**DENR Administrative Order**
**No. 49**
**Series of 1998**

**Subject: Technical Guidelines For Municipal Solid Waste Disposal**

**WHEREAS,** the disposal of municipal solid waste in the Philippines is mostly through open dumps that cause environmental damage and adverse impact on public health;

**WHEREAS,** the Department of Environment and Natural Resources as the primary government agency in charge of environmental and natural resources management and as Chairman of the Presidential Task Force on Waste Management is tasked with providing appropriate guidelines in all aspects of waste management;

**WHEREAS,** Republic Act 7160, otherwise known as the Philippine Local Government Code devolved the responsibility for the provision of basic services, such as but not limited to general hygiene and sanitation, beautification and solid waste management to local government units (LGUs);

**WHEREAS,** the DENR recognizes the value of strengthening its coordination and cooperation with the LGUs in the planning and implementation of solid waste management strategies;

**WHEREAS,** by virtue of Presidential Decree 1152 (the Philippine Environmental Policy), Presidential Decree 984 (the Pollution Control Law) and Administrative Order no. 90 there is a need to improve the present disposal practices of municipal solid waste to make then environmentally- sound;

**NOW, THEREFORE,** for and in consideration of the above premises, the Department of Environment and Natural Resources hereby adopts and promulgates the following guidelines:

**Section 1.** ***Title.*** These guidelines shall be known as "The Technical Guidelines for Municipal Solid Waste Disposal"

**Section 2.** ***Declaration of Policy*****.** It is hereby declared a policy of the DENR to provide direct technical guidance to the LGUs in order to promote their adoption of environmentally-sound, technically-feasible and economically-sustainable solid waste management options, through standards and guidelines that could be consistently applied to different LGUs throughout the country.

**Section 3.** ***Scope.*** These Guidelines shall cover the development of new municipal solid waste disposal sites in the Philippines including a phased schedule for the conversion and upgrading of existing dumpsites into a more sanitary and environmentally acceptable manner.

**Section 4.** ***Role of the DENR.*** To ensure the effective implementation of these Guidelines, the DENR shall:

4.1 supervise and monitor the gradual phase of existing open dumps nationwide in coordination with the Department of Health, the Department of Interior and Local Government, various local government units and other relevant entities; and,

4.2 provide technical assistance in the planning and implementation of the upgrading of existing open dumpsites to environmentally-sound landfills with regards to its adherence to the herein prescribed engineering and environmental standards.

**Section 5.** ***Role of the Local Government Units.*** The LGUs shall prepare and implement local action plans and formulate local regulations to facilitate and support the closure and upgrading of existing open dumps.

**Section 6.** ***Technical Guidelines for Municipal Solid Waste Disposal*****.** The Guidelines including its definition of terms, technical norms, environmental quality requirements and operational performance standards are set out in ANNEX A and shall form an integral part of this Order.

**Section 7.** ***Timeframe for Implementation.*** All LGUs are required to fulfill the upgrading plan for existing open dumps as prescribed in ANNEX A in accordance with the following schedule:

7.1 All highly urbanized cities are required to convert/upgrade all their open dumps to controlled dumps within three (3) years from the promulgation of this Order or not later than December 2001; from controlled dumps to sanitary landfill level 1 no later than December 2008; and, from sanitary landfill level I to sanitary landfill level II by December 2009.

7.2 All independent component, component and first class cities and municipalities are required to convert/upgrade all their existing open dumps to controlled dumps within five (5) years from the promulgation of this Order or not later than December 2003; and from controlled dumps to sanitary landfill level I by December 2009.

7.3 All second class cities and municipalities are required to convert/upgrade their existing open dumps into controlled dump within seven (7) years from the promulgation of this Order or no later than December 2005.

7.4 All remaining classes of cities and municipalities are required to convert their existing open dumps to controlled dumps no later than December 2009.

While the above timeframe sets out the deadline for the phased improvements of existing open dumps for different classes of LGUs, all LGUs are encouraged to upgrade their existing disposal facilities to sanitary landfill level as soon as technically and financially feasible.

**Section 8.** ***Separability Clause.*** If any section or provision of these guidelines is held or declared unconstitutional or invalid by a competent court, the other sections or provisions hereof shall continue to be in force as if the sections or provisions so annulled or voided have never been incorporated herein.

**Section 9.** ***Repealing Clause.*** All pertinent guidelines, rules and regulations or portions thereof inconsistent with these Guidelines are hereby revised, amended and/or modified accordingly.

**Section 10.** ***Amendments.*** These Guidelines may be amended/and or modified in whole or parts hereof from time to time by the DENR.

**Section 11.** ***Effectivity.*** The Guidelines shall take effect within thirty (30) days after publication in the Official Gazette or in a newspaper of general circulation.

**(Sgd.) VICTOR O. RAMOS**
Secretary, DENR
Chairman, Presidential Task Force on Waste Management

**ANNEX A**

# TECHNICAL GUIDELINES for MUNICIPAL SOLID WASTE DISPOSAL

## 1. INTRODUCTION

### 1.1 Responsibilities for Management of Municipal Solid Wastes

The Local Government Code (Republic Act 7160 of 1991) places overall responsibility of solid waste management with the Local Government Units (LGUs). The responsibilities extend to the collection, storage and transfer of Municipal Solid Waste (WSW) up to, and including, the point of final disposal. Under, *inter alia*, the Sanitation Code (PD 856 of 1975) and the Pollution Control Act (PD 984 of 1978), LGUs have a duty to deal with all aspects of the management of their solid waste in such a manner that does not cause pollution to the environment.

### 1.2 Disposal of Municipal Solid Wastes

The most relevant method of disposal of MSW currently used in the Philippines is open dumping. Open dumps are considered by many to be the only form of disposal that is affordable to LGUs. However, the basis of the analysis, expressed in financial terms only, neglects the direct and indirect costs associated with continuing and increasing environmental degradation which impacts upon public health and the safety of the population as a whole, *viz.*:

- impacts upon air quality (smoke, dust and persistent foul odors);
- the presence of insects and vermin, potential vectors for the spread of disease;
- contamination of surface water and groundwater; and
- impacts upon the overall quality of the environment.

When the potential and actual impacts of these latter aspects are considered, there appears to be a fundamental need for upgrading the overall standards of final disposal of MSW;

### 1.3 National Strategy to Improve Solid Waste Management

In recognition of the problems besetting SWM in the Philippines, under Presidential Administrative Order No. 90 (signed October 1993) an Integrated National Solid Waste Management Systems Framework (INSWMSF) was adopted under the auspices of the Presidential Task Force on Waste Management (PTFWM).
One principal objective of the INSWMSF is to secure the disposal of solid waste, at the highest level of protection to public health and safety and to the environment as a whole, commensurate with what is affordable. A medium-term goal of this aspects of the INSWMSF is the phased closure of all open dump sites and their replacement by

more environmentally secure methods of waste disposal. The initial target dates were to commence the phased closure of all open dump sites by 1994 and to achieve full closure of all open dump sites throughout the Philippines by 1996, this latter target being associated with a fundamental shift to environmentally acceptable disposal systems.

A review of the INSWMSF has been completed recently in the first half of 1998, resulting in a revised strategy for improving solid waste management in the Philippines over the next ten years. The strategy, and associated Action Plan, has been adopted by the Government of the Philippines. Objective 14 of the Action Plan identifies the progressive upgrading of the existing municipal solid waste treatment and disposal systems as a priority target area.

## 1.4 The Fundamental Need for Landfill

The principles of *Ecological Waste Management (EWM)* have been adopted by the Department of Environment and Natural Resources (DENR) and the PTFWM as the main strategy to address the growing problems of solid waste management. These principles centre of the so-called 3Rs of effective solid waste management:

- reduction of waste (waste minimization);
- recovery of waste for recycling; and
- re-use of materials, primarily for energy generation.

Notwithstanding the effectiveness of any of these programs, it is impossible, in the near future, to envisage the scenario of zero waste. Waste will continue to be generated and, with increasing economic development and rising standards of living, it is likely that the per capita generation of waste will also grow, a phenomena well documented throughout the industrialized and newly- industrializing nations. With current technology and available resources, programs for waste reduction, waste recovery, recycling and re-use cannot eliminate waste in its entirety; experience in the western world indicates that even with intensive efforts significant quantities of waste still go to landfills.

For alternative waste management technologies to succeed they must, ultimately, be sustainable, from environmental, commercial and economic considerations. The requirement for additional processing of waste invariably is associated with increased costs; at present the use of landfills remains, in financial terms, the least cost solution for final disposal of MSW. With the exception of landfill, all alternative treatment systems deal only with some portion of the waste stream. Alternative waste treatment systems in themselves give rise to residues that require disposal ultimately via landfill (*Table 1*). Accordingly, in the short to medium term (next 5 to 25 years), more secure methods of landfill remain the only option for replacing open dump sites.

Secure environmentally sound facilities for final disposal of MSW form one element in an integrated system of waste management based on ecological principles. Landfills should not be viewed as being in competition with other waste management technologies; landfills complement alternative waste management technologies and provides a necessary and a essential outlet for the disposal of residues.

## 1.5 Scope and Use of the Guidelines

The lack of a technical strategy in upgrading the standards of waste disposal system has been identified as a major constraint to improving solid waste management in the Philippines. Accordingly, these Technical Guidelines have been prepared as part of Action 14.1 of Objective 14 of the revised strategy of the Integrated National Solid Waste Management Systems Framework.

These Technical Guidelines address the technical norms, environmental quality requirements and operational performance standards for upgrading the disposal systems for Municipal Solid Waste (MSW) in the Philippines. In so doing, the Technical Guidelines identify a number of stages for the phased and progressive upgrading of the present system of open dumping to a system of sanitary landfills meeting prescribed national standards on environmental quality.

Each facility, existing or proposed, should be assessed on the basis of site-specific information and in relation to the environmental sensitivity of the site. Accordingly, the Technical Guidelines do not discuss, in detail, the siting, design, engineering, operation and management of waste disposal facilities but serve to identify minimum acceptable standards to safeguard the environment.

**Table 1. Comparison of Available Waste Disposal Systems for Low-Middle Income Countries**

| Item | Waste Treatment System | Typical % of Waste Treated (1) | Typical Residue of treated waste | Total Residue of treated & untreated waste |
|---|---|---|---|---|
| *1a* | Open Dumping | 100% | 0% | 0% |
| *1b* | Controlled Dumping | 100% | 0% | 0% |
| *1c* | Engineered Landfill | 100% | 0% | 0% |
| *1d* | Sanitary landfill | 100% | 0% | 0% |

**Table 1. Comparison of Available Waste Disposal Systems for Low-Middle Income Countries**

*(continued)*

| Item | Waste Treatment System | Typical % of Waste Treated (1) | Typical Residue of treated waste | Total Residue of treated & untreated waste |
|---|---|---|---|---|
| *2a* | Waste picking (informal) | 0.5% | 0% | 99.5% |
| *2b* | Recycling (varies with technology and types of materials being recycled) | 5-15% | 10% | 86.5 - 95.5% |
| *2c* | Source Separation Scheme | 25% | 10% | 77.5% |
| *3b* | Composting municipal solid wastes (medium-high technology) | 50-75% | 25-33% | 50 - 62.5% |
| *4a* | Bio-gas systems for green waste | 15-25% | 10-20% | 80 - 86.5% |
| *4b* | Bio-gas systems for MSW | 75% | 33% | 50% |
| *5* | Waste to Energy Systems and Refuse Derived Fuels | 50% | 20% | 60% |
| *6* | Incineration | 65-80% | 15-20% | 40-45% |

1. Provides the estimated maximum percentage of waste that can be treated by a specific waste management system, given the present composition of the waste stream in the majority of the Philippines.

# 2. LANDFILLS

## 2.1 Classification of Landfills

As noted in Section 1.4, landfills are a vital component of any system of management of MSW; in many cases, a landfill is the only option available to an LGU after the MSW is collected. For the purposes of planning it is convenient to classify landfills into a number of 'principal stages' in the progression from open dumps to fully engineered, environmentally secure, sanitary disposal sites as follows:

- Open Dump;
- Controlled Dump; and
- Sanitary Landfill.

In reality, each 'stage' of landfill development is not discrete but a point on a continuum, involving progressively higher and more sophisticated levels of site engineering, operation and management, all of which may be desirable or necessary but not always achievable in the short term. While open dumps are considered to be unacceptable, controlled dumps and engineered sanitary landfills can provide effective disposal of an LGU's MSW in accordance with appropriate local health and environmental standards.

## 2.2 Key Characteristics of Different Types of Landfills

### 2.2.1 *Open Dumps*

Open Dumps have the lowest initial capital investment and operating cost of the three basic types of landfills. They are generally sited in vacant plots of land and are typically developed in low-lying marshy lands, often as a means of reclaiming land for subsequent development. They may be located adjacent to existing residential development because of constraints on availability of suitable land or, alternatively, may attract the development of communities involved in recycling activities. As a consequence of the proximity of residential communities. Open Dumps are often of small size, of limited capacity and pose high potential environmental risks *(Table 2.1)*.

**Table 2.1 Potential Environmental Impacts of Open Dumps**

| Parameter | Potential Impacts |
|---|---|
| **Water** | Contamination of groundwater and surface water; and Major effect on water resources and water supply (aquifers). |
| **Flooding** | Reduction in flood storage capacity and an increased risks of flooding upstream of the site. Need for costly flood control flood control measures. |
| **Ecology** | Loss of wetland habitats, including flora and fauna |
| **Pests** | Vermin, pests and scavenging animals attracted to fresh and exposed waste; |
| **Health** | Risks from water-borne diseases and potential for the spread of communicable diseases via pests. Contact with clinical and industrial wastes. |
| **Air Quality Safety** | High levels of odor and dust because waste is not covered. Uncontrolled settlement beneath buildings and structures constructed on old sites. Landfill gas build-up and migration with potential to cause explosions or asphyxiation. Stability of high and steep faces of deposited waste. |
| **Aesthetic** | Visual blight from uncovered waste, blown litter, *etc.* |
| **Socio-economic** | Distress to local residents, stigma associated with presence of dump site and loss in property values. |

The high potential environmental impacts from Open Dumps derive from the following:

- they are unplanned;
- there are no controls over waste inputs (both waste quantities and waste composition); and
- there are no controls over emissions of pollutants released from waste decomposition.

### *2.2.2 Controlled Dump*

A Controlled Dump is a non-engineered disposal site at which MSW is deposited in accordance with minimum prescribed standards of site operation. Typically

Controlled Dumps have minimal site infrastructure. Controlled Dumps are the first stage in the progression from Open Dumps. In upgrading from Open Dump to Controlled Dump there are generally no significant investments required in capital works or equipment purchases; rather, upgrading is concentrated primarily on improvements to operational and management issues. Basic operational controls include:

- control over size of waste emplacement (working) area, with waste spread and compacted in thin layers in a small working area;
- waste outside of the area being actively worked is covered with soil/sand/inert material, working area is covered at the end of each day;
- covering and seeding/planting of completed areas;
- supervision of site operations by trained staff;
- no fires permitted on site; and
- organization of informal waste picking activities with scavenging controlled by agreeing 'rules' with the waste pickers (e.g. restrictions on location and time allowed following waste deposition, no disturbance of waste after it has been covered).

Where resources permit, capital investments should be channeled into haul road construction, peripheral site drainage and litter fencing, supplemented by mobile plant for spreading and compacting waste and inert cover.

The site of a Controlled Dump is generally identified on the basis of land availability and convenience and is already being used as an open dump; typically a site is not selected on the basis of technical, environmental or financial criteria. Accordingly, there is typically little provision for the management of pollutants released during decomposition of municipal solid waste. Simple and rudimentary control of pollutants may be achieved through good site operational practices and, where feasible, peripheral drainage works.

### *2.2.3 Sanitary Landfill*

The most significant jump in technology, expertise and technical resources required arises at the transition from Controlled Dump to an engineered Sanitary Landfill. A Sanitary Landfill is a disposal site designed, constructed, operated and maintained in a manner that exerts engineering control over significant potential environmental impacts arising from the development and operation of the facility. In particular, engineering of the site is undertaken to contain and regulate the uncontrolled migration of leachate (water contaminated from contact with decomposing waste) and landfill gas.

In siting a Sanitary Landfill, significant effort is directed into identifying and selecting a favorable location with respect to existing environmental conditions in order that the requirements for landfill engineering are kept to a minimum or the overall potential impacts of site development are considered to be least significant. In practice, land availability is often the fundamental factor and most sites for Sanitary Landfills are

selected in far from ideal settings, necessitating that the site is designed and engineered in a manner that minimizes environmental impact.

Allied with engineering design is also the fundamental requirement that the Sanitary Landfill is constructed, operated, managed and maintained to the standards stipulated as the basis of the design. Failure to maintain the specified design standards for all aspects of site engineering, operation and management will inevitably lead to an overall site performance lower than anticipated and, at worst, no better than that of an Open Dump.

Overall, four basic criteria should be met by both site design and site operations before a waste disposal site may be regarded as a truly sanitary landfill:

- isolation of the waste from the surrounding environment, unless the site is low environmental sensitivity or the waste deposited is considered to be inert and non-polluting;

- containment, collection and treatment of pollutants derived from degradation of waste, on-going throughout the life of the site ***and following completion of the site,*** until such time as the waste has degraded biologically, chemically and physically so as to pose no harm to the surrounding environment;

- managed release of treated pollutants back into the surrounding environment when considered 'safe', supplemented by environmental monitoring to assess the impacts of such releases; and

- full control over site operations, with well-qualified and adequately trained staff supervising and recording the progress of waste disposal.

The key elements in the progression from Open and Controlled Dump to Sanitary Landfill focus upon gradual changes to site design and key operational management practices, including:

- selection of an appropriate location for the site;

- full or partial geological/hydrogeological isolation of the site;

- designing the site-the civil engineering, operational methods and restoration/afteruse;

- site preparation in advance of waste deposition to aid leachate control and collection;

- phasing of waste deposition to exert maximum operational control;

- control of groundwater and surface water entering the site;

- collection and disposal of leachate (may include simple on-site treatment);

- spreading and compaction of wastes in defined operational areas;

- installation of landfill gas control and venting measures; and

- phased and progressive restoration of the site following waste deposition.

### 2.2.4 *Planning and Engineering of Landfills*

The degree of site-specific engineering undertaken is dependent upon several factors, including the following:

- Waste composition, particularly the presence of polluting or toxic substances;
- affordability;
- available expertise;
- environmental sensitivity of the site (prevailing conditions);
- potential impacts and consequences of landfilling; and
- prevailing legislation.

Notwithstanding the issues of affordability and available expertise, in general the more sensitive the environmental setting or the greater the potential impact of landfill development, the greater the level of engineering that may be required, as illustrated schematically in *Table 2.2.*

**Table 2.2 Typical Standard of Landfill Required for Different Environmental Settings**

| **Environmental Sensitivity** | **Potential Impact** | | |
|---|---|---|---|
| | **Insignificant** | **Moderate** | **Severe** |
| Low | Controlled | Controlled | Sanitary (Level 1) |
| Medium | Controlled | Sanitary (Level 1) | Sanitary (Level 2) |
| High | Sanitary (Level 1) | Sanitary (Level 2) | Sanitary (Level 2) |

At a fundamental level, a Sanitary Landfill is distinguished from a Controlled Dump by the basic requirement to plan and design the engineering of the site, regardless of whether:

- the engineering subsequently adopted is simple (for example, Sanitary Landfill based upon a philosophy of dilute and attenuate or minimum levels of containment engineering); or

- highly complex (for example, a Sanitary Landfill operated as a bioreactor landfill, with high standards of containment engineering and sophisticated leachate control and management involving re-circulation and on-site; treatment).

Beyond this, the level of engineering is dictated by site-specific conditions and the prevailing environmental legislation and standards. Nevertheless, for planning purposes only, it is possible to recognize at least two fundamental levels of Sanitary Landfill, which may be described briefly as follows:

***Sanitary Landfill (Level 1)*** : Basic level of site engineering undertaken, to minimum prescribed standards, particularly in respect of the standards and methods of containment engineering advocated and in the methods and procedures adopted for site operation and management; and

***Sanitary Landfill (Level 2)*** : Level of site engineering required and established by a risk assessment of the environmental impacts of specified design rates of seepage of leachate. Engineering of the site typically encompasses comprehensive containment, treatment and management of leachate and landfill gas, the latter regulated by prescribed minimum standards for active landfill gas control.

## 2.3 Summary of Key Characteristics

A summary of the key characteristics of each of the principal stages and types of landfill is provided below in *Table 2.3.*

| Type | Key Characteristics |
|---|---|
| **Open Dump** | • Unplanned, poorly sited and open of small capacity<br>• No site preparation and no cell planning-waste deposited across large part of the site<br>• Thin layers of waste-relatively rapid aerobic decomposition<br>• No leachate or landfill gas management<br>• Contamination of surface water and groundwater<br>• No or only occasional cover and with no or intermittent compaction of waste<br>• Litter blow within and beyond site boundary-no fence<br>• No record keeping and no control over waste inputs<br>• Uncontrolled presence of vermin, pests and scavenging animals<br>• Waste picking and trading |

| | |
|---|---|
| | • Significant potential for environmental impacts |
| **Controlled Dump** | • May be hydrogeologically sited, but generally not<br>• No cell planning but waste deposition restricted to small working areas<br>• Anaerobic and aerobic decomposition<br>• Peripheral site drainage and surface water control<br>• No leachate or landfill gas management<br>• Regular, but not necessarily daily, inert cover, with compaction in some cases<br>• Fence, including provision for litter control<br>• Basic record keeping but no control over waste inputs<br>• Provision of maintained access road<br>• Controlled waste picking and trading<br>• Site covered and replanted following completion of waste |
| **Sanitary Landfill Level 1** | • Site design based on hydrogeological considerations<br>• Planned capacity with phased cell development<br>• Site preparation including surface water control and containment engineering where necessary<br>• Primarily anaerobic decomposition<br>• Leachate management with leachate abstraction and simple treatment<br>• Landfill gas management with passive Landfill gas measures<br>• Application of cover materials<br>• Compaction of waste to minimum specified target densities<br>• Specified operational procedures to protect local amenity, including vector control |

| | |
|---|---|
| | • Fence, gate and other site infrastructure with surfaced primary access road<br>• Full record of waste volumes, types and source<br>• Special provisions and procedures for dealing with special wastes<br>• Fully trained labor force and experienced site management<br>• Provision for aftercare following site restoration and closure<br>• No waste picking |
| **Sanitary Landfill Level 2** | • Site design based on environmental risk assessment<br>• Key factors in site design are often hydrogeological site conditions<br>• Planned capacity with phased cell development<br>• Extensive site preparation and containment engineering<br>• Primarily anaerobic decomposition<br>• Full leachate management with leachate abstraction and treatment<br>• Full gas management with active landfill gas abstraction where necessary<br>• Application of daily, intermediate and final cover<br>• Compaction of waste to minimum specified target densities |
| **Sanitary Landfill Level 2** | • Specified operational procedure to protect local amenity including vector control<br>• Fence, gate and other site infrastructure<br>• Surfaced primary access road and maintained secondary and tertiary haul roads<br>• Full record of waste volumes, types and source<br>• Special provisions and procedures for dealing with special wastes, including on-site laboratory<br>• Fully trained labor force and experienced site management Extended lifetime<br>• Provision for aftercare following site restoration and closure<br>• No waste picking |

## 3. THE PROCESS OF UPGRADING

### 3.1 Introduction

The upgrading of landfill standards inevitably must take place gradually and progressively over time. It is not feasible to instigate radical changes in one go since the proposed changes need to accommodate the following factors:

- political will on part of the Government of the Philippines, the LGUs and the public at large to higher standards of environmental quality and environmental protection;
- access to appropriate expertise in the design and construction of more secure disposal sites;
- access to appropriate expertise to operate and manage disposal sites higher standards than hitherto;
- the affordability of enhanced standards of landfill disposal; and
- access to adequate resources (finance, equipment and manpower) to ensure that the sites are constructed and operated to the standards to which they are designated in order to maintain the environmental integrity of the landfill facility.

The last point is, perhaps, the most critical. The upgrading of waste disposal practices and overall landfill standards will not occur simply through adopting more sophisticated engineering of selected disposal sites-without appropriate operation and management of Sanitary Landfills rapidly revert to open dumps with the following serious consequences:

- capital investment in landfill construction is wasted;
- if site engineering is successful, pollutant loadings (volume and concentration) are often greatly elevated in comparison to non-engineered sites, thereby posing a significantly greater threat of contamination to the immediate environment of the site; and
- the public perception of sanitary methods of waste disposal is compromised, thereby jeopardizing any attempts at cost recovery.

### 3.2 Conversion of Open Dumps

The option of upgrading existing Open Dumps to higher-grade facilities, particularly Sanitary Landfill, is a solution which has several advantages in that it solves two problems at the same time:

- If a new site is chosen the old site has to be closed and rehabilitated; and
- It avoids the need for new land, which is often scarce and expensive.

If carried out sensitively, with due consideration for the protection of the environment including groundwater and surface waters, conversion of Open Dumps may be feasible in some circumstances. However, in the majority of cases, the unplanned nature of the existing development would generally preclude conversion of the site into anything other than a Controlled Dump. Exceptional cases are likely to be found where the site is located in hydrogeologically suitable locations and only a small part of the site has been developed to date. Upgrading of Open Dump to Controlled Dump is relatively simple and relies upon changes more in operational and management practices. **Improvements can be made to Open Dumps with little capital outlay and few increased costs.**

Simple recommendations and management procedures that have been implemented successfully elsewhere and that may be appropriate include the following:

- rather than owning specific items of mobile plant for site preparation and operation, a LGU may rent the heavy equipment necessary to improve the infrastructure and grading of the site;

- alternatively, the work of maintaining the Controlled Dump and site infrastructure could be subcontracted to a private engineering firm with appropriate resources;

- one LGU may own equipment that is rented to/shared with adjacent LGUs periodically;

- heavy plant and equipment could be rented periodically (about every two to three months) to adjust the grading of the site and excavate suitable cover material;

- subsequently, maintenance of the grading of the site and the application of cover material could be undertaken manually by municipal workers.

### 3.3 Progressive and Staged Upgrading

Direct upgrading of landfill standards to meet the currently very strict national standards is not possible for most cities in the Philippines. It is, therefore, essential to adopt a step-by-step approach in order:

- to improve the overall standards of landfills;

- to phase out Open Dumps; and

- to rehabilitate existing abandoned dump sites to protect the public and the environment.

It should, however, be emphasized that this is not an end in itself and the upgrading of standards is a continuous process. The eventual aims is that all LGUs eventually reach a level of environmental and health protection in line with national standards. The selection of an appropriate level of landfill design and construction standards should be based upon the environmental impacts associated with the specific site *(see Table 2.2),* as well as the financial condition of the LGUs and should be evaluated carefully on the basis of site specific feasibility studies.

3.3.1 *Highly Urbanized Cities (HUG)*

Waste disposal by properly designed and constructed sanitary landfill facilities should be provided for all HUC as a matter of urgency. Those HUCs that have sufficient human and financial resources should plan and upgrade to full Sanitary Landfill (Level 2, unless the evaluated environmental sensitivity of the site dictates that Level 1 is acceptable) without undue delay. For HUCs with insufficient resources as an intermediate stage of upgrading to Controlled Dump or Sanitary Landfill (Level1) will be required.

3.3.2 *First Class Cities and Municipalities*

In order to allow for step-wise improvement in landfill practices in less wealthy areas it is essential that medium level standards are developed and selected and applied on the basis of the ability of the respective LGU or LGU cluster to pay. Those LGUs that cannot afford to adopt Sanitary Landfill in the short-term should first upgrade to Controlled Dump and later to Sanitary Landfill (Level 1), as permitted by the resources available to them.

*3.3.3 Second and Lower Class Cities and Municipalities*

In order to allow for step-wise improvement in landfill practices in less wealthy areas it is essential that medium level standards are developed and selected and applied on the basis of the ability of the respective LGU or LGU cluster to pay. Those LGUs that cannot afford to adopt Sanitary Landfill (Level 1) should upgrade to Controlled Dump.

## 3.4 Clustering

3.4.1 *Rationale*

It is inevitable that the adoption of higher environment standards landfills, as embodied in one of the goals of the INSWMSF for more environmentally secure methods of waste disposal, will result in higher costs for disposal of MSW than hitherto faced by most LGUs. Thus one of the key issues already identified in the process of upgrading is affordability.

It is well established that significant economies of scale arise from developing landfills of relatively large capacity rather than a series of individual small sites of limited capacity. Consideration of the costs (including efficiency) of a number of items including, but not limited to, the following:

- site acquisition;
- site support infrastructure;
- treatment facilities;
- use of mobile plant and equipment;
- containment engineering and site preparation; and

- provision of environmental controls.

demonstrate that the overall costs per tonne of waste disposed, or the cost per $m^3$ of void space consumed progressively reduces as the capacity of the site increases and the volume of waste handled on a daily basis increases.

For smaller LGUs the process of upgrading over time from an Open Dump to a Sanitary Landfill (whether Level 1 or Level 2) may not be deemed to be affordable in the foreseeable future if the disposal facility is funded solely by the resources of a single LGU. However, a Sanitary Landfill constructed to serve a group (cluster) of two or more LGUs on a more regional basis will generally prove to be more a cost-effective solution than could be adopted by each individual LGU in isolation.

Accordingly, the construction of a regional Sanitary Landfill offers the possibility of a cluster of cities and municipalities being able to construct facilities that have better environmental controls than could otherwise be afforded by each individual LGU.

### *3.4.2 Size of Cluster*

There are no well developed rules for establishing the optimum size of clusters. The development of a regional landfill to serve several municipalities must be evaluated thoroughly by a full feasibility study.

However, as a preliminary indication, the following general guidance may be offered:

- significant economies of scale, in terms of the efficient use of a single set of mobile plant and equipment dedicated to a site, will generally be obtained with a daily rate of waste input of at least 300 tonnes per day. On the basis of an average waste generation rate of 0.5 kg. per capita per day, the 'minimum' size of the population served by the landfill, therefore, should be approximately 600,000;

- smaller served populations are still likely to prove feasible although the economies of scale achieved will be somewhat less;

- larger served populations may benefit from significant economies of scale if the landfill facility is able to handle in excess of 500 tonnes per day;

- the location of the regional landfill should be as close as possible to the center of gravity of the population of the area served by the landfill in order to minimize the costs of waste collection and transfer, and

- it is probably economic, in terms of the cost of waste transfer, to service an area within a radius of 30 km to 40 km of the regional landfill facility or within 1 hour to 1.5 hours travel time of the landfill facility. For haulage distances in excess of 10 km tom 15 km to the regional landfill, it would be necessary to use transfer stations as a cost efficient means of minimizing the overall cost of waste transfer to the landfill.

## 3.5 Technical Norms

Suggested technical norms, environmental quality requirements and operational performance standards for each stage of landfill are set out in the following Sections:

- *Section 4 - Controlled Dumps;*
- *Section 5 - Sanitary Landfill (Level 1); and*
- *Section 6 - Sanitary Landfill (Level 2).*

The Technical Guidelines are provided to assist LGUs in upgrading landfills in accordance with DAO 98-49. The operational performance standards set out are for guidance as an illustration of minimum acceptable standards.

## 4. GUIDELINES FOR CONTROLLED DUMPS

Suggested technical norms, environmental quality requirements and operational performance standards for Controlled Dumps are set out in *Table 3.*

**Table 3. Controlled Dump**

| Technical Norms | Environmental Quality Requirements | Operational Performance Standards |
|---|---|---|
| **Site Availability** | Daylight hours only where feasible and consistent with waste collection and waste transfer operations.<br><br>Avoid nighttime hours which are the most sensitive with respect to noise and artificial light, unless the site is remote from sensitive receivers. | 06.00-18.00, 365 days per year.<br><br>If nighttime working required, restrict working times to discrete periods (for example, mid evening and around day-break). |
| **Road Construction** | Good access to the site off the principal haulage routes.<br><br>Primary access road constructed to high standard to minimize wear and tear on delivery vehicles and maintain trafficability of haulage routes to waste discharge areas in wet weather conditions. | Permanent roads surfaced supporting two-way traffic flow.<br><br>Minimum width of road 6 m (excluding shoulders).<br><br>Temporary roads designed to facilitate drainage. |
| **Surface Water and Stormwater Drainage** | Isolate surface water and stormwater flows from deposited waste in order to avoid potential wash-out. | Surface water interception ditches to drain slopes upgradient of the area being filled.<br><br>Minimize size of active area. |
| **Restoration** | Site restored progressively upon completion of filling in any particular phase. | Cover layer - minimum thickness for public open space s 600 mm (300 mm for drainage and 300 mm for soil).<br><br>Grade slopes to promote surface run-off. |

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| | | Completed parts of the site should be seeded and planted with native species of grass as soon as possible on order to reduce the potential for soil erosion |
| **Afteruse** | Upon completion of the controlled dump the site should be returned to some form of productive use. | Public open space, recreational use, grazing and some other forms of agriculture (with suitable depth of soil) are compatible afteruses.<br><br>Building works are not recommended. |
| **Other Site Infrastructure** | Site support facilities to provide minimum levels of environmental control. | Provisions may include the following:<br>• Services (electricity, water, etc.); and<br>• Small site office |
| **Site Management** | Particular responsibilities with regard to:<br>• Securing resource requirements;<br>• Recruitment and appropriate training of staff, and<br>• Enforcement of site operational practices | Experienced Operations Manager with drive and commitment. |
| **Site Access** | Protection of the public from potentially dangerous site activities (e.g. mobile plant) | Access to site regulated. Waste pickers on site controlled by site management according to agreed rules and procedures (e.g. no setting fire to waste). |
| **Waste Recording** | Forward planning of site operations and efficient utilization of available void space. | Quantity of waste loads and types of waste to be recorded manually by a site clerk.<br><br>Information on difficult/special wastes to be |

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| | | recorded, including location of waste deposition. |
| **Protection of Local Amenities** | Reduce impacts of site activities upon developments adjacent to the site to minimum levels. | Key measures are:<br>• Use of litter fences;<br>• Daily liner patrols within and beyond site boundary;<br>• Elimination of smoke from waste on fire;<br>• Control of pests and vermin; and<br>• Reduction in persistent odors through the application of cover. |
| **Environmental Monitoring** | Monitoring of the groundwater | Monitor existing water wells using approved water quality monitoring methods to determine and record the baseline quality of the groundwater while open dumping was resorted to.<br><br>Regular monitoring thereafter to establish how controlled dump is affecting the quality of the groundwater |
| **Waste Emplacement** | Key issues in waste emplacement are as follows:<br>• Minimize active filling area to exert maximum environmental control;<br>• Minimize potential for environmental nuisance and impact to local amenity; and<br>• Maximize available void space. | Supervision of waste deposition by trained staff.<br><br>Restriction of active waste deposition area to c. 2 Ha. And two faces.<br><br>Compaction of waste by mobile plant to crush large hollow items and a minimum number of 3 passes of mobile plant.<br><br>Limit layer thickness to a maximum of 0.75 m. |

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| | | Place inert cover materials, 100 mm thick, on exposed faces of waste daily (if available), at the very least every 3 days.<br><br>Intermediate cover, 150 mm thick, placed on temporarily completed areas of waste. Grade to drain clean water. |
| **Maintenance** | Efficient functioning of the following components should be maintained:<br><br>• Site roads;<br><br>• Drainage works; and<br><br>• Any mobile plant. | Regular daily and weekly servicing of mobile plant by qualified mechanic / fitter.<br><br>Supply of spare parts of key items and components held on site.<br><br>Maintenance of drainage works in advance of rainy season.<br><br>Maintenance of site roads as and when required, at least quarterly. In wet weather re-grade as required. |

## 5. GUIDELINES FOR SANITARY LANDFILL (LEVEL 1)

Suggested technical norms, environmental quality requirements and operational performance standards for a relatively simple Sanitary Landfill (Level1) are set out in Table 4. The degree of engineering assumes a site with 'moderate' levels of environmental sensitivity (i.e. in close proximity to *potential* surface water or groundwater resources) where the potential impacts of landfill development are not severe. The site engineering, therefore, relies upon in *situ* strata to provide requisite levels of site containment.

**Table 4 Sanitary Landfill (Level 1)**

| Technical Norms | Environmental Quality Requirements | Operational Performance Standards |
|---|---|---|
| **Site Design** | Based upon detailed site-specific surveys, *inter alia, of:*<br>• Geology;<br>• Hydrogeology (groundwater);<br>• Hydrology (surface water);<br>• Properties of site materials; and<br>• Socio-economic conditions adjacent to the site. | Prevailing legislation relating to ambient environmental conditions.<br><br>Risk assessment of key-environmental constraints to establish appropriate levels of site engineering (as required).<br><br>Specified mitigation measures to minimize potential impact of site development (Environmental Management Plan). |
| **Site Availability** | Daylight hours only where feasible and consistent with waste collection and waste collection and waste transfer operations.<br><br>Avoid nighttime hours which are the most sensitive with respect to noise and artificial light, unless the site is remote and/or screened from sensitive receivers. | 07.00-18.00, 365 days per year.<br><br>If nighttime working required, working areas must be provided with adequate noise screening and floodlighting to minimize environmental impacts and health and safety risks. |

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| **Buffer Zones And Standoffs** | Dependent upon siting criteria - *where practicable* landfill boundary at least 60 m from residential properties and at least 300 m from ecologically and environmentally sensitive areas (e.g. school, religious center).<br><br>Landfill footprint > 10 m from site boundary to permit:<br><br>• Installation of screening measures as required;<br><br>• Remedial engineering measures. | Putrescible water to be deposited no closer than 50 m to isolated dwellings and 100 m from more extensive residential dwellings<br><br>Wherever practicable, putrescible waste to be deposited no closer than 100 m to isolated dwellings and 200 m to more extensive residential development. |
| **Site Development** | Minimize active operational area (visual impact).<br><br>Minimize area taken from potential productive use (economic impact).<br><br>Return parts of the site to use as rapidly as possible. | Progressive phased site development and restoration.<br><br>Area method of filling using cellular approach.<br><br>Operational Plan to include fill sequencing. |
| **Containment Engineering (Basal, lateral and Upper surface)** | Protection of groundwater and surface water resources - no discernible impact on existing (*i.e.* pre-construction/baseline) water quality.<br><br>No discernible impact on the ability of surface water or groundwater to:<br><br>• support aquatic or plant life; or<br><br>• be used by humans (e.g. irrigation, industrial). | Minimum level of basal and lateral containment acceptable assessed on basis of environmental sensitivity of the site.<br><br>Where feasible, provided by 1 m (or more) of non-fissured, remoulded and recompacted clay with a hydraulic conductivity less than $1 \times 10^{-9}$ $ms^{-1}$<br><br>For attenuate and disperse sites criteria to be developed based upon existing water quality, established groundwater flow regime and anticipated |

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| | | contaminant loading. |
| **Leachate Control and Management** | Minimize the generation of contaminated water (leachate) that poses a risk to the environment or that requires to be processed and treated.<br><br>Minimize the potential for seepage through the basal containment system and avoid a build-up of leachate within the site.<br><br>Treat leachate before effluent is permitted to be discharged back into the environment. | Adopt cellular method of filling, with cell size based on water balance principles.<br><br>Segregate clean water (see surface water/stormwater drainage).<br><br>Maximum head of leachate above the basal lining system of 3.0m. Grade base of landfill to promote leachate drainage and collection. Install provision for abstracting leachate from the landfill. Install provision for simple leachate treatment on-site. Treated effluent to meet minimum quality standards specified by environmental legislation. |
| **Landfill Gas Control and Management** | Reduce the potential for:<br><br>• gas pressurization within the deposited waste beneath the capped surface;<br><br>• the uncontrolled migration of landfill gas beyond the site boundary; and<br><br>• the build-up of landfill gas in confined spaces and the potential for explosions, asphyxiation, fires, *etc.* within the site or beyond the site boundary. | Install simple landfill gas collection system during site construction comprising vertical gas wells.<br><br>Provide passive gas venting or temporary flare.<br><br>Containment engineering (lateral and capping) to retard gas migration.<br><br>Maximum concentration of gases at the site boundary:<br><br>• methane - 1% by volume;<br><br>• carbon dioxide - 1.5% by volume.<br><br>• Flammable gas - 30 ppm (ambient/ground surface). |
| **Road Construction** | Good access to the site off the principal haulage routes with uninterrupted access to emergency | Surfaced road supporting two-way traffic Minimum width of surfaced road 6.8 m (excluding shoulders). |

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| | vehicles at all times.<br><br>Primary access road constructed to high standard to minimize wear and tear on delivery vehicles.<br><br>Road routed away from sensitive residential developments to minimize potential noise, air quality and safety impacts.<br><br>Maintain trafficability of haulage routes to waste deposition areas under all weather conditions. | Designed to conventional highway standards based upon projected traffic flows and equivalent axle loadings.<br><br>Road routed in buffer zone. Screening mounds, vegetation belts and noise fencing as required.<br><br>Permanent roads surfaced. Temporary roads designed to facilitate drainage. Maintained, repaired and re-graded on a regular basis. |
| **Surface Water and Stormwater Drainage** | Isolate surface water and stormwater flows from deposited waste in order to avoid potential wash-out and to minimize the production of leachate.<br><br>Where feasible avoid or re-route surface flows.<br><br>If unavoidable culvert flows beneath containment layer. | Surface water interception ditches to drain slopes upgradient of the area being filled.<br><br>Construct temporary or permanent berms/bunds to prevent run-on of surface water and stormwater and to segregate clean water from contaminated water.<br><br>Grading slopes in filled areas (temporarily or permanently capped) to shed water rapidly. Minimize size of active area. |
| **Groundwater Drainage** | Isolate groundwater (including springs and seepages) from deposited waste in order to minimize the production of leachate.<br><br>Avoid the potential for pressure build-up on the underside of the containment layer potentially leading to uplift. | Install underdrain system to intercept groundwater flows and to eliminate uplift pressures on the underside of the containment layer. |
| **Restoration** | Site restored progressively upon completion of filling in any particular phase.<br><br>Restored slopes consistent with: | Capping layer overlain by agricultural solum comprising a subsoil drainage layer and organic subsoil and topsoil. Thickness of solum depends upon intended afteruse. |

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| | • Prevailing topography;<br>• slope stability considerations;<br>• intended afteruse; and<br>• site drainage<br><br>Minimize soil erosion and transport of suspended sediment in surface water. | Minimum thickness for public open space is 600 mm (300 mm for drainage and 300 mm for soil).<br><br>Restoration Plan to be produced as a formal part of the Working Plan.<br><br>Restored slopes lie typically in the range 1:6 (vertical: horizontal) to 1:30. Steeper/shallower slopes are not shallow settlement may disrupt the surface drainage pattern.<br><br>Completed parts of the site should be seeded and planted with native species of grass as soon as possible in order to reduce the potential of soil erosion and desiccation of the capping layer.<br><br>Sedimentation traps as part of surface water drainage system. |
| **Afteruse** | Upon completion the landfill facility should be returned to some form of productive use. | Public open space, recreational use, grazing and other forms of agriculture are compatible afteruses.<br><br>Buildings and industrial activities are not recommended, especially on deep and/or large sites (continued settlement, leachate and landfill gas generation). |
| **Aftercare** | Potential for contamination of the surrounding environment is high if operational controls are not maintained and site engineering fails or is breached. | Aftercare provisions may be of limited duration, extending only to the maintenance and re-grading/filling of capping layer and agricultural solum.<br><br>Continued operational of all components of the leachate and landfill gas control and management system should also be included. |

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| | | Continue environmental monitoring until stabilization is achieved. |
| **Other Site Infrastructure** | Site support facilities to underpin site construction and operation to specified environmental standards. | Provisions may include the following:<br>• Services (electricity, water, etc.);<br>• Site offices;<br>• Weighbridge(s) and office;<br>• Workshop and stores;<br>• Fuel compound;<br>• Waste inspection/quarantine area;<br>• Vehicle washing facilities. |
| **Working Plan** | Guidance on how the site will be operated and developed in accordance with the site design. An essential component in order to maintain the environmental integrity of the site. | The Working Plan should include the following:<br>• Construction Methods Statements;<br>• Phasing Plan;<br>• Operational Plan;<br>• Site Management Plan;<br>• Environmental Management Plan;<br>• Environmental Monitoring Plan; |

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| | | • Restoration and Aftercare Plan;<br>• Health and Safety Plan;<br>• Emergency Response and Procedures Plan; and<br>• Plant and Infrastructure Maintenance Protocol. |
| **Site Management** | Particular responsibilities with regard to:<br>• Forward planning of human technical and financial resource requirements;<br>• Recruitment and appropriate training of staff;<br>• Enforcement of site operational practices;<br>• Implementation of H&S Policy, Emergency Response & Procedures Plan, Environmental Monitoring Plan. | Operational of the landfill facility as designed, in full compliance with the specified Working Plan.<br>Appropriately qualified and experienced Operations Manager, with established vocational training qualifications (if possible). |
| **Site Access** | Protection of site engineering measures, particularly containment engineering.<br>Protection of the public from potentially dangerous site activities (*e.g.* mobile plant, potentially unstable slopes, landfill gas, etc.). | Site to be securely fenced, particularly in the following areas:<br>• Waste reception area;<br>• Waste quarantine area;<br>• Mobile Plant compound |

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| | | • Treatment plants;<br>• Active waste emplacement cell(s);<br>• Ponds and lagoons;<br>• Uncapped areas of the site.<br><br>Access to site regulated-visitors to sign in. Accommodation for waste pickers activities by organizing multiple working faces or recycling/picking area adjacent to the waste reception area. |
| **Waste Recording** | Forward planning of site operation and efficient utilization of available void space. | Quantities, sources and origin of waste loads to be recorded accurately over a weighbridge and logged electronically. |
| **Waste Inspection and Checking** | To try to ensure that only permitted wastes are accepted at the landfill facility.<br><br>To identify non-conforming loads and loads on fire. | Specification of permitted waste in the Site License.<br><br>Routine visual inspection of waste loads at the waste reception area and at the active face prior to incorporation into the landfill. Adequately trained and alert and responsive site operatives (waste marshals and banksmen).<br><br>Quarantine of suspect loads pending receipt of analytical results. |
| **Protection of Local Amenities** | No significant impact of site activities upon developments adjacent to the site.<br><br>Environmental impacts no more intrusive or significant than assessed in the Environmental Assessment and incorporated in the Environmental Management Plan. | Range of site-specific operational procedures to deal with potential nuisance.<br>Effectiveness judged against:<br><br>• No litter beyond site boundary (excl. severe weather conditions); |

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| | | • No fires and no smoke on site;<br>• No mud transferred to public highway;<br>• Control on pests and vermin;<br>• Escape of fugitive dust;<br>• Absence of persistent odors;<br>• Noise levels at sensitive receivers.<br><br>Control/trigger levels where specified in existing legislation should be used (*e.g.* ambient air quality, noise levels). Where it is not possible to stimulate controls quantitatively, effectiveness should be judged against a pre-determined response time to address any inherent problem. |
| **Waste Emplacement** | A number of key issues are involved in waste emplacement in order that waste may be off loaded and deposited in the most secure, efficient and safest manner, with respect to site users, site personnel and the site environs:<br><br>• Minimize active filling area to exert maximum environmental control (e.g. minimize leachate generation);<br><br>• Minimize potential for environmental nuisance and impact to local amenity; and<br><br>• Maximize available void space. | Supervision of waste deposition by adequately trained and experienced staff.<br><br>Phased site development and cellular method of filling; cell size optimized on the basis of water balance principles.<br><br>Compaction of waste by mobile plant to specified target placement densities, typically between 0.8-0.9 t/$m^3$, adopting a maximum layer thickness of 0.5m.<br><br>Inert cover materials placed on exposed faces of waste at the end of each day or upon completion of a lift (2.5 m high).<br>Cover material-usually 300 mm thick, placed on-temporarily completed areas of water. |

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| **Maintenance** | Efficient functioning of all components of the landfill facility should be maintained, including, inter alia, the following:<br>• Site roads;<br>• Drainage works;<br>• Leachate collection and transfer system;<br>• Landfill gas transfer system;<br>• Treatment plants;<br>• Buildings; and<br>• Mobile plant, fixed plant and vehicles. | Built-in redundancy and flexibility for key elements of site construction and operation (*e.g.* .modular leachate treatment plant with duty and standby pumps).<br>Standby/alternate power supply.<br>Preventive maintenance schedule to be adopted allied with routine and regular servicing by qualified mechanic/fitter.<br>Supply of spare parts of key items and components held on site. |
| **Environmental Monitoring** | Site operations shall comply, at all times, with relevant National, Provincial and Local Environmental Legislation currently in force. Monitoring provides the mechanism for:<br>• Assessing the overall environmental impacts of site development;<br>• Determining, at an early stage, potential pollution emanating from the site;<br>• Identifying any deviations from acceptable standards of site operation; and<br>• Formulating proposals for site remediation measures, as necessary | Environmental monitoring to be undertaken on a regular basis during all phases of site development, site restoration and upon, and following, completion of site activities.<br>Measurements should include:<br>• Surface water,<br>• Groundwater;<br>• Leachate<br>• Landfill gas<br>• Noise |

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| | | • Air quality<br><br>The number of locations monitored, and the range of parameter monitored, is site specific. However, the following generalizations can be made:<br><br>***Water quality*** - indicator parameters (pH conductivity or total dissolved solids, BOD, COD, ammoniacal nitrogen or nitrate, chloride and sulphate) monitored monthly at a minimum of jour locations. More extensive suite, including major elements and ions and trace metals monitored quarterly.<br><br>***Water level*** - groundwater level monitored monthly at a minimum of six locations.<br><br>***Landfill gas*** - $CO_2$, $CH_4$, O and flammable gas measured routinely, at least monthly in confined spaces (buildings and boreholes) and along the site boundary.<br><br>*Noise* - weekly measurement at locations adjacent to noise sensitive receivers.<br><br>***Air quality*** - measurement of Total Suspended Particulates (TSP) and Respirable Suspended Particulates (RSP) weekly during major construction activities; fortnightly to monthly thereafter. Sulfur Dioxide ($SO_2$) and Oxides of Nitrogen ($NO_x$) may also be measured monthly in critical/ sensitive locations. |

## 6. GUIDELINES FOR SANITARY LANDFILL (LEVEL 2)

Suggested technical norms, environmental quality requirements and operational performance standards for a more sophisticated Sanitary Landfill (Level 2) are set out in Table 5. The degree of engineering - assumes a site with 'moderate to high' levels of environmental sensitivity (i.e. in close proximity to potential surface water or groundwater resources) where - the potential impacts of landfill development are potentially severe. The site engineering, therefore, relies upon a composite lining system determined by risk analysis to provide requisite levels of site containment.

**Table 5 Sanitary Landfill (Level 2)**

| Technical Norms | Environmental Quality Requirements | Operational Performance Standards |
|---|---|---|
| **Site Design** | Based upon detailed site-specific surveys, *inter alia* of:<br>• Geology;<br>• Hydrogeology (groundwater);<br>• Hydrology (surface water);<br>• Properties of site materials; and<br>• Socio-economic conditions adjacent to the site. | Prevailing legislation relating to ambient environmental conditions.<br><br>Risk assessment of-key environmental constraints to establish appropriate levels of site engineering.<br><br>Specified mitigation measures to minimize potential impact of site development (Environmental Management Plan). |
| **Site Availability** | Daylight hours only where feasible and consistent with waste collection and waste transfer operations.<br><br>Avoid nighttime hours which are the most sensitive | 07.00-18.00,365 days per year.<br><br>If nighttime working required, working areas must be provided with adequate noise screening and |

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| | with respect to noise and artificial light, unless remote and/or screened from sensitive receivers. | floodlighting to minimize environmental impacts and health and safety risks. |
| **Buffer Zones And Standoffs** | Dependent upon siting criteria - *where practicable* landfill boundary at least 100 m from residential properties and at least 500 m from ecologically and environmentally sensitive areas (*e.g.* school, religious center).<br><br>Landfill footprint >20 m from site boundary to permit:<br><br>• installation of screening measures as required; and<br><br>• remedial engineering measures. | Putrescible waste to be deposited no closer than 50 m to isolated dwellings and 100 m from more extensive residential dwellings.<br><br>Wherever practicable, putrescible waste to be deposited no closer than 200 m to isolated dwellings and 250 m to more extensive residential development. |
| **Site Development** | Minimize active operational area (visual impact).<br><br>Minimize area taken from potential productive use (economic impact).<br><br>Return parts of the site to use as rapidly as possible. | Progressive phased site development and restoration.<br><br>Area method of filling using cellular approach.<br><br>Operational Plan to include fill sequencing. |
| **Containment Engineering (Basal, lateral and Upper surface)** | Protection of groundwater and surface water resources - no discernible impact on existing (*i.e.* pre construction baseline) water quality.<br><br>No discernible impact on the ability of surface water or groundwater to:<br><br>• support aquatic or plant life; or<br><br>be used by humans (*e.g.* irrigation, industrial). | Maximum specified permissible leakage rate determined from a risk assessment of the anticipated impact of the seepage of leachate. Based upon the environmental sensitivity of the site.<br><br>Minimum standard is a multi-layered system, with synthetic and natural components, comprising 1.5 mm/2mm HDPE combined with 0.6 m of clay with a permeability.>1.0 x $10^{-9}$ $ms^{-1}$. |
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| **Leachate Control and Management** | Minimize the generation of contaminated water (leachate) that poses a risk to the environment or that requires to be processed and treated.<br><br>Minimize the potential for seepage through the basal containment system and avoid a build-up of leachate within the site.<br><br>Treat leachate before effluent is permitted to be discharged back into the environment. | Adopt cellular method of filling, with cell size based on water balance principles. Advocate leachate recirculation to dry absorptive waste where feasible. Segregate clean water (see surface water/stormwater drainage).<br><br>Maximum head of leachate above the basal lining system of 1.0 m.<br>Install leachate collection system above the basal containment layer.<br>Minimum hydraulic conductivity of drainage layer -1 x $10^{-4}$ $ms^{-1}$<br><br>Install provision for abstracting leachate from the landfill;<br><br>Install provision for leachate treatment on-site or off-site at a suitable Sewage Treatment Plant (STP).<br><br>Treated effluent to meet minimum quality standards specified by prevailing environmental legislation with respect to effluent standards. |
| **Landfill Gas Control and Management** | Reduce the potential for the uncontrolled migration of landfill gas beyond the site boundary.<br><br>Reduce the potential for gas pressurization within the deposited waste beneath the capped surface.<br><br>Avoid build-up of landfill gas in confined spaces and the potential for explosions, asphyxiation, fires, *etc* within the site or beyond the site boundary. | Install landfill gas collection system during site construction comprising vertical gas wells and horizontal collection pipes.<br>Containment engineering (lateral and capping) to retard gas migration.<br><br>For large and/or deep sites install active landfill gas extraction system, with gas plant, in order to regulate gas pressure within the landfill. Specify maximum permitted pressure above atmospheric pressure at a depth of 1 m below the capping layer (typical value-10mb above atmospheric). |

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| | | Maximum concentration of gases at the site boundary:<br>• methane - 1 % by volume;<br>• carbon dioxide - 1.5 8 by volume.<br>• Flammable gas -30 ppm (ambient/ground surface) |
| **Road Construction** | Good access to the site off the principal haulage routes with uninterrupted access to emergency vehicles at all times.<br><br>Primary access road constructed to high standard to minimize wear-and tear on delivery vehicles.<br><br>Road routed away from sensitive residential developments to minimize potential noise, air quality and safety impacts.<br><br>Maintain trafficability of haulage routes to waste deposition areas under all weather conditions. | Surfaced road supporting two-way traffic. Minimum width of surfaced road 7.3m (excluding shoulders).<br><br>Designed to conventional highway standards based upon projected traffic flows and equivalent axle loadings.<br><br>Road routed in buffer zone. Screening mounds, vegetation belts and noise fencing required.<br><br>Permanent roads surfaced. Temporary roads designed to facilitate drainage. Maintained, repaired and re-graded on a regular basis. |
| **Surface Water and Stormwater Drainage** | Isolate surface water and stormwater flows from deposited waste in order to avoid potential wash-out and to minimize the production of leachate.<br><br>Where feasible avoid or re-route surface flows.<br><br>If unavoidable culvert flows beneath containment layer. | Surface water interception ditches to drain slopes upgradient of the area being filled.<br><br>Construct temporary or permanent berms/bunds to prevent run-on of surface water and stormwater and to segregate clean water from contaminated water.<br><br>Grading of slopes in filled areas (temporarily or permanently capped) to shed water rapidly.<br><br>Minimize size of active area |

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| **Groundwater Drainage** | Isolate groundwater (including springs and seepages) from deposited waste in order to minimize the production of leachate.<br><br>Avoid the potential for pressure build-up on the underside of the containment layer potentially leading to uplift. | Install underdrain system to intercept groundwater flows and to eliminate uplift pressures on the underside of the containment layer. |
| **Restoration** | Site restored progressively upon completion of filling in any particular phase.<br><br>Restored slopes consistent with:<br>• Prevailing topography;<br>• slope stability considerations;<br>• intended afteruse; and<br>• site drainage.<br><br>Minimize soil erosion and transport of suspended sediment in surface water. | Capping layer overlain by agricultural solum comprising a subsoil drainage layer and organic and topsoil. Thickness of solum depends upon intended afteruse. Minimum thickness for public open space is 600 m (300mm for drainage and 300 mm for soil).<br><br>Restoration Plan to be produced as a formal part of the Working Plan. Restored slopes lie typically in the range 1:4 (vertical:horizontal) to !:30. Steeper and shallower slopes are not recommended. If slopes are too shallow settlement may disrupt the surface drainage pattern.<br><br>Completed parts of the site should be seeded and planted with native species of grass as soon as possible in order to reduce the potential for soil erosion and desiccation of the capping layer.<br><br>Sedimentation traps as part of surface water drainage system. |
| **Afteruse** | Upon completion the landfill facility should be returned to some form of productive use. | Public open space, recreational use, grazing and other forms of agriculture are compatible afteruses.<br><br>Buildings and industrial activities are not recommended, especially on deep and/or large sites (continued settlement leachate and landfill gas generation. |

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| **Aftercare** | Potential for contamination of the surrounding environment is high if operational controls are not maintained and site engineering fails or is breached. | Aftercare Plan to be produced as formal par of the Working plan.<br><br>Continued operation of all components of the leachate and landfill gas control and management systems.<br><br>Continued environmental monitoring.<br><br>Maintenance and re-grading/filling of capping layer and agricultural solum. |
| **Other site Infrastructure** | Site support facilities to underpin site construction and operation to high environmental standards. | Provisions may include the following.<br>• Services (electricity, water, etc.);<br>• Site offices;<br>• Amenity block and messroom;<br>• Weighbridge(s) and office;<br>• Workshops and stores;<br>• Fuel compound;<br>• Waste inspection/quarantine area;<br>• On-site laboratory; and<br>• Vehicle washing facilities. |
| **Working Plan** | Guidance on how the site will be operated and developed in accordance with the site design. An | The working Plan should include the following. |

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| | essential component in order to maintain the environmental integrity of the site. | • Construction Method Statements;<br>• Construction Quality Assurance Protocol;<br>• Construction Program;<br>• Phasing Plan;<br>• Operational Plan;<br>• Site Management Plan;<br>• Environmental Management Plan;<br>• Environmental Monitoring Plan;<br>• Restoration and Aftercare Plan;<br>• Health and Safety Plan;<br>• Emergency Response and Procedures Plan; and<br>• Plant and Infrastructure Maintenance Protocol. |
| **Site Management** | Particular responsibilities with regard to:<br>• Forward planning of human technical and financial resource requirements;<br>• Recruitment and appropriate training of staff;<br>• Enforcement of site operational practices; | Operation of the landfill facility as designed, in full compliance with the specified Working Plan.<br>Appropriately qualified and experienced Operations Manager, with established vocational training qualifications (if possible). |

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| | • Implementation of H7S Policy, Emergency Response & Procedures Plan, Environmental Management Plan and Environmental Monitoring Plan. | |
| **Site Access** | Protection of site engineering measures, particularly containment engineering.<br><br>Protection of the public from potentially dangerous site activities (e.g. mobile plant, potentially unstable slopes landfill gas, etc.). | Site to be securely fenced, particularly in the following areas:<br><br>• Waste reception area;<br>• Waste quarantine area;<br>• Mobile Plant compound<br>• Treatment plants;<br>• Active waste emplacement cell(s);<br>• Ponds and lagoons;<br>• Uncapped areas of the site.<br><br>Access to site regulated- visitors to sign in. No waste pickers permitted on site. |
| **Waste Recording** | Forward planning of site operations and efficient utilization of available void space. | Quantities, sources and origin of waste loads to be recorded accurately over a weighbridge and logged electronically. |
| **Waste Inspection and Checking** | To try to ensure that only permitted wastes are accepted at the landfill facility.<br><br>To identify non-conforming loads and loads on fire. | |

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| **Protection of Local Amenities** | No significant impact of site activities upon developments adjacent to the site . Environmental impacts no more intrusive- or significant than assessed in the Environmental Assessment and incorporated in the Environmental Management Plan. | Specification of permitted waste in the Site License.<br><br>Routine visual inspection of waste loads at the waste reception area and at the active face prior to incorporation into the landfill. Adequately trained and alert and responsive site operatives (waste marshals and banksmen).<br><br>Chemical and physical analysis of waste loads at random and when the loads suspect. Quarantine of suspect loads pending receipt of analytical results.<br><br>Effectiveness judged against:<br><br>• No litter beyond site boundary (excluding severe weather conditions);<br><br>• No fires and no smoke on site;<br><br>• No mud transferred to public highways;<br><br>• Control of pests and vermin;<br><br>• Escape of fugitive dust;<br><br>• Absence of persistent odors;<br><br>• Noise levels at sensitive receivers.<br><br>Control/trigger levels where specified existing legislation should be used (*e.g.* ambient air quality, noise levels). Where it is not possible to stipulate controls quantitatively, effectiveness should be judged |

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| | | against a pre-determined response time to address any inherent problem. |
| Waste Emplacement | A number of key issues are involved in waste emplacement in order that waste may be off loaded and deposited in the most secure, efficient and safest manner, with respect to site users, site personnel and the site environs:<br><br>• Minimize active filling area to exert maximum environmental control (*e.g.* .minimize leachate generation);<br>• Minimize potential for environmental nuisance and impact to local amenity; and<br>• Maximize available void space. | Supervision of waste deposition by adequately trained and experienced staff.<br><br>Phased site development and cellular method of filling; cell size optimized on the basis of water balance principles.<br><br>Compaction of waste by mobile plant to specified target placements densities, typically between 0.8-0.9 t/$m^3$ adopting a maximum layer thickness of 0.5m.<br><br>Inert cover materials placed on exposed faces of waste at the end of each day or upon completion of a life (2.5 m high). Cover material - usually 300 mm thick.<br><br>Intermediate cover, usually 300 mm thick, placed on temporarily completed areas of waste. |
| **Maintenance** | Efficient functioning of all components of the landfill facility should be maintained, including, *inter alia,* the following:<br><br>• Site roads;<br><br>• Drainage works;<br><br>• Leachate collection and transfer system;<br><br>• Landfill gas transfer system; | Built-in redundancy and flexibility for key elements of site construction and operation (*e.g.* modular leachate treatment plant with duty and standby pumps).<br><br>Standby/alternate power supply.<br><br>Preventative maintenance schedule to be adopted allied with routine and regular servicing by qualified mechanic/fitter.<br><br>Supply of spare parts of key items and components held on site. |

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| | • Treatment plants;<br>• Buildings; and<br>• Mobile plant, fixed plant and vehicles. | |
| **Environmental Monitoring** | Site operations shall comply, at all times, with relevant National, Provincial and Local Environmental Legislation currently in force. Monitoring provides the mechanism for:<br>• Assessing the overall environmental impacts of site development;<br>• Determining, at an early stage, potential pollution emanating from the site;<br>• Identifying any deviations from acceptable standards of site operation; and<br>• Formulating proposals for site remediation measures, as necessary. | Environmental monitoring to be undertaken on a regular basis during all phases of site development, site restoration and upon, and following, completion of site activities.<br>Measurements should include:<br>• Surface water<br>• Groundwater;<br>• Leachate<br>• Landfill gas; Noise;<br>• Air quality<br>The number of locations monitored and the range of parameter monitored, is site specific. However, the following generalizations can be made:<br>***Water quality*** - indicator parameters (pH, conductivity or total dissolved solids, BOD, COD, ammoniacal nitrogen or nitrate, chloride and sulphate) monitored monthly at a minimum of four locations. More extensive suite, including major elements and ions and trace metal monitored quarterly.<br>***Water level*** - groundwater level monitored monthly at |

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| | | a minimum of six locations.<br><br>***Landfill gas*** - CO2' CH4' O and flammable gas measured routinely, at least monthly in confined spaces (buildings and boreholes) and along the site boundary.<br><br>***Noise -*** weekly measurement at locations adjacent to noise sensitive receivers.<br><br>***Air Quality*** - measurement of Total Suspended Particulates (TSP) and Respirable Suspended Particulates (RSP) weekly during major construction activities; fortnightly to monthly thereafter. Sulphur Dioxide ($SO_2$) and Oxides of Nitrogen ($NO_x$) may also be measured monthly in critical/sensitive locations. |

## ENVIRONMENTAL STANDARDS AND REGULATIONS

The construction and operation of Sanitary Landfills will generally conform to standards laid down in existing rules and regulations governing environmental quality. In particular , attention is drawn to the following legislation, current at the time publishing these Technical Guidelines:

**DAO 90-34:** Revised water usage and classification, Water Quality criteria amending Section Nos. 68 and 69, Chapter III of the 1978 NPCC Rules and Regulations;

**DAO 90-35:** Revised effluent regulations of 1990, revising and amending the effluent regulations of 1982;

**DAO 93-14:** Revising Chapter II, Sections 57 to 66 of the 1978 Implementing Rules and Regulations for P.D. 984 (Air Quality);

**DOH 1993 :** Philippine National Standards for Drinking Water; and

**National Pollution Control Commission (1978):** Noise Control Regulations