Institutional Strengthening of the Solid Waste Management Authority and the Department of the Environment in Solid Waste Management

TECHNICAL REGULATORY STANDARDS FOR THE SITING, DESIGN, CONSTRUCTION, OPERATION & MAINTENANCE, CLOSURE AND POST CLOSURE OF SWM FACILITIES

FINAL

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Prepared for:

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APPENDIX A.

1.0 INTRODUCTION

The Solid Waste Management Program being implemented in Belize is intended to comprehensively address the improvement of disposal and collection in the four municipalities in the Western Corridor namely:

- Belize City,
- San Pedro Ambergris Caye,
- Caye Caulker,
- San Ignacio/Santa Elena

The Program, which is scheduled for implementation over a four year period consist of four components:

a. The closure of the Belize City open dumpsite;

b. Construction of a Regional Sanitary Landfill at Mile 24 on the Western Highway;

c. The construction of waste transfer, recycling and composting facilities, at San Ignacio/Santa Elena, Caye Caulker and San Pedro, Ambergris Caye;

d. Institutional strengthening of the newly established Solid Waste Management Authority (SWMA) and its sister agencies associated with the management of the solid waste management function.

Of the four components identified above the first three will require the adoption and use of established regulatory standards and guidelines in order to ensure the integrity of these facilities while also providing adequate protection of the environment and human populations during its operations. While there currently exists a wide array of legislation and regulations to govern the management of waste, the construction of these facilities as well as the daily operations and maintenance, cannot be prescribed by legislation alone, but requires the adoption and adherence to strict standards and guidelines, if they are to fully satisfy the overall goals and objectives of the program.

As a first step in the determination of standards and guidelines was the review of current legislation, regulations and practices, to determine, first of all, their adequacy, and where there are gaps, identify the most appropriate means for addressing them. Secondly, in order to bring the highest level of guidelines and standards to this exercise, current practices in other countries, including Canada, the US as well as other Caribbean countries, were also reviewed.

In presenting these standards and guidelines all of the proposed activities were considered including practices with respect to collection, transportation and disposal of waste; standards in respect of the siting and design of facilities (Transfer Stations, Materials Recovery Facilities, Landfill and Composting); operations of these facilities, and their closure.

An integral aspect of facilities being proposed is their operations. In this regard, the facilities and their operations must be monitored. Environmental monitoring is a major and vital component of any waste management plan as it permits to ensure facility performance and to assess environmental impact of the various facilities and rapidly implement corrective action measures as required before any important environmental damages occur. A monitoring regime which was initially requested as a separate task (Task 8) to address the concerns raised above has now been incorporated into Task 5.

Monitoring strategies may vary according to the type of facility and the environmental setting as well as the potential contaminants. Among the parameters considered for monitoring are groundwater and surface water bodies, leachate emissions, and biogas and air emissions.

The proposed guidelines and standards have therefore been developed in accordance with established practices and taking into consideration all relevant components of the waste management plan including the siting, design, construction, and monitoring of operations.

1. WASTE COLLECTION AND TRANSPORTATION (MSW)

Waste collection is the first step of waste management. It can influence the subsequent steps of wastes management. For example, better waste separation reduces the need for complex material recovery facilities and final disposal sites such as landfills. On the other hand, it requires the participation of the population and usually involves higher collection costs. There are several collection systems, each with its advantages and disadvantages. The table on the following page presents the different alternatives and the advantages and disadvantages of each collection system.

When the participation of the population is required, it should be kept in mind that the implementation of such systems should be gradual and that public education is essential to the success of the project. Pilot projects should be undertaken to test the population's willingness and support for such changes before implementation of costly projects such as co-collection.

After being collected, wastes can be transported directly in the collection vehicle to the treatment facility or the final disposal site. However it can also be transferred to another vehicle in a transfer center. Transportation can then be done by truck, train wagon or barge. The choice of transportation should take into consideration the destination of the wastes, the types of wastes, the existing infrastructures (railroads, bridges, etc.) and the cost of each transportation method. Transfer centers, like all other waste facilities, should be regulated to prevent any pollution or nuisance.

The choice of a collection system should be done carefully and should consider the following parameters. An example is given for each of them to illustrate their potential importance in the choice of a collection and transportation system.

- Density of population
    - In rural areas where population density is relatively low, drop-off centers can be a cost-effective alternative to door-to-door waste collection.
    - In areas of high density population, automated bins collection, is the best option.
    - Existing and planned facilities for wastes disposal
    - If there is no existing or planned recycling facility nearby, a separated collection system is not necessary.

Table 1 Types of collection systems

Collection type	Unstaffed drop-off centers	Staffed drop-off centers	Manual Curb-side collection system (without separation)	Semi-automated collection system (without separation)	Automated collection system (without separation)	Door-to-door co-collection system	Door-to-door separate collection system
Description	Citizens are responsible for disposing of their wastes at identified drop-off points. These drop-off centers are always accessible. They collect generally residential wastes only.	They serve the same purpose as unstaffed drop-off centers. However, being staffed, they allow the possibility of charging each citizen for his/her wastes and the staff can educate the population and reduce the occurrence of disposal errors	Collection vehicles travel every road and collect wastes without separating them. Staff members are required to lift each bin and empty it in the collection vehicle. Citizen may be required to place the bin near the road (curb-side collection), or in their backyard or at the side of their house (backyard and side of the house collection).	Collection vehicles travel every road and collect wastes without separating them. Each vehicle is equipped with a lift. Staff members are required to place the bin on the lift. This type of collection system requires specialized bins that have the correct size and form to adapt to the lift. Semi-automated collection systems are generally done curb-side. However, backyard and side of the house collection can be done. In that case, staff members bring the bin to the collection vehicles and return it to its emplacement after the emptying.	Collection vehicles travel every road and collect wastes without separating them. Each vehicle is equipped with a lift which can seize the bins without manual help. The lift is usually a claw-like device which can extend out from the vehicle and grab the container. This is a curb-side collection system only as there is usually only one staff member (the driver) in the vehicle.	Wastes and recyclables are separated at the source and are collected in the same vehicle. The vehicle can either have separated compartments (one compartment for wastes and one for recyclables) or the waste collection vehicle can be equipped with a trailer to collect recyclables. The wastes and recyclables are usually separated by the generator and placed in two different bins. Further recyclables separation (glass, paper, plastic, etc.) can either be done by the generator or by the collection crew members. Waste and recyclables collection can either be manual, semi-automated or fully automated. However, further separation of recyclables (either by the generator or by collection crew members) is usually manual. Co-collection system can either be curb-side or backyard and side of the house collection.	Wastes and recyclables are separated at the source and are collected in different vehicles. Recyclables and wastes can either be done the same day or different days. The collection can either be manual, semi-automated or fully automated. The collection of the bin can be done curb-side or in the backyard or the side of the house.
Advantages	▪ Low operation costs ▪ Offer the opportunity to collect and separate a variety of materials that would be prohibitively costly to separate otherwise ▪ The waste can be received at any time	▪ Better wastes separation at low cost ▪ Offer the possibility to make each generator pay according to the volume of wastes produced ▪ Staffed drop off center, allows the use of other equipment such as static compaction boxes, for minimizing the volume of waste and minimizing the hauling cost.	▪ Requires minimal participation from the population ▪ Ensures that most of the wastes are collected and disposed of properly (less littering) ▪ Less expensive than separate door-to-door an co-collection systems ▪ The bins don´t have to be standardized in this case. It acquisition and maintenance are in user charge.	▪ Same advantages as manual door-to-door collection system ▪ Minimizes staff injuries since no heavy lifting or waste handling is required ▪ Collection bins are standardized and are generally equipped with a lid which reduces flies and rodents problems. ▪ Due to bins standardized and automated collection this alternative is more efficiently than manual collection.	▪ Same advantages as the door-to-door collection system ▪ Reduces significantly staff injuries ▪ Collection bins are standardized and are generally equipped with a lid which reduces flies and rodents problems. ▪ Number of staff personnel are minimized ▪ Physical abilities of staff members are less important since they are vehicle operators and not collectors	▪ Ensures that most of the wastes are collected and disposed of properly (less littering) ▪ Fewer collection vehicles on the roads ▪ Requires less complex material recovery facilities since wastes and recyclables are separated at the source	▪ Ensure that most of the wastes are collected and disposed of properly (less littering) ▪ Wastes and recyclables collections frequencies can be adapted to minimize cost and inconveniences to the population (recyclables collection less frequent than wastes collection, for example) ▪ Requires less complex material recovery facilities than the collection, since wastes and recyclables are separated in a better way at the source
Disadvantages	▪ Public areas, near generation sources, are required to site the drop-off facilities. This situation may engender social resistant to these facilities. ▪ Requires population education and participation. ▪ Risk of urban micro dumps generation, due to low willingness of population to drop their waste into these facilities if these are too far from their house. ▪ .Without staff, illegal dumping or separation errors can reduce the value of the recyclables collected ▪ High risk of vandalism ▪ Risk of waste pickers presence on site	▪ Public areas, near generation sources, are required to site the drop-off facilities. This situation may engender social resistant to these facilities. ▪ Requires population education and participation ▪ Risk of urban micro dumps generation, due to low population compromise, to drop their waste into these facilities if these are too far from their house ▪ Opening hours must be such that every citizen can dispose of his/her wastes at convenient times.	▪ Requires more complex material recovery facilities if recyclables and biodegradable materials are to be removed from the wastes stream ▪ Low density of wastes require multiple travels or wastes compaction directly inside the collection vehicle ▪ Heavy lifting and waste handling can cause injuries to staff members ▪ Physical abilities of crew members are important, which reduces the employment pool ▪ Backyard and side of the house collection is time consuming and can result in legal suits or complaints from homeowners ▪ Volume waste collection must be done in differential service.	▪ Requires specialized collection vehicles and bins. ▪ Requires more complex material recovery facilities if recyclables and biodegradable materials are to be removed from the wastes stream ▪ Low density of wastes require multiple travels or wastes compaction directly inside the collection vehicle ▪ Physical abilities of crew members are still important since they have to dismount the vehicle at every stop ▪ Collection on both sides is required for efficiency ▪ Backyard and side of the house collection is time consuming and can result in legal suits or complaints from homeowners	▪ Requires specialized collection vehicles and bins ▪ Requires more complex material recovery facilities if recyclables and biodegradable materials are to be removed from the wastes stream ▪ This service needs the implementation of bins washing system, and bins maintenance and reposition plan. ▪ Low density of wastes require multiple travels or wastes compaction directly inside the collection vehicle ▪ Since collection crew members don't have to lift the bins, the volume of the bins can be bigger, thus reducing the frequency of the collects (some restrictions may require higher frequencies, such as odours and pests). ▪ Bins siting may generate some social resistance. ▪ Risk of vehicular accidents due to street bins placement.	▪ When recyclables collection is done manually, the collection time is longer ▪ Requires specialized collection vehicles ▪ A fully automated co-collection system is difficult to implement as it requires highly specialized collection vehicles and standardized bins ▪ This service needs the implementation of bins washing system, and bins maintenance and reposition plan ▪ Bins location may generate some social resistance. ▪ Risk of vehicular accidents due to street bins placement ▪ If MRF and final disposal of waste facility are far from each other, co-collection transport cost can be prohibitive. ▪ Requires participation of the population to separate the recyclables from the wastes	▪ Higher costs (transportation, vehicles, etc.) ▪ Higher number of collection vehicles on the road ▪ Requires participation of the population to separate the recyclables from the wastes ▪ This service needs the implementation of bins washing system, and bins maintenance and reposition plan ▪ Bins location may generate some social resistant. ▪ Risk of vehicular accidents due to street bins placement

Note: Any collection system to be implemented must address urban waste pickers involuntary resettlement, if are present at the study area.

- Waste Pickers presence
    - This situation may produce some interference on source separation strategies, if they are not included in the proposed collection system to be implemented.

- Accessibility and traffic condition.
    - Width and characteristics of the street and traffic may be a conditional for equipment selection.
    - Automated bin collection is more suitable on High traffic condition, than manual door to door collection.

- Weather
    - Hot weather can accelerate the biodegradation process of biodegradable wastes causing emission of unpleasant odours; it is thus preferable to have a higher frequency of collection. Since collecting wastes more frequently diminishes the volume collected each time, an automated system may not be able to diminish the collection frequency because the frequency will not be based on the maximum weight lifted by the crew members but on the reduction of nuisances.
    - In this case, it would be recommended to separate the organic waste collection, from recyclables, to minimize collection cost. Each waste stream may have differential collection frequency, increasing only the frequency of organic waste stream.

- Population participation
    - Before introducing recycling and composting, it is important to educate the population about the importance of such measures to insure the success of the system. Moreover, it is important to choose a collection system that is approved by the population. Pilot projects and public consultations can help determine the collection system that works best in a given setting.

- Cost of the system
    - The cost of the system must be covered by governments or directly by generators. Some systems, such as door-to-door separated collection, are expensive and funding must be planned before their implementation to insure their sustainability.

- Type of wastes
    - Some wastes, such as medical and hazardous wastes, require specific transportation characteristics. These characteristics influence the type of collection.

- Volume waste collection, as green waste and white line waste, require differential collection system.
- Demolition waste, have to be collected by an independent collection system due to their weight and abrasive characteristics, and final disposal required.

Throughout Belize, different districts or towns may find that different collection and transportation are best for them. National regulations should not prevent a district or a municipality from choosing the best collection and transportation system. Moreover, inside a district or a municipality, different collection systems can be used simultaneously. For example, waste can be collected door-to-door and recyclables and hazardous wastes can be collected at drop-off centers at one specified municipality.

Regulations should therefore evaluate the national performance standards of collection and transportation systems, so as to prevent any harm to human health and any deterioration of the environment.

2. WASTE COLLECTION AND TRANSPORTATION (MSW)

The choice of a collection system should be done carefully and should consider the following parameters.

- Density of population
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  - Volume waste collection, as green waste and white line waste, require differential collection system.
  - Demolition waste, have to be collected by an independent collection system due to their weight and abrasive characteristics, and final disposal required.

2.1 Wastes Collection and Transportation

- Littering:
  - Municipal wastes collection and transportation systems should be designed to prevent littering and dispersion of wastes, during the initial disposal, and collecting works.

  - Waste transportation should prevent any blowing of wastes, and leachate spilling

- Hazardous Wastes:
  - Hazardous waste should never be mixed with municipal solid waste.
  - They must be collected in differential way.
  - And must be disposed at secured landfill, and never in a municipal solid waste landfill.

- Collecting frequencies:
  - Collecting frequencies should be sufficient to prevent the accumulation of any wastes, given weather conditions, while at the same time allowing cost effectiveness.
  - Collecting frequencies should be adopted depending on the type and characteristics of the waste, the generation rate of them, and the conditions of the initial disposal.

- Vehicles:
  - Transportation of wastes should be done in vehicles which are in good working order and posing no threat to public safety or the environment.
  - Vehicles used for door-to-door collection should have a clearly visible sign and caution lights at their back indicating that they make frequent stops.
  - If the collection is done manually, the vehicle should be adapted to prevent repetitive movements that could cause injury to crew members.
  - The collection vehicles must respect national transport regulations.

Note: *Vehicles are generally adapted to prevent workers from mounting and dismounting repeatedly. This can be done by adding a platform and handles at the back or the side of the vehicles where the worker can stand during low speed displacements or by using a low floor cabin where workers can stand. If a platform is used, mirrors or a communication system should be added so that the vehicle driver can make sure that his co-worker(s) are securely in place before putting the vehicle in movement.*

- Protection of workers:
  - Collection crew members should be protected from injuries and health hazards.
  - They should not individually lift weights above 30 kg alone.
  - They should be provided with equipment to prevent them from coming into direct contact with wastes.
  - Worker´s clothes must have bright color, with reflective attachments, to make visible to drivers, to prevent accidents risk.

  - Worker´s shoes must be suitable to work condition, to prevent worker lesions.
  - Vehicle hopper loading height should be such that it minimizes injury to the collection crew during the loading process.
  - Safety equipment should be kept in working order and replaced when needed.
  - Continuous information should be provided to each collection crew member to describe working procedures that protect the worker's health.
  - Scheduled medical examinations should be conducted for workers.
  - Scheduled training should be provided to workers.

- Inspection:
  - The DOE has the right, at any time, to inspect the vehicles used for the transportation of wastes.

***Note**: The DOE or any other officer appointed by the Minister responsible for environment should have means of enforcing the regulations. The enforcement can be done by applying fines when the regulations are not respected, by the periodic renewal of a transportation permit which is subject to conditions or with both ways. The choice of a way of enforcing technical regulations is subject to the resources available and should be analysed thoroughly before being integrated in regulations.*

- Curb-side collection:
  - The generator is responsible for setting and maintenance of his/her waste bin at the curb on the collection day.
  - In residential areas, wastes should be placed at the curb no earlier and later than the collection time schedule informed to the population (the waste have not be initial disposed more than four hour at the public via).
  - Wastes should be placed near the road and be easily identifiable for the collector.
  - Wastes should not be placed in any way that can cause a traffic or pedestrian hazard, allow access to animals, or cause littering.
  - Wastes should be placed in containers or one-way storage units (i.e. plastic bags) that ensure that collection workers do not have to come into direct contact with the wastes. Each container should not exceed 20.5 kg. Containers with exposed wastes or damaged containers will not be collected.
  - Sharp wastes must be correctly disposed to prevent workers injured.
  - Non habitual wastes initial disposal, must be regulated (green waste, demolition waste, etc)
  - User penalties must be established when these rules are not respected.
  - A hot line service condition claims must be settled, to reception claims on collection service failure.

Note: *If a semi-automated or an automated collection system is chosen, the type of wastes bin, and its placement in public places should also be regulated.*

- Transfer:
  - Transfer of wastes from collection vehicles to transfer trailers should always be done in an approved transfer station. This installation must come with an EIA and operational permits approvals.
  - Waste transfer should prevent any blowing of wastes, and leachate spilling.
  - At these installations, the waste must not be stored more than 24 hours in regular conditions.

- Barging:
  - Disposal of wastes at sea or at water courses should be strictly prohibited.
  - Wastes storing on barges for more than two hours before its departure to the port should be strictly prohibited. If wastes accumulation is necessary due to low volume of wastes production, wastes should be kept inside an approved station in proper containers.
  - Wastes should be transported on barges only if it is demonstrated, to the satisfaction of the CEO, that there are no alternative means of disposal of the wastes or this is not sustainable in time.
  - Wastes should be placed in suitable containers when they are transported on barges, preventing litter production, and leachate spillage, and minimize multimodal handling and transportation.
  - This kind of waste transfers must come with EIA and operational permits approvals.

Note: *Since wastes handling, to and from barges is likely to be done outside rather that at a transfer station center, the use of labelled airtight and watertight containers prevent any littering.*

  - Containers should be inspected regularly. Any container presenting signs susceptible of affecting its integrity (rust, dent, hole, etc.) should be immediately discarded.
  - Wastes should be placed in airtight and watertight containers when they are transported on barges.
  - The CEO or any other officer appointed to do so should have the right, at any time, to inspect the containers used on a barge.
  - The barges must be surrounded by floating barriers during load and unload operations to contain and retain any waste that may fall at the sea. Wastes must be removed immediately after these operations have been finished.

3. LANDFILLS (MSW)

3.1 Introduction

Sanitary landfills are a major component of the solid waste management process. They are used for final disposal of municipal solid waste (MSW). Because of this long term time frame, they must be built and managed with a very long term view, so as to protect the environment for future generations.

Landfill technology has greatly evolved over the past few decades. Initially, *open dumps* were used for final disposal, with open burning a common practice. This approach obviously had important negative environmental impacts, namely air and groundwater/surface water pollution. Starting in the 60's and 70's, governments began requiring disposal in *sanitary landfills*; these were mostly based on attenuation by underlying soils which were supposed to attenuate the pollution percolating out of the landfill. However, this also negatively affects the environment as groundwater was impacted and biogas migrated from the landfill. The 90's saw a major shift in the approach to landfilling with the introduction of synthetic material as *confinement materials in sanitary landfills*. In this case, waste is confined with highly secure confinement systems and leachate and biogas are collected and treated to acceptable levels before being released into the environment.

Sanitary landfills are now recognized as environmentally safe. More than 2000 have been built throughout North America and performance data has demonstrated their efficiency in protecting the environment. Liners have lifespan estimated in hundreds of years, many times longer than the period for which waste may be a liability; treatment technologies have also evolved to ensure that landfills emissions (leachate and biogas) are rendered inoffensive to the environment. However, landfills are now complex systems which incorporate many technical aspects and must be managed efficiently if they are to meet expected performance levels. Regulations must therefore be developed to address these issues.

3.2 Landfills in the Belizean Context

Belize essentially disposes of its waste in open dumps. The government has decided to gradually put an end to this practice so as to ensure better protection of the environment. Based on experience gained in the evolution of landfilling in other countries, it is obvious that Belize should adopt sanitary landfills as the preferred option for this component of the solid waste management process. The proposed regulations are therefore based on this approach.

Landfill regulations should address 4 major issues, namely:

- Selection and Siting criteria
- Technical and construction aspects

- Operations
- Monitoring and Maintenance

See Appendix A. Section 1-3, for recommended regulatory specifications for Sanitary Landfills.

4. MUNICIPAL SOLID WASTE TRANSFER STATIONS AND MATERIAL RECOVERY FACILITIES

In the context of an integrated solid waste management system, a *Transfer Station* is basically an infrastructure used to transfer solid waste from small vehicles (used for collection) to larger ones (used for hauling). The obvious reason for doing so is to save on hauling costs when the distance between waste generators and final disposal sites becomes important. Other advantages include:

- Less wear and tear on collection and hauling equipment;
- Reduced environmental impacts (reduction in greenhouse gases, less fuel consumption, etc);
- Reduced highway traffic, increased security;
- Optimal distribution of resources between collection and haulage;
- More flexibility in siting of final disposal sites (i.e. landfills).

Transfer stations are either stand-alone facilities, but are often integrated with *Material Recovery Facilities (MRF's)* because of the obvious economies of scale and optimization of resources. These facilities permit the separation, sorting and treatment of wastes so that they may be recycled as useful products.

The options available to decision makers who plan these infrastructures are numerous and varied; the designs themselves and the choice of equipment are even more diverse. Transfer stations and MRF's must be intimately coordinated with upstream and downstream operations if they are to be efficient. Decisions taken on any component of the integrated solid waste process will have an impact on all the others. Careful planning based on factual data is therefore critical to successful implementation.

The objective of this exercise is to propose technical regulatory standards for the siting design, construction, operation, maintenance and closure of TS and MRFs. However, it should be underlined that the actual processes retained are the responsibility of the facility owner and his design team and that regulations should address concerns that relate to environmental and safety issues, not technical aspects.

4.1 Transfer Stations

Transfer stations can be very simple or complex facilities, based on the quantity of waste to be handled and the intended components of the operations. In its simplest form, a transfer station can be containers with hinged lids where residents come to deposit their waste; these containers are then emptied into compaction trucks for hauling. In some cases, waste can be deposited directly into compaction trucks available at specified times. Another system often seen in rural settings involves sealed bins into which collection trucks can unload their contents which are later tipped into larger transfer vehicles; however, this system generally requires specialized equipment.

The previous systems are not considered typical transfer stations as such. It is generally recognized that a transfer station involves the reception of waste by small collection vehicles with reloading into bigger vehicles for transport.

Transfer stations can be classified in many ways, but generally they are separated into two categories, namely *direct load* or *with compaction.* Direct load are more typical for small transfer stations (100 to 500 tons/day). Transfer can be done in several ways: waste can be loaded directly from collection trucks into the top of the transfer trailer which must be at a lower level; dumping can also be done on a tipping floor, with or without material recovery, and the waste is then either pushed into the top of the transfer trailer which is at a lower level or picked up by a loader type vehicle and top-loaded; in some cases, if there are important variations in waste received, a surge pit can be used to store waste temporarily, giving more flexibility to the operation.

When transfer stations must handle larger quantities of waste, it may be cost-effective to install compaction equipment so as to put more waste into the transfer trailers. These are generally of two types. The first is a stationary compactor which typically uses a hydraulic piston to compact the waste directly into the transfer trailer; the latter must be stronger than a normal trailer to resist the compressive forces, thereby increasing its weight and decreasing the maximum payload. The second type involves pre-compaction of the waste which is then pushed into the transfer trailer. Baling is also an option, but in all cases, compaction equipment is expensive and requires back-up and maintenance.

4.2 Material Recovery Facilities (MRF'S)

MRFs are infrastructures used for the recovery of materials from the solid waste stream for their subsequent re-use or recycling. These facilities are very diverse and depend on the up-stream waste components as well as the down-stream user. Various materials can be recovered, the main ones being paper and cardboard, plastics, glass, ferrous and non-ferrous metals as well as yard waste; these can be further segregated into different categories depending on the end-user market requirements.

Up-stream operations can be of numerous types. Waste can be collected directly from households without any segregation; this obviously results in a soiled waste stream and does not produce quality recyclable material. However, some sorting can be done at a MRF or transfer station to pull out major items such as wood, etc., but the reject rate is as expected, quite high. To obtain quality material, some up-stream segregation is required. Waste can be *source-separated*, usually manually by the waste generator. This can be done with drop-off centers where there are bins or containers for different material types into which users deposit the pre-segregated wastes. Another approach is to use *multiple bins* for various waste types; residents deposit the recyclable materials into these various bins for segregated collection, but this approach results in high collection costs. The most common approach is *commingling* of the various targeted recyclable materials and separate door to door collection of these; further segregation is then carried out at the MRF.

MRF's can take various forms, depending on the type of waste to be recovered. They can be very simple and labour-intensive, using hand-sorting of the waste which passes before the workers on a conveyor belt; they can also be highly mechanized, using screens, compactors, balers, shredders, magnetic separators, eddy current devices, air blowers, etc. to separate out the various recyclables. Numerous suppliers exist for each type of equipment, each with its own characteristics. The variations can be numerous and specific to each situation.

Because of this great variability in installations, technical aspects of MRF's are generally not regulated and a facility owner adapts the process to his particular situation. What is important is to make sure that environmental and health issues are taken into consideration during the design and operation of these facilities. The proposed regulations will therefore focus on these concerns.

Waste Transfer Stations and MRF's are similar in the sense that they handle waste received by collection vehicles and reload these for transport either to a final disposal site or to an end-user. In regards to impacts on health and the environment, they raise basically the same concerns, so the proposed technical guidelines should apply to both these infrastructures. The term "transfer station" will be used to represent both types of facilities.

See Appendix A. Section 4, for detailed regulatory standards for TS and MRFs.

5. INCINERATION: Municipal Solid Waste (MSW)

Incineration is basically a thermal treatment of solid waste involving its combustion in the presence of oxygen. Other thermal treatment technologies include *pyrolysis* (combustion in the absence of oxygen) and *gasification* (partial combustion to produce a combustible fuel gas).

Incineration is primarily used for the volume reduction of the solid waste stream; final volumes for disposal after incineration can be reduced to 25% of the initial solid waste volume, therefore increasing the life span of the final disposal site. Incinerators often include energy recovery systems, producing hot water or steam that can be used to generate electricity. Because of the high combustion temperature, incinerators also destroy pathogens and are often used for destruction of infectious waste.

The site that is ultimately selected for the location of an incinerator facility should reflect the requirement of each individual component unit. In general, factors that should be considered in any site selection process for an integrated hazardous waste management facility may be grouped into the main headings of site suitability and public acceptance.

Once suitable candidate sites have been identified, a detailed assessment shall be done to determine the environmental, technical and economical feasibility of the proposed facility at a particular site. The issues that shall be considered include:

- site hydrology (surface water);
- geology of the site;
- hydrogeology of the site;
- presence of sensitive habitat;
- urbanization of surrounding areas;
- socio-economic aspects (including impacts of transportation);
- streams in and around the site, stream flow rates, and public use of stream water;
- location of markets for any recovered materials and proximity of potential energy users;
- availability and cost of land;
- cost of site development;
- ambient air quality conditions, dispersion characteristics and wind direction;
- economic viability (including transport costs).

Incinerators are generally of two basic types, either *mass-burn* or *refuse derived fuel (RDF)* types. In mass-burn incinerators, the waste stream receives little if no pre-treatment; waste is mingled as it is discharged from the collection vehicles before being placed into the combustion chamber chute. In RDF incinerators, the fuel is derived from segregation of combustible material from the waste stream prior to incineration, generally in a material recovery facility (MRF); the fuel is either in a shredded or fluff-type format or densified to create pellets. Because of the heterogeneous nature of bulk waste, mass-burn incinerators are more variable in energy output and air/ash quality; however, because of their overall lower capital and operating costs (due to less waste processing) and their relative simplicity, these facilities are more popular than RDF type facilities.

To ensure maximum combustion, it is necessary to ensure that there is always enough air that reaches all parts of the waste. At the same time, too much air results in lower combustion temperatures. Air injection and mixing of the waste are therefore critical factors in determining overall system performance. Grates (the actual surface on which the waste burns) are consequently an important aspect of incinerator components.

Typical mass-burn incinerator operations are as follows:

- Waste is dumped from the collection vehicle into a storage pit whose size is based on burn rate and waste volumes received;
- The waste is then transferred by overhead crane into a chute or hopper which directs it to the combustion chamber or furnace;
- The waste travels down the moving grate as it burns. Air is injected over and under the grate to ensure adequate air supply;
- Combustion gases are cleaned before discharge through a flue or stack and bottom ash falls through the grate for cooling and final disposal.

Depending on waste volume variation and to ensure system flexibility, incinerators normally have multiple combustion chambers. This also permits maintenance and back-up in case of unplanned shutdowns. If there is energy recovery, this involves one of two methods. *Waterwall combustion chambers* recover heat through the walls of the combustion chamber which is lined with tubes through which water circulates, thereby generating steam. In the case of *waste heat boilers*, the hot stack gases pass through a boiler located outside of the furnace.

In all cases, modern incinerators are very capital intensive and require important pollution control equipment. Designs and equipment are very specific to each application and supplier.

See Appendix A. Section 5, for detailed regulatory standards for Incineration of municipal solid waste.

6. CONTROLLED DUMPSITE

In rural regions, it may be difficult to conform with regulations regarding wastes management due to the low volume of wastes generated and to the important cost of transport. In those cases, it may be necessary to manage the wastes of isolated communities on site with controlled dumpsite.

Controlled dumpsites are unlined landfills designed to receive small volumes (less than 2.000 ton per year) of residential wastes. For these reasons, controlled dumpsites should be reserved to small communities of not more than 5.000 inhabitants where the volumes of wastes are very small and where no cost-effective alternative is readily available or regional solution cannot be implemented.

In these cases, it is recommended to adopt source separation strategies. The elemental source separation in dry and wet waste is recommended.

The wet waste portion would be composted, and the dry portion (not compostable) would be final disposed into the controlled dump.

The compost would be done by the users, or at the final disposal site. In this last case, biopile aerobic composting is recommended.

This situation will produce a fast organic stabilization, and this product may be used as final cover material on site.

This action will produce a dry landfill, so the cell may be excavated without isolation. The soil excavated may be used as a daily cover material.

It is important to limit the number of controlled landfills to a minimum. They should be permitted only in particular settings and when there is no other solution available. The following proposed regulations are assessing where controlled dumpsites should be permitted and the technical requirements that should pertain to the sitting and operation of a controlled dumpsite. See Appendix A, Section 6, for detailed regulatory standards for Controlled Dumpsites.

7. OPEN DUMPSITES OR ILLEGAL DUMPING

Open dumpsites are generally unorganized disposal sites used by the community. They usually take place on vacant terrains and abandoned facilities.

Open dumpsites pose significant health risks. Most of the time, open dumpsites are easily accessible to people, like children, who are vulnerable to the physical threats (rusted nails, sharp ends, etc) and to the chemical threats (harmful fluids or dusts) posed by wastes. Moreover, open dumpsites can be the source of proliferation of the vectors of diseases, such as mosquitoes and rodents. For these reasons, they are strictly prohibited and wastes found in these dumpsites must be declared to the authority to solve this situation as soon as possible.

Illegal dumpsites are generally the consequence of two problems:

- Lack of alternative wastes disposal;
- Lack of enforced solid waste regulations and/or population awareness.

The cost of disposing of wastes appropriately may be prohibitive because of the lack of alternative wastes disposal. Citizens may think it is acceptable to dispose of wastes in open dumpsites as they usually don't see immediately the negative effects and external cost that such sites can have on the environment and public health.

The local authorities have to close such illegal dumping and must take immediately measurements to reduce and control the access, to avoid health risk, and control the dumping of wastes at a site.

Once closed, actions in the United States have proven that the embellishment of the site, such as transforming it into a public park, may have a positive impact[1].

Educating the population about the risks posed by illegal dumping sites may not completely alleviate the problem but it can help reduce greatly the volume of wastes dumped. Moreover, concerned members of the population are the first line of defence against illegal dumping as they can relay the information about new illegal dumping sites to the authorities faster than any other monitoring system.

See Appendix A, Section 7 for technical regulatory standards to be followed in closing every illegal dumping site in Belize.

[1] US EPA, Illegal Dumping Prevention Guidebook, March 1998, EPA 905-B-97-001.

8. COMPOSTING

Landfills are a major component of the solid waste management process. They are used for final disposal of many types of wastes. However, the disposal of large quantities of biodegradable wastes in landfill can have impacts such as higher methane and leachate production. These impacts can be assessed and controlled by landfill design and operation or by rerouting biodegradable waste towards an alternative means of disposal.

Composting is one of these alternatives. It consists of the biological decomposition of organic waste in order to obtain an end-product that is stable and free of pathogens. The main advantage of compost is that produce an important reduction on the waste stream that must be filled at the landfill.

Many wastes can be suitable for composting. Major categories include organic fraction of MSW, and yard wastes (grass clipping, leaves, etc.). However, a composting facility owner should keep in mind that the nature of the substrates used influences the rate and the nature of the microbial reaction and the quality of the final product.

Composting can be achieved on a very small scale. Kitchen and yard wastes can be composted directly by citizens in their own backyard with no or little inconveniences. This practice is well documented and information as to what wastes should or shouldn't be added to this kind of compost is readily available. There is no technical regulation required for this type of composting other that the municipal regulations already in place to minimize neighbourhood inconveniences (odours, pest control, etc.).

The objective of this section is to give a general overview of the options available for commercial composting facilities as well as to propose technical regulatory standards applicable to those facilities. However, it should be underlined that the actual processes retained are the responsibility of the facility owner and his design team and that regulations should address concerns that relate to environmental and safety issues, not technical aspects.

8.1 Belizean Situation

According to a study realized in 1998[2], fishing, agriculture and aquaculture industries are the source of the majority of the industrial wastes in Belize. These industries produce generally wastes assimilable to MSW, with high biodegradable contents and few impurities (plastic, metals, etc.). Composting is particularly appropriate for these types of wastes because they require little to no pre-processing as compared to municipal solid wastes.

[2] Inception Report, Belize Solid Waste Management Project, Stanley International Group inc. May 1998.

Therefore, it may be pertinent to encourage the implementation of composting facilities to treat the industrial wastes coming from food production industries. Centralized operations can receive wastes from different industries and treat large volumes of wastes. Due to large volumes, the use of more complex composting and odours management techniques can be economically feasible. Smaller scale composting facilities can be installed at proximities to the industries and treat only wastes produced by a few sources. These installations reduce the need to transport the wastes, but the operating costs generally prohibit the use of complex composting and odours management techniques. The choice of the installations types depend therefore on generators' location, the availability of sites to install composting facilities and the total cost of alternative means of disposal such as landfilling and incineration. See Appendix A, Section 8 for technical regulatory standards for composting in Belize.

9. Proposed Analysis Standards for Environmental Monitoring Program

Wastes may contain harmful substances that can pose a threat to public and environmental safety. Periodic analyses of groundwater, surface water, waste water and air can help to measure the impact of a wastes management facility and to prevent any harmful consequences. However, to obtain reliable results, analyses must be performed using standard methods.

For each parameter stipulated by regulation, an accepted standard test method should be promulgated by the Government.

Although standard methods may be develop from scratch to answer specific needs, it is usually easier to use existing standard methods developed by international organizations or other countries to answer similar needs.

US EPA Standard Methods: The environmental protection agency of the United States of America has developed numerous standard methods for the analysis of air, water and soil.

The methods concerning the quality of air emissions are available online at http://www.epa.gov/ttn/emc/promgate.html.

The methods concerning the quality of water and wastewater used in the United States and approved by the US EPA are available online at http://www.standardmethods.org/.

ISO Standards: ISO is the world largest developer and publisher of international standards. There are ISO standards for a large range of subjects including environmental analyses. ISO Standards can be found online at http://www.iso.org/iso/home.html.

British Standards: British standards have been developed by United Kingdom to regulate methods inside the country. Some of them have been replaced by ISO Standards in the last decades but some are still in use in the United Kingdom and other countries. British standards can be found online at http://www.bsigroup.com/.

For each parameter integrated in Belizean regulation, these international standards should be compared and, when available, they should be integrated to Belizean regulations.

Appendix A.

Technical Regulatory Standards for the Siting, Design, Construction, Operation & Maintenance, Closure and Post Closure of SWM Facilities

Table of Contents

<u>LIST OF TABLES:</u>

10. LANDFILLS (MSW)

Landfill regulations should address 4 major issues, namely:

- Selection and Siting criteria
- Technical and construction aspects
- Operations
- Monitoring and Maintenance

A. Selection and Siting Criteria

The following siting criteria are proposed:

1. Buffer zone: sanitary landfills must have a minimum buffer zone of 50 metres surrounding the landfill area. No construction is permitted in this zone except for access roads to the landfill area.

Note: The main purpose of this buffer zone is to establish a visual barrier to mitigate visual impact of surrounding.

2. Water intakes: landfills must be located at least 500 metres from water sources used for human consumption. This setback is not required if it is demonstrated that the water quality of this water source (superficial or underground body), is not suitable for irrigation or human consumption.

3. Landfills must be located outside of 100 year recurrence floodplains.

4. Landfills must be located on geotechnical stable soils. They must also be located 100 m from known fault areas and be designed to withstand surface motion due to earthquakes.

5. Landfills must be located at least 5 kilometres from all airports used by turbojet aircraft and 2 kilometres from airports used by only piston type aircraft.

6. Landfills must not be located on wetlands.

7. The following setback criteria must be respected:
    a) 1 kilometres from residential areas
    b) 500 m from individual homes and public buildings
    c) 150 m from lakes and watercourses
    d) 50 m from streams
    e) 500 m from ecologically sensitive or protected areas.

f) Preferably down-wind from housing areas

g) The bottom of the cell has to be placed one meter above the first water table. The soil permeability in between has to be less than 10^{-7} cm/seg. If the soil permeability is higher than this value, this requirement it could be compliment by an engineered solution. The impermeable barrier had to be High density Polyethylene layer of 1500 microns thick at least, as second container barrier.

h) Soil use classification at the site area must be rural or industrial exclusive.

B. Site Investigation and Location

All Municipal Solid Waste Management Facilities shall be located, designed and constructed to ensure environmental protection, and facilitate environmentally sound site operation, decommissioning and future use of the site. The following information on site location should be transmitted to the DOE as part of the site investigation:

1. An accurate description of the proposed location. This description must include all information described at task 2.3 “Sitting criteria”, and include a description of the site geology, hydrogeology and environmental condition.

2. A legal survey; describing site property, and any use restriction that this may have.

3. plans showing all property boundaries, buildings, roads, utility corridors, contours, drainage channels, water bodies, rights of way, easements, forested areas and adjacent land uses

4. GPS coordinates/GIS system mapping of facility features in a compatible and manageable format and level of detail.

5. Site compatibility with other land uses, and any environmental sensitivity of the area must be commented and addressed.

6. Facility location, a surveyed plot plan, a description of the required infrastructure design specifications, access requirements and support services to handle the anticipated waste volume to be received / processed/ stored / disposed over the life of the facility.

7. Siting perfectibility (A Municipal project perfectibility certificate) of the site

C. Design Criteria

The following design criteria are proposed based on state-of-the-art practice observed in other jurisdictions:

1. Liner requirements: Landfills must be designed to prevent leakage of leachate and biogas to the environment. Two types of liner designs may be used in landfills:

    a) **Low permeability soil liner**: In-situ low permeability soils may be used for containment landfills. In this case, the soil aquitard must be at least 6 metres thick, be continuous and have a hydraulic conductivity of less than 1 x^{-} (10^{-7})cm/s. In the case that this in situ hydrogeology is not present, and Alternative barriers may be permitted, as composite liner described below, or other engineered solution if it is demonstrated that they have an equivalent performance.

    b) **Composite liner**: Composite liners must be used if the requirements for a low permeability soil liner are not present. Composite liners must have two components: an upper 1.5 mm high density polyethylene (HDPE) geomembrane and an underlying clay component composed of 100 cm of compacted low permeability soil having a uniform hydraulic conductivity of 1 X (10^{-7})cm/s or less. In-situ soil is acceptable if it meets these hydraulic conductivity requirements, is continuous and homogeneous and has a minimum thickness of 1 m. Geosynthetic clay liners (GCL) are allowed as an equivalent to the low permeability soil component. The geomembrane must be installed in direct and uniform contact with the underlying low permeability soil component if is free of debris or particles that can affect HDPE liner integrity, if not nonwoven geotextile is required in between to protect the HDPE liner. Base grades must be above maximum groundwater levels as determined by a qualified hydrogeologist. **The note should go one line below)** ***Note:*** *Composite liners are recognized as being very efficient liquid barriers. Geomembranes alone have very low hydraulic conductivities, but if the underlying material is permeable, defects act as orifices and flows can be quite high. If clay or low permeable soil liners are used alone, leakage will occur across the area subject to a hydraulic gradient; in this case also, leakage can be quite high. In the case of a composite liner, leakage will occur where there are defects in the geomembrane, but it will be quite low due to the hydraulic impedance of the underlying low permeability soil. Actual field date shows that composite liners can achieve efficiencies greater than 99.99 %. Intimate contact between the geomembrane and soil components is however required to achieve a composite effect.*

Note: *Liner systems must be installed above maximum groundwater levels to avoid up-lift of the lining system during construction to prevent up-lift pressures created by high groundwater levels. To prevent this situation, the minimum distance between the bottom cell and the first water table must be at least one meter*

2. Quality Assurance: All liner and drainage components must be subjected to a quality assurance/quality control (QA/QC) program which must be approved by SWaMA. This program must include:

    a) Acceptable materials and specifications
    b) Compliance testing of all materials;
    c) Material storage, handling and installation procedures;
    d) Drawings of the HDPE layers placement for welding,
    e) Detail drawings of inserts to be executed or geomembranes and GCL
    f) Installer qualifications;
        i. *Company history;*
        ii. *Description of the available equipments and qualified installers;*
        iii. *A list of at list 5 similar projects realized in the past.*
        iv. *A description of the quality assurance system used by the Installer;*
        v. *CV of all installers that will participate during the construction.*
    g) Destructive and non destructive testing of all seams
    h) Project documentation and reporting.

Note: *All liner systems are prone to possible defects. Experience has shown that a comprehensive QA/QC program reduces defects by a factor of 10 to 30 and leakage by a factor of at least 10. A QA/QC program is therefore essential to attain anticipated performances.*

3. Leachate Collection and Removal System (LCRS): landfills must be designed to efficiently remove leachate to avoid head build up on the liner. Designs must meet the following criteria:
    a) For sites using low permeability soil liners, the LCRS must be designed to prevent further reduce liquids from reaching waste deposited in the landfill. That means that leachate accumulation, if any, should occur in the leachate collection system located below the wastes and above the liner. The LCRS must be composed of granular material with a minimum thickness of 30 cm and must be placed above a nonwoven geotextile to prevent granular material mixing with the low permeability soil placed below. This LCRS must also have a minimum hydraulic conductivity of 1×10^{-4} m/sec.

b) For sites using composite liners, the LCRS must be designed to limit head build-up to a maximum of 50 cm. The LCRS must be composed of granular material with a minimum thickness of 50 cm to act as a protective layer for the geomembrane. It must also have a minimum hydraulic conductivity of 1 X 10^{-4} m/sec. If the material used in the protective layer contains elements which may puncture the geomembrane, a protective nonwoven geotextile cushion must be installed over the liner; this cushion must be designed using documented (published and accepted) procedures, based on future waste height and asperities of the drainage material. Other engineered solution may be used with equivalent performance.

c) Seepage from landfill side/slopes must be collected and sent to the leachate treatment facility.

Note: *Leachate removal is almost as important as the liner system. Leakage is in direct relation to head positioning on liner. The lower the head, the less potential leakage there is.*

4. Leachate Collection pipes type of material: Leachate collection pipes must be installed in the drainage layer. They must be designed based on anticipated flows, with a minimum diameter of 15 cm and a minimum grade of 0.5 % for collector and slope of branches (calculated after base grade settlement). They must have access ports for periodic cleaning. These pipes holes must be phased to prevent loss of pipe flex resistant. Holes diameter must be adequate to granular particle dimension, to prevent fine sedimentation into the pipe. If geotextile were used to prevent this effect, the fines of the granular material must be controlled to prevent clogging.

5. Daily Cover: At the end of each day, the waste must be covered by a 20 cm of soil layer for vector control, and minimize littering. The cell loss volume due to daily cover must be taken in account on cell capacity calculation.

6. Final cover: As the landfill successively fills up, a final cover must be installed on the top and side slopes of the parts of the landfill that have attained the authorized height of waste. This cover must have minimum grades of 5 % to enhance runoff and a maximum grade of 30 %. An erosion analysis must be carried out and the design must incorporate erosion control measures as required. The cover must include, from top to bottom, the following components:
   a) A 15 cm soil layer suitable for vegetation;
   b) A 30 cm thick protective layer;
   c) An impervious layer composed of one of the two following options:

i. A 45 cm low permeability soil having a maximum hydraulic conductivity of 1 X 10^{-7} m/sec;

ii. A GCL with equivalent permeability.

Note: *the use of polyethylene geomembrane is not recommended to avoid geomembrane up – lift pressure due to biogas migration.*

Note: *All liner systems are prone to possible defects. Experience has shown that a comprehensive QA/QC program reduces defects by a factor of 10 to 30 and leakage by a factor of at least 10. A QA/QC program is therefore essential to attain anticipated performances.*

Note: *Final cover (or capping) is an essential element of a confinement landfill. Without an impervious cover, leachate production can reach very high levels and necessitate important treatment costs. Also, impervious covers enhance biogas collection, thereby contributing to reduce greenhouse gas emissions (when coupled with a gas destruction facility).*

7. Landfill height: Landfill waste height must be calculated as its slopes grades, based on the following:
   a) Base grade stability: A geotechnical stability analysis must be carried out by a qualified certified engineer and an appropriate safety factor must be maintained to avoid failure of underlying soils
   b) Slopes stability: A geotechnical stability analysis must be carried out by a qualified certified engineer and an appropriate safety factor must be maintained to avoid failure of the waste pile;
   c) Visual integration: The site should be visually integrated into the surrounding landscape to minimize visual impact.

8. Surface Water Management: The landfill must be designed to prevent all surface water flow into the disposal area. Surface water control systems must be designed to handle, at a minimum, water volume generated by a 24 hour and 25 year storm event and must have erosion control as required.

9. Biogas Management: Landfills must have systems that permit biogas collection and safe release of the collected biogas to the environment. For landfills receiving less than 50.000 tonnes per year, biogas can be passively released to the atmosphere with passive vents or wells and materials installed through the final cover at the time of construction of the latter. For sites receiving more than 50.000 tonnes per year, gas must be collected using gas blowers or compressors to actively extract gas from the waste. Gas production must be estimated using recognized modelling techniques and the extraction system must be sized to handle all the gas produced. Once gas is collected actively, it must be burned or valorized. Gas collection

surface systems must be installed within a maximum of 5 years of site start-up. Extraction wells must be installed during the site is in operation, as the waste is final disposed.

10. Flaring Station: If gas is burned, it must be done utilising enclosed flares which are certified to attain 98% destruction of all non-methane volatile organic compounds (NMVOC). The minimum retention time for the gas in the flare is 0.3 seconds with a minimum temperature of 760 °C. Any valorization technique must ensure equivalent destruction efficiency. Public access to the blower and flaring station must be limited by installing the equipment in a building or by surrounding the installation by a fence. During operation, gas volumes and methane concentrations must be measured on a continuous basis.

Note: *Biogas results from the degradation of organic matter contained in the waste stream. It contains many components, including methane in concentrations up to 70 %. As methane is flammable between 5 and 15 % concentration by volume, there is a potential that uncontrolled gas may cause damage if it is exposed to an ignition source. Methane is also a recognized greenhouse gas which has 21 times more impact than* CO_2 *on global warming. Collection and destruction of this gas should therefore be highly encouraged.*

11. Leachate Treatment: Landfills must have treatment systems designed to treat collected leachate to the following effluent standards before being discharged to the environment:

Table 1: Effluent Standards for Treated Landfill Leachate

Parameters	Maximum values	Average Monthly Values[1]
Ammonia nitrogen (expressed as N)	50 mg/l	20 mg/l
Fecal coliforms	Non applicable	1000 CFU/100 ml
Phenolic compounds	1.0 mg/l	0.40 mg/l
5 day Biochemical Oxygen Demand	175 mg/l	75mg/l
Suspended solids	130 mg/l	50 mg/l
Zinc	5.0 mg/l	2.0 mg/l
pH	Greater than 6 and lower than 9	

[1.] *These values are calculated using an arithmetic average, except for fecal coliforms which are calculated using a geometric average*.

a) Different or additional parameters or limits may be required as determined by the regulating authority based on the receiving water body usages.

b) Leachate recirculation in the waste mass is permitted as long as there is at least 4 metres of waste in-place and that the LCRS is designed considering the anticipated flows. This situation must be considered in geotechnical stability analysis.

c) Treatment systems must meet the following prescriptions:

   i. Treatment systems must be surrounded by a fence to prevent public access.

   ii. All ponds or lagoons used for leachate storage or treatment must be underlain by a composite liner or a clay liner meeting specifications stated above in Sec. 2.5 (see liner requirements).

D. Construction

1. All waste management facilities are to be constructed:
   a) according to the approved design;
   b) following approved Quality Assurance and Quality Control protocol; and
   c) consistent with sound environmental practices for construction activities (following the Environmental Management Plan).

2. Prior to the site opening, the proponent shall provide documentation, in the form of a Certificate of Completion, that the landfill site has been constructed as proposed, that all environmental systems are in place and functional, and that the landfill facility is ready to receive waste.

3. The Certificate of Completion shall include:
   a) as-built drawings;
   b) quality control certifications as applicable; and
   c) a Certificate of Completion report from the Design Engineer stating that the facility has been constructed as designed and outlining any deviations from the original design and the rationale for those deviations.
   d) a description of facilities constructed along with photographic records; and
   e) a facility operations and maintenance manual.

E. Operations

To ensure adequate protection of the environment, landfills must be operated in accordance with environmentally sound practices (defined into the Environmental Management Plan). The following specifications are considered basic to achieve adequate protection levels:

1. Acceptable waste: In addition to municipal solid waste, the following wastes may be accepted at sanitary landfills:
   a) Construction and demolition waste;

b) Green waste,
c) Used tires,
d) Industrial and commercial waste assimilable as municipal solid waste.
e) Autoclaved biomedical waste
f) All other types of waste approved by the DOE.

2. Prohibited waste: The following materials are not to be admitted to a containment landfill:
   a) Hazardous waste including radioactive waste;
   b) Wastes which are liquid at 20 °C;
   c) Wastes containing pesticides or untreated biomedical waste;
   d) Sludge with a water content greater than 15 %;
   e) Derelict motor vehicles;
   f) Livestock wastes;
   g) Ash or other volatile wastes which is fine enough to disperse into the atmosphere during its discharge in to the landfill
   h) Corrosive wastes
   i) Explosive wastes.
   j) inflammable or reactive wastes

3. Fill sequence: The fill sequence must be such that the fill area is limited and that it permits the placement of final cover as soon as possible. This fill sequence must be designed with the Leachate collection and removal system (LCRS) design.

Note: *This is to limit leachate production. Experience has shown that leachate volumes are greatly reduced in areas having received an impervious final cover.*

4. Inspections: received waste must be visually inspected at the working face by the site operator to ensure that the waste is acceptable. Prohibited waste must be separated, removed and returned to the waste generator.

Note: *If a prohibited waste load were to be transported to the landfill by mistake, it should not be landfilled. It has to be transported elsewhere and disposed.*

5. Weighing: All waste must be weighed before being admitted to the landfill. Landfills must have scales or take measures so that vehicles are weighed off-site. Data must be registered in a logbook containing the following information:
   a) Date and time
   b) Name of the generator
   c) ID of the carrier truck
   d) Quantity of waste

e) Type of waste (municipal, construction etc.)

6. Active area: The work face must be minimized in area. The working reception face design will depend on the kind of vehicles that may arrive there. Manual discharge vehicles must be separated from mechanical discharge.

7. Picking activities: Waste picking must be prohibited at the active area.

8. Waste compaction: Waste must be spread and compacted (at least at 750 kg/m3) as soon as they are received at the landfill using appropriate equipment. A monthly survey must be done to verify the compaction factor reached during the landfill operation.

Note: *If sludge is a permitted waste, this waste must be landfilled in a separate and special cell, to prevent stability failures.*

9. Animal carcasses or parts must be covered by at least 15 cm of soil or equivalent material as soon as they are placed in the landfill and before their compaction.

10. If baled wastes are expected to arrived at the site, depending on their quantity, special cell may be required, because the unloading and placement procedures are quite different from *traditional landfill, otherwise, the bales must be spotted and compacted as the rest.*

11. Daily Cover: Waste must be covered at least at the end of each operating day. The cover must be at least 20 cm of soil or equivalent material to prevent blowing litter, spread of fires, release of odours, and proliferation of insects and animals and excessive infiltration during rainfall. It must have a hydraulic conductivity greater than 1 X 10^{-6} m/sec and contain less than 20 % by weight of particles 0.08 mm or finer in diameter.

12. Burning of waste is strictly prohibited.

13. Control of Litter: The landfill operator must take the necessary measures to control the wind dispersal of litter. This may include the use of litter fences. The surrounding site and access road must be periodically cleaned of litter.

14. Annual Reporting: The site owner must prepare an annual report to be submitted to SWaMA with copy to the DOE within 90 days of the end of each year. The report must contain, at a minimum:
    a) Problems or complaints and the resolution;
    b) A compilation of the quantity and nature of the waste received;

c) A plan and appropriate data showing site progression and an estimate of remaining facility operating life or landfill capacity;
d) A summary and evaluation of environmental monitoring data/reports and facility performance in terms of regulatory compliance and environmental protection;
e) Description of any environmental incidents / contingency plan implementation
f) Description of work carried out during the year.

F. Site Safety and Security

1. Access to the site shall be designed to accommodate vehicles, which include large compactor trucks, transfer tractor trailers and heavy equipment normally used to move waste at the site.

2. Access shall be restricted to hours of operation, when operating personnel are present.
3. Access to the site shall be controlled by the use of barriers, fencing and gates. The type and extent of fencing will depend on the existing natural vegetation and topographic features and is to be approved by *SWaMA*. All access points are to have locking gates.

4. All roads on site shall be properly maintained to minimize the potential for dust, mud or wastes from the facility being carried onto access, public or private roads.

5. Suitable waste drop off areas shall be provided for public use.

6. Information regarding the conditions of access and restrictions shall be posted at the site entrance.

G. Signage

1. Legible and appropriate signage is required:
   a) At the site entrance(s) stating the name and purpose of the facility and listing materials acceptable for disposal, hours of operation, emergency and general contact information; and
   b) to direct vehicles to the appropriate solid waste unloading areas such that small vehicles do not have direct access to the landfill working face.

2. Specifications regarding the signage, fencing and gates are to be provided by SWaMA and based on local traffic regulations.

H. Prohibited Activities

1. Open burning and scavenging are strictly prohibited.

2. There shall be no smoking at any waste management facility, with the exception of a location designated for the use of employees who smoke.

I. Personal Protective Equipment

1. There shall be an appropriate number of on-site trained personnel at all times while the facility/site is open for operation. The facility and site shall be closed and locked outside hours of operation.

2. All personnel shall be familiar with the Operations and Maintenance manual/ plan, and the Environmental Health and Safety Contingency Plan, and have detailed knowledge of plan information for the part of the facility where they are stationed.

3. All personnel shall be equipped with Personal Protective Equipment appropriate to their level of training and assigned tasks. Safety and Emergency Response training shall be kept current and reinforced with regular exercises.

4. Emergency response equipment and exits shall be conveniently located and clearly marked.

5. Provision for emergency shutdown of machinery shall be consistent with industry standards and safety guidelines.

J. Staff Training and Certification

1. Key personnel shall be trained in operations of the waste management facility and be certified by an accepted certifying body.

2. On-site operators shall be trained to identify hazardous and unacceptable materials.

K. Employee and Administrative Facilities

1. Appropriate employee and administration facilities are to be provided, to satisfy occupational health and safety regulations and provide for worker comfort. Secure storage space is also required for administrative records, personal protective equipment, tools, and for any combustible materials that may be used on-site.

L. Public Education and Awareness

1. The owner/operator of the waste management facility/system has the responsibility to ensure that the public is provided the information they require to effectively and safely participate in modern waste management activities. This includes an

understanding of the respective roles and requirements of system participants, and a general understanding of how facilities operate and of any hazards/safety considerations.

2. Monitoring Requirements

During the operations period landfills must be monitored to ensure that they are performing properly and are not a source of contamination. Each site must therefore have a dedicated monitoring plan adapted to its particular situation.

1. A landfill owner must prepare a monitoring program which must be approved by the DOE. This program must be carried out for the active life of the landfill as well as the post-closure period. This plan must indicate:
   a) The sampling stations and their construction details;
   b) Sampling frequency;
   c) The parameters tested and testing methods;
   d) Recording procedures.
2. Leachate: Treated leachate must be tested on a weekly basis for all periods during which there is effluent emitted to the environment. Raw leachate must be tested prior to treatment at least four times per year so as to assess treatment system performance. In the case that raw leachate meets effluent standards it must be tested four times per year to ensure compliance. Treated leachate flows emitted to the environment must be measured on a continuous basis. Compliance is based on the reported procedures as indicated in the present document.

3. Groundwater: Groundwater must be analysed on a quarterly basis. The required parameters and compliance standards for containment landfills are indicated in Table 2 below; however, if background levels are observed for any of these parameters, the compliance levels are adjusted by adding the background levels to the compliance standards. For indicative parameters, any significant increase in historical levels obtained after 2 years of sampling is considered an anomaly and is to be investigated. Samples are to be collected in observation wells installed as follows, and tested by and independent party:
   a) One groundwater observation well must be located up-gradient of the site to establish background values;
   b) Three down-gradient observation wells are to be installed for the first 8 ha of approved landfill area and one extra well for each increment of 8 ha.;
   c) Wells must be screened in the aquifer most likely to be affected in case of a leak from the landfill; and their design must prevent cross contamination between aquifers.
   d) Observation wells must be located at a maximum of 150 metres from the edge of the landfill area.

Table 2: Groundwater Criteria for Landfills

Parameter	*Compliance level*
- Ammonia nitrogen (expressed as N)	*1.5 mg/l*
- Chlorides (expressed as C-)	*250 mg/l*
- Iron (Fe)	*0,3 mg/l*
- Nitrates and nitrites (expressed as N)	*10 mg/l*
- Zinc (Zn)	*5 mg/l*
Indicative Parameters	
Total phenols	
Chemical Oxygen Demand	
Electric Conductivity	
pH	

4. Biogas: Biogas in the unconsolidated deposits and in on- site buildings must be tested on a quarterly basis to ensure there is no gas migration. Compliance is based on a maximum value of 25 % of the lower explosive limit of methane, or 1.25 % by volume at or in on-site or off-site structures. The gas observation wells must meet the following criteria:
    a) *Four observation wells are to be installed for the first 8 ha of approved landfill area and one extra well for each increment of 8 ha.;*
    b) *Wells must be screened in the unsaturated soils surrounding the landfill and sealed at the surface;*
    c) *Wells must be located at a maximum of 150 metres from the edge of the landfill area.*
5. Surface water: Surface water emitted from the landfill area must be tested on a quarterly basis when there are flows. Compliance is based on the “average monthly values” for treated leachate.

6. Corrective action: in the case that monitoring results demonstrate non-compliance, the site owner must report the occurrence to the DOE within 7 days of its observation. Measures must be taken as soon as possible to correct the situation. A corrective action plan must be submitted to the DOE within 60 days after disclosure.

3. Post Closure Care: Decommissioning

The design of the waste management landfill system components shall take into consideration the requirements for proper closure and decommissioning at the end of the operating life.

A. Preliminary Decommissioning Plan

1. A Preliminary Decommissioning Plan based on the estimated operating life shall be submitted to the *DOE* prior to issuance of a permit for the Construction and Operation of a Waste Management Facility/System. The information that may be required, depending upon the nature of the facility is as follows:

    a) A closure activities itinerary / tentative schedule.
    b) Operation plans for pollution abatement engineering works such as leachate collection and treatment systems;
    c) Post-closure environmental monitoring programs for leachate, groundwater and surface water quality;
    d) A plan to stop accepting waste and remove all remaining waste material in advance of closure.
    e) A description of what may be remaining on the site in perpetuity, and any remedial work that may be involved.
    f) Removal of infrastructure or renovation for an acceptable future activity.
    g) Current and projected cost estimates to complete decommissioning, and the corresponding details regarding acceptable financial assurance;
    h) Proposed post-closure use of the property; and any other information required by the regulating authority.

B. Notification of Final Closure/Decommissioning

1. The owner/operator shall notify the community(ies), site users and the *DOE* in writing of the pending shutdown of the site at least 180 days in advance of the site ceasing operation and provide an estimate of the engineering costs to complete the decommissioning.

2. The detailed decommissioning plan for the site must be approved by the *DOE* and the *DOE* notified when the site decommissioning activities begin and are completed.

3. Appropriate signage shall be placed at the site entrance to notify site users of the pending decommissioning of the site, along with the date of shutdown and details on where waste shall be taken once the site closes.

C. Detailed Decommissioning Plan

1. The final decommissioning plan is to be approved by the *DOE* at least 6 months prior to final closure of the waste management facility / waste disposal site. Based on the premise that an approved, contained municipal solid waste management facility has been appropriately operated, consistently maintained, and progressively

decommissioned in the case of a landfill, site cleanup, preparation and remedial work should be completed in a very timely manner.

2. Information to be provided/ updated includes:
   a) Notification requirements and alternate disposal site locations;
   b) Description, schedule and costs associated with decommissioning activities;
   c) Final cover design and installation details, and any additional work required;
   d) Measures taken to ensure that access to the closed site is restricted or removed.
   e) Contingency plans for fire, illegal dumping and nuisance control post-decommissioning;
   f) Post-decommissioning monitoring and maintenance, including security and Environmental monitoring requirements.

3. As part of the decommissioning plan the owner/operator shall provide as built drawings for all remaining facilities, components and installations. An up to date and accurate plot plan, including geographic positioning system coordinates for site features, and showing the locations of permanent survey markers shall also be provided.

4. For landfills, the environmental management systems and the monitoring regime for surface and ground water quality; the integrity of the final cover, landfill gas control and leachate management should be clearly described. There should be no waste remaining on site following closure and decommissioning of any other types of waste management facility. However, site specific arrangements for ongoing monitoring will be required in the event that some contamination occurred during the operation of a facility e.g. in the event of a fire, or a hazardous material incident.

5. This detailed plan will likely elaborate on the preliminary decommissioning plan submitted with the original application for site approval.

D. Post-Decommissioning Monitoring and Maintenance

1. A proposed schedule for environmental monitoring and maintenance activities for the decommissioned facility/site will be required to ensure no long-term negative impacts to the environment. The extent of monitoring and maintenance requirements will be facility/site specific and shall be approved by the *DOE.*

E. Decommissioning / Post-Decommissioning Reporting

1. A decommissioning summary report and annual reports thereafter, consistent with the proposed environmental monitoring and maintenance regime, will be required by the *DOE*. A decommissioning summary report shall describe decommissioning activities and the condition of the site at closure noting any problems, on or off-site impacts, and an assessment of future impacts.

2. The site owner shall submit annual reports to the *DOE* detailing the post-decommissioning monitoring and maintenance activities, laboratory analyses of all sampling programs, and summarizing the results of all inspections. The duration of the post- closure/decommissioning monitoring period will be site specific and related to any potential environmental impacts identified or problems encountered.

3. Once landfills are closed, gas and leachate production decreases but it is essential to maintain the treatment of emissions up to the point where they become inoffensive to the environment.

4. Landfill owners must continue to maintain the landfill after its closure up until raw leachate effluents meet the levels required for treated leachate and untreated biogas contains less than 25 % of the lower explosive limit (LEL). These levels must be maintained for a continuous period of 5 years before treatment is stopped. During the post closure care period, monitoring systems must be maintained as well as sampling and yearly reports. Cover systems must also be maintained and all subsidence of the final cover backfilled to ensure proper runoff. The integrity of the impervious barrier must also be maintained.

5. The owner of the site shall immediately advise the *DOE* of any adverse effects on the environment and take corrective action as required. Site records and reports shall be made available to the *DOE* upon request. The *DOE* may vary the frequency of inspections should the results of inspections determine that this is justified.

F. Future use of the Site

1. The future use of the site should be consistent with recommendations of the de-commissioning report and approved by the *DOE*.

4. MUNICIPAL SOLID WASTE TRANSFER STATIONS AND MATERIAL RECOVERY FACILITIES

A. Siting Criteria

Materials Recovery Facilities (MRFs) and Transfer Stations (TS) typically are not the source of many environmental impacts due to the fact that waste is not disposed of at the site, there is no long term storage of waste and all waste shall be contained while on site, but can cause nuisances such as dust, odours, etc. and their siting should be done in such a way so as to minimize these nuisances.

1. Buffer Zone: Transfer stations must have a minimum buffer zone of 20 metres of which the last 10 m is reserved for vegetation or landscape screening;

2. Transfer stations must be located outside of 100 year recurrence floodplains;

3. Transfer stations must not be located on wetlands;

4. Transfer stations must be located at least 5 kilometres from all airports used by turbojet aircraft and 2 kilometres from airports used by only piston type aircraft. These distances may be reduced if it is demonstrated to the regulating authority that bird control measures are in place such that bird hazards are minimal;

5. Transfer station must be located at areas with good access and roads that can support induced truck traffic.

6. The following setback criteria must be respected:
   a) 50 m from drinking water supply
   b) 100 m from residential and institutional property. If the TS is an enclosed building facility, this distance may be decreased.
   c) 100 m from commercial property. If the TS is an enclosed building facility, this distance may be decreased.
   d) 200 m form Hospitals, schools, and other sensitive facilities or institutions
   e) 50 m from high water marks of all water bodies
   f) 200 m from ecologically sensitive areas.

B. Technical Requirements

Technical requirements proposed under this section mostly provide for measures relating to the environmental and health protection and not the actual processing of waste itself.

1. Liquids management: transfer stations must be designed so as to prevent liquids from leaving the premises. All interior surfaces must be sloped to liquid collection drains and sumps for removal and proper treatment of the collected liquids;

2. Run off and storm water: transfer stations and the surrounding property must be designed so as to avoid run off and storm water from coming into contact with waste. All control infrastructures must be designed to handle 100 year storms;

3. Tipping floors and all areas where waste may be deposited or temporarily stored must be impervious. These surfaces must be designed to withstand the stresses imposed by the machinery used;

4. All transfer operations must be carried out in an enclosed building. Openings for vehicle access must be situated in regards to predominant winds so as to minimize blowing of litter in and outside of the facility;

5. The transfer station must be surrounded by a chain link fence to prevent public access. All access points must have lockable gates;

6. The building area must be of a sufficient size to permit transfer operations safely. There must be as much clear spans as possible, without columns. There must also be a designated holding and inspection area for unloading non-complying loads. Ceiling clearance must be able to accommodate the machinery within the facility;

7. The facility must be designed to accommodate the expected truck types (in-coming and out-going);

8. The property must have the area necessary to prevent queuing of vehicles on public roads. If required, off-site parking areas must be provided;

9. The design must take into consideration worker security and respect all applicable health and safety regulatory requirements. Guard rails must be installed where there are risks of falling.

C. Health and Safety

1. Smoking and open fires are strictly prohibited on the premises and within the transfer station;
2. The transfer station must have potable water supply and have a sufficient capacity for fire fighting, as required by the fire department;

3. The transfer station must have appropriate fire extinguishers as required by the fire department and telephone service in case of emergencies.

4. The facility must have staff amenities (toilets, showers, etc). Personnel must have scheduled first aid training and appropriate and timely replacement of personal protection gear;

5. Workers must be provided with appropriate Personal Protective Equipment (i.e. facemask, dusk masks, protective boots, gloves etc.) when working within the facility, unless adequate dust collection or dust suppression units are installed. In MRF's, dust collection and treatment equipment must be installed based on the type of operations carried out. Workers must also have adequate ear protection based on the machinery used;

6. Workers must also be provided with annually medical examinations given the potential occupational health conditions within the transfer station.

D. Operations

1. Only waste which is acceptable at the final disposal facility or the end-user in the case of material recovery may be admitted to the transfer station. Trained operators must oversee unloading of all waste;

2. All waste must be transferred within the building. No waste may be stockpiled outside the building;

3. Liquids must meet the effluent standards established by the DOE before being emitted to the environment. If needed, they must be transferred to an authorized treatment facility;

4. All incoming and outgoing waste must be weighed;

5. Operating hours must be approved by SWaMA;

6. When transfer activities cease for periods greater than 12 hours, all waste must be removed, unless there is adequate air collection and treatment systems installed to prevent odours and explosive or flammable gas build-up. This provision does not apply to inert waste;

7. The transfer station property must be maintained and free of litter. Moveable wind screens or similar barriers must be used as required to minimize blowing litter;

8. A contingency plan must be submitted to SWaMA for approval. This plan must address procedures for how to deal with unforeseen or dangerous situations including liquid spills, gas releases, explosions, fires, personal injuries, leachate management, power outages, unscheduled equipment downtime, delivery of unacceptable wastes and all other environmental or emergency issues.

9. Transfer station operators must keep detailed operating records reporting information on in-coming waste vehicles (date, time, origin, weight and type of waste), out-going loads (date, time, vehicle number, weight of waste,, destination), unusual events, accidents, releases, leachate management and all other pertinent information:

10. Transfer station operators must submit to SWaMA an annual report summarizing information on the waste handled during the previous year.

5. INCINERATION: Municipal Solid Waste (MSW)

Incineration is basically a thermal treatment of solid waste involving its combustion in the presence of oxygen. Other thermal treatment technologies include *pyrolysis* (combustion in the absence of oxygen) and *gasification* (partial combustion to produce a combustible fuel gas).

Incineration is primarily used for the volume reduction of the solid waste stream; final volumes for disposal after incineration can be reduced to 25% of the initial solid waste volume, therefore increasing the life span of the final disposal site. Incinerators often include energy recovery systems, producing hot water or steam that can be used to generate electricity. Because of the high combustion temperature, incinerators also destroy pathogens and are often used for destruction of infectious waste.

A. Environmental Concerns

1. Besides heat, incinerators produce air emissions and ash. Process water used for cooling or energy recovery systems is also a secondary by-product. Air emissions contain various gases and particulate matter; when recovered, the latter is called fly-ash, compared to bottom ash which falls through the grates.

2. Air emissions are dependent on the waste type and the combustion efficiency, which in turn is related to incinerator design and operations. In general, they contain particulate matter, acidic gases and trace gases. Control equipment includes

electrostatic precipitators and filter bags for particulate removal, and wet and dry scrubbers for acid gases. Source separation and combustion control are also helpful strategies to reduce air emissions.

3. Bottom ash may contain metals and glass as well as unburned organics. It is generally disposed of without processing in a confinement landfill; attempts have been made and are on-going to re-use this matter, but this is very site specific. Fly ash represents a greater risk than bottom ash because metals which are vaporized in the combustion process condenses on the surface of the fly ash particles as gases cool down. Because of their small size and higher surface area, metal concentrations may be quite high; they are also more leachable because of their conversion into soluble salts during condensation. Fly ash is therefore generally considered a hazardous waste and must be treated accordingly.

B. Regulatory Requirements

Regulatory standards focus mainly on performance standards and emission limits. They cover four aspects, namely operation, air emissions, disposal of residues and liquid emissions.

C. Operation Criteria

1. Waste handling and processing:
   a) *Waste stocking, processing and handling should be done in an enclosed area.*
   b) *No waste or incineration ashes should be stockpiled outside of the facility.*
   c) *No waste or ashes should be stockpiled inside a transport vehicle (truck, railway wagon, etc.) more than one hour before its departure from the facility.*
   d) *No medical waste should be burned at an incinerator unless the facility has conformed to regulations pertaining to the incineration of medical waste and that this usage has been expressly allowed by by the DOE.*

2. No odour, dust or airborne contaminant should be emitted at ground level at the property limits of the incinerator. If odour, dust or airborne contaminant emissions were to be measured at ground level at the property limits, immediate actions should be taken by the facility owner.

3. The incinerator should be operated so as to minimize inconveniences relating to noise, increase of traffic, dust and odours.

4. The inner temperature of the gas in the combustion chamber must be at least 850°C for a period of at least two seconds when burning waste, as measured near

the inner wall or at another representative point authorized by the DOE. If hazardous wastes containing halogenated organic substances in significant quantity are incinerated, the temperatures in the combustion chamber must reach 1100°C for at least two seconds. Incinerators should be equipped with auxiliary burners that are automatically switched on when the minimum operation falls below 850°C or 1100°C.

5. Waste feed in the combustion chamber should be automatically interrupted when the temperature in the combustion chamber falls below 850°C or 1100°C.

6. The heat generated by the incineration process should be recovered as far as the existing technologies allow.

7. The incinerator should be operated so that the loss on ignition of the bottom ashes should be less than 5% of the dry weight of the material.

D. Air emissions criteria

1. The measurement equipment, its location and techniques used should allow for the monitoring of the parameters relevant to the incineration;

2. The appropriate installation and functioning of the measurement equipment should be subject to control and to maintenance at least once every year during the operation of the incinerator. Calibration of the measurement equipment should be done at least every three years and follow manufacturer's recommendations. The owner of the facility should keep a registry of the maintenance and calibration operation and should transmit it to the DOE on demand;

3. The following measurements of air pollutants should be carried out at any incineration facility:
    a) Continuous measurements of the following substances: NO_x, CO, total dust, total organic carbon (TOC), HCl, HF, SO_2;
    b) Continuous measurements of the following process operation parameters: temperature near the inner wall or at another representative point of the combustion chamber as authorised by government officials, concentration of oxygen, pressure, temperature and water vapour content of the exhaust gas;
    c) At least two measurements per year of heavy metals, dioxins and furans;

4. Results of air emissions analysis should be kept at the incinerator and transmitted to the DOE on demand. The tables 3 to 6 present the air emission limit values.

Table 3: Daily Average Value

Total Dust	**10 mg/m³**
Carbon monoxide (CO)	**50 mg/m³***
Gaseous and vaporous organic substances, expressed as total organic carbon (TOC)	**10 mg/m³**
Hydrogen chloride (HCl)	**10 mg/m³**
Hydrogen fluoride (HF)	**1 mg/m³**
Sulphur dioxide (SO_2)	**50 mg/m³**
Nitrogen monoxide (NO) and nitrogen dioxide (NO_2), expressed as nitrogen dioxide	**200 mg/m³**

* Excluding the start-up and shut-down phase

Table 4: Half-hourly Average Values

Air Emissions	(100%) A**	(97%) B**
Total dust	30 mg/m³	**10 mg/m³**
Carbon monoxide (CO)	100 mg/m³*	**-**
Gaseous and vaporous organic substances, expressed as total organic carbon (TOC)	20 mg/m³	**10 mg/m³**
Hydrogen chloride (HCl)	60 mg/m³	**10 mg/m³**
Hydrogen fluoride (HF)	4 mg/m³	**2 mg/m³**
Sulphur dioxide (SO_2)	200 mg/m³	**50 mg/m³**
Nitrogen monoxide (NO) and nitrogen dioxide (NO_2), expressed as nitrogen dioxide	**400 mg/m³**	**200 mg/m³**

* Excluding the start-up and shut-down phase

** None of the half-hourly average values may exceed limits of column A. On an annual basis, at least 97% of the half-hourly values must comply with the limits stated in column B.

Table 5: All Average Values for Metallic Compounds (Over the sample period of a minimum 30 minutes and maximum of 8 hours)

Cadmium and its compounds, expressed as cadmium (Cd)	**total 0,05 mg/m³**
Thallium and its compounds, expressed as thallium (Tl)	
Mercury and its compounds, expressed as mercury (Hg)	**0,05 mg/m³**
Antimony and its compounds, expressed as antimony (Sb)	**total 0,5 mg/m³**
Arsenic and its compounds, expressed as arsenic (As)	
Lead and its compounds, expressed as lead (Pb)	
Chromium and its compounds, expressed as chromium (Cr)	
Cobalt and its compounds, expressed as cobalt (Co)	
Copper and its compounds, expressed as copper (Cu)	
Manganese and its compounds, expressed as	

manganese (Mn)	
Nickel and its compounds, expressed as nickel (Ni)	
Vanadium and its compounds, expressed as vanadium (V)	

Table 6: Average Values for Dioxins and Furans
(Over a sample period of a minimum of 6 hours and a maximum of 8 hours)

Dioxins and furans**	**0,1 ng/m³**

** The emission limit value refers to the total concentration of dioxins and furans calculated using the concept of toxic equivalence in accordance with table 7.

Table 7: Equivalence Factors for Dibenzo-p-dioxins and Dibenzofurans

	Toxic equivalence factor***
2,3,7,8 – Tretrachlorodibenzodioxin (TCDD)	**1**
1,2,3,7,8 – Pentachlorodibenzodioxin (PeCDD)	**0,5**
1,2,3,4,7,8 – Hexachlorodibenzodioxin (HxCDD)	**0,1**
1,2,3,6,7,8 – Hexachlorodibenzodioxin (HxCDD)	**0,1**
1,2,3,7,8,9 – Hexachlorodibenzodioxin (HxCDD)	**0,1**
1,2,3,4,6,7,8 – Heptachlorodibenzodioxin (HpCDD)	**0,01**
– Octachlorodibenzodioxin (OCDD)	**0,001**
2,3,7,8 – Tretrachlorodibenzofuran (TCDF)	**0,1**
2,3,4,7,8 – Pentachlorodibenzofuran (PeCDF)	**0,5**
1,2,3,7,8 – Pentachlorodibenzofuran (PeCDF)	**0,05**
1,2,3,4,7,8 – Hexachlorodibenzofuran (HxCDF)	**0,1**
1,2,3,6,7,8 – Hexachlorodibenzofuran (HxCDF)	**0,1**
1,2,3,7,8,9 – Hexachlorodibenzofuran (HxCDF)	**0,1**
2,3,4,6,7,8 – Hexachlorodibenzofuran (HxCDF)	**0,1**
1,2,3,4,6,7,8 – Heptachlorodibenzofuran (HpCDF)	**0,01**
1,2,3,4,7,8,9 – Heptachlorodibenzofuran (HpCDF)	**0,01**
– Octachlorodibenzofuran (OCDF)	**0,001**

*** For the determination of the total concentration (TE) of dioxins and furans, the mass concentrations of the following dibenzo-p-dioxins and dibenzofurans should be multiplied by these equivalence factors before summing.

5. The results of the measurements made should be standardized at temperature 0°C, pressure 101,3 kPa, 11% oxygen, dry gas before verification of their compliance with limit values presented in tables 1 to 4.

6. The incinerator should not continue to incinerate waste for a period of more than four hours uninterrupted where emissions limits value are exceeded or where emissions control devices or emissions measurements devices are out of service due to maintenance or failure.

7. The DOE can add or subtract polluting substances to be measured or can modify emissions limit values for air emissions criteria to allow for site specific characteristics.

E. Disposal of Residues

1. Residues should be disposed of so as to prevent any degradation of the environment or any risk to the health of the population.

2. The disposal site for the residues must be approved by the DOE before its utilization.

3. Residues can be disposed of in a landfill. The residues temperature at the time of their disposal in a landfill must not pose a fire threat and must not threaten the integrity of the landfill liner system. If their temperature is too high, the residues must be stockpiled in an enclosed area where appropriate water and air control systems prevent any emissions. At no time, the temperature of residues disposed of in a landfill lined with a HDPE liner may be superior to 40°C.

4. Residues must be transported in closed containers to prevent dispersal of the fine particles.

F. Liquid Emissions

1. Water that may have been in contact with waste or combustion residues and water that has been used during the incinerator operation should be collected and detained in a lined basin or tank. Discharge of water to the environment should be authorized by the DOE and should respect, at all time, the applicable effluent standards.

2. If the measurements taken exceed the applicable effluent standards, the DOE should be informed without delay and the discharge of water to the environment should be suspended immediately.

3. Batch discharge is strictly prohibited. Discharge flow should not vary significantly over short periods of time.

4. During discharge of water to the environment, pH, temperature and flow should be measured continuously at the point of discharge. The results should be recorded and kept at the incinerator. The results should be transmitted on demand to the DOE. Tables 8 and 9 present the effluent standards values.

Table 8: Effluent Standards for Discharges of Waste Water (In contact with ashes or that has been used for the cleaning of exhaust gases)

Polluting substances	Emission Limit Values (expressed in mass concentrations for unfiltered samples)
Total suspended solids	45 mg/l
Mercury and its compounds, expressed as mercury (Hg)	0,03 mg/l
Cadmium and its compounds, expressed as cadmium (Cd)	0,05 mg/l
Thallium and its compounds, expressed as thallium (Tl)	0,05 mg/l
Arsenic and its compounds, expressed as arsenic (As)	0,15 mg/l
Lead and its compounds, expressed as lead (Pb)	0,2 mg/l
Chromium and its compounds, expressed as chromium (Cr)	0,5 mg/l
Copper and its compounds, expressed as copper (Cu)	0,5 mg/l
Nickel and its compounds, expressed as nickel (Ni)	0,5 mg/l
Zinc and its compounds, expressed as zinc (Zn)	1,5 mg/l
Dioxins and furans, defined as the sum of the individual dioxins and furans evaluated in accordance to table 5	0,3 mg/l

Table 9: Effluent Standards Values for Discharges of Waste Water (In contact with waste prior to its incineration)

Polluting substances	Emission limit values expressed in mass concentrations for unfiltered samples	Monthly average emission limit values expressed in mass concentrations for unfiltered samples*
Ammonia NH_4, expressed as nitrogen (N)	25 mg/l	10 mg/l
Fecal coliform bacteria	275 CFU/100 ml	100 CFU/100 ml
Phenols	0,085 mg/l	0,03 mg/l
5 day biochemical	150 mg/l	65 mg/l

oxygen demand (BOD_5)		
Total suspended solids	**90 mg/l**	**35 mg/l**
Zinc and its compounds, expressed as zinc (Zn)	**0,17 mg/l**	**0,07 mg/l**
pH	**higher than 6,0 but less than 9,5**	**-**

* Average Effluent Standards values are arithmetic means, except for the monthly average emission limit value of fecal coliform bacteria which is a geometric mean.

5. Wastewater that has been in contact with waste prior to its incineration should not be discharged to the environment unless it complies with the effluent standards stated in table 10.

6. Wastewater that has been in contact with ashes or that has been used for the cleaning of exhaust gases should not be discharged to the environment unless it complies with the values stated in table 10.

7. If the waste water basin or tank contains water that has been in contact with waste prior to its incineration and water that has been in contact with ashes or that has been used for the cleaning of exhaust gases, it should comply with the values for discharge of both tables 9 and 10.

8. Except for pH, which must be measured continuously during discharge, the concentration of the polluting substances presented in tables 9 and 10 must be measured at least once a week during discharge.

9. DOE can add polluting substances to be measured or can modify effluent standards presented in tables 9 and 10 to allow for site specific characteristics.

6. CONTROLLED DUMPSITE

It is important to limit the number of controlled landfills to a minimum. They should be permitted only in particular settings and when there is no other solution available.

A. Restrictions

1. Controlled dumpsites should at no time serve more than a specified number of persons (or more than 5,000 inhabitants).

2. Controlled dumpsites should only serve communities which are situated at more than 50 km, by road, or boat, of an existing wastes management facility approved by *the DOE*[3].

3. No hazardous, medical, institutional, industrial or commercial waste may be disposed of in a controlled landfill unless the generator demonstrates, to the satisfaction of *the DOE*, that the waste does not pose a threat to public and environmental safety.

B. Sitting:

1. A controlled dumpsite should be:
   a) At a minimal distance of 200 m of any body of water;
   b) At a minimal distance of 500 m of any surface water or groundwater catchment intended for human consumption or used for irrigation.
   c) The bottom of a controlled dumpsite must be at least 50 cm above the groundwater level.
   d) At a minimal distance of 500 m of any inhabited house.
   e) In the case of predominant wind direction goes to populated area, the site must be located at least 3 km from this area
   f) At a minimal distance of 500 m of high traffic road.
   g) Minimal buffer zone of 100 m.
   h) Site surface must have the potential to dispose 30 year of waste production.
   i) Floodplains or alluvial plain risk terrain will be avoided.

D. Operation:

1. The burning of wastes is not allowed at a controlled dumpsite.

[3] The distance can be modified to better represent the local population. However, an analysis is required to determine the optimal distance based on population distribution and transportation cost. A distance too small will result in the multiplication of dumpsites.

2. Wastes must be covered by a layer of soil at least 15 cm thick at the end of each day.

3. When the elevation of the wastes reaches 30 cm below the natural ground level, the controlled dumpsite must be covered with a layer of soil at least 30 cm thick of which at least 15 cm is suitable for vegetation[4].

4. The final cover surface must be graded to a slope of at least 5% to allow runoff water to flow away from the dumpsite.

5. Access to a controlled dumpsite should be restricted.

6. Perimeter Olympic fence must be installed.

7. At least a 80 HP back hoe excavator, must be on site, to mechanical biopile aeration, and daily cover execution.

8. Complimentary facilities, as vigilance entrance building, a warehouse, and bathrooms must be executed on site.

9. Minimal supporting services as electrical power and water for human consumption must be provided on site.

[4] Controlled dumpsites are excavated. No waste is placed above ground.

7. OPEN DUMPSITES OR ILLEGAL DUMPING

To close every illegal dumping site in Belize, the following steps should be realized:

1. Assess the problem throughout the country
   a) During the first assessment of the problem, the following topics should be examined:
      i. *The nature of the problem*
      ii. *The players involved*
      iii. *Census the waste pickers if there is any presence of them at the site.*
      iv. *Past and ongoing efforts to reduce illegal dumping*
      v. *Resources available*

2. Create local working groups
   a) These groups should be composed of local officials, professional specialists, and community members and industries representatives. They will be able to further define the source of the illegal dumping in their region as the sources of wastes illegally dumped may vary according to location.
   b) Find a solution to include the waste pickers into the new waste management scheme to be implemented.

3. Apply the solutions designed by the working groups
   a) Implementation of a new waste management facility to the application of fines for those who still dump wastes illegally.
   b) However public education must be part of every solution. Public consultation is important to ensure that the population understands that open dumping is illegal and that proper alternatives are in place.
   c) Moreover, the existing open dumpsites should be closed in order to discourage these practices.

4. Monitor the evolution of the problem after the implementation of the solution
   a) The monitoring of closed illegal dumping sites is important to ensure that there are no reversions and that the solution has addressed each and every environmental impact.

8. COMPOSTING

1. Since it is preferable to encourage on-site small-scale composting as it reduces the amount of waste needing transportation and disposal, the proposed technical guidelines should be applied only to facilities that can compost more than 150 m³ at

any given time. However, this restriction should only apply if the waste received by such a facility doesn't contain industrial waste or contaminants (sewer sludges, slaughterhouses wastes, petroleum based wastes, pesticides, etc.).

A. Siting Criteria

Composting can cause inconveniences such as odours, noises and dust. Moreover, composting leachate can be damaging to existing water bodies since it generally has high values of biochemical oxygen demand (BOD). The siting of composting commercial facilities should therefore be done so as to minimize their potential environmental and social impacts.

1. Buffer zone: composting facilities must have a minimum buffer zone of 20 meters. For outdoor non-reactor composting systems, the buffer zone must be screened with wind breaks and vegetation.

2. Composting facilities must be sited:
   a) at least 300 m of any drinkable water source;
   b) at least 150 m from any body of water;
   c) at least 300 m of a lake;
   d) outside of 100 year recurrence floodplains;
   e) outside any wetland;
   f) at least 3 km away from any residential, commercial or public area unless the buildings are owned by the compost facility owner.

3. Alternative siting criteria for a covered facility may be approved by the DOE on a case by case basis.[5]

B. Design Criteria

1. Composting facilities must be designed to prevent leakage of leachate to the environment. All composting activity (composting pile, stockpiling of waste, stockpiling of amendments, etc.) that can produce leachate must be performed on a lined surface or indoors. There are two types of liner that can be used at an outdoor composting facility:
   a) Low permeability soil liner: in-situ low permeability soils may be used for composting facilities. In this case, the soil must have a hydraulic conductivity of less than 1×10^{-8} m/s, be at least 3 metres thick and be continuous;
   b) Synthetic liner: synthetic liners must be used if the requirements for a low permeability soil liner are not present. Synthetic liners are composed of a 1.5 mm high density polyethylene (HDPE) geomembrane or any liner (concrete,

[5] For a covered facility, the minimum distances stated above could be reduced. However, this reduction should be applied on a case by case basis based on the sensitivity of the surroundings of the facilities.

bituminous concrete, etc.). Synthetic liners must be inspected annually and any defect susceptible of affecting their permeability must be corrected within the year.

2. Leachate must be collected, and may be used as process liquid (to maintain biopile humidity) or treated in wastewater treatment plant.

3. Odour control must be done by controlling the critical parameters in aerobic composting. In anaerobic composting, off gas must be treated.

4. Operational controls and environmental monitoring facilities must be executed.

C. Construction

1. The Compost Facility is required to meet the generally accepted environmental standards for construction, including an approved design, quality control/assurance protocol and environmentally sound construction practices.

2. Prior to opening the composting facility, the owner and/or operator shall provide documentation to the SWaMA, in the form of a Certificate of Completion, that the site has been constructed as per the approved design, that all facilities and systems are in place and functional, and the site is ready to receive compostable materials/approved feedstocks.

3. Prior to opening the compost facility all permits, approvals and authorizations shall have been obtained, all regulatory requirements shall be met; and, environmental controls shall be in place.

D. Operating Criteria

1. Leachate collection system: All leachate produced by a composting facility must be collected and stored in a lined basin or a tank. The composting site must be graded to avoid pooling of leachate at any other point than the retention area. Representative leachate samples must be collected and analyzed. If the concentration of the analyzed parameters is higher than those stipulated by regulations, the leachate must be treated before being discharged to the environment. The leachate may also be used in the composting process to maintain the humidity required. The utilization of leachate as fertilizer is avoided. The following table (Table 10) presents the parameters that should be analysed.

Table 11: Effluent Standards for Treated Composting Leachate

Parameters	*Maximum Values*	*Average Monthly Values*[1]
Ammonia nitrogen (expressed as N)	*25 mg/l*	***10 mg/l***

Fecal coliforms	*Non applicable*	***1000 CFU/100 ml***
Phenolic compounds	*0,085 mg/l*	***0,030 mg/l***
5 day Biochemical Oxygen Demand	*150 mg/l*	***65 mg/l***
Suspended solids	*90 mg/l*	***35 mg/l***
Zinc	*1.0 mg/l*	***0,25 mg/l***
pH	***Greater than 6 and lower than 9***	

[1.] *These values are calculated using an arithmetic average, except for fecal coliforms which are calculated using a geometric average*.

2. The list of analysed parameters for a particular composting facility can be modified by the DOE to address specific particularities.

3. Surface water management: Runoff water must be intercepted and redirected before it reaches the composting area.

4. Odours management: The site should be designed so as to ensure that no perceptible odours are emitted at the facility property limits and in no public areas located near the facility. If necessary, simulation modeling should be realized prior to the installation of the facility.

E. Monitoring Criteria

1. Groundwater monitoring: Groundwater monitoring wells must be installed in a 50 meters radius around the composting area. The number of wells is determined according to the waste volume composted and to the importance and number of aquifers to be monitored. However, all composting facilities must have at least two groundwater monitoring wells; one upstream of the composting area and one downstream. At least four (4) groundwater samples must be taken yearly. The following parameters should be analysed.

Table 12: Groundwater Criteria for Landfills

Parameter	Compliance Level
- Ammonia nitrogen (expressed as N)	1.5 mg/l
- Chlorides (expressed as C-)	250 mg/l
- Iron (Fe)	0,3 mg/l
- Nitrates and nitrites (expressed as N)	10 mg/l
- Zinc (Zn)	5 mg/l
Indicative parameters	
Total phenols	
Chemical Oxygen Demand	
Electric Conductivity	

2. The list of analysed parameters for a particular composting facility can be modified by the DOE to address specific particularities.

3. Height of composting pile: In a non-reactor process, the height of a composting pile must not exceed two (2) meters to prevent pile compaction.

4. Aerobic conditions: The composting biopile process must be in aerobic conditions at all times. The aerobic conditions must be demonstrated to SWaMA's satisfaction prior to the site operation. A detailed operations manual must be provided to SWaMA's.

5. Temperature of the reaction: Compost should reach a minimal temperature of 50°C during the composting process. Moreover, this temperature should be sustained for at least five days. If temperature is not monitored, fecal coliforms or Salmonella should be measured as indicators. Fecal coliforms should not exceed 1000 MPN/g and salmonella should not exceed 3 MPN/g. If this is not the case, the compost should not be used as natural organic amended soil on agricultural land.

6. Waste must be integrated into the composting process no later than eighteen (18) hours after its arrival at the composting facility.

7. Pests, odours and dust must be controlled and minimized.

8. Site access: The composting facility must be secured to prevent unauthorized access.

9. Open burning of solid waste at a composting facility is strictly prohibited.

10. Access to fire equipment and fire fighting services must be provided at all times.