents occurring on the job which result in any of the following:

- puncture from sharps instruments;
- injury or illness;
- damage to a bio-hazardous waste transportation vehicle; and,
- uncontrolled release of bio-hazardous waste requiring evacuation of at least that immediate spill area.

Serious injury or illness posing a life-threatening situation shall be reported immediately to the local emergency response medical services.

Injuries and illnesses shall be reported, by the injured employee, to the infectious control officer or inspection officer in person or by phone as soon after any first aid attention has been sought. If the injured employee is unable to report immediately, then the incident should be reported as soon as possible.

Examples of "non-reportable" injuries and illnesses include small paper cuts, common colds, and small bruises not resulting in work restrictions or requiring first aid or medical attention.

Other incidents such as near misses, which occur strictly by chance and do not result in actual or observable injury, illness, death, or property damage are required to be reported. The information obtained from such reporting can be extremely useful in identifying and mitigating problems before they result in actual personal or property damage. Examples of near miss incidences required to be reported include the falling of a compressed gas cylinder in hospital facilities, over exposures to chemical, biological, or physical agents (not resulting in an immediately observable manifestation of illness or injury), slipping and falling on a wet surface without injury, and bio-hazardous waste vehicle near accidents.

3.4.1 Accident Report Format

The following outline is useful in developing the information to be included in a formal accident report (refer to Appendix D for a sample report format) :

1. Background Information should include:

- Where and when the accident occurred;
- Who and what were involved; and,
- List of operating personnel and other witnesses.

2. Account of the Accident (What happened):

- Sequence of events;
- Extent of damage;
- Accident type; and,
- Source (of energy or hazardous material).

3. Discussion (Analysis of the Accident - HOW and WHY):

- Direct causes (energy sources; hazardous materials);
- Indirect causes (unsafe acts and conditions); and,

- Basic causes (management policies; personal or environmental factors).

4. Recommendations (to prevent a recurrence) for immediate and long-range action to remedy:

- Basic causes;
- Indirect causes; and,
- Direct causes (such as reduced quantities or protective equipment or structures).

All accident reports will be maintained on file permanently. They shall receive timely review by upper management to ensure proper corrective actions have been taken.

3.4.2 Evaluating the Cause of the Accident

Obvious accident causes are most probably symptoms of a "root cause" problem. Some examples of Unsafe Acts and Unsafe Conditions which may lead to accidents are:

Unsafe Acts include:

- Unauthorized operation of equipment;
- Running - horse play, not following procedures, by-passing safety devices;
- Not using protective equipment; and,
- Under influence of drugs or alcohol.

Unsafe Conditions include:

- Ergonomic hazards;
- Environmental hazards;
- Inadequate housekeeping;
- Blocked walkways;

- Improper or damaged personal protective equipment; and,

- Inadequate machine guarding.

3.4.3 Recommendations

As a result of the findings from the investigation, recommendations will need to be made in which the need to make changes to the following:

- Employee training;

- Work area design;

- On-site working conditions;

- Selection of equipment and vehicles;

- Selection of personnel; and,

- Policies or procedures.

3.5 Follow-up Monitoring Activities

With the increasing incidence of HIV and Hepatitis B, the bio-hazardous waste management plan must be cognizant of the well being of those employees at higher risk. When all preventative measures and controls have failed, and an employee has been injured by used sharps, certain follow-up procedures should be performed, after immediate decontamination and reporting has taken place, including:

- The infectious control officer needs to establish a counseling relationship and be able to provide instructions;

- Prophylasis measures should be taken. Hepatitis B vaccine should be administered since Hepatitis B poses the greatest concern at this stage;

- A baseline assessment of HIV and Hepatitis B should be established followed at three (3) and six (6) months intervals;
- The source of the contact should be evaluated if possible. If applicable, consent should be obtained from the contact patient/client; and,

- On-going counseling sessions should be conducted and where appropriate, family members should be included to allay fears and anxiety.

The infectious waste management plan should be reviewed on a regular basis. New advances in applicable health and safety issues will be followed-up on a continuous basis in order to determine if such advances would be beneficial to the infectious waste management plan.

3.6 Occupational Health and Safety Guidelines

Healthcare bio-hazardous waste management policies or plans should include provision for the continuous monitoring of workers' health and safety to ensure that correct handling, treatment, storage, and disposal procedures are being followed (as discussed above in Section 3.3). General health and safety guidelines are provided below.

Occupational health and safety measures typically include the following:

- Proper training of workers;
- Provision of equipment and clothing for personal protection;
- Establishment of an effective occupational health program that includes monitoring, immunization, post-exposure treatment, and medical surveillance.

The workers at risk of exposure to potentially infectious wastes include healthcare providers, hospital cleaners, maintenance workers, operators of waste treatment equipment, and all operators involved in waste handling and disposal within and outside healthcare facilities. Health and safety training of these persons should, as a minimum, ensure that workers know of and understand the potential risks associated with healthcare waste, the value of immunization programs, and the importance of consistent use of personal protection equipment.

3.6.1 Personal Protective Equipment

The generation, segregation, transportation, treatment, and disposal of bio-hazardous waste results in human exposure to potentially hazardous and infectious materials as a result of various handling activities. Therefore, protection against personal injury is essential for all workers who are at risk. The individuals responsible for the management of bio-hazardous waste should ensure that all risks are identified and that suitable protection from those risks is provided.

A comprehensive risk assessment of all activities involved in bio-hazardous waste management should be carried out at all facilities which will require the implementation of a bio-hazardous waste management plan in order to allow for the identification of required protection measures. These measures should be designed to prevent exposure to bio-hazardous materials or at least to keep exposure levels within safe limits.

3.6.1.1 Protective Clothing Minimum Requirements

Waste handlers should always be appropriately clothed and wear personal protective equipment so that harmful agents, whether physical, chemical, or infectious, are prevented from gaining access to open wounds, cuts, by absorption through the skin or by inhalation as applicable. The type of protective clothing used will depend upon, to a certain extent, the risk associated with the healthcare waste being handled. Although, the following should be made available to all personnel who collect or handle healthcare wastes:

- Helmets, with or without visors - depending on the operation.
- Face masks and/or respirators - depending on operation.
- Eye protectors (safety goggles) - depending on operation.
- Overalls (coveralls) or long pants with long-sleeved shirt - obligatory.
- Industrial aprons - depending on operation.
- Leg protectors and/or industrial boots - obligatory.
- Disposable gloves (for medical staff) or heavy-duty gloves (for waste handlers) - obligatory.

Industrial boots and heavy-duty gloves are particularly important for waste handlers given the nature of the waste being handled. The thick soles of the boots offer protection in the storage area, as a precaution from spilled sharps, and where floors are slippery. If segregation is inadequate, needles or other sharp items may have been placed in plastic bags; such items may also pierce thin-walled or weak plastic containers. If it is likely that healthcare waste bags will come into contact with workers' legs during handling, leg protectors may also need to be worn.

Personnel that operate waste treatment technologies, which require manual loading and unloading of wastes, should wear protective face visors, respirators, and helmets in addition to the body protective clothing described above. During ash and slag removal and other operations that create dust, face visors with HEPA filter respirators should be provided for operators.

3.6.1.2 Personnel Hygiene

Personal hygiene is very important for reducing the pathogenic risks associated with the handling of bio-hazardous wastes. Thus, convenient washing facilities, with warm water and soap (preferably with disinfectants), should be available to personnel who are exposed to bio-hazardous wastes, particularly those who work at large storage facilities and all those at treatment facilities.

Bio-hazardous waste treatment facilities should also have appropriate decontamination quarters equipped with showers, washer facilities, disinfectants, and laundry facilities such that daily working clothes do not leave the treatment facility without being properly cleaned and disinfected for re-use. This minimizes the spread of potentially infectious materials into the general public.

3.6.1.3 Immunization Programs

Viral hepatitis B infections have been reported among healthcare personnel and waste handlers. Thus, personnel exposed to the different bio-hazardous wastes should be immunized against HBV. In addition, personnel should also be up-to-date for tetanus, diphtheria, and polio. While polio boosters may not be necessary, 10-year boosters for tetanus and diphtheria are recommended.

In facilities where personnel are in contact with animals and their associated wastes, rabies vaccination should be considered for personnel if the animals being handled are suspected of carrying the rabies virus.

3.6.1.4 Special Precautions During Clean-up of Hazardous Substances

For cleaning up spills of body fluids or other potentially hazardous substances, particularly if there is any risk of splashing, ***eye protectors and masks should be worn***, in addition to gloves and coveralls.

Respirators are also needed during any activities that potentially involves exposure to volatilized and/or airborne hazardous substances. For example, during the cleaning of incinerator residues, or the cleaning of certain contaminated equipment.

Residues should be recovered as completely as possible using hand tools (e.g. a shovel), and then packaged safely. It is especially important to recover spilled droplets of metallic mercury. If a leakage or spillage involves infectious material, the floor should be cleaned and disinfected after most of the waste has been recovered.

3.6.1.5 Special Precautions for Handling Sharps

Special precautions should be taken when handling sharps. Sharps pose a dual hazard: transmission of infection by inoculation, and physical injury. As such, they must be contained and handled properly. Sharps must be contained in puncture-proof containers as specified above in Section 2.1.3 of this waste management plan.

It is important to remember that exposure to a needle or other sharp object contaminated with the blood of an infectious person presents the greatest potential risk for transmission of HBV, HIV, and other bloodborne pathogens to the healthcare worker and waste handler.

In general, recapping of needles must be avoided. Used needles are to be placed in sharps disposal containers without recapping. In certain instances in which recapping is unavoidable, recapping by some method other than the traditional two-handed method should be conducted. Many safe recapping methods and devices are available. If such devices are used, they must be reliable and readily available, and appropriate education must be provided concerning their use. Acceptable methods in North America include the use of self-sheathing needles or other auxiliary devices such as re-sheathing instruments or forceps. The properly performed one-hand scoop technique may also be used.

Needles must not be manually clipped, bent or broken before disposal. However, where there exists a concern of needles being re-used, then needle braking devices can be employed for breaking the needles prior to disposing them. If such devices are to be used, then they will need to be readily available. Another option is to use “one-use” needles, which are, as their name implies, only useable once.

3.6.1.5 General Precautions During Healthcare Activities

As described throughout this management plan, two basic principles govern the main measures that should be taken in order to prevent the spread of infections in healthcare facilities:

- Separate the infection source from the rest of the hospital; and,
- Cut off any route of transmission.

The separation of the source not only includes the isolation of infected patients, but also includes all the measures (i.e. aseptic techniques) that are taken, which are intended to act as a barrier between infected or potentially contaminated tissues (and other materials) and the surrounding environment, including other patients and personnel. It is important to note that ***all objects that come in contact with patients should be considered as potentially contaminated***. If an object is disposable, it should be discarded as waste. If it is reusable, transmission of infective agents must be prevented by cleaning, disinfection, or sterilization (as discussed in the following section).

Generally speaking, in the healthcare environment, it is virtually impossible to avoid all contact with infected tissue or potentially contaminated body fluids, excreta, and secretions. Even when they are not directly contacted with the bare hands, exposure through contact with instruments, containers, linen, etc., can occur. Thus, standard precautions should be taken during the care of patients in the healthcare industry in order to protect healthcare workers from bloodborne infections (such as HIV, HBV and HCV).
Some standard precautions that can be used in the healthcare industry include (*WHO, 1999*):

3. **Hand washing**

   i. Wash hands after touching blood, secretions, excretions and contaminated items, whether or not gloves are worn. Wash hands immediately after gloves are removed, between patient contacts.

   ii. Use a plain soap for routine hand washing.

   iii. Use an antimicrobial agent for specific circumstances.

4. **Gloves**

i. Wear gloves when touching blood, body fluids, secretions, excretions, and contaminated items. Put on clean gloves just before touching mucous membranes and non-intact skin.

5. **Mask, eye protection, face shield**

i. Wear a mask and eye protection or a face shield during procedures and patient-care activities that are likely to generate splashes or sprays of blood, body fluids, secretions, and excretions.

6. **Gown**

i. Wear a gown during procedures and patient-care activities that are likely to generate splashes or sprays of blood, body fluids, secretions, or excretions.

7. **Patient-care equipment**

i. Ensure that reusable equipment is not used for the care of another patient until it has been cleaned and reprocessed appropriately.

8. **Environmental control**

i. Ensure that the hospital has adequate procedures for the routine care, cleaning, and disinfection of environmental surfaces.

9. **Linen**

i. Handle used linen, soiled with blood, body fluids, secretions, and excretions in a manner that prevents skin and mucous membrane exposures, and that avoids transfer of microorganisms to other patients and environments.

10. **Occupational health and bloodborne pathogens**

    i. Take care to prevent injuries when using needles, scalpels, and other sharp instruments or devices.

    ii. Use ventilation devices as an alternative to mouth-to-mouth resuscitation methods.

11. **Place of care of the patient**

    i. Place a patient who contaminates the environment or who does not assist in maintaining appropriate hygiene in an isolated (or separate) room.

3.6.2 Cleaning, Sterilization and Disinfection Guidelines

One of the most basic measures for the maintenance of hygiene, and one that is particularly important in the hospital environment, is cleaning. The principal aim of cleaning is to remove visible dirt. It is essentially a mechanical process: the dirt is dissolved by water, diluted until it is no longer visible, and rinsed off. Soaps and detergents act as solubility-promoting agents. The microbiological effect of cleaning is also essentially mechanical: bacteria and other microorganisms are suspended in the cleaning fluid and removed from the surface. The efficiency of the cleaning process depends completely on this mechanical action, since neither soap nor detergents possess any antimicrobial activity. Thorough cleaning will remove more than 90% of microorganisms. However, careless and superficial cleaning is much less effective; ***it is even possible that it has a negative effect, by dispersing the microorganisms over a greater surface and increasing the chance that they may contaminate other objects.*** Cleaning has therefore to be carried out in a standardized manner or, better, by automated means that will guarantee an adequate level of cleanliness.

Diluting and removing the dirt also removes the breeding-ground or culture medium for bacteria and fungi. Most non-sporulating bacteria and viruses survive only when they are protected by dirt or a film of organic matter; otherwise they dry out and die. Non-sporulating bacteria are unlikely to survive on clean surfaces.

The effectiveness of disinfection and sterilization is increased by prior or simultaneous cleaning.

An object is considered sterile, (i.e. free of microorganisms), after sterilization. However, it is important to remember that sterilization is never absolute; by definition, it effects a reduction in the number of microorganisms by a factor of more than 10^6 (i.e. more than 99.9999% are killed or 6 log kill rule). Given that more than one out of 1,000,000 sterilized items may still bear microorganisms, it is important to minimize the level of contamination of the material to be sterilized. This is done by sterilizing only objects that are clean (free of visible dirt) and applying the principles of good manufacturing practice. Sterilization can be achieved by both physical and chemical means. Physical methods are based on the action of heat (autoclaving, dry thermal or wet thermal sterilization), on irradiation (g-irradiation), or on mechanical separation by filtration. Chemical means include gas sterilization with ethylene oxide or other gases, and immersion in a disinfectant solution with sterilizing properties (e.g. glutaraldehyde).

The term disinfection is difficult to define, as the activity of a disinfectant process can vary widely. The following distinctions can be made in the levels of disinfection (WHO, 1999):

- *High-level disinfection:* can be expected to destroy all microorganisms, with the exception of large numbers of bacterial spores.

- *Intermediate disinfection:* inactivates *mycobacterium tuberculosis*, vegetative bacteria, most viruses, and most fungi; does not necessarily kill bacterial spores.

- *Low-level disinfection*: can kill most bacteria, some viruses, and some fungi; cannot be relied on to kill resistant microorganisms such as tubercle bacilli or bacterial spores.

There is no ideal disinfectant and the best compromise should be chosen according to the situation. A disinfectant solution is considered appropriate when the compromise between the antimicrobial activity and the toxicity of the product is satisfactory for the given application. Another consideration may well be the cost. The more active disinfectants are automatically the more toxic ones; potentially toxic products can be applied to inanimate objects or surfaces, whereas for disinfection of human tissues only the less toxic disinfectants can be considered. For antisepsis, different disinfectants are used for application to the intact skin (e.g. alcoholic solutions) and to mucous membranes or wounds (only aqueous solutions of non-toxic substances). Cost is a less important consideration for an antiseptic than for a disinfectant.

The principal requirements for a good antiseptic are absence of toxicity and rapid and adequate activity on both the natural flora and, especially, pathogenic bacteria and other microorganisms after a very short exposure time. Essential requirements for a disinfectant are somewhat different: there must be adequate activity against bacteria, fungi, and viruses that may be present in large numbers and protected by dirt or organic matter. In addition, since disinfectants are applied in large quantities they should be of low ecotoxicity.

In general, use of the chosen disinfectant, at the appropriate concentration and for the appropriate time, should kill pathogenic microorganisms rendering an object safe for use in a patient, or human tissue free of pathogens to exclude cross-contamination.

An overview of the characteristics of the main groups of disinfectants is provided in the following table.

Table 3-1: Characteristics of the main disinfectant groups (WHO, 1999)

Disinfectants	Bactericidal Activity	Tuberculocidal Activity	Fungicidal Activity	Virucidal Activity	Sporicidal Activity	Local Human Toxicity	Applications
Alcohol	Very active	Very active	Very active	Very active	Not active	Moderate	Skin antisepsis. Disinfection of small surfaces.
Chlorhexidine	Less active against Gram-negative bacilli	Not active	Less active	Not active	Not active	Low	Skin and wound antisepsis.
Chlorine Compounds (chloramine, hypochlorite)	Very active	Active	Active	Very active	Less active	Moderate	Skin and wound antisepsis. Water treatment. Surface disinfection.
Formaldehyde	Very active	Very active	Very active	Very active	less active	High	

							Disinfection of inanimate objects and surfaces.
Glutaraldehyde	Very active	Very active	Very active	Very active	Very active	High	Disinfection of inanimate objects.
Hydrogen Peroxide	Less active	Active	Active	Active	Less Active	Low	Wound antisepsis.
Iodophore	Active	Active	less active	Active	Not active	Moderate	Skin and wound antisepsis.
Peracetic acid	Very active	Active	Active	Active	Active	High	Disinfection of inanimate objects.
Phenolic compounds	Very active	Very active	Very active	Less active	Not active	High	Disinfection of inanimate objects and surfaces.
Quaternary ammonium	Less active against Gram-	Not active	Less active	Less active	Not active	Low	In

compounds	negative bacilli						combination with other compounds.

3.6.3 General Cytotoxic Safety

As previously mentioned, hospitals should appoint a full-time Infectious Control Officer who's duties should include, amongst other things, the supervision of the safe management of cytotoxic wastes. The following key measures are essential in minimizing exposure to cytotoxic wastes:

- Written procedures that specify safe working methods for each process;
- Data sheets, based on the supplier's specifications, to provide information on potential hazards;
- Established procedure for emergency response in case of spillage or other occupational accident;
- Appropriate education and training for all personnel involved in the handling of cytotoxic drugs.

These measures are unlikely to be needed in rural or urban district hospitals of middle- and low-income countries, such as Saint Lucia, which do not typically use genotoxic products (either the cytotoxic or radioactive products). However, by implementing a bio-hazardous waste management program, hospitals of Saint Lucia will be able to provide additional healthcare services, such as chemotherapy, in the future.

In hospitals that currently do use cytotoxic products, specific guidelines on their safe handling should be established for the protection of personnel as outlined in this document. Minimal protective measures for all waste workers who handle cytotoxic waste should include protective clothing, gloves, goggles, and masks.

3.7 Emergency Response General Procedures

3.7.1 General Principles

At each facility where bio-hazardous wastes are generated, one person should be designated as responsible for the handling of bio-hazardous waste emergencies, including coordination of actions, reporting to managers and regulators, and liasing with emergency services. In addition, a second person should be designated and trained to carry out the role in the absence of the primary person.

In healthcare establishments, spillage is probably the most common type of emergency involving infectious or other hazardous material or waste. Response procedures are essentially the same regardless of whether the spillage involves waste or material in use. Spill response procedures should ensure that:

- The waste management plan is respected;
- The area affected by the spill is kept as small as possible;
- Contaminated areas are cleaned and, if necessary, disinfected;
- Exposure of workers is limited as much as possible during the cleanup operation; and,
- The impact on patients, medical and other personnel, and the environment is as limited as possible.

Healthcare personnel and waste handlers should be trained for emergency response, and the necessary equipment should be readily available at all times to ensure that all required measures can be implemented safely and rapidly. Written procedures for the different types of emergencies should be drawn up. ***For dangerous spills, the clean-up operation should be carried out by designated personnel specially trained for the purpose.***

In case of a needle stick injury, bleeding of the wound should be encouraged and the area should be washed under clean running water.

3.7.2 Emergency Spill Response

Spills usually require clean-up only of the contaminated area. For spills or uncontrolled release of infectious material, however, it is important to determine the type of infectious agent; in some cases, immediate evacuation of the area may be necessary. In general, the more hazardous spills tend to occur in laboratories rather than in the medical wards of hospitals.

Procedures for dealing with spills should specify safe handling operations and appropriate protective clothing. Appropriate equipment for collecting the waste and new containers should be available, as well as means for disinfection.

In case of skin and eye contact with hazardous substances, there should be immediate decontamination. The exposed person should be removed from the area of the incident for decontamination, generally with copious amounts of water. Special attention should be paid to the eyes and any open wounds.

In case of eye contact with corrosive chemicals, the eyes should be irrigated continuously with clean water for 10-30 minutes; the entire face should be washed in a basin, with the eyes being continuously opened and closed.

The following list details the procedures to be taken after a spill has occurred:

1. **Evacuate** the contaminated area.

2. **Decontaminate** as necessary the eyes and skin of exposed personnel ***immediately***.

3. Provide **first aid** and medical care to injured individuals.

4. **Contain** the spill with containment materials (e.g. absorbents, spill containment barriers, etc.) so as to prevent the further spread of contaminated materials. This action should be performed without any direct human contact with the contaminated materials.

5. **Secure** the area to prevent exposure of additional individuals.

6. **Inform** the designated person (including the Infectious Control Officer, or the Waste Management Officer, or the Inspection Officer - depending on where the spill occurred), who will then coordinate the necessary remedial actions.

7. Determine the **nature** of the spill.

8. **Evacuate** all the people not involved in cleaning up if the spill involves a particularly hazardous substance.

9. Provide **first aid** and medical care to injured individuals.

10. Provide adequate **protective clothing** to personnel involved in cleaning-up including disposable suits (e.g. Tyvek suites), gloves, and steel toe boots as a minimum, with face shields and respirators used as required.

11. **Collect** all spilt and contaminated material. **Sharps should never be picked up by hand**; brushes, scoops, pans, brooms or shovels, or other suitable tools should be used. Spilt material and disposable contaminated items used for cleaning should be placed in the appropriate bio-hazardous waste bags or containers. The cleanup should occur in a manner which will minimize splashing, spraying and splattering of the spilt material.

12. **Decontaminate or disinfect** the affected area. During wipe-up activities, a cloth (or other absorbent material) should never be turned over because this will/may spread the contamination. In addition, only one side of the absorbent cloth should be used in order to reduce contact with contaminated liquid. The decontamination should be carried out by working from the least to the most contaminated part, with a frequent change of cloth. Dry cloths should be used in the case of liquid spills; for spills of solids, cloths impregnated with water (acidic, basic, or neutral as appropriate) should be used.

13. **Rinse** the area, and wipe dry with absorbent cloth.

14. Dispose of all single use tools with the bio-hazardous wastes, and decontaminate or disinfect any re-usable tools that were utilized during the cleanup. Appropriate bio-hazardous bags and containers should be readily available to dispose of all single use contaminated equipment.

15. Remove protective clothing and decontaminate or disinfect as necessary. Wash hands and other potentially exposed areas (such as the head) after the protective clothing has been removed. Shoes and boots can also become contaminated during cleanup

activities, thus the use of disposable and impervious shoe/boot covering should be considered and used accordingly. When removing contaminated protective clothing, the gloves should be worn and removed only after all protective clothing has been removed.

16. **Seek medical attention** if exposure to hazardous material is believed to have occurred during the cleanup operation.

The following table outlines the various actions taken during a spill, along with the associated tools and cleanup items used during the cleanup of a bio-hazardous waste spill.

Table 3-2: Summary of typical tools and items used for spill cleanups (WHO, 1999)

Action	Tools or Items
Approaching the spillage	Protective equipment (see section 3.6.1).
Containing the spillage	Absorbent material (e.g. absorbent paper, towels, gauze pads, specialized hazardous chemical absorbent pads).
Neutralizing or disinfecting the spillage (if necessary)	*For infectious material:* disinfectant.[1] *For acids:* sodium carbonate, calcium carbonate, or other base. *For bases:* citric acid powder or other acid. *For cytotoxic material:* special chemical degradation substances.
Collecting the spillage	*For liquids:* absorbent paper, gauze pads, wood shavings, saw dust, calcium bentonite, diatomaceous earth. *For solids:* forceps, broom, dust pan or shovel. *Mercury:* mercury sponge or vacuum pump.
Containment for disposal	Plastic bag (red, yellow, as appropriate), sharps container.
Decontamination or disinfection of the area	*For infectious material:* disinfectants.[1] *For hazardous chemicals:* suitable solvent or water.

1 For example: bleaching powder, which is a mixture of calcium hydroxide, calcium chloride, and sodium hypochlorite, used in the powder form or in solution of varying dilution (1 : 1 to 1 : 100) depending on the nature of the spilled material.

3.7.3 Personnel Injury and Exposure Response

A program of response should be established at each of the facilities where bio-hazardous wastes are generated. This program should prescribe the actions to be taken in the event of injury or exposure to a hazardous substance. All staff who handle bio-hazardous waste should be trained to deal with injuries and exposures. The program should include the following elements:

- Immediate first-aid measures, such as cleansing of wounds and skin, and irrigation (splashing) of eyes with clean water;
- Initiation of isolating injured personnel from source of injury;
- An immediate report of the incident to a designated responsible person;
- Retention, if possible, of the item involved in the incident; details of its source for identification of possible infection;
- Additional medical attention in an accident and emergency or occupational health department, as soon as possible;
- Medical surveillance (i.e. follow-up medical attention to monitor potential progression of illnesses);
- Blood or other tests if required, as determined by a medical specialist;
- Recording of the incident;
- Investigation of the incident, and identification and implementation of remedial action to prevent similar incidents in the future.

The remaining elements of the accident response plan should then be followed.

3.8 Workplace Hazardous Materials Information System - WHMIS

The Workplace Hazardous Materials Information System (WHMIS for short) is a Canadian comprehensive system for the safe management of hazardous chemicals. WHMIS aims to ensure that people have ready access to the information they need to work safely with chemicals. WHMIS applies whenever people work with chemicals in the workplace including the healthcare, veterinary, and agriculture industries.

WHMIS is concerned with those chemicals which are considered dangerous goods or control products that meet WHMIS criteria. Because the criteria considers both health and safety risks, most dangerous chemicals are included. Any chemical that does meet any WHMIS criteria, which is therefore exempt from WHMIS, presents very low risks.

Under WHMIS, suppliers (including manufacturers, importers, packagers and processors) should label and prepare Material Safety Data Sheets (MSDSs) for products they make, import, package, or process. The buyers of these products must make sure that these products are correctly labelled and that MSDSs are available.

Employers must set up worker education programs that instruct workers about the contents and significance of labels and MSDSs and how to work safely with hazardous materials.

In summary, WHMIS delivers the necessary information by means of:

- Cautionary labels on containers of controlled products;
- The provision of an MSDS for each controlled product; and,
- A worker education program.

A summary of the different WHMIS classes is provided in Appendix F.

4.0 CONCEPTUAL TREATMENT FACILITY DESIGN AND OPERATION

The following subsections outline the typical requirements of a centralized bio-hazardous treatment facility designed to handle all bio-hazardous wastes being generated in Saint Lucia. It is important to note that the conceptual treatment facility design provided in this management plan is for illustrative purposes only. The final design and layout of the facility may vary significantly for the conceptual design due to various factors including, the cost and availability of labour and construction materials, the treatment technology selected, the costs and availability of various equipment, vendor specific requirements, and the availability of utilities.

4.1 Site Description and Layout

The facility is expected to be constructed at the Deglos landfill facility. Land has been (or will be) reportedly allocated within the recycle area of the Deglos landfill facility for the bio-hazardous waste treatment facility. Based on review of existing site plans, the optimum location for the bio-hazardous treatment facility at the Deglos landfill site would be within the recycle area at the elevation of 12.0 m, as outlined in Figure 4-1. The bio-hazardous facility would require a foot print up to approximately 20 m by 20 m (or a total of 400 m^2). It is important to note that additional space may be required, for the reasons indicated above. Proper landscaping for drainage around the facility building will also be required in order to prevent flooding of the bio-hazardous treatment facility.

As indicated in the Figure 4-1, access to the proposed location of the bio-hazardous waste treatment facility is provided by an access road leading from the scale house and sloping down onto the recycle area. The access road shall reportedly be a Standard Secondary Two Lane Road designed in accordance with the development control authority's manual for developers and the requirements of the MCWT&PU. This will be sufficient to support the loads generated from the bio-hazardous waste transport vehicles.

4.2 Utility and Fuel Requirements

Based on the two technologies selected, and the various facility equipment identified in the conceptual facility design, the following utilities are required:

Electricity: Electricity will be required to operate various electrical components through out the facility including, but not limited to, control panels, motors, blowers, fans, equipment sensors, electric boiler, conveyors, computers, weigh scales, condensers, and lighting. Currently available in Saint Lucia is single phase, 240 volt, 50 HZ, and three phase, 415 volt, 50 HZ.

Water: Water will be required for various purposes including cart cleaning, facility cleaning, boiler water for autoclave treatment, water for scrubbing emissions from an incinerator, washroom facilities, and drinking.

Fuel type: Depending on the equipment selected fuel will be required in varying quantities. Diesel fuel will be required for an incinerator technology. Vehicles for the collection of bio-hazardous waste will also require fuel, with the fuel type depending on the vehicle engine. If a fired boiler is selected, as part of the autoclave system, then additional fuel will be required. Fuel may also be required for a steam or hot water pressure washer. Based on the technology selected, an above ground fuel storage tank will be required, however the quantity of fuel stored on-site will be dependent on the facility usage rate.

4.3 Conceptual Facility Design and Operation

Conceptual facility layouts for the two technologies selected are provided in Figures 4-2 and 4-3. As indicated in these figures, the facility should be laid out into zones in order to conduct facility operations in a safe and efficient manner while minimizing exposure to bio-hazardous waste. The different zones (or areas) could include:

- Bio-hazardous waste drop-off zone and clean/disinfected empty bin loading zone;
- Bio-hazardous waste weighing zone;
- Bio-hazardous waste cold storage zone;
- Waste tipping and treatment zone;

- Re-usable cart/bin cleaning and drying and storage zone;
- Chemical storage zone;
- Office/administration zone;
- Decontamination zone;
- Non-treatable hazardous waste storage zone; and,
- Treated waste collection zone.

The building should be a pre-engineered building, erected on slab-on-grade foundations complete with required electrical and mechanical systems. The building and equipment foundations will need to be designed of sufficient load bearing capacity in order to support the waste treatment equipment and all associated facility equipment. The building should be steel frame with metal roofing. Complete exterior walls around the facility will not be required given the fact that the treatment technologies will generate considerable amount of heat. For this reason, the treatment facility should be fenced. The cold storage facility should be designed to operate outdoors as it would be located adjacent to the facility building (as indicted in Figures 4-2 and 4-3). The office space, washrooms, decontamination rooms, and the chemical storage area should be complete with walls and doors (as appropriate). In addition, the cart cleaning area should also be closed-in to contain spray cleaning activities.

The following subsections outline the general approach for conducting day-to-day operations of a typical bio-hazardous waste treatment facility.

4.3.1 Site Access

Due to the nature of the waste and the operations of the facility, site access must be restricted to authorized personnel. Given the fact that the treatment facility will be located at the Deglos landfill site, the need to fence the bio-hazardous treatment facility will need to be evaluated. However, in order to limit human exposure to bio-hazardous wastes, the treatment facility grounds should be fenced, with access limited through one (1) security checkpoint. Safety placards and warning signs should be posted in key areas of the facility to make the public aware of the potential dangers on-site.

All employees of the treatment facility should be issued photo-identification cards and required to pass through the security checkpoint whenever entering or exiting the treatment facility. All delivery vehicles must pass through the security checkpoint as well.

All visitors must be pre-approved for site access. Only visitors with scheduled appointments should be allowed to enter the facility with restrictions to the area in which they can visit. In addition, all visitors must receive on-site safety training. Safety training for visitors can be in the form of a 30-minute video presentation which can be viewed at the administration office at the facility. A visitor safety compliance card should be issued and made valid for a limited time (e.g. three (3) months). Throughout the site visit, each visitor must be accompanied by a designated facility employee. Certain areas of the site may remain restricted to visitors as deemed appropriate by the facility manager.

4.3.2 Bio-Hazardous Waste Collection

Bio-hazardous waste generated at the various hospitals should be picked-up on a daily basis. Smaller amounts of bio-hazardous waste from the lower volume health clinics may be collected every other day depending on the quantity of waste being generated. If necessary, daily waste collection from the health clinics can also be performed. In addition, single or multiple pick-ups may be necessary each day for some bio-hazardous waste generators.

During waste collection, clean/disinfected empty containers (e.g. wheeled tote bins or tote boxes) will be dropped-off at the bio-hazardous waste generator facility and exchanged for the bio-hazardous waste filled containers. The number of containers and their ID numbers will be recorded by the vehicle driver on the waste manifest forms. The bio-hazardous waste filled containers should be covered, secured, and loaded onto the delivery vehicle for safe transport to the bio-hazardous waste incinerator facility.

Once the delivery vehicle is fully loaded with bio-hazardous waste, the delivery truck will return to the treatment facility. Upon arrival at the treatment facility, the filled containers should be off-loaded, inspected then placed into the weighing queue. Vehicles are then loaded with clean, empty containers. The delivery vehicle can then return to its delivery route as scheduled. This cycle should be repeated by multiple vehicles throughout the day, as needed. Each vehicle should have appropriate communication equipment in order to maintain communication with the facility administrator in case of emergencies, vehicle failure, traffic, or other related problems.

4.3.3 On-Site Bio-Hazardous Waste Handling

At the treatment facility, the waste filled containers are off-loaded from the delivery vehicles and inspected to ensure that the waste manifests are consistent with the wastes being off-loaded. Once accepted, the waste is then wheeled to the weighing queue. The signed copy of the manifest is to be retained by the driver and the remaining manifest copies are to be retained by the facility. Given that the drivers will likely be working for the treatment facility, all copies of the waste manifests can be retained by the facility. However, if the carrier is an independent waste hauler, then the carrier will need to maintain records of all waste transported, and thus will need to retain a copy of each waste manifest once waste is accepted by the treatment facility (consignee).

Using a floor level weigh scale, waste filled containers are to be weighed and their weighs recorded, along with the time and date they were weighed and the person performing the weighing. This information should be recorded on the waste manifests.

4.3.4 On-Site Bio-Hazardous Waste Storage

Once the waste is weighed, the waste is either placed in the queue for treatment, or it is placed into the cold storage facility until it is going to be treated. The treatment facility should have sufficient storage capacity to store a minimum of 48 hours (2 days) worth of bio-hazardous waste. If waste processing rates are relatively low compared to the waste generation rate, then a combination of lengthening the treatment system operating time and expanding the on-site cold storage facility will need to be considered. It is important to note that the storage capacity should be of sufficient size to provide up to 4 days of storage, such that wastes are not stored more than 4 days.

The bio-hazardous waste storage area should be securely closed during down times in order to keep the storage room as cool as possible. Sufficient room should be available within the storage room in order for waste containers to be easily manoeuvred. In addition, depending on the storage room configuration, the room can be equipped with two access doors, one for bringing waste in, and one for removing wastes. By doing so, waste that have been in storage for extended periods can be easily removed as new waste is placed in the storage room.

The conceptual facility design, presented in this report, has a cold storage facility with the dimensions: 8 ft high, 10 ft wide and 25 ft long. Thus providing approximately 250 ft^2 of storage capacity. If, for example, Rubbermaid brand 50 US gal containers are used for transporting bio-hazardous wastes, approximately 70 containers can be stored on-site in the storage facility. Furthermore, given that there are 5 hospitals and 34 health clinics, if 4 containers are provided to each hospital, and 1 container is provided for each health clinic, a total of 54 containers are needed on-site at any one time. Accordingly, at the very least, 110 containers are needed for the hospitals and health clinics. In addition, it is important to note that the containers used by the health clinics will likely be smaller than the containers used by the hospitals due to the relatively low bio-hazardous waste generation rates. Thus the above indicated storage capacity should suffice.

The actual size of the storage facility will be dependent on the number and size of containers selected during the implementation phase of this project. Consideration should also be given for providing cold storage space for all bio-hazardous waste generated by the various waste generating facilities.

4.3.5 Container Processing

As described above, once the containers holding bio-hazardous waste are brought to the treatment facility, they are inspected, weighted, placed in cold storage until the waste within the container is to be treated. When the waste is to be treated, the containers are tipped and the waste emptied into the feed mechanism of the treatment technology. After being emptied, the containers should then be re-inspected for any damage, cleaned and disinfection prior to reuse. Container disinfecting can be accomplished with the use of steam and disinfectant, or a high-pressure washer using hot water and disinfectant. Following disinfection, the cleaned, empty containers should be dried prior to being loaded back onto the delivery vehicles and reused to collect bio-hazardous waste. Water should be collected in floor drains and discharged with the sanitary (or grey) water generated at the facility.

The containers should be cleaned after each use so as to eliminate the possibility of cross-contamination as well as odours. Damaged containers should be repaired or replaced as necessary.

4.3.6 Health and Safety

In order to ensure the health and safety of the treatment facility personnel and any visitors to the facility, a comprehensive Health and Safety Plan (H&SP) should be developed and implemented. A copy of the plan should be kept on-site for quick reference. The plan should include training of all staff by qualified personnel, a comprehensive instruction manual, adequate hygienic facilities, suitable monitoring plans (e.g. stack emission monitoring in the case of an incinerator facility), and the banning of activities that can cause health or safety risks on-site. All employees should be instructed on all relevant rules, procedures and statutory requirements concerning workplace health and safety. An integral component of the H&SP will be the implementation of a medical screening program for all full-time employees. In addition, employees who are at highest risk of being exposed to the bio-hazardous waste would require additional protection through vaccination for Hepatitis B.

The H&SP should outline emergency equipment and first aid materials available on-site, as well as outlining emergency procedures for handling various emergencies including fires, equipment failure, accidental chemical and/or bio-hazardous waste spills, and personal injuries. Qualified staff should be instructed on appropriate emergency procedures, and should undergo regular training sessions and practice drills to simulate accidents and fires. Furthermore, all personnel should be required to wear proper protective clothing at all times during the handling and processing of wastes. An outline of the minimum personal protective equipment requirements including occupational health and safety issues are provided in Sections 3.6 and 3.7 of this waste management program.

In order for the H&SP to be properly implemented, a Site Safety Officer should be on-site to deal with all issues and concerns regarding the safety and protection against accidents of all staff and labour. This officer should be qualified for this work and should have the authority to take appropriate protective measures to prevent accidents.

4.3.7 Facility Staffing

The following facility staffing requirements are provided for illustrative purposes only and are based on the conceptual design presented in this document. It is important to note that the actual number of personnel required to operate the treatment facility will ultimately be dependent on the technology selected, the final design of the facility, and the selected treatment capacity.

The conceptual treatment facility would require an average of five (5) personnel per day to operate the facility and two (2) drivers to operate the bio-hazardous waste transport vehicles. If the facility operates eight (8) hour per day, six (6) days per week, and personnel are expected to work only 40 hours per week , then additional part-time workers would be required in order to operate the facility for six days. Approximately three (3) additional part-time workers. Alternatively, existing staff can be utilized by working overtime for the additional two days.

The conceptual treatment facility has been sized to treat approximately 600 kg of bio-hazardous waste per day, during an eight hour day, six days per week. If bio-hazardous waste generation rates exceed equipment capacity, then additional operating shifts can be added in order to handling the additional waste load. In this case, additional personnel would be needed. However, the number of personnel required for additional shifts would not necessarily double for each additional shift of operation added.

Based on the preliminary design, the facility personnel would include:

- Facility Administrator/Chief Engineer (1 full-time employee)
- Receptionist/Secretary (1 full-time employee, 1 part-time employee)
- Equipment Operator/Waste Handler (1 full-time employee)
- Cleaning Staff/Waste Handler (1 part-time employee)
- Site Security (1 full-time employee, 1 part-time employee)
- Drivers (2 full-time employee, 2 part-time employee)
- House Keeping (1 part-time)

A job description suitable for each of the above noted staff members is provided below.

Facility Administrator/Chief Engineer: The Facility Administrator/Chief Engineer (FA/CE) should be college-educated, preferably with a professional engineering certification (or equivalent) with a minimum of five years experience with chemical processing systems and a minimum five (5) years experience with facility management. The work would require experience with using personal computers and software. The FA/CE would coordinate the facility operations including facility budget, public relations, safety, waste collection, and truck routing. In addition, the FA/CE would also be the liaison between SLSWMA, Ministry of Health, Ministry of Agriculture, Saint Lucia Air and Sea Port Authority, hospital administrators, and other governmental authorities (as needed). In addition, the FA/CE would be responsible for all equipment operations, troubleshooting, maintenance, repair, utilities, chemical stock and inventory, spare parts inventory, and overall equipment efficiency. The FA/CE would manage and schedule all shift work, operators and labourers. In addition, the FA/CE should be trained as the facility health and safety officer.

Receptionist/Secretary: The Receptionist/Secretary (RS) shall have a minimum of five (5) years of experience as an executive assistant. No technical knowledge is necessary. The RS will be responsible for assisting the FA and other senior staff with execution of the administrative operations of the facility. This work would require experience with computers, word processing and spread sheet software programs, scheduling appointments, answering telephones, tracking vehicles, filing and other executive assistant duties.

Equipment Operator/Waste Handler: The Equipment Operator/Waste Handler (EO) should be college-educated, preferably with a degree in mechanical and/or electrical engineering with a minimum of five (5) years experience with chemical processing systems. The EO/WH should be responsible for the operation of the waste treatment equipment and support equipment including monitoring and maintaining operating conditions within design parameters. The EO/WH would report any operational problems to the FA/CE and assist the FA/CE in resolving any technical problems. In addition, the EO/WH would also empty waste bins, clean empty bins, and aid in off-loading waste and loading empty clean containers into the transport vehicles. In the absence of the FA/CE, the EO/WH would manage the facility. In addition to the EO/WH's regular duties, the EO/WH should also be trained as the health and safety officer (in the absence of the FA/CE), thus ensuring that at least one health and safety officer is present on-site during all operation hours.

Cleaning Staff/Waste Handler : The Cleaning Officer/Waste Handler (CO/WH) should have a high-school education. The CO/WH would be responsible for emptying waste containers, cleaning empty waste containers, loading and off-loading bio-hazardous waste vehicles, general facility housekeeping, and filling out manifests forms. The CO/WH could also be mechanically inclined in order to repair and maintain the vehicles and other mechanical equipment used at the disposal facility.

Drivers: The Drivers should have a high-school education. The drivers should have two years experience with waste handling practices, a valid drivers license (or certificate) for operating bio-hazardous vehicles, experience with general maintenance and repair of vehicles, and a good knowledge of the roadways in Saint Lucia. The Driver would be responsible for collected waste, loading and off-loading waste, and maintaining vehicles.

Security Officer: The Security Officer should have a high-school education. The Security Officer would be responsible for manning access to the site and into the facility. The security officer would only allow access to the facility to authorized personnel or those people with special written permission by senior facility staff (e.g. expected visitors). Depending on the night security at the Deglos landfill, the need for night security would need to be evaluated.

House Keeping Staff: House Keeping staff should have a high-school education. The House Keeping staff would be responsible for keeping the facility grounds, bathrooms, offices and other non-restricted areas clean. House Keeping staff would only work a couple of hours two to three times per week. If cleaning services are required more frequently, then additional working hours can be added to their schedule.

Table 4-1: Summary of Facility Personnel Requirements.

Personnel Positions	M	T	W	T	F	S	S
Facility Administrator/Chief Engineer	x	x	x	x	x		
Secretary/Reception	x	x	x	x	x		
Secretary/Reception (part-time)						x	
Equipment Operator/Waste Handler			x	x	x	x	
Cleaning Staff/Waste Handler	x	x				x	
Security Officers	x	x	x	x	x		
Security Officers						x	
Driver	x	x	x	x	x		
Driver	x	x	x	x	x		
Driver						x	
Driver						x	
House Keeping Staff		(x)		(x)		(x)	

Figure 4-1:Site Diagram of the Deglos Landfill Recycling Area.

Figure 4-2:Conceptual Incinerator Treatment Facility Layout.

Figure 4-3:Conceptual Autoclave Treatment Facility Layout.

5.0 COST SUMMARY OF BIO-HAZARDOUS WASTE TREATMENT FACILITY

The following cost analysis was conducted in order to provide Saint Lucia Solid Waste and the various other stake holders with cost estimates associated with the two bio-hazardous waste treatment technologies selected for review, as well as the cost estimates associated with the design, construction, and operation of a bio-hazardous waste treatment facility. These cost estimates are budgetary costs only and are based on the assumptions made including current market values. Cost items which could not be easily estimated, conservative assumptions were made in order to ensure that actual costs would likely be lower than those costs presented in this report.

As previously indicated, bio-hazardous waste production rates in Saint Lucia are as follows:

- 2,100 kg/week (or approximately 110 tonnes/yr) of medical hazardous waste;
- 1,200 kg/week (or approximately 63 tonnes/yr) of condemned meat; and,
- 200 kg/week (or 10 tonnes/yr) of quarantined food.

In addition, for the purposes of this cost summary, GPEC assumed that the treatment facility would be operated (i.e. treat waste) six days per week. Under this assumption, the daily combined bio-hazardous waste production rate would be approximately 600 kg/day. Accordingly, the cost estimates associated with the treatment technologies and facility are based on the combined daily bio-hazardous waste production rate of approximately 600 kg/day.

There are two key groups of costs that were evaluated in estimating the costs associated with the treatment facility. The first group are capital costs, which consists primarily of all materials and equipment costs to initially construct the facility and procure vehicles. The second group are operational costs, which consist of all costs associated with the day to day running of the facility and vehicles.

It is important to note that all costs leading up to the procurement of the bio-hazardous waste treatment technology and facility (e.g. costs associated with the tendering process) are not included in the cost estimates provided in the following subsections. In addition, project management costs are also not included in the cost estimates provided below.

5.1 Capital Costs Associated with An Incinerator Treatment Facility

An Incinerator Treatment Facility would require, as a minimum, the procurement of the following major capital equipment:

- A Fixed Hearth Incinerator rated at 100 kg/hr (with all associated equipment including the emissions stack, electronic controls, quench/after cooler, acid scrubber, and automatic waste feed);
- Pre-engineered building;
- Weigh scale;
- Cold storage facility;
- Ash collection bin;
- Above ground fuel storage tank;
- Bio-hazardous waste carts;
- Waste cart washing system;
- Waste transportation vehicles;
- Maintenance tools and supplies;
- Spare parts;
- Sanitary and decontamination facilities; and,
- Computer systems and other office equipment and supplies;

The cost estimate of the incinerator equipment, rated at 100 kg/hr, equipped with an emissions stack, electronic controllers, quench/after cooler, acid scrubber, and automatic waste feeder, is up to US $435,000.00. This cost includes design, manufacturing, pre-commissioning testing, shipping to the Deglos site, installation, spare parts, and commissioning of the equipment.

The cost estimate for the remaining equipment required to operate the treatment facility, as listed above, is up to US $425,000.00.

The total estimated capital costs for a fixed hearth incinerator treatment facility designed to treat approximately 600 kg/day of bio-hazardous waste is up to US $860,000.00. It is important to note that the actual costs incurred by the Government of Saint Lucia for an incinerator treatment facility equipped with all the items listed above may differ from the cost estimates provided in this report. The actual costs will depend on the equipment selected.

Provided in the table on the following page is the estimated cost breakdown for all major components of an incinerator system and treatment facility building and associated equipment.

Table 5-1: Estimated Cost Breakdown of all Major Components of an Incinerator Treatment Facility.

Item No.	Equipment	Total US $	Total EC $
A. Incinerator Equipment			
1	Fixed Hearth with Stack	115,000.00	310,500.00
2	Quench/ After Cooler and Acid Scrubber	160,000.00	432,000.00
3	Automatic Waste Feeder	50,000.00	135,000.00
4	Pre-Commissioning Services	5,000.00	13,500.00
5	Spare Parts Inventory	20,000.00	54,000.00
6	Shipment of Equipment to Deglos Site	25,000.00	67,500.00
7	Installation/Commissioning/Training	20,000.00	54,000.00

8	Contingency Planning (approx. 10%)	40,000.00	108,000.00
9	**SUBTOTAL**	**435,000.00**	**1,174,500.00**
B.	**Treatment Facility Building and Associated Equipment**		
10	Waste Weigh Scale	7,000.00	18,900.00
11	Cold Storage Facility (10 ft x 25 ft x 8ft)	14,000.00	37,800.00
12	Waste Cart Washing System	7,000.00	18,900.00
13	Pre-Engineered Building (2000 ft^2)	200,000.00	540,000.00
14	Bio-Hazardous Waste Cart (Re-usable)	15,000.00	40,500.00
15	Ash Waste Collection Bin	1,000.00	2,700.00

16	Office Equipment and Supplies	10,000.00	27,000.00
17	Waste Transport Vehicles (two vehicles)	100,000.00	270,000.00
18	Spare Parts	30,000.00	81,000.00
19	Miscellaneous	30,000.00	81,000.00
20	Shipment of Cold Storage Facility	11,000.00	29,700.00
21	**SUBTOTAL**	**425,000.00**	**1,147,500.00**
C.	**Bio-Hazardous Waste Treatment Facility**		
22	**TOTAL COST**	**860,000.00**	**2,322,000.00**

5.2 Operational Costs Associated with An Incinerator Treatment Facility

The operational costs associated with an incinerator facility will depend on various items. These will include, but not limited to, the equipment selected, the design and management of the treatment facility, utilities available and their associated costs, selected labour force, insurance costs, loan costs, method of depreciation of equipment, and hours of operation.

For the purpose of this cost summary, the following operational cost items were considered:

- Labour force;
- Utility requirements;
- Payback of capital costs;
- Depreciation associated with vehicles and the incinerator equipment;
- Insurance;
- Facility maintenance and cleaning supplies;
- Maintenance and repair associated with vehicles and the incinerator equipment;
- Scrubber reagent and disinfectant chemicals; and
- Office supplies;

The annual operating costs to operate an incinerator treatment facility is estimated to be up to EC $ 1,240,000.00. The following assumptions were made in estimating the annual operational costs:

- Electricity rate is EC $0.55 per kW hr;
- Diesel fuel rate is EC $6.00 per imp gal;
- Water usage rate is EC $ 14.00 per 1,000 imp gal;
- Loan payments for capital costs of US $860,000.00 amortized over 10 years at 10% interest, compounded monthly;

- Incinerator depreciation costs based on 15 year lifespan of equipment, using straight line depreciation with no salvage value at the end of the lifespan;
- Vehicle depreciation costs based on 7 year lifespan of equipment, using straight line depreciation with no salvage value at the end of the lifespan;
- Scrubber chemical usage rate of approximately 50 gal per day;
- Scrubber and quenching water usage rate of approximately 50 gal/hr;
- Vehicle fuel usage rate of approximately 400 litres per week;
- Treatment facility has a labour force as previously indicted (e.g. approximately 6 full time and 6 part time employees); and,
- Facility operating hours at 8 hours per day, 6 days per week.

Provided in the table on the following page is a cost breakdown for the operation of the conceptual incinerator facility presented in this report. The facility is designed to treat approximately 600 kg/day of bio-hazardous waste and operate eight (8) hours per day, six (6) days per week.

Table 5-2: Typical Operational Costs for an Incinerator Treatment Facility.

Item No.	ITEM	Units	Unit Cost EC $ / Unit	Total Cost EC $ / Annum
1	**Annual Labour Costs**			
	Facility Administrator/Chief Engineer (1 full time)	hr	40.00	85,000.00
	Receptionist/Secretary (1 part time, 1 full time)	hr	13.00	40,000.00
	Equipment Operator/Waste Handler (1 full time)	hr	30.00	64,000.00
	Cleaning Staff/Waste Handler (1 part time)	hr	12.00	12,000.00
	Security Officer (1 full time, 1 part time)	hr	10.00	30,000.00
	Vehicle Drivers (2 full time, 2 part time)	hr	10.00	55,000.00
	House Keeping (part time)	hr	5.00	4,000.00
	SUBTOTAL			**290,000.00**
2	**Incinerator Equipment Utility Costs**			
	Electricity for incinerator	kW hr	0.55	10,000.00
	Fuel for incinerator	imp gal	6.00	100,000.00
	Water consumption by incinerator (quench/after cooler and scrubber system)	1000 gal	14.00	3,000.00
	SUBTOTAL			**113,000.00**
3	**Facility Utility Costs**			
	Electricity for Cold Storage Facility	kW hr	0.55	30,000.00
	Fuel for cart pressure washer	imp gal	6.00	2,000.00
	Fuel for vehicles	imp gal	6.00	150,000.00
	Water consumption by pressure washer	1000 gal	14.00	60,000.00
	Water consumption by rest of facility	1000 gal	14.00	2,000.00
	SUBTOTAL			**244,000.00**

4	**Equipment Costs**			
	Capital costs (loan payments for US $ 860,000.00)			375,000.00
	Incinerator equipment maintenance/repair			30,000.00
	Depreciation of incinerator (15 yr life)			80,000.00
	Scrubber Reagent (50% caustic solution)			8,000.00
	Vehicle maintenance/repair			15,000.00
	Depreciation of vehicles (7 yr life)			15,000.00
	Miscellaneous			70,000.00
	SUBTOTAL			**593,000.00**
5	**TOTAL OPERATIONAL COSTS**			**1,240,000.00**

5.3 Capital Costs Associated with A Steam Sterilization Treatment Facility

A steam sterilization treatment facility would require, as a minimum, the procurement of the following capital equipment:

- A steam sterilizer rated at 600 kg/day (with all associated equipment including the boiler, condenser, waste tipper, electronic controller, shredder, and compactor);
- Pre-engineered building;
- Weigh scale;
- Cold storage room;
- Treated waste collection bin;
- Above ground fuel storage tank;
- Waste carts;
- Waste cart washing system;
- Waste transportation vehicles;
- Maintenance tools and supplies;
- Spare parts;
- Sanitary and decontamination facilities; and,
- Computer system and other office equipment and supplies.

The cost estimate of the steam sterilization equipment, rated at 600 kg/day, equipped with a boiler, controller, shredder, compactor, and waste tipper, is up to US $350,000.00 which includes design, manufacturing, pre-commissioning testing, shipping to the Deglos site, installation, spare parts, and commissioning of the equipment.

The cost estimate for the remaining equipment required to operate the treatment facility, as listed above, is up to US $425,000.00.

Thus the total estimated capital cost for a steam sterilization treatment facility designed to treat approximately 600 kg/day of bio-hazardous waste is up to US $775,000.00. It is important to note that the actual costs incurred by the Government of Saint Lucia for a steam sterilization treatment facility equipped with all the items listed above may differ from the cost estimates provided in this report. The actual costs will depend on the equipment selected.

Provided in the table on the following page is the estimated cost breakdown for all major components of a steam sterilization system and treatment facility building and associated equipment.

Table 5-3: Estimated Cost Breakdown of all Major Components of a Steam Sterilization Treatment Facility.

Item No.	Equipment	Total US $	Total EC $
A. Steam Sterilization Equipment			
1	Steam sterilizer vessel (equipment)	110,000.00	297,000.00
2	Automatic Waste Tipper (for some systems)	5,000.00	13,500.00
3	Boiler	15,000.00	40,500.00
4	Shredder (with or without conveyor system)	115,000.00	310,500.00
5	Compactor	40,000.00	108,000.00
6	Spare Parts Inventory	10,000.00	27,000.00
7	Shipment of Equipment to Deglos Site	15,000.00	40,500.00

8	Installation/Commissioning/Training	10,000.00	27,000.00
9	Contingency Planning (approx. 10%)	30,000.00	81,000.00
10	**SUBTOTAL**	**350,000.00**	**945,000.00**
B.	**Treatment Facility Building and Associated Equipment**		
10	Waste Weigh Scale	7,000.00	18,900.00
11	Cold Storage Facility (10 ft x 25 ft x 8ft)	14,000.00	37,800.00
12	Waste Cart Washing System	7,000.00	18,900.00
13	Pre-Engineered Building (2000 ft^2)	200,000.00	540,000.00
14	Bio-Hazardous Waste Cart (Re-usable)	15,000.00	40,500.00

15	Treated Waste Collection Bin	1,000.00	2,700.00
16	Office Equipment and Supplies	10,000.00	27,000.00
17	Waste Transport Vehicles	100,000.00	270,000.00
18	Spare Parts	30,000.00	81,000.00
19	Miscellaneous	30,000.00	81,000.00
20	Shipment of Cold Storage Facility	11,000.00	29,700.00
21	**SUBTOTAL**	**425,000.00**	**1,147,500.00**
C.	**Bio-Hazardous Waste Treatment Facility**		
22	**TOTAL COST**	**775,000.00**	**2,092,500.00**

5.4 Operational Costs Associated with A Steam Sterilization Treatment Facility

The operational costs associated with a steam sterilization facility will depend various items. These will include, but are not limited to, on the equipment selected, the design and management of the treatment facility, utilities available and their associated costs, selected labour force, insurance costs, loan costs, hours of operation, and any tipping fees.

For the purposed of this cost analysis, the following operational cost items were considered:

- Labour force;
- Utility requirements;
- Payback of capital costs;
- Depreciation associated with vehicles and the steam sterilizer equipment;
- Insurance;
- Facility maintenance and cleaning supplies;
- Maintenance and repair associated with vehicles and the steam sterilizer equipment;
- Boiler water chemicals; and
- Office supplies;

The annual costs to operate a steam sterilization treatment facility is estimated to be up to EC $ 1,120,000.00. The following assumptions were made in estimating the annual operational costs:

- Electricity rate is EC $0.55 per kW hr;
- Diesel fuel rate is EC $6.00 per imp gal;
- Water usage rate is EC $ 14.00 per 1000 imp gal;
- Loan payments for capital costs of US $ 775,000.00, amortized over 10 years at 10% interest, compounded monthly;

- Steam Sterilizer depreciation costs based on 15 year lifespan of equipment, using straight line depreciation with no salvage value at the end of the lifespan;

- Vehicle depreciation costs based on 7 year lifespan of equipment, using straight line depreciation with no salvage value at the end of the lifespan;

- Vehicle fuel usage rate of approximately 400 litres per week;

- Treatment facility has a labour force of approximately 6 full time and 6 part time employees; and,

- Facility operating hours of 6 days per week, 8 hours per day.

Provided in the table on the following page is a cost breakdown for the operation of the conceptual steam sterilization treatment facility presented in this report. The facility is designed to treat approximately 600 kg/day of bio-hazardous waste and operate eight (8) hours per day, six (6) days per week.

Table 5-4: Typical Operational Costs for a Steam Sterilization Treatment Facility.

Item No.	ITEM	Units	Unit Cost EC $ / Unit	Total Cost EC $ / Annum
1	**Annual Labour Costs**			
	Facility Administrator/Chief Engineer (1 full time)	hr	40.00	85,000.00
	Receptionist/Secretary (1 part time, 1 full time)	hr	13.00	40,000.00
	Equipment Operator/Waste Handler (1 full time)	hr	30.00	64,000.00
	Cleaning Staff/Waste Handler (1 part time)	hr	12.00	12,000.00
	Security Officer (1 full time, 1 part time)	hr	10.00	30,000.00
	Vehicle Drivers (2 full time, 2 part time)	hr	10.00	55,000.00
	House Keeping (part time)	hr	5.00	4,000.00
	SUBTOTAL			**290,000.00**
2	**Steam Sterilizer Equipment Utility Costs**			
	Electricity for Steam Sterilizer system (e.g. shredder, boiler, and compactor)	kW hr	0.55	50,000.00
	Water consumption by a steam sterilizer system	1000 gal	14.00	13,000.00
	SUBTOTAL			**63,000.00**
3	**Facility Utility Costs**			
	Electricity for Cold Storage Facility	kW hr	0.55	30,000.00
	Fuel for cart pressure washer	imp gal	6.00	2,000.00
	Fuel for vehicles	imp gal	6.00	150,000.00
	Water consumption by pressure washer	1000 gal	14.00	60,000.00
	Water consumption by rest of facility	1000 gal	14.00	2,000.00
	SUBTOTAL			**244,000.00**

4	**Equipment Costs**			
	Capital costs (loan payments for US $ 775,000.00)			335,000.00
	Steam Sterilizer equipment maintenance/repair			20,000.00
	Depreciation of steam sterilizer (15 yr life)			65,000.00
	Boiler Water Chemicals			3,000.00
	Vehicle maintenance/repair			15,000.00
	Depreciation of vehicles (7 yr life)			15,000.00
	Miscellaneous			70,000.00
	SUBTOTAL			**523,000.00**
5	**TOTAL OPERATIONAL COSTS**			**1,120,000.00**

5.5 Summary Comparison Between Incineration and Steam Sterilization

Based on the currently available technologies, both steam sterilization (autoclave) and incineration technologies are designed to effectively treat bio-hazardous wastes (i.e. they are able to achieve 6 log kill). However, each of these technologies are limited in what they can treat, as outlined in the following discussion.

The following are key characteristics associated with the incineration bio-hazardous wastes:

- Can treat all bio-hazardous waste streams, depending on composition of the waste stream.

- Cannot be used to treat some healthcare wastes such as mercury or cadmium (from thermometers and used batteries), heavy metal containing pharmaceuticals, compressed gas containers, halogenated plastics (e.g. PVC).

- Typically can render the waste as unrecognizable.

- Requires air pollution control equipment (APCE) to minimize the emission of air pollutants, thus increasing capital expenditure. Typical APCE includes an acid scrubber system to remove hydrogen chloride (HCl) from the gas stream, a quenching system to cool gas emissions, and a bag house to remove airborne particulates (only needed for systems which agitate the waste while burning).

- Typically requires more fuel compared to other treatment technologies, thus increasing the cost per unit waste treated.

- Ash residue can be a potential leachate problem when landfilled if metals are present in the waste feed.

- Incineration is a well established bio-hazardous waste treatment technology.

The following are key characteristics associated with the steam sterilization (autoclaving) of bio-hazardous wastes:

- Depending on the treatment process, steam sterilizers can typically treat all bio-hazardous waste streams generated in the healthcare industry except for cytotoxic chemicals, other pharmaceuticals, and compressed gas containers.

- Depending on the autoclaving technology, not all steam sterilization systems agitate or fragment wastes during the sterilization process. Thus some systems will not achieve 6 log kill for some dense waste streams (such as anatomical wastes).

- Autoclaving requires steam, thus if steam is not available, a boiler is require for steam generation. This results in an increase in capital costs.

- Autoclaving does not render the waste unrecognizable, thus a shredder technology is required. This results in an increase capital and operational costs. In addition, if landfill costs are a concern, a compactor unit will also be needed, thus further increasing capital and operational costs.

- Typically has lower operational costs compared to other technologies such as incineration.

- Steam sterilization is well established for sterilizing microbiological wastes.

- Autoclaving systems are relatively simply to operate.

The following is a summary of the capital and operational costs associated with the steam sterilization and incineration treatment technologies investigated, along with the associated treatment facility costs.

Cost Items	**Incinerator**	**Steam Sterilizer**
Capital costs of treatment equipment	US $ 435,000	US $ 350,000
Capital costs of treatment facility	US $ 425,000	US $ 425,000
Total Capital Costs	**US $ 860,000**	**US $ 775,000**
Total Operational Costs	**EC $1,240,000 / yr**	**EC $1,120,000 / yr**

APPENDIX A: GENERAL RISKS ASSOCIATED WITH BIO-HAZARDOUS WASTES

APPENDIX B: LIST OF INFECTIOUS AGENTS FOUND IN BIO-HAZARDOUS WASTES

APPENDIX C: BIO-HAZARDOUS WASTE MANIFESTING AND TRACKING FORM

APPENDIX D: ACCIDENT/INCIDENT REPORTING FORM

APPENDIX E: REVIEW OF AVAILABLE BIO-HAZARDOUS WASTE TREATMENT TECHNOLOGIES

APPENDIX F: WORKPLACE HAZARDOUS MATERIAL INFORMATION SYSTEM CLASSIFICATION

APPENDIX G: REFERENCES

APPENDIX H: LIST OF ACRONYMS AND TERMS

APPENDIX A

GENERAL RISKS ASSOCIATED WITH BIO-HAZARDOUS WASTES

A.0 General Risks Associated With Bio-Hazardous Wastes

Hospitals, health clinics, medical laboratories, and doctors', dentists' and veterinarians' offices, regularly dispose of materials that have been used in providing some form of healthcare or medical treatment. Some of these materials are potentially infectious (i.e. exposure to these wastes has the potential to cause some kind of infection and/or disease). Examples of medical bio-hazardous wastes include: "sharps"- which consist of hypodermic needles and syringes, IV needles, scalpel blades, and glass items, as well as all other wastes that are capable of cutting or puncturing; items containing or soaked with blood or certain other body fluids; human or animal organs or body parts; lab cultures that may contain disease-causing agents; and things like gloves, bedding, dressings, sponges, and other items that have been used in surgery, autopsy, or treatment of patients with certain contagious diseases. Other bio-hazardous wastes which are also potentially infectious and/or able to cause disease are condemned meats (e.g. livestock meats, fish and poultry) and quarantined foodstuff(e.g. plant material quarantined by the port authority). Thus, bio-hazardous wastes include those wastes, as described above, which have the potential to cause infection and/or disease.

All individuals exposed to bio-hazardous wastes are potentially at risk, including those within healthcare facilities that generate these hazardous waste, and those outside these sources who either handle such wastes or are exposed to it as a consequence of careless management. The main groups at risk are the following:

- medical doctors, nurses, healthcare auxiliaries, and hospital maintenance personnel;
- patients in healthcare facilities or receiving home care;
- visitors to healthcare facilities;
- workers in support services allied to healthcare establishments, such as laundries, waste handling, and transportation;
- workers involved in the handling of quarantined foodstuff, such as port authority personnel;
- workers involved in the handling of condemned meats, from various sources including ports, abattoirs, packaging facilities, and grocery stores; and,
- workers in waste treatment and disposal facilities, including scavengers.

The hazards associated with scattered, small sources of health-care waste should not be overlooked; waste from these sources includes that generated by home-based healthcare, such as dialysis, and that generated by illicit drug use (usually intravenous).

As indicated above, the major concern created by bio-hazardous waste is that it can cause infection and/or disease, and of particular concern is the potential infection with human immunodeficiency virus (HIV) and hepatitis B and C (HBV and HCV), due to the strong evidence of transmission via healthcare wastes. The existence in healthcare establishments of bacteria resistant to antibiotics and chemical disinfectants may also contribute to the hazards created by poorly managed healthcare waste. It has been demonstrated, for example, that plasmids from laboratory strains contained in healthcare waste were transferred to indigenous bacteria via the waste disposal system. Moreover, antibiotic-resistant *Escherichia coli* have been shown to survive in an activated sludge wastewater treatment plant, although there does not seem to be significant transfer of this organism under normal conditions of wastewater disposal and treatment.

However, it is important to keep in mind that certain types of materials are classified as bio-hazardous waste because they might cause disease. Blood, for example, is considered infectious because it might contain viruses. However, any given sample of blood or blood-soaked material may, in fact, be harmless.

In order for a person to develop a disease or infection through exposure to bio-hazardous waste, three events must occur. ***First***, infectious agents (e.g. viruses, or bacteria) must be present in the waste and must survive in the waste in large enough quantities to be able to cause an infection if an exposure occurs. The hepatitis B virus (HBV), for example, is usually present in the blood of persons infected with hepatitis B in higher quantities than the human immunodeficiency virus (HIV) (which is the virus responsible for causing acquired immunodeficiency syndrome [AIDS]) is in persons infected with HIV. For this reason, it is much easier to contract hepatitis B than AIDS from exposure to infected blood. Furthermore, HIV normally does not survive for very long outside a living organism.

In general, pathogenic microorganisms have limited ability to survive in the open environment, with out a host organism (e.g. human, animal, plant, etc.). This ability is specific to each microorganism and is a function of its resistance to environmental conditions such as temperature, humidity, ultraviolet irradiation, availability of organic substrate material, presence of predators, and other factors. HBV is very persistent in dry air and can survive for several weeks on a surface; it is also resistant to brief exposure to boiling water. It can survive exposure to some antiseptics and to 70% ethanol and remains viable for up to 10 hours at a temperature of 60 ^{o}C. The Japanese Association for Research on Medical Waste found that an infective dose of hepatitis B or C virus can survive for up to a week in a blood droplet trapped inside a hypodermic needle.

By contrast, HIV is much less resistant. It survives for no more than 15 minutes when exposed to 70% ethanol and only 3-7 days at ambient temperature. In addition, it becomes inactivated at 56 ^{o}C.

Bacteria are generally less resistant to environmental factors than viruses. However, less is known about the survival of ***prions*** and other agents of degenerative neurological diseases (e.g. Creutzfeldt-Jakob disease, kuru, scrapies, etc.), which seem to be very resistant.

With the exception of waste containing pathogenic cultures or excreta of infected patients, the microbial load of healthcare wastes is generally not very high. Furthermore, healthcare wastes do not seem to provide favourable media for the survival of pathogens, perhaps because they frequently contain antiseptics. Studies have shown that the concentration of indicator microorganisms in healthcare wastes are generally in concentrations similar to domestic wastes, and that survival rates are relatively low.

In evaluating the survival or spread of pathogenic microorganisms in the environment, the role of vectors such as rodents and insects should be considered. This applies to management of healthcare waste both within and outside healthcare establishments. Vectors such as rats, flies, and cockroaches, which feed or breed on organic waste, are well known passive carriers of microbial pathogens; their populations may increase dramatically where there is mismanagement of waste. Thus waste management strategies must identify a means (i.e. establish engineered controls) to minimize the spread of pathogenic microorganisms via vectors.

The ***Second*** event that must occur to develop a disease is an exposure has to occur in a manner that will be effective in transmitting the disease. There are four basic ways that a person can be exposed to infections:

- Through the skin due to a puncture, abrasion, or cut in the skin;
- Through mucous membranes in the eyes, nose, and mouth;
- By inhaling infectious agents; and,
- By ingesting infectious agents.

Not all of these "routes" of infection will actually transmit a given disease. For example, AIDS can only be transmitted by sexual contact; by contact with the blood of an infected person on mucous membranes, broken skin, or through needle sticks; or from a pregnant woman to her fetus. It cannot be transmitted by inhalation or by touching an infected person.

The ***Third and Final*** event necessary to occur in order for exposure to cause disease, is that enough of an infectious agent must be transmitted to the person who is exposed so that his immune system cannot effectively protect him or her from the disease.

However, even if the waste does contain a large enough concentration of a disease-causing agent, and exposure does occur in a way that could transmit the disease, disease may or may not develop. For example, HIV can be transmitted through being stuck by a needle that contains the blood of an HIV-infected person. However, the chance of contracting AIDS from a single needle stick, even if the needle does contain HIV-infected blood, has been estimated by the US Centers for Disease Control to be only approximately 0.4% (or 1 in 250). The chances of becoming infected with hepatitis B from a single needle-stick, even if the needle contains blood of an infected person, is between 6 and 30 percent. A person's chances of not contracting the disease from an exposure are usually better if he or she receives prompt medical attention.

In addition to being able to cause disease, bio-hazardous waste is also dangerous for other reasons. For example, sharps (such as scalpels, or broken glass) can cause cuts. Some of the material disposed of by hospitals and other healthcare facilities may be hazardous for other reasons as well. The waste may contain hazardous pharmaceutical chemicals such as cytotoxic drugs.

Many of the chemicals and pharmaceuticals used in healthcare facilities are hazardous (e.g. toxic, genotoxic, corrosive, flammable, reactive, explosive, shock-sensitive). These substances are commonly present in small quantities in health-care waste; larger quantities may be found when unwanted or outdated chemicals and pharmaceuticals are disposed. They may cause intoxication, either by acute or by chronic exposure, and injuries, including burns. Intoxication can result from absorption of a chemical or pharmaceutical through the skin or mucous membranes, or from inhalation or ingestion. Injuries to the skin, the eyes, or the mucous membranes of the airways can be caused by contact with flammable, corrosive, or reactive chemicals (e.g. formaldehyde and other volatile substances). The most common injuries are burns. Disinfectants are particularly important members of this group since they are often corrosive and used in large quantities in hospitals and other healthcare facilities. It should also be noted that reactive chemicals may form highly toxic secondary compounds.

Chemical residues, generated in healthcare facilities, that are discharged into the sewerage system may have adverse effects on the operation of biological sewage treatment systems or toxic effects on the natural ecosystems of receiving waters. Similarly, discharge of some pharmaceutical residues may also adversely effect the operation of biological sewage treatment systems or have toxic effects on the natural ecosystem of the receiving waters. These pharmaceutical residues may include antibiotics, heavy metals (such as mercury), phenols, derivatives, and disinfectants and antiseptics.

On the other hand, not all waste created at healthcare facilities is dangerous. Hospitals contain offices and cafeterias that create waste that is not dangerous, and much of the waste generated by patient care poses little threat to waste management workers. Even materials that have been classified as bio-hazardous waste will not always cause disease, instead they merely pose a risk that must always be considered in handling, storing, transportation and disposal.

APPENDIX B

LIST OF INFECTIOUS AGENTS FOUND IN BIO-HAZARDOUS WASTE

Agents of Bio-Hazardous Animal Wastes

12. Bacteria

a. Bacillus anthracis
b. Brucella - all species
c. Francisella tularensis, type A (biovar tularensis)
d. M. tuberculosis
e. Pseudomonas malleri; P. pseudomallei
f. Yersinia pestis

13. Viruses

a. Arenaviridae
   i. Lymphocytic choriomeningitis virus,
   ii. neurotropic strains

b. Bunyaviridae
   i. Unclassified Bunyavirus
      (1) Hantaan, Korean haemorrhagic fever and epidemic nephrosis viruses

c. Herpesviridae
   i. Gammaherpesvirinae
      (1) Genus Rhadinovirus: Herpesvirus ateles;
      (2) Herpesvirus saimiri

d. Retroviridae
   i. Oncovirinae
      (1) Genus Oncornavirus C
         (a) Human T-cell leukaemia/lymphoma virus (HTLV-I, HTLV-II,if cultured)
      (2) Genus Oncornavirus D
         (a) Mason-Pfizer monkey virus
         (b) Viruses from primates
   ii. Lentivirinae
      (1) Human immunodeficiency viruses (HIV -all isolates if cultured)

e. Rhabdoviridae
   i. Genus Vesiculovirus
      (1) Piry

ii. Genus Lyssavirus
(1) Rabies, street virus

f. Togaviridae
i. Genus Alphavirus
(1) Eastern equine encephalitis virus
(2) Chikungunya (recent isolates)
(3) Venezuelan equine encephalitis (except Strain TC-83)

g. Unclassified Viruses
i. Chronic infectious neuropathic agents (CHINAs) Kuru, Creutzfeldt-Jakob agent

h. Arenaviridae
i. Lassa, Junin, Machupo viruses

i. Bunyaviridae
i. Genus Nairovirus
ii. Crimean-Congo haemorrhagic fever

j. Filoviridae
i. Marburg virus
ii. Ebola virus

k. Flaviviridae
i. Tick-borne encephalitis complex, including:
(1) Russian Spring-Summer Encephalitis
(2) Kyasanur forest virus
(3) Omsk haemorrhagic fever virus

l. Herpesviridae
i. Alphaherpesvirinae
(1) Genus Simplexvirus: Herpes B virus (Monkey B virus)

m. Poxviridae
i. Genus Orthopoxvirinae
(1) Variola
(2) Monkeypox

14. Parasites

a. Echinococcus (gravid segments)

Agents of "Other" Bio-Hazardous Wastes Requiring Special Handling

1. Bacteria

a. Rickettsi
   i. Coxiella burnetii

2. Viruses

a. Arenaviridae
   i. Lassa, Junin, Machupo viruses

b. Bunyaviridae
   i. Genus Nairovirus
      (1) Crimean-Congo haemorrhagic fever

c. Filoviridae
   i. Marburg virus
   ii. Ebola virus

d. Flaviviridae
   i. Tick-borne encephalitis complex, including :
      (1) Russian Spring-Summer Encephalitis
      (2) Kyasanur forest virus
      (3) Omsk haemorrhagic fever virus

e. Herpesviridae
   i. Alphaherpesvirinae
      (1) Genus Simplexvirus: Herpes B virus (Monkey B virus)

f. Poxviridae
   i. Genus Orthopoxvirinae
      (1) Variola
      (2) Monkeypox

APPENDIX C

BIO-HAZARDOUS WASTE MANIFESTING AND TRACKING FORM

Saint Lucia Solid Waste Authority **Saint Lucia, W.I.**	**Department Address:**

BIO-HAZARDOUS WASTES MANIFESTING AND TRACKING

CONSIGNOR (GENERATOR)	
Consignor (Generator) Name and Mailing Address:	Telephone Number:
	Container Conditions:
Description and quantity of containers being released to carrier:	Biohazardous Containrer ID Number (if applicable):

CARRIER	
Carrier Name and Mailing Address:	Telephone Number:
	Vehicle ID Number:
Quantity of containers being released to consignee:	Biohazardous Containrer ID Number (if applicable):
Signature for waste release to consignee: Name (PRINT): Signature Date and Time	

Signature for waste release to carrier:

Name (PRINT):

Signature Date and Time

INSTRUCTIONS FOR COMPLETING BIO-HAZARDOUS WASTES MANIFESTING AND TRACKING FORM

COPY 1 – CONSIGNOR (GENERATOR) COPY: Mailed by Destination Facility to Consignor

COPY 2 -- DESTINATION FACILITY COPY: Retained by the Destination Facility (Consignee)

COPY 3 – CARRIER COPY: Retained by transporter

COPY 4 – CONSIGNOR COPY: Retained by the generator

CONSIGNEE

Consignee Name and Mailing Address:

Telephone Number:

Date and time received at facility:

Total weight recieved:

TREATMENT	DISPOSAL
Date and time treated:	Date and time treated waste disposed:

	Signature of treatment facility Manager: Name (PRINT): Signature	Signature of authorized landfill personnel: Name (PRINT): Signature

APPENDIX D

ACCIDENT/INCIDENT REPORTING FORM

Accident/Incident Reporting

Date and time of Incident:	Name of Person(s) Involved:		Check One: Employee ( ) Visitor ( )
Facility:	Immediate Supervisor:	Supervisor's Phone Number:	Location of Incident:
List operating personnel and witnesses:			
Describe the nature of the accident/incident (Please attach additional paper if necessary):			
Describe the task the employee was performing (or intended to perform):			
Describe how the accident/incident occurred (include sequence of events and extent of damage):			

Was task specific training conducted, including the communication of all safety procedures provided, prior to job assignment? (Explain training provided for job)			
Was there a source (object or substance) or pre-existing hazardous condition responsible for the accident/incident? (Identify source and explain)			
Was personal protective equipment required for the task? If so, please list what personal protective equipment was required for the job. Was the required personal protective equipment worn during the task?			
What corrective action(s) has/have been or will be taken to prevent a similar occurrence from occurring in the future?			
Date of Proposed Corrective Action Implementation:		Date Corrective Action Completed:	
Investigated By:	Date:	Reviewed By:	Date:

APPENDIX E

REVIEW OF AVAILABLE BIO-HAZARDOUS WASTE TREATMENT TECHNOLOGIES

E.0 Review of Available Bio-Hazardous Waste Treatment Technologies

Several bio-hazardous waste treatment technologies (as outlined below) are currently available. In general, these technologies have been designed to either destroy or inactivate the disease causing pathogens such that the waste no longer poses a of disease and/or infection. The following is a list of some of the more common bio-hazardous waste treatment technologies currently available:

- Incineration
- Steam sterilization (autoclaving)
- Chemical disinfection
- Low temperature infrared disinfection
- Thermal inactivation
- Gas/vapour sterilization
- Irradiation sterilization
- Plasma torch
- Pyrolysis
- Microwave disinfection

The following subsections briefly describe the different medical waste treatment technologies listed above.

E.1 Incineration

Incineration is the process by which waste materials are oxidized (or combusted) at high temperatures in the presence oxygen. The design of the bio-hazardous waste incinerator requires sufficient residence time to ensure the destruction of disease causing pathogens and to convert combustible materials into non-combustible residue or ash.

There are three major types of incinerators currently used to incinerate hospital wastes in the United States and Canada including: fix hearth (including excess air and controlled air), retort, and rotary kiln. In each case, a secondary combustion chamber is used to completely combust all non-combusted gases leaving the primary incinerator chamber. The treated gases are vented through an emission control system, while the residue or ash can be safely disposed of in a sanitary landfill. Incineration provides the advantage of reducing the mass and volume of bio-hazardous waste, often by more than 95 percent, thereby reducing the cost of disposal and reducing the waste load on the landfill site, which increases the lifespan of the landfill facility. The three major types of incinerators currently in use are described below in detail.

E.1.1 Fixed Hearth Incinerators

Controlled Air-Fixed Hearth: This incinerator technology is also known as “starved air” and “modular” incineration. The combustion of wastes in a controlled air incinerator occurs in two stages. Waste is fed into the primary, or lower, combustion chamber which is operated with less than the full amount of air/oxygen required for complete combustion (i.e. substoichiometric conditions). Under these conditions, the waste is dried, heated, and all non-vapourized materials are pyrolized. This results in the volatilization of water and other volatile components. A portion of the combustible waste is burned in the primary chamber to provide some heat to drive the volatilization and pyrolysis. The non-combustible portion of waste accumulates as ash. Water, volatiles, and combustible gases from the primary chamber flow upward through a connecting section where they are mixed with air prior to entering the secondary combustion chamber. A second burner is located near the entrance to the secondary chamber. The remaining combustion occurs in the secondary chamber, with the resultant gases either released directly to the atmosphere or treated through air pollution control equipment before being released to the atmosphere.

Controlled air has been the predominant method of small capacity, on-site incinerators in North American hospital in the past. Generally, it is only applicable for treatment of less than 450 kg/hr (1000 lb/hr) of bio-hazardous waste. The technology has been around for several decades, and has been appropriate for the limited regulations that have applied up until recently. However, the increasing move towards larger capacity regional incinerators for a group of hospitals, and new tighter regulations regarding air emissions, has led to a shift towards the rotary kiln incinerator type. Furthermore, depending on the waste feed composition and feeding rate, the ash quality may be objectionable (i.e. not all ash will be non-recognizable). Thus the objectionable ash may require additional incineration

Excess Air-Fixed Hearth: The combustion of wastes in a excess air-fixed hearth incinerator occurs chiefly in the primary chamber as opposed to the controlled air-fixed hearth technology where combustion occurs mainly in the secondary combustion chamber. Waste is fed into the primary combustion chamber which is operated with excess air (i.e. above stoichiometric conditions). The non-combustible portion of the waste accumulates as ash in the primary chamber. The off-gases from the primary chamber enters the secondary chamber where the gas temperature is raised via a burner located near the entrance of the chamber in order to complete the combustion (or oxidation) of off-gases into carbon dioxide and water. The combusted off-gases generated in the secondary chamber are either released directly to the atmosphere or treated through air pollution control equipment (due to the presence of air pollutants such as hydrogen chloride) prior to being released to the atmosphere.

The advantages of an excess air-fixed hearth are improved ash quality and higher operational efficiency as compared to the controlled air-fixed hearth incinerator technology described above.

E.1.2 Retort Incinerator

This incinerator technology is a compact furnace in the form of a cube with multiple internal baffles. In this unit the waste is dried, ignited, and combusted by heat provided by a primary chamber burner, as well as by the hot chamber walls heated by flue gases. Moisture and volatile components in the waste feed are vaporized and pass, along with combustion gases, out of the primary chamber and through a flame port connecting the primary chamber to the secondary chamber. Secondary air is added through the flame port and is mixed with the volatile components in the secondary chamber. The retort incinerator is not easily adaptable to automatic or continuous operation.

E.1.3 Rotary Kiln Incinerator

Rotary kiln incineration consists of a primary chamber in which all the waste is heated, volatilized, and completely combusted. A secondary chamber equipped with a high temperature burner is used to ensure that any trace combustibles are completely destroyed. The primary chamber is a horizontal refractory lined cylinder that rotates about its horizontal axis. The kiln is declined slightly so that the waste material migrates from the waste feeding end to the ash discharge end as the kiln rotates. The rate of rotation and the angle at which the kiln is declined controls the throughput rate. Air in excess of stoichiometric requirements is provided to the kiln to burn out the wastes. The rotating movement of the kiln provides enough action to mix the waste and expose it to air which promotes combustion of the waste. Pollution control equipment is added to restrict particulate and other hazardous compounds from entering the atmosphere.

Rotary kiln incinerators have several advantages over fixed hearth incinerators. Rotary kiln incinerator systems can be designed to be larger than fixed hearth incinerators and capable of burning whole containers of bio-hazardous waste. This ability to accept whole containers avoids the need to empty bio-hazardous waste from the delivery containers, or the need to process or shred the bio-hazardous waste prior to being treated. The inherent design of rotary kiln incinerators allows for stable operation even with widely varying wastes with differing chemical and thermal properties. Due to the rotary kiln chamber, this type of incinerator has more moving parts than the other types of incinerators and generally leads to increased maintenance requirements.

E.1.4 Air Emission Control Systems for Incinerator Technologies

Until recently, in Canada and the United States, bio-hazardous waste incinerators were not required to be equipped with sophisticated emission control systems. However, changes in regulations have resulted in more stringent emission criteria to be met by incinerators. Therefore, it has become inherent for incinerators to be designed with appropriate emission control systems. Given the lack of current emission standards in Saint Lucia, it is suggested that any emission control equipment selected for use in Saint Lucia should be designed to meet US EPA emissions for new medical waste incinerators and/or European Union air quality guidelines as summarized above in Tables 2-2 to 2-3.

In general, the emission control systems are designed to control the release of various gaseous compounds and airborne particulate including particulate matter (soot and smoke), inorganic gases and acids (e.g. carbon monoxide, nitrogen oxides, hydrogen chloride, sulfur dioxide), organic gases (e.g. PCB, polychlorindated dibenzodioxins, polychlorinated dibenzofurans), and metals (e.g. mercury). The various types of air emission control systems that have been designed to meet current air pollution guidelines are described below.

Dry Impingement Separators: Impingement separators are essentially a series of baffles placed in the gas stream. The relatively high inertia of the particulate matter within the gas stream will maintain their direction of flow while the gaseous component of the stream will change its direction of flow around a baffle. Consequently, the particulate matter will drop out of the gas stream upon colliding with a baffle. This system is effective for particulate above 15 microns in diameter. Such systems are normally used to reduce particle load for other emission control systems.

Dry Cyclonic Separator: The cyclone is an inertial separator. Gas entering the cyclone forms a vortex which eventually reverses direction and forms a second vortex leaving the cyclonic chamber. Due to inertia forces, particulate matter will tend to move toward the outside wall. Particulate matter is then collected and removed for disposal. The cut-off size of the particulates is generally dependent on the size fraction of particles, gas velocity entering the cyclone, and cyclone configuration.

Venturi Scrubber: Venturi scrubbers are widely used where water is readily available, as high-efficiency, high-energy gas cleaning (i.e. removal of pollutants) devices. The heart of the system is a wetted venturi “throat” where gases pass through a constricted area, reaching velocities of 200 to 600 feet per second, and then pass through an expansion section. From the expansion section the gas enters a large chamber where its velocity suddenly decreases. The differential pressure across the venturi atomizes the water which in turn captures the particulate matter. The particulate laden water is then collected and removed.

Electrostatic Precipitator: Electrostatic precipitators (ESP) are effective devices for the removal of airborne particulate matter. The gas stream passes through a series of discharge electrodes that are negatively charged. A negative charge is induced in particulate matter passing through the discharge electrodes (corona). A grounded surface, or collector electrode, surrounds the discharge electrodes. Charged particulate will collect on the grounded surface, usually in the form of plate surfaces. The particulate matter is removed from the collector surface by a series of rappers for collection and ultimate disposal. Another method of cleaning plates from an ESP is to wet them down. Wet ESPs have been developed where sprays wet the incoming flue gas stream to a saturated or super-saturated condition. The electric charge is transferred to the liquid droplets and the liquid charges, collects, and washes away particulate from the gas stream.

Dry Scrubbers/Fabric Filters: Fabric filters or "baghouses" are prevalent in many types of industrial applications. They are essentially a series of permeable bags which allow the passage of gas but catch particulate matter, and utilize growth of caught particulate to catch still smaller particles. They are effective for particle sizes down to submicron range. Collected particulate is periodically removed from the bags by a series of shaker mechanisms, such as by compressed air pulses or by other methods.

Wet Acid Gas Scrubbing: Acid gases in an incinerator exhaust generally refer to hydrogen chloride and sulfur dioxide. From these compounds hydrochloric acid and through the formation of the related compound sulfur trioxide, sulfuric acid is generated. In a common setup the temperature of the gas stream is reduced, and the acidic components are removed. This system is normally operated with a venturi scrubber for particulate control, and followed by a tray tower or a packed tower. The tower provides an relatively high surface area for acid neutralizing compounds to come in contract with the acidic compounds present in the gas stream. An alkali solution such as sodium hydroxide, or calcium hydroxide, lime, or caustic soda, can be circulated into the tower to neutralize and remove the acidic components from the gas stream.

Semi-Dry Scrubbing Systems: Semi-dry scrubbing systems used to remove acid components of the gas stream operate as sorbent systems rather than neutralizing systems such as the wet acid gas scrubber. An adsorbent (lime slurry) is injected into the adsorber (spray dryer) as a finely atomized spray, producing droplets in the range of 30 to 100 microns in diameter. The adsorber is sized to provide at least 10 seconds gas residence time. With this retention and appropriate absorber geometry, water within the lime slurry is evaporated and does not come in contact with the reactor walls. Flue gases exiting the absorber are passed through a collection (or control) device, either an electrostatic precipitator or a fabric-filter baghouse. Particulate matter, hydrogen chloride, sulfur oxides and organics are adsorbed on to the surface of the lime particles. The lime sorbent, as well as any other particles within the gas stream, are collected in a control device downstream of the scrubber.

E.2 Steam Sterilization (Autoclaving)

Steam sterilization (or autoclaving) of bio-hazardous waste utilizes saturated steam within a pressure vessel at temperatures sufficient to kill infectious agents present in the waste. Disinfection of the waste occurs primarily from steam penetration and steam generation within the water based organisms. Heat conduction provides a secondary source of heat transfer. Treatment is time and temperature dependent, therefore it is essential that the entire waste load is exposed to the necessary temperature for the minimum required residence time. Accordingly, for effective and efficient treatment, the degree of steam penetration is the critical factor. Wastes with low density, such as plastics, are more amenable to steam sterilization. High density wastes such as large quantities of animal bedding and fluids inhibit direct steam penetration and accordingly require longer sterilization times. The shredding of bio-hazardous wastes substantially improves the effectiveness of the steam sterilization process by decreasing waste density, thus increasing steam penetration and reducing treatment residence time, thereby increasing the efficiency of autoclaving.

The typical operating conditions for a steam sterilization system to effectively kill infectious agents (or achieve 6 log kill) are a temperature of 121 ^{o}C and a pressure of 15 pounds per square inch (psi) for a minimum residence time of 30 minutes.

If a shredding system is not implemented with a stream sterilization unit, certain problems associated with this technology may potentially arise. For example in some steam sterilization units pathological wastes cannot be effectively treated if the waste is not shredded prior to being subjected to high temperature steam, due to the incomplete steam penetration (i.e. poor steam penetration) for an adequate period into this waste type. In addition, it is potentially difficult to accurately determine if the bio-hazardous waste has been sufficiently treated due to the dense nature of pathological wastes (including anatomical wastes).

Furthermore, autoclaving alone does not significantly reduce the volume of the waste, nor does it render the waste, such as sharps or pathological wastes, unrecognizable. However, with the use of shredders and compactors, a volume reduction of 60% to 80% can be achieved while rendering the waste unrecognizable. Thus, a shredding system will be required to make this technology a viable option for treating bio-hazardous waste in Saint Lucia.

Indirect steam sterilization is another autoclaving technology which is an effective bio-hazardous waste treatment technology. This technology involves essentially a double-walled cylindrical vessel, horizontally mounted, with one or more top loading doors, and a smaller unloading door at the bottom. The vessel is fitted with a motor driven shaft, to which are attached powerful fragmenting/mixing arms that slowly rotate inside the vessel. When steam is introduced in the vessel jacket it transmits heat rapidly to the fragmented waste, which in turn produces steam of its own. The resultant dynamic interaction will sterilize the waste by action of the high temperature and pressure steam, similar to conventional steam sterilization but with faster and more even heat penetration. The organic components of the waste are hydrolized and the water content of the waste is removed via dehydration. The treated, fragmented waste becomes acceptable for landfilling or can be subsequently shredded prior to landfilling.

The typical operating conditions, for an indirect steam sterilization unit (ISSU), required to effectively kill infectious agents (or achieve 6 log kill) are a temperature of 121 ^{o}C and a pressure of 15 psi for a minimum residence time of 30 minutes. However, if the ISSU is operated at a temperature of 132 ^{o}C the required residence time is reduced to 15 minutes. Thus, operating at 132 ^{o}C, the ISSU provides a means to process more waste within a given time frame compared to other steam sterilization treatment systems.

As indicated above, bio-hazardous waste has multiple hazards associated with it, some of which cannot be properly treated using steam sterilization. Such wastes include antineoplastic drugs or pharmaceutical drugs or chemicals that would be volatilized by steam. However, since antineoplastic (cytotoxic) drugs are not considered to be a significant component of the bio-hazardous waste stream in Saint Lucia, this problem is of less concern.

E.3 Chemical Disinfection

In this method, certain chemicals are added to bio-hazardous waste which kill pathogens on contact. This method is most appropriate for use on liquid bio-hazardous waste where thorough mixing with the chemical disinfectant is likely to occur. The use of chemicals on solid, potentially infectious waste will be dependent on the type of microorganisms, degree of contamination, type of disinfectant, contact time, temperature and moisture, and mixing method. Chemical disinfection is effective with a narrower range of waste types and pathogens, rather than use against all potentially infectious wastes unlike many other waste treatment methods. More specifically, chemical disinfection may be appropriate for treating microbiological wastes, human blood and body fluid wastes, and sharps. Chemical disinfection is most often applied to liquid wastes before disposal. It can also be useful for decontaminating spills when they occur.

Chemical disinfection also does not reduce the volume of waste, nor does it render the bio-hazardous waste unrecognizable unless equipped with a shredder. For example, chemical disinfected sharps can still pose as a hazard to those handling the waste. Thus chemical disinfection must be coupled with mechanical shredding. However, chemical disinfection coupled with shredding is not suitable for body and animal tissue, large metal objects, radioactive material, and any materials incompatible with the chemical treatment solution (eg. chlorine and sulfuric acid).

Furthermore, the disinfection chemicals are strong oxidizing chemicals (e.g. sodium hypochlorite) and their presence and handling increases work place safety concerns.

When considering chemical disinfection several factors should be considered including type of microorganism degree of contamination, type of disinfectant used, and concentration and quantity of disinfectant. Other relevant factors to consider include temperature, pH, degree of mixing, and length of time the disinfectant is in contact with the contaminated waste.

E.4 Low Temperature Infrared Disinfection

This is a relatively new technology that heats bio-hazardous waste to sufficiently high temperatures required to sterilize any pathogens. This is done by exposing these wastes to infrared frequencies. The infrared disinfection system has six major components including a feed system, shredding system, treatment screw conveyor, infrared treatment system, sterile discharge conveyor, and a Programmable Logic Control system. Waste is fed into a shredder unit which rips, tears, and chops the waste prior to being exposed to infrared treatment. The shredded waste is conveyed down a chamber, with the waste being exposed to infrared heaters along the inside of the chamber. Temperatures reach approximately 150 °C in the chamber. The treated waste is cooled and ready for disposal to a landfill facility. This process operates continuously unlike many other technologies described in this section that can be operated as a batch or continuous process.

This technology provides volume reduction of greater than 75% as compared to the feed material, however, the treated material is not as non-recognizable as ash from an incinerator process.

E.5 Thermal Inactivation

Thermal inactivation includes those treatment methods that utilize heat transfer to provide conditions that reduce the presence of infectious agents in waste. For the treatment of liquid and solids, different thermal inactivation techniques are used. Thermal inactivation of solid infectious waste is achieved by subjecting the bio-hazardous waste to dry heat treatment. In this technique, the waste is heated in an oven which is operated by electricity. Since dry heat is less efficient than steam sterilization, higher temperatures and/or longer holding times are necessary. A typical dry heat sterilization treatment includes the heating of bio-hazardous waste to 320 ^{o} F to 338 ^{o} F (160 ^{o}C to 170 ^{o}C) for two to four hours.

This technology is very time consuming and requires large amounts of energy relative to other treatment processes and is currently not widely used for the treatment of bio-hazardous waste.

E.6 Gas/Vapour Sterilization

Although gas/vapour sterilization techniques are used for sterilizing medical supplies, it can also be used for treating certain infectious wastes. In this technology, the sterilizing agent is a gaseous or vapourized chemical such as ethylene oxide or formaldehyde. However, these chemicals are known to pose serious health hazards and are potentially carcinogenic to humans. Furthermore, wastes treated with these chemicals may continue to expose waste handlers to these chemicals because these chemicals can be adsorbed to porous materials or form residues. In both cases, the chemical gases are continually released for substantial periods of time after the treatment. Therefore, workers must exercise caution when using these chemicals.

This technology does not reduce the waste volume nor does it render the waste non-recognizable, therefore this technology has limited application for treating bio-hazardous waste.

E.7 Irradiation Sterilization

Irradiation (or ionization radiation) by gamma or electron-beam affects the microbial population of bio-hazardous waste significantly; it has little effect on its physical or chemical characteristics. A gamma irradiation system consists of three major components, the irradiation chamber (including a source storage pool), the product handling mechanism (including control and safety sub-systems), and the radiation source (including the source movement mechanism). Cobalt-60 is an example of a gamma radiation source. The irradiation chamber serves two primary functions; 1) it provides safe shielding from the radiation source; and, 2) it provides a chamber in which to irradiate the material being processed. The irradiation chamber consists of a concrete room and a water-filled pool. In order to operate the irradiation process, the ceiling and walls of the irradiation chamber need to be built to a minimum thickness of 1.8 m.

The advantages of ionizing radiation sterilization for treatment of bio-hazardous waste relative to other technologies include:

- nominal electricity requirements;
- no steam requirements; and,
- no residual heat in treated waste.

The principle disadvantages of a radiation sterilization process include:

- high capital costs;
- requirement of highly trained operating and support personnel;
- requirement of large space (i.e. relatively large footprint);
- Safety concerns related to the presence of gamma-ray radiation source on-site;
- problems with the ultimate disposal of the decayed radiation source; and,

X unless equipped with a shredder, this technology does not reduce the volume of waste, nor is the waste non-recognizable.

E.8 Plasma Torch

In this technology, highly ionized compressed air is used to vapourize infectious waste at temperatures over 3,000 ^{o} F. All organic material is broken down into individual atoms (gas) and the inorganic material, such as heavy metals and glass, is melted and transformed into a vitreous material which chemically binds the heavy metals creating a "slag". Emissions or "off-gases" from this process consist primarily of hydrogen and carbon monoxide. For each pound of bio-hazardous waste processed, approximately 0.05 lb to 0.075 lb of glassy slag and 16 ft^3 to 17.5 ft^3 of combustable gas is produced. The gas generated has a heating value of approximately 340 Btu/lb. A wet scrubber system is used to control emissions, while the glass-like-slag is disposed in a landfill.

While this process, relative to incineration, produces less emissions and by operating at higher temperatures minimizes the production of hazardous dioxins and furans, it requires advanced pollution control equipment, consumes a large amount of energy and water, requires highly trained employees, and typically has higher initial capital costs and maintenance costs than most other technologies.

These bio-hazardous waste treatment units have limited waste applications (e.g. moisture content of incoming waste must be less than 35 %, and that it cannot treat infectious liquid wastes).

E.9 Pyrolysis

Pyrolysis systems break down infectious waste into gases and a small amount of ash using high temperatures ranging from 425^{o}C to 1,925^{o}C (800^{o}F to 3,500^{o}F) in the absence of air. Depending on the system operating conditions, the major products of combustion will vary from carbon dioxide and water vapour (which are produced when sufficient air is present) to hydrogen gas and carbon monoxide(which are produced when insufficient air is present). The waste stream is fed into a reaction chamber which can have two carbon electrodes located opposite one another near the bottom of the reactor chamber. The electrodes are set up to create a powerful electric arc. As the waste is fed into the reactor, the waste is vapourized near the electric arc and as the hot vapour rises, the remaining waste is pyrolysed. Other reaction chambers are heated electrically in a vacuum. While these technologies have the potential to handle the full range of bio-hazardous wastes they are still in the development stages for bio-hazardous waste application.

E.10 Microwave Disinfection

In microwave disinfection, bio-hazardous waste is automatically lifted and emptied into the in-feed hopper. The loading mechanism can be designed to accept a wide variety of standard cart systems. The in-feed hopper is sealed and waste is ground into tiny particles by a sophisticated shredding system designed specifically for medical waste. Grinding creates a more even waste stream that can be effectively treated at lower temperatures than competing systems, thereby eliminating the potentially harmful air emissions associated with other units. Shredding reduces the waste volume by 80%, and renders it unrecognizable.

Air from the in-feed hopper is drawn by a fan through a series of filters including a High Efficiency Particulate Air (HEPA) filter and a carbon filter to control odours. Air tests performed on the system confirm that no harmful air emissions are released during waste processing.

Waste is then picked up by a stainless steel screw conveyor, moistened with steam, and passed by a series of microwave units. Microwave energy is extremely efficient at thermally treating each individual waste particle from the inside out, assuring thorough disinfection.

The entire process is controlled by an on-board microprocessor. A highly sophisticated computer program is required to monitor the waste treatment cycle, assuring that all time and temperature parameters required for treatment are met before any waste is discharged.

This enclosed, automated system produces a slightly moist solid residue. The microwave generators are typically equipped with several 1,200 watt microwave generators. Waste is treated for a minimum of 25 minutes depending on waste type and load. The treatment temperature is maintained at 97^{o} C (205^{o}F).

This process is not suitable for body and animal tissues, radioactive materials, and chemotherapeutic drugs. Furthermore, liquids should not exceed 10 % by weight, and metals should not exceed 1% by weight. As well, larger metal objects pose problems for the grinder/shredder and microwave unit.

E.11 Recommended Treatment Technologies

Different bio-hazardous waste treatment technologies are currently available and being employed in Saint Lucia. However, none of these technologies likely come close to meeting current World Health Organization (WHO) or North American standards of effectiveness in the destruction of pathogens. To promote the safe destruction of bio-hazardous wastes in Saint Lucia and meet WHO and/or North American standards, GPEC has selected two treatment technologies for consideration in Saint Lucia based on the following:

- Observations made by GPEC during site visits made to several healthcare facilities in Saint Lucia;
- The findings of the bio-hazardous waste generation survey conducted by SLSWMA;
- Previous bio-hazardous waste investigations conducted in Saint Lucia;
- Discussions with various government officials, and other informed persons;
- Current regulations existing in Saint Lucia;
- Costs associated with the various treatment technologies;
- Efficiency of the treatment technology to achieve 99.9999% destruction (i.e. 6 log kill) of *Bacillus Stearothermophilius* or *Bacillus Subtilis* spores;
- Level of expertise required to operate the different treatment technologies; and,
- Availability of space at the proposed treatment facility site.

The two treatment technologies include fixed hearth incineration and steam sterilization (or autoclaving). A comparison of these two technologies is provided in Section 5.0 of this waste management plan.

APPENDIX F

WORKPLACE HAZARDOUS MATERIALS INFORMATION SYSTEM CLASSES

F.0 WHMIS CLASSES

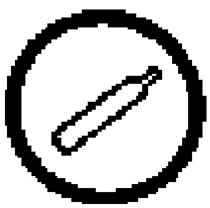
Chemical hazards may be described under three broad headings - flammability, reactivity and health.

> ***Flammability:*** Flammable substances are those that readily catch fire and burn in air. A flammable liquid does not itself burn; it is the vapours from the liquid that burn. For a liquid, the flash point, auto-ignition temperature, explosive limits, vapour density and ability to accumulate an electrostatic charge are important factors in determining the degree of fire hazard.
>
> ***Reactivity:*** Reactive chemical hazards invariably involve the release of energy (heat) in relatively high quantities or at a rapid rate. If the heat evolved in a reaction is not dissipated, the reaction rate can increase until an explosion results.
>
> Some chemicals decompose rapidly when heated. Light or mechanical shock can also initiate explosive reactions. Some compounds are inherently unstable and can detonate under certain conditions of pressure and temperature, while others react violently with water or when exposed to air.
>
> ***Health:*** Contact with many chemicals can result in adverse health effects. The nature and magnitude of toxic effects will depend on many factors including the nature of the substance, route of exposure, magnitude of the dose, duration of exposure, and individual susceptibility.

WHMIS classifies chemicals into 6 classes according to the chemical and physical or toxic properties of the product. Each class can be further subdivided and represented by symbols which give a snapshot view of the hazards that the chemical presents. The different classes include:

A	-	Compressed Gas
B1	-	Flammable Gases
B2	-	Flammable Liquids
B3	-	Combustible Liquids
B4	-	Flammable Solids
B5	-	Flammable Aerosols
B6	-	Reactive Flammable Materials

C	-	Oxidizing Material
D1A	-	Very toxic material causing immediate and serious effects
D1B	-	Toxic material causing immediate and serious effects
D2A	-	Very toxic material causing other toxic effects
D2B	-	Toxic material causing other toxic effects
D3	-	Biohazardous infectious material
E	-	Corrosive material
F	-	Dangerously reactive material



A - Compressed Gas

Cylinders store compressed gases under pressure. Because gas leaking from a cylinder, a value or a regulator can cause injury or damage, WHMIS treats all compressed gases as controlled products. Gases which are also flammable, toxic or have other hazardous properties will also be found in other classes.

Typical compressed gases are oxygen, which is used in health care and welding, and ammonia which is used in some large scale refrigeration systems.

B - Flammable and Combustible Materials

WHMIS groups together into a single class all those chemicals which pose a fire hazard. There are 6 subdivisions to the flammable and combustible materials class. Chemicals covered by any of the subdivisions all carry the same stylized flame symbol.

B1 - Flammable Gases

All gases such as hydrogen and butane which can form ignitable mixtures in air, are classed as flammable gases. Cylinders of these gases carry both the compressed gas and the flammable material symbols.

B2 - Flammable Liquids

All those liquids which present an extreme fire hazard are called flammable liquids. A spark or other ignition source can easily ignite flammable liquids at or below room temperature.

Gasoline is a typical flammable liquid. Even at temperature as low as -40 ^{o}C, gasoline gives off enough vapour to form a vapour/air mixture that will burn.

B3 - Combustible Liquids

Although they are more difficult to ignite, when a combustible liquid is heated, it gives off enough vapour to form a vapour/mixture that will burn. Combustible liquids are those liquids which present a fire risk when the liquid is heated to temperatures between room temperature and about 100 ^{o}F.

Diesel fuel and many other more difficult to ignite liquids are combustible liquids. Many commercial and industrial liquid products that are based upon petroleum or other organic solvents are combustible liquids.

B4 - Flammable Solids

WHMIS regulates all those solids that ignite through friction such as white phosphorus, or that can be readily ignited and burn vigorously such as magnesium and a number of other finely divided metals.

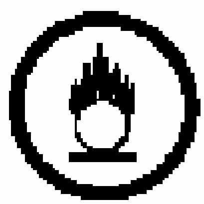
B5 - Flammable Aerosols

Aerosol products containing flammable ingredients or that use a flammable propellant such as propane, butane and dimethyl ether, present a workplace fire hazard. All such products which pass a flame projection or flash back test are included in the flammable aerosol subdivision.

B6 - Reactive Flammable Materials

WHMIS places a few particularly dangerous materials in this subdivision. Included are chemicals that are spontaneously combustible under normal conditions of use or chemicals which, when in contact with water, become flammable or give off a flammable gas.

This group includes such chemicals as aluminum alkyls, metallic sodium and lithium aluminum hydride. All of these chemicals are uncommon outside of the laboratory.



C - Oxidizing Materials

Fire is really a chemical reaction involving a fuel and oxygen. Some chemicals called oxidizers, can provide oxygen that can increase the risk that a fire will break out. Once a fire is underway, oxidizers can cause the fire to burn more intensely.

Oxidizing materials are not particularly common in a typical shop or office environment. However, they are found fairly often in certain laboratory settings, as well as in some construction settings. A typical family of oxidizers are called organic peroxides.

The symbol carried by all oxidizing materials resembles the flammable materials symbol in that it also depicts a flame. But the flame rests on an "O" which signifies that oxidizers contribute oxygen.

D - Poisonous and Infectious Materials

WHMIS considers all the toxic effects of chemicals in this class. Because there are a variety health hazards that need to be considered, WHMIS deals with the health hazards in 3 subdivisions.

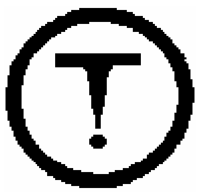
D1 - Materials Causing Immediate and Serious Toxic Effects.

Materials included in this subdivision are generally those highly toxic chemicals which cause death within a short period following exposure. At high enough doses, almost any chemical can have serious and even fatal consequences. But the massive doses of weakly toxic chemicals that would be needed to produce death are unlikely in the workplace. However, chemicals which are sufficiently toxic to cause death following a workplace exposure, such as many cyanides, are placed in subdivision D1-A. Other chemicals for which higher doses are needed to produce lethality, are placed in subdivision D1-B.

Subdivision A - Very Toxic material

Subdivision B- Toxic material

All the chemicals that meet the criteria for inclusion in the Materials Causing Immediate and Serious Toxic Effects, regardless of whether they fall into the Very Toxic or Toxic subdivisions, carry the skull and crossbones symbol.



D2 - Materials Causing Other Toxic Effects

As well as short term poisoning, chemicals can cause other effects. Prolonged exposure to chemicals at exposure levels that are below those which cause short term symptoms can also be harmful to health. WHMIS places chemicals which irritate the skin and eyes and chemicals which present a long term health risk, in a separate class.

Containers of these chemicals are marked with the WHMIS "T" symbol. Some people refer to the symbol as "a T over a period" to reinforce the idea that many of the criteria that place chemicals in this division, deal with long term hazards.

Contact with many chemicals, including some chemicals as familiar as vinegar, cause skin and eye irritation. As a consequence, when they are sold for industrial or commercial use, these chemicals carry the WHMIS T symbol. People working with these chemicals need to consult the MSDS to find out whether a product is classed as causing "other toxic effects" because it causes irritation or because it poses a long term health risk.

Toxic Effects Included Among "Other Toxic Effects"

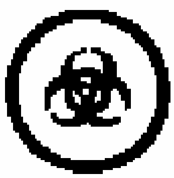
- Skin and eye irritation and chronic toxic effect;
- Mutagenicity- causing genetic damage;
- Sensitization- causing skin or respiratory allergies;
- Carcinogenicity- causing cancer;
- Teratogenicity- causing birth deformities;

- Embryotoxicity- causing fetal death; and,
- Reproductive toxicity

Again, this division is divided into 2 subdivisions to reflect the differing risks presents by highly toxic and less toxic chemicals:

Subdivision A - Very Toxic material

Subdivision B- Toxic material



D3 - Biohazardous Infectious Materials

Few people outside a research or clinic laboratory of a hospital are likely to encounter a material classed as a Biohazardous infectious agent. Materials which fall into this class include viruses and bacteria which can cause infection in people. Also included are the toxins that some of these viruses and bacteria produce.

Containers of biohazardous infectious materials carry the internationally recognized three broken rings symbol.

E - Corrosive Materials

WHMIS groups together chemicals which can corrode metal or destroy skin into a corrosive materials class. Included in the class are many of the common acids such as sulfuric acid, (used in automotive batteries) hydrochloric (muriatic) acid and others. Lye (also called caustic soda or sodium hydroxide) is another corrosive chemical that is present in many commonly used products such as household oven cleaner.

The symbol demonstrates the corrosivity of these chemicals in attacking metal and human skin.

F - Dangerously Reactive Materials

The last WHMIS class brings together all those chemicals which present a hazard as a result of their tendency to undergo violent reaction. The chemical reaction can sometimes lead to a fire or an explosion. This class also includes a few chemicals such as sodium cyanide which can react with water to produce a toxic gas.

Dangerously reactive chemicals are not common outside of the laboratory.

APPENDIX G

REFERENCES

REFERENCES

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MOE, 1994: The Management of Biomedical Waste in Ontario; guideline C-4; Ontario Ministry of the Environment; April, 1994.

US EPA, 1986: EPA Guide for Infectious Waste Management; United States Environmental Protection Agency, Office of Solid Waste and Emergency Responses; May, 1986.

US EPA, 1997: Environmental Protection Agency Standards of performance for new stationary sources and emission guidelines for existing sources: hospital/medical/infectious waste incinerators; final rule. Federal register, 62 (178); 1997.

WHO, 1999: Safe Management of Wastes from Health-care Activities; World Health Organization; edited by A. Pruss, E. Giroult, and P. Rushbrook; Geneva, 1999.

APPENDIX H

LIST OF ACRONYMS AND TERMS

LIST OF ACRONYMS AND TERMS

List of Acronyms	
AIDS	Acquired Immunodeficiency Syndrom
CCME	Canadian Council of Ministers of the Environment
EHO	Ministry of Health Environmental Health Officers
HBV	Hepatitis B
HCV	Hepatitis C
HEPA filter	High Efficiency Particle Air filter
HIV	Human Immunodeficiency Virus
ISSU	Indirect Steam Sterilization Unit
MOA	Ministry of Agriculture
MOE	Ontario Ministry of the Environment
MOH	Ministry of Health
SLASPA	Saint Lucia Air and Sea Port Authority
SLSWMA	Saint Lucia Solid Waste Management Authority
US EPA	United States Environmental Protection Agency
WHMIS	Workplace Hazardous Materials Information System
WHO	World Health Organization
List of Terms	
Animal wastes	Consists of contaminated carcasses, body parts, body fluids, tissues, organs, blood, and bedding of animals that were intentionally exposed to pathogens in research, in the production of biologicals, or in the *in vivo* testing of pharmaceuticals.
Bio-Hazardous Waste Management	All activities, administrative and operational, involved in the handling, packaging, transportation, storage, treatment, and disposal of bio-hazardous wastes.
Carrier	A bio-hazardous waste hauling (transportation) company
Condemned meats	Include quantities of fish, meat, and poultry deemed by government officials (Saint Lucia Ministry of Health) as not meeting national health requirements. Sources of these materials include abattoirs, packaging facilities, grocery stores, and incoming shipments at ports throughout the island.
Consignee	A bio-hazardous waste treatment facility

Consignor	Any person or facility engaged in activities that generate bio-hazardous waste
Container	Vessel in which bio-hazardous waste is placed for safe handling, transportation, storage, and/or eventual disposal. The bio-hazardous waste container is a component of the waste package. Containers can be re-usable or disposable and can be equipped with wheels and/or handles for safe and easy transport of bio-hazardous wastes.
Contaminated sharps	Sharps include needles, needles attached to syringes, and blades; or broken glass or other materials which are capable of causing punctures or cuts and which have come into contact with human blood or body fluid or in contact with animal blood or animal body fluid.
Cytotoxic wastes	Cytotoxic drugs possess a specific destructive action designed specifically to destroy certain cells, including antineoplastic drugs which selectively kill dividing cells. Waste cytotoxic drugs includes leftover or unused cytotoxic drugs as well as syringes, tubing, IV bags, tissues, needles, gloves and any other items which may have come into contact with a cytotoxic drug.
Disinfectant	Chemical agent that is able to reduce the viability of microogranisms.
Disinfection	Treatment aimed at reducing the number of vegetative microogranisms to safe or relatively safe levels (or in some cases even sterilization levels).
Disposal	Intentional burial, deposit, discharge, dumping, placing, or release of any waste material into or on any air, land, or water.
General wastes (refuse)	General refuse is considered non-infectious and non-hazardous and includes office waste, food waste, hospital maintenance waste (excluding chemicals, dry-wall, boards) as well as non-infectious, non-anatomical waste from patient care areas (i.e. disposable diapers, pads, gloves, trays, catheters/bags (empty) and casts).
Hazardous wastes	Hazardous wastes (as defined by the Government of Saint Lucia and/or as classified under Workplace Hazardous Materials Information System [WHMIS]) generated during regular health care activities, which are not infectious but require special handling, storage, transportation and disposal based on the physical and chemical properties of the waste. Some examples of these hazardous wastes include solvents, cleaning detergents, pesticides, mercury, pressurized cylinders.
Human blood and body fluid wastes	Consists of all human blood, semi-liquid blood and blood products, which should all be managed as infectious wastes. This class of wastes also includes items contaminated with blood or blood products that would release liquid or semi-liquid blood if compressed, body fluids visibly contaminated with blood, and body fluids removed in the course of surgery, treatment (e.g. waste being discarded from renal dialysis), autopsy, embalming or for diagnosis, excluding urine and faeces.
Isolation bed wastes (highly infectious waste):	Consists of wastes generated by hospitalized patients who are isolated to protect others from communicable diseases.

Microbiological/ Laboratory bio-hazardous wastes	Consists of laboratory cultures, stocks or specimens of microorganisms, live or attenuated vaccines, serums, human or animal cell cultures used in research, and laboratory materials (such as culture dishes and other devices used to transfer, inoculate, and mix cultures) that have come in contact with the above wastes. In addition, this category includes any discarded laboratory waste which has come in contact with pathogenic organisms and which has not been rendered noninfectious by autoclaving or other sterilization techniques.
Microorganism	Any microbiological entity, cellular or non-cellular, capable of replication or of transferring genetic material.
Pathological/Anatomical wastes	Consists of tissues, organs, anatomical parts, and body fluids that are removed during surgery, obstetrical procedures, autopsy, and laboratory procedures.
Pharmaceutical wastes	All prescription drugs (excluding cytotoxic drugs) and narcotics which have expired, perished or deemed unusable for its intended use.
Prion	A poorly characterized slow infectious protein agent. Prions are believed to be the cause of a number of neurodegenerative diseases, e.g. Creutzfeldt-Jakob disease.
Quarantine foodstuff	Include plant (produce) material deemed by government officials (Saint Lucia Ministry of Agriculture) as representing a risk to agriculture and/or the island's ecosystem. The primary source for these materials is via incoming passengers at air and seaports.
Residue	The material remaining after treatment of bio-hazardous wastes such as ash or slag or shredded material.
Risk	The probability that a hazard will cause harm, and the severity of that harm.
Segregation	The systematic separation of various waste streams into designated categories.
Sterilization	A reduction (or destruction) of microorganisms of more than 10^6 or 6 log kill (more than 99.9999% of the microorganism are killed) achieved by physical, chemical, or mechanical methods or by irradiation.
Waste Treatment	Any method, technique or process for altering the biological, chemical, or physical characteristics of waste to reduce the hazards it presents and facilitate, or reduce the costs of, disposal. The basic treatment objectives include volume reduction, disinfection (i.e. 6 log kill), neutralization, or other change of composition to reduce hazards.