

**Solid Waste Management  
Privatization Procedural Manual**

**LANDFILLING  
AND OPEN DUMP  
CLOSURE**



**SOLID WASTE TECHNICAL ASSISTANCE**



Ministry of State for Environmental Affairs



U.S. Agency for International Development



Egyptian Environmental Policy Program

**Egyptian Environmental Policy Program  
Solid Waste Technical Assistance Program  
Solid Waste Management Privatization Procedural Manual**

**CHAPTER 16**  
**LANDFILLING  
AND OPEN  
DUMP  
CLOSURE**

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# INTRODUCTION

**L**andfills are an indispensable part of any integrated solid waste management (ISWM) system whether operated by a public agency or a private contractor. This is the case no matter how successful solid waste recovery or processing is in diverting and recovering materials from the waste stream. Even the most efficient waste reduction, recycling, compost, or waste-to-energy program will leave some residuals that require disposal.

The success of any landfill depends on its ability to fit harmoniously into a local setting. Factors determining this ability include the following:

- The natural physical characteristics of the site of the landfill.
- The thoroughness and effectiveness of the landfill design.
- The landfill's compliance with the planned design and regulatory standards.
- The skill, knowledge, honesty, and effort of the landfill staff and management in operating and maintaining the systems that comprise the landfill.

When the disposal element of an ISWM system is privatized, the private contractor will be responsible for at least the last three items above. A private contractor may not be in the best position to determine the site of the landfill, as discussed later in this chapter.

Current disposal practices throughout the world range from uncontrolled open dumps to secure landfills. In middle income countries, probably less than 10 percent of collected wastes are deposited in controlled landfills, and less than 5 percent is deposited in sanitary landfills. The rest is placed into open dumps, many of which openly burn wastes or have dangerously steep sideslopes. In low-income countries, nearly all collected solid waste is placed in open dumps.

In most developing countries comprehensive hazardous waste (HW) treatment and disposal facilities have not yet been implemented and hazardous wastes are often co-mingled for disposal with municipal solid waste (MSW) despite laws to the contrary. This is generally the case in Egypt where many existing disposal areas are substandard open dumps and, in some cases, located on sites with poor natural characteristics.

Improperly sited, designed, or operated landfills can cause a number of health, environmental, and social problems including:

- Health impacts on solid waste workers, including the following:
  - Back and joint injuries from lifting heavy waste-filled containers and driving heavy landfill and loading equipment.
  - Respiratory illness from ingesting particulates and volatile organics, and from working in smoky and dusty conditions.
  - Infections from direct contact with contaminated materials, dog and rodent bites, or consuming meat from waste-fed animals.
  - Puncture wounds potentially leading to tetanus, hepatitis, or HIV infection.
  - Injuries due to surface subsidence (settling), underground fires, and slides.
  - Headaches and nausea from conditions where disposal sites have high landfill gas (LFG) emissions.
  - Increased cancer risk due to direct contact with chemicals such as solvents, poly-chlorinated bi-phenyls (PCBs), medical wastes, and other waste forms with dangerous properties.



**Compacting the soil liner.**

*A World Health Organization study of solid waste workers in Egypt showed that they experienced a number of health conditions including: respiratory diseases particularly chronic bronchitis, eye diseases such as conjunctivitis, skin disease, parasitic infections, accidents (particularly wounds), back injuries, dog bites, and sunstroke.*

- Groundwater and surface water contamination can occur as a result of contact with landfill leachate. Leachate from solid waste disposal sites is a highly mineralized liquid containing constituents such as chloride, iron, lead, and various organic chemicals. Industrial waste (IW) and hazardous waste disposed in the landfill can add other hazardous constituents to leachate such as cyanide, cadmium, chromium, chlorinated hydrocarbons, and PCBs. Leachate can affect drinking water sources and cause contaminants to enter the food chain.
- Scavengers are often in direct contact with dangerous materials as they search for materials to recover.
- Waste decomposition in a landfill generates landfill gas that can cause explosions or fires as well as create health problems for the people exposed to it. Adequate venting or another form of gas control is usually required to assure that landfill gas does not migrate from the landfill site.
- Smoke from burning solid waste at open dumps can contain toxic substances that endanger the lives of people at the disposal site as well as site neighbors.
- Direct physical harm can occur due to collapse of unstable slopes of waste and waste related accidents (transport, etc.). There are examples throughout the world of people killed as a result of collapsing landfill masses due to steep unstable sideslopes. This has been the case particularly at disposal areas where there are a large number of scavengers who also live next to the landfill.
- Improper disposal areas can affect people's perception of the local or regional area in which the disposal site is located, and affect adjoining property values.
- Poor solid waste management practices can reflect poorly on people's perceptions of solid waste managers and political leaders.

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*Solid waste regulations in the United States require a post-closure care period of at least 30 years. Landfill operators must be financially capable of paying for required activities during this post-closure period. Examples of post-closure activities include leachate collection, treatment, and disposal, and landfill gas management, as well as ongoing environmental monitoring.*

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Disposal sites are unique in that the waste material placed in them can continue to have negative environmental and health effects for a long time until its organic and leachable components have completely decomposed. Disposal sites can therefore be an environmental liability for many years. In the United States (US) and the European Union (EU), landfill owners and/or operators are held responsible for the environmental performance of disposal sites well beyond their physical closure.

Many of the undesirable effects observed in open dumps can be minimized with the proper location, design, construction, and operation of new facilities

or with the effective upgrade of existing ones. There is currently a wide gap between the technical and design standards applied to landfills in industrialized countries, such as those in the US and the EU, and current disposal sites in many Egyptian communities.

Lawmakers in industrialized countries have come to realize that the potential damage caused by poor disposal facilities justifies the development and enforcement of stringent rules and regulations (with resulting higher direct costs) aimed at mitigating potential negative environmental consequences. Similar rules and regulations are evolving in Egypt that will lead to improved waste disposal techniques and facilities when properly enforced. The process of developing a private sector disposal program will help to establish better practices since the technical requirements of the Request for Tender (RFT) and resulting contract can require improved standards of design, construction, and operations on the part of the contractor.

Common problems at substandard disposal facilities can affect the health and welfare of common receptors. A receptor is either a person or an animal that is most likely at risk due to the hazards posed by an effect resulting from a disposal area. The basic intent of good design is to reduce the contact between the dangerous properties of the solid waste placed in a disposal area and the receptors that can be affected by them.

An improved ISWM program should include the development and operation of controlled landfills that take into consideration natural and constructed site features aimed at mitigating environmental and health effects. To accomplish this, design, construction, and operational procedures must be used that are aimed at the safe disposal of solid waste in a controlled and engineered manner. At a minimum, the standards should conform to current Egyptian Environmental Affairs Agency (EEAA) guidelines as well as generally accepted sound practice for solid waste disposal. All state-of-the-art landfills are a combination of structures and systems such as liners, leachate collection and treatment systems, landfill gas management systems, etc. For design and operations to be effective, all of the required systems must be integrated into a configuration that accomplishes the overall landfill facility design intent.

This chapter will attempt to define sound practices for new or expanded disposal areas in Egypt.



**Phase I Construction of the Alexandria Landfill.**





**Enclosed landfill gas flare.**

### **EEAA Guidelines**

A summary of laws and regulations that affect solid waste disposal in Egypt are presented in Appendix A. As a result of those laws, EEAA issued guidelines in July 2001 that relate to new disposal areas. The objectives of these guidelines are as follows:

- Improve waste disposal methods and decrease negative environmental impacts.
- Control air pollution and waste self-ignition.
- Reduce insects and other disease vectors.
- Protect health and safety of the residents near public dumpsites.
- Protect worker health and safety.

In seeking to achieve these objectives, the EEAA guidelines require the following for new disposal areas:

- Fenced dumping areas to prevent unauthorized entry by people and animals.
- Fire extinguishers.
- Offices for the landfill supervisors equipped with necessary utilities.
- Water sprays for dust control.
- Garages for equipment storage and maintenance.
- Maintenance workshops and storage for spare parts for facilities handling 500 tons per day (tpd) or more.
- Truck scales for large disposal facilities.
- Laborers for directing incoming and outgoing waste collection trucks.
- Separate roads inside the site for animal drawn carts.
- Areas inside large sites for parking waste collection trucks.
- Studies of site soils for safe sideslopes.
- Paved site entrances to make it safe for earth moving equipment and waste collection trucks.
- Access roads wide enough for vehicle movements in both directions unless one way traffic is designed.
- Internal roads designed to move from one cell to cell.
- Maintenance of access and internal roads.
- Recording of incoming waste loads (nature, origin, weight), and prohibit site use after working hours.
- Inspections of waste before entry.
- Prohibit open burning of waste.
- Cover waste with inert materials.
- Control insects and rodents.
- Clean dumpsite area once a week.
- Fuel stations inside, or adjacent to, the site with supplies for operating the site equipment for at least a week.
- Periodic equipment inspections and maintenance.
- Areas inside of site for storing construction and demolition debris (C&D) as daily cover material. C&D or other inert materials may be used for daily cover.
- Designs for waste cells.
- Waste separation areas close to the disposal area.
- Waste separation procedures following environmental and health/safety rules.
- Waste cells at least 2 meters (m) thick in layers of 30 centimeters (cm).
- Storage of sufficient cover material for 2 weeks of normal operations.

- Use of low permeability soils for the site cap.
- Cap slopes between 2 and 5 percent.
- Protective gear for the laborers.
- Appropriate tools for waste separators.
- Maintain and repair gaps/damage in the site fence.

These guidelines should form the basis for the technical requirements stipulated for prospective contractors in the technical specifications of the RFT.

### **Disposal Area Classification**

Disposal sites can be grouped into three general categories:

1. Open dumps.
2. Controlled dumps.
3. Secure landfills.

Controlled dumps and secure landfills can provide effective disposal of solid waste within reasonable standards of performance and environmental protection. Countries with well-developed landfill standards have gone through a gradual technology evolution to reach their current regulatory standards. Figure 16.1 describes the steps to achieve improvements.

*A perception that an open dump is the only choice available because of the higher cost associated with improved practices is incorrect.*

Open dumps have the lowest initial capital investment and operating cost of the three basic disposal area types. Solid waste managers in many countries with evolving solid waste management standards have often stated that open dumps are the only type of disposal facility that they can afford, but when the potential environmental damage and health effects caused by improper solid waste disposal is taken into consideration, this approach is extremely costly. A good example of high inherent costs is the potential economic impact of groundwater remediation due to contamination caused by poorly designed or sited disposal areas. Loss in land values associated with poor waste management practices and the costs associated with treating people who are sick as a result of contact with improperly managed solid waste are inherent in the costs of open dump systems.

Many open dumps start as controlled dumps and degrade due to lack of management and other resources. These degraded sites are common in developing countries. They pose significant risks to human health and the environment, especially as MSW becomes more dangerous through the introduction of manufacturing-based waste materials as industry develops. Fundamental to



**Alexandria scalehouse.**

landfill considerations is the relative mobility of pollutants as they flow through the soil to pollute groundwater and, ultimately, to drinking water wells. Organic chemicals often associated with some forms of industrial waste have been found to be the most mobile pollutants escaping from unlined solid waste disposal areas.

### Figure 16.1: STEPS FOR IMPROVING DISPOSAL AREAS

A private sector contract can provide a means for accomplishing improved disposal practices in a short period of time as compared with the normal pace of improvement represented by these steps.

**Step 1: From open dumping to controlled dumping.** (Involves little investment but a change in philosophy.)

- Reduce working area to manageable size.
- Cover with soil or any other convenient material all areas that are not active.
- Eliminate fires.
- Establish on-site rules with scavengers.

**Step 2: From controlled dumping to controlled landfill.** (Often the longest period of improvement where managers gain experience in proper landfill techniques and begin to apply them.)

- Gradual adoption of engineering methods to avoid and control surface water from entering the site.
- Begin covering waste materials on a regular basis.
- Where possible, attempt to collect leachate into lagoons.
- Spread and compact waste into smaller layers.
- Prepare new sections with excavation equipment.
- Begin isolating waste from surrounding geology and surface features.

**Step 3: From engineered landfill to sanitary landfill.** (This phase accomplishes the desired disposal standards.)

### Conditions in Egypt Affecting Landfills

The climatic and hydrogeological characteristics of any landfill site affect the design criteria and operational procedures required for effective and safe disposal. Areas with low rainfall and high evaporation present less risk of leachate migration than areas with high rainfall and low evaporation. This is the situation in Egypt where the average rainfall is only 10 millimeters (mm)/year while evaporation rates are high (about 3,000 mm/year). Egypt's dry climate will help to minimize leachate production and, as a result, pollutant mobility from landfills.

Egyptian landfills will still generate leachate because of the moisture content of the disposed wastes as well as from the limited rainfall that does occur. While the quantity of leachate may be low, its unit pollutant loading is apt to be high due to a lack of the dilution that would be created through greater rainfall or surface water contact.

The vulnerability of groundwater to pollution from a disposal area is also based on a number of other hydrogeological factors including:

1. **Leaching capacity of the soils or bedrock in contact with the base of the disposal area:** At solid waste disposal sites, the leaching capacity of the upper soils and the depth to groundwater determines the rate at which natural attenuation will treat the leachate

emanating from the solid waste contained at the site. Natural attenuation is a term given to the natural chemical or physical treatment processes that pollutants are exposed to as leachate flows through a soil structure. Low permeability soils such as silt or clay will logically impart greater attenuation treatment than high permeability soils such as sand and gravel. The chemical composition of the soils through which the leachate flows also affects their natural attenuation properties since soil chemical content may interact with the chemical content of the leachate.

2. **Depth of groundwater beneath the disposal area:** The depth to groundwater directly relates to the length of time that pollutants are in contact with attenuating soils in the unsaturated zone. The unsaturated zone is that portion of the soil under a site where the pores between soil particles are primarily filled with air. Once the groundwater table is reached, pores are primarily filled with water. Once pollutants reach the groundwater, the attenuation processes continue but are generally not as effective as when leachate is flowing through the unsaturated zone above the groundwater table.

3. **Groundwater flow direction:** Groundwater flow direction is important in determining the potential for transport of pollutants to nearby, down-gradient receptors, such as the people who use downstream wells and springs. The potential health effect of pollutants is decreased if the flow of groundwater that has been exposed to contaminants is away from potential receptor sites. Similarly, the natural dispersion of pollutants in groundwater flow usually decreases the concentration of the pollutant as it travels away from the point of origin. This emphasizes the importance of minimum separation distances from pollution sources to potential receptor sites such as wells and springs.



Landfill working face.

Within the Nile River Valley and in outlying oases, groundwater is a very important source for drinking water and irrigation. Groundwater is used extensively for agricultural, industrial, domestic, and recreational purposes. Landfills can contribute to contamination if they are not designed to prevent solid waste leachate from entering the groundwater especially in sensitive areas. Cleaning-up contaminated groundwater is a long and costly process, and in some cases, may never be totally successful.

Egypt's dry climate will also impact landfill gas generation rates and periods. The microbes responsible for landfill gas generation need moisture to thrive. In Egypt's dry climate the rate of landfill gas generation will be slower resulting in a longer time over which the landfill gas is generated.

There are four basic conditions that disposal area design should attempt to accomplish in controlling or eliminating the above potential effects:

- **Full or partial hydrogeological isolation:** A disposal site should be preferably located in an area with low permeability soils to inhibit leachate migration into an underlying aquifer. If this is not possible, additional materials may be brought to the site to serve as a liner to reduce the permeability of the base of the disposal area. These will help control leachate movement into the groundwater and surrounding strata and, if necessary, allow leachate to be collected for treatment. The current standard in the US and EU calls for full hydrogeological isolation through

the use of a lining system. This may not be required in Egypt because of the low level of precipitation.

- **Formal engineering preparations:** A good disposal area should be constructed from prepared engineering designs that are based on the existing conditions at the site. For example, if liners are to be used, good design should require that the liner be installed above the groundwater table and on stable soils. The engineering plans should define the starting and final grades of the landfill so that its life expectancy can be tracked and closure activities can be planned.
- **Permanent control:** An effective disposal area should have a sufficient number of trained staff to supervise and direct all preparations, site construction, and waste placement activities. Depending on the technical standards adopted for the disposal area, staff may also be responsible for managing relatively complex technologies such as leachate or landfill gas collection and treatment systems. The design intent should be to keep control of all functions involved in the construction and operation of the landfill. In industrialized countries, this control extends well into the time after the facility has formally closed.
- **Planned waste placement and cover:** Waste should be spread in layers and, if necessary, compacted mechanically as part of the placement process. It should not be dumped over a cliff-like working face. Where practical, the waste should be deposited in as small a working area as possible and covered daily or periodically to render it less accessible to vectors such as insects and rodents.

The above four points are the fundamental basis for the minimum technical specifications for the disposal function of a contracted ISWM program. Many of the standard specifications and minimum technical requirements described in Appendix B are based on the above principles.

The technical specifications of the RFT should attempt to place a significant part of the responsibility for safe disposal and effective operations on a contractor. This responsibility should mandate effective design, operation, and maintenance of the new or upgraded disposal area. The contractor should be



Landfill compactor.

required to develop the disposal function in accordance with your directed terms as presented in the RFT minimum technical requirements. The standards that you adopt in defining these requirements should be based on:

1. The EEAA guidelines.
2. Sound practice.
3. Any specific issues that you choose to require of the contractor (and are willing to pay for).



HDPE liner welding machine.

There is a limit, however, to what you can or should require your contractor to do. Experience has shown that it is often very difficult for private contractors to identify and secure new disposal facility sites. The task of finding a new disposal site may best be accomplished by the governorate prior to or during the development of the RFT, as the governorate has greater sensitivity to the political and social issues that will be important in the siting process.

### Sound Disposal Practice and Performance Standards

There are a number of sound practices that define good controlled and secure landfills. These should be the basis by which you define what you expect from the contractor. The sound practices, at a minimum, relate to the following parameters:

- Liners.
- Leachate management and environmental impact minimization.
- Landfill gas management and risk reduction.
- Access security.
- Operations:
  - Working face operations.
  - Record keeping to document operations.
  - Waste compaction and application of cover.
  - Documented and effective operating procedures and worker training and safety programs. Effective landfills require active management where all functions are controlled by dedicated staff and managers responsible for all activities at the landfills and who work at the facility during all hours of operations.
- Establishment and maintenance of good community relations.
- Closure and post-closure planning.

These should be the basis for the technical requirements and performance standards that you require of the contractor through the technical specifications of the RFT. Important considerations for some of these sound practice elements are described below.

#### Liners

Landfill liners are either engineered or in-situ barriers used to prevent or minimize the migration of leachate and landfill gas out of the landfill into the surrounding soils and/or groundwater. There are a number of liner materials that are used in solid waste landfills including:

- Natural or processed soil materials such as clay.
- Synthetic membrane materials such as high density polyethylene (HDPE).

The use of liners at landfills is not new. Their use evolved as knowledge of the potential impact of leachate on groundwater increased. This has led to liner designs intended to provide increasing protection and safeguards for long

term performance. Previously, landfill sites were selected based, in part, on general soil conditions that were felt to be effective in treating leachate without significant groundwater contamination. Such landfills were called “attenuation” landfills. Unfortunately, we now realize that it is generally not possible to prevent some contamination unless the landfill is designed as a secure facility where all leachate is collected and removed from the landfill. In Egypt, decisions as to whether a liner should be used will be a function of the soil conditions on which a landfill is to be sited and the value of the groundwater resources to be protected.

In the last 10 years, liner designs for solid waste landfills have ranged from single compacted clay or geomembrane liners, to double flexible membrane or composite liners with leak detection. The selection of liner materials and the configurations used in design are a function of using materials that can be installed with a minimum of defects so that they can be effective for a long time. Liners are difficult to install and require rigid quality control if they are to be successful in holding leachate. Some of the typical liner designs used at landfill facilities include:

- **Clay Liners:** Recompact clay soils are used as a lining material in the construction of landfills with a single clay liner or as a component of a composite liner. Clay has a number of characteristics that make it a useful liner material. Clay consists primarily of uniform, very fine, soil particles. While this may result in a large proportion of pore spaces between the particles, clay soils also have strong retentive properties that keep water from flowing through the pore spaces. The actual swelling behavior of natural soil mixtures containing clay will depend on what clay minerals are present in the clay soil mixture.
- **Flexible Membrane Liners:** Flexible membrane liners (FMLs) are used individually or in combination with clay materials to form a composite liner. While there are thousands of possible chemical combinations that can be used to make up geomembrane materials, there are only a few that have been used extensively in lining surface impoundments and landfills. Liner materials are commonly produced by manufacturers under rigid quality control processes. The type of liner material used is a function of the application for which the liner is applied. Some liner materials are more suitable for some waste materials than others.
- **Composite Liners:** A composite liner consists of two liner elements with different properties that work in conjunction with each other to prevent leakage. The United States Environmental Protection Agency (USEPA) standard composite liner design consists of an upper geomembrane liner and a lower compacted soil liner. The geomembrane is typically HDPE at least 60 mils thick. Based on USEPA regulations, the soil (clay) component of the composite liner is usually at least 122 cm thick and must have a hydraulic conductivity of less than  $1 \times 10^{-7}$  cm per second after it has been placed.



Landfill gas control.

### Leachate

Leachate is the liquid produced when water seeps or percolates through solid waste and dissolves its soluble constituents. Typically a dark liquid with a strong odor, leachate can contaminate surface water and groundwater. Direct exposure should be avoided. Some basic facts regarding leachate include the following:



**Landfill entrance control.**

- Water is the “universal solvent”. Nearly anything that comes in contact with it may be dissolved to some extent.
- Many components of solid waste are organic and are easily leached. Other materials, such as metals, take longer but still leach.
- Leachate contains dissolved organic and inorganic matter, suspended materials, and microorganisms (viruses, bacteria, etc.). Some of these materials are dangerous to humans and animals.
- Leachate components and their concentration depend on the age of the landfill. The variation is due to such conditions as: more rapid decomposition of organic wastes, the amount of water moving through the landfill, and operational practices such as leachate recirculation, etc.
- Leachate may be more concentrated if the quantity is low as a result of low levels of infiltration.

Leachate generation can be minimized by keeping liquids out of the landfill so that they do not come into contact with solid waste materials. Careful control of surface water flow can help to eliminate contact of rainwater with materials that can contaminate it. Once rainwater or surface water comes into contact with solid waste, it has to be handled as leachate because of its contamination. Egypt’s arid climate helps to minimize this potential effect.

Leachate characteristics are function of the type of waste placed in a disposal area. Some forms of industrial waste, for example, can have a significant impact on the characteristics of generated leachate. This is one of the reasons that landfills designed for hazardous solid waste disposal are often designed with a greater level of protection—such as double liners—against leachate migration.

In lined secure landfills, leachate is retained by the liner and removed by a leachate collection system installed above the liner. The leachate collection system usually consists of a network of perforated pipes that collect the leachate and allows it to flow to a storage or treatment location. The design of the collection system must not allow leachate to build-up over the liner since leachate accumulation can increase the potential of leakage through the liner.

If leachate is collected, it should be treated or disposed of in a manner that does not result in the environmental damage that its collection is intended to prevent. In countries with arid conditions, leachate can be collected in a lined holding pond constructed downhill from the landfill. In such an impoundment, leachate is allowed to evaporate. The success of this approach depends on the climactic conditions in the region where the landfill is located.

### **Landfill Gas Management**

Landfill gas is derived from the biological decomposition of MSW and is primarily a mixture of methane and carbon dioxide. The general properties of landfill gas are a function of the chemical constituents from which the gas is composed and, therefore, a function of the type of solid waste placed in the landfill. The general composition of landfill gas derived from MSW is shown in Table 16.1.



**Table 16.1: MAJOR CONSTITUENTS OF LANDFILL GAS**

<b>Constituent</b>	<b>Formula</b>	<b>Volume %</b>
Methane	CH <sub>4</sub>	0 to 85
Carbon Dioxide	CO <sub>2</sub>	0 to 88
Carbon Monoxide	CO	0 to 3
Hydrogen	H <sub>2</sub>	0 to 3.6
Oxygen	O <sub>2</sub>	0 to 31
Nitrogen	N <sub>2</sub>	0 to 82.5
Ammonia	NH <sub>3</sub>	0 to 0.35 (vol. ppm)
Hydrogen Sulfide	H <sub>2</sub> S	0 to 70 (vol. ppm)

Methane, a principal component of landfill gas, is highly flammable and poses a risk of fire and explosion at on or off site locations. During normal landfill activities, landfill gas will escape to the atmosphere through uncovered waste or through the daily and intermediate cover soil. However, as materials decompose, formed gas can increase in pressure, and it will migrate, seeking release.

When this pressure is allowed to increase, landfill gas migration problems can occur, especially after the landfill has been completely filled and a final layer of impermeable soil cover or an impermeable synthetic cap is applied. This final cover soil or cap structure may block the escape of gas to the atmosphere. To alleviate this pressure buildup, passive or active gas vents are often installed through the final cover soil at the upper grades of the landfill. Without controlled vents, landfill gas will seek available points of least resistance such as pipe trenches, permeable soils, bedrock fissures, etc. to flow to offsite locations. If these gases flow to a location where an ignition source is present such as house or garage, an explosion or fire can occur. A good example of an ignition source at a disposal site is maintenance shops where welding operations are carried out during the repair of landfill equipment.

The effective management of landfill gas is therefore important in the design and operation of a landfill for a number of reasons:

1. Landfill gas can damage a closure cap system.
2. Landfill gas can destroy vegetation that may exist over the capped landfill. This destruction can occur because of the depletion of soil oxygen due to its physical displacement or biological reduction. The presence of landfill gas causes a displacement of oxygen and vegetation effectively asphyxiates.
3. It can create explosive conditions within the landfill's site or at off-site locations.
4. It can contribute to air pollution emissions in the form of trace organic compounds and greenhouse gases such as carbon dioxide and methane.

5. It can create human health and safety risks due to potential explosion and/or fire as well as air emissions.

The production rate of landfill gas is influenced primarily by moisture content and temperature in the landfill. Higher moisture and temperature generally increase the level of gas production by enhancing the solid waste decomposition process. Landfill gas can be produced for years even after a landfill has been closed. For this reason, effective closure plans often include a means for either venting or collecting landfill gas for treatment.

The general options available for managing landfill gas after collection include:

- Direct venting to the atmosphere.
- Burning through use of a flare system.
- Incineration.
- Energy recovery for the generation of electricity or development of industrial or utility quality gas.

There are two basic configurations used to collect landfill gas to achieve the above results. These consist of passive and active collection systems which basically are as follows:

- **Passive Collection Systems:** These are the simplest type of landfill gas collection systems. They make use of the vent trenches and/or vent wells without the use of mechanical devices (pumps and blowers) to move the gas. The design premise of passive systems is that gas movement can be accomplished by providing a pathway for gas to leave the landfill in a controlled location usually at the top of the landfill through the cap. The basis for this movement is the pressure that builds in the landfill causing the gas to move to locations of lower pressure. These are normally installed as sections of a landfill reach their capacity and close.
- **Active Collection Systems:** In active gas collection systems, a vacuum or negative air pressure is applied to extraction wells or trenches within the landfill mass to draw gas to a site location where it can be treated. The vacuum serves the purpose of drawing the gas from the landfill to the vicinity of the extraction wells and then into the collection system and then on to a location where the landfill gas can be burned in a flare or used as a fuel.



Landfill gas header.

### **Access Control**

Landfills should be designed to restrict unauthorized access to the disposal area and to keep out stray animals. Depending on site characteristics, a fence, wall, or vegetative hedge should be installed along the entire perimeter of the site. Depending on their design, these structures can also assist in catching paper or plastic debris that becomes airborne because of windy conditions.

A staffed gate should be the point of entry to the disposal site for vehicles and any others who have business at the site. Ideally, the gate location at a disposal area should be equipped with a scale for weighing vehicles as they enter and exit the facility. This provides a record of the tonnage of material received at the disposal facility. However, the size of the landfill may determine the economic viability of supporting the installation of features such as truck scales. In the case of the small to moderately-sized disposal area (less than 200 tpd), calibrated tables of weight-to-volume for delivery vehicles may be used to provide an estimate of the quantity of solid waste brought to the landfill for disposal. Some monitoring of the amount received is a crucial sound practice since it provides important information to monitor use of the facility and to plan for future solid waste management needs.

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### **Scavenging Considerations**

*Landfill operations and machinery can pose dangers to untrained people. If scavenging persists at landfills, licensing and cooperation between scavengers and landfill staff can help to minimize problems. Access to a landfill should be restricted to trained personnel and solid waste haulers authorized to bring waste materials to the disposal site. Allowing scavengers access to secure facilities at controlled locations and providing basic health services such as vaccinations for infectious diseases and tetanus will reduce health problems. Operating under a permit structure may provide greater control of scavenger activity by providing greater accountability to the landfill operations plan. The best sound practice, however, is to forbid scavenging. This can be stipulated in the technical specifications of the RFT.*

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All trucks must be required to use the designated access road. All other access points to the landfill must be blocked. Trucks should only unload waste at locations designated by the landfill staff. Uncontrolled truck access often leads to dumping in improper locations that may impede effective operations, require considerable clean-up effort or cause environmental damage. The landfill hours of operation (defined as the hours that the full time staff works at the landfill) should be coordinated with the anticipated time (hours per day, days per week) of collection and delivery of solid waste to the landfill. Private haulers should be made aware of the hours of solid waste receipt at the landfill and these hours should be strictly enforced. The manner in which your private contractor adheres to a structured access policy should be stipulated in the RFT.

### **Landfill Operations**

Sound practice for disposal areas does not only focus on the design and nature of a landfill's infrastructure. Proper operational procedures are equally important in assuring environmentally effective function. The RFT should

clearly demonstrate that you are placing the burden of effective operations on the contractor. It should also attempt to provide some definition of the minimum performance standards that you expect the contractor to accomplish in assuring effective operations.

The basic principle associated with operations is to maintain control of all activities. So as to explain that control, it may be useful to define and illustrate some common terms when discussing landfill workface operations. These will help to define landfill operations that may be predefined for the contractor in the RFT.

- A cell is the basic structural unit by which a landfill is developed. It is the general area where incoming waste is off-loaded from trucks, spread, compacted, and covered. A basic cell consists of a base of synthetic or soil liner (or previously placed solid waste), compacted MSW, and a compacted cover layer of soil. Cells typically range in height from 2 to 3 m. The actual dimensions of a cell depend on:
  - The type of equipment being used to deliver, place, and compact the solid waste.
  - The quantity of solid waste received for disposal.
  - The dimensions and configuration of the overall site.

Special cells in the landfill may be reserved for unique materials such as treated medical waste or C&D.

- A lift is the completed layer of compacted waste cells. Once a completed layer of cells is constructed, a second layer of waste is then spread over the first and subsequently compacted. The process is continued until the desired height of the lift is attained. A completed lift is normally covered with 15 to 30 cm thick layer of compacted soil. Some landfills use multiple lifts. Thus, when one cell is completed, another is placed above it. This second level of cells is usually not begun until the first level is filled with cells at the same level. It is customary to stack cells into a final pyramidal structure. When stacked cells are employed, the final slope of the outside of the landfill mass should be chosen to ensure the stability of the structure. If the resulting structure is too steep, failure could occur with dire consequences.
- The working face is the length and width of the row in which the waste is being deposited during any particular day. A major intent of controlled operations should be to keep the overall size of the workface to a minimum. This will help to decrease overall costs by decreasing the area that must be covered daily. It will also increase the ability to control workface activities and environmental effects by providing a more focused area in which workface personnel may observe solid waste delivery.



**Landfill gas open flare.**

The size of the active waste receipt area or workface depends on the number of trucks at the landfill at any one time. Different truck designs affect the time that it takes to empty the truck at the disposal site. It often takes more time to empty a small static bed truck than it does to empty a large capacity waste packer that can eject its payload in a short time. The function and technical characteristics of the waste collection system greatly influences operations at the landfill. Because of this, the technical specifications for the collection sys-



Landfill gas open flare.

*Lack of control of the dumping process at the landfill means that collection vehicles will often look for a discharge location that is most convenient for them rather than for the efficient operation of the disposal area. This can lead to disposal sites that consist of indiscriminate mounds of waste covering extensive areas both on and off of the site.*

tem and disposal facility should be coordinated to assure an effective collection/disposal interface. This coordinated design can be specified in the RFT, or the contractor can have some flexibility in designing.

Solid waste should be dropped off at the working cell or working face. This requires the construction and maintenance of access roads to workface locations within the site. The truck discharge process must be actively managed if the cell is to be constructed to its smallest possible size. Waste should be placed only in locations designated by the landfill staff. Waste delivery truck drivers should be directed to place each load as close as possible to allow for the maximum number of loads to be placed in each area. This will help to decrease the frequency of periodic compaction and coverage of the waste. Otherwise, waste becomes indiscriminately scattered throughout the disposal area with no means for controlling its effects.

The goal for waste screening at a landfill is to identify unacceptable waste as quickly as possible, preferably before it has been off-loaded. Landfills need to guard against unacceptable materials that could cause damage to the environment or danger to operators. Rigid controls are needed to assure that hazardous materials are not inadvertently or deliberately delivered, or that other materials that may have reuse or recycle value are not placed in the landfill.

The ability to enforce waste receipt standards will often be a function of available alternatives for the disposition of unacceptable materials. If alternative disposal facilities are not available, the political will to enforce waste receipt standards may be insufficient to keep these materials out of your disposal area. This will need to be considered in the development of the technical specifications of the RFT.

There are a number of wastes received at landfills that require special handling procedures. These types of waste often have unique properties that may influence operator safety or cause other problems (odors, etc.) at the landfill. Examples of hard-to-handle wastes include:

- **Bulky Waste:** Some bulky materials that must be placed into the landfill should be placed so that they take up as little airspace as necessary. Airspace is the effective volume of the landfill into which solid waste can be placed. In landfills where permitting strictly defines starting and ending grades of a landfill structure, the management of airspace is crucial. This can help to lengthen the effective life of the facility.
- **Construction and Demolition Debris:** In some cases, landfills receive C&D. These materials are generally inert and take up significant landfill space. This material may be processed for recovery of some components of the material. Depending on its physical characteristics, it may also be used as daily or intermediate cover. This can decrease the overall cost of operating the landfill.
- **Containers:** Workface personnel must also watch for containers that may be received in loads of waste materials. These need to be checked carefully since they may contain liquids that can cause safety or environmental problems. These may cause environmental damage and exposures for landfill staff.
- **Asbestos Containing Materials (ACMs):** The primary danger associated with asbestos is in inhaling the microscopic fibers which have been shown to cause debilitating or life threatening health conditions. Asbestos containing materials are inert and

should be disposed in landfills to prevent further human contact. ACMs will not decompose nor pollute groundwater. However, these materials must be carefully handled because of the potential danger to workface personnel.

- **Treated Medical Waste Residue:** At some landfills, treated medical waste may be received for disposal. Although most properly treated medical waste residues no longer pose an infectious threat, landfill operators still should handle any treated medical waste as if it still had infectious properties. This will ensure proper respect for the material that will help prevent operator health problems. Particular attention needs to be paid to the potential of receiving sharps (needles, broken glass, etc.) as part of the medical waste stream. Hypodermic needles are often observed at landfills. Often, these come from home insulin use by diabetics and have not been treated.

Waste compaction increases the capacity and life of the landfill. Effective waste compaction accomplishes the following:

- Reduces the rate of airspace consumption, extending the life of the landfill.
- Results in less waste settlement and minimizes long-term care problems that result from excessive settlement.
- Reduces the amount of litter that needs to be collected.
- Improves the ability to travel over the entire landfill including the workface.
- Limits the potential spread of any fires occur at the workface.

*Information on hard-to-handle waste in the service area should be presented in the RFT to assist prospective contractors in preparing a responsive proposal.*

The density of solid waste in a landfill may vary depending on the type of waste and the means by which it is being compacted. In engineered landfills with a fixed amount of designed air space (the volume that can be utilized for waste placement in a, engineered design), compaction is achieved by mechanical means. Mechanical compactors achieve densities of 500 to 900 kilograms (kg) per cubic meter (m<sup>3</sup>).

To maximize the use of designed airspace, you may want to specify a required minimum level of compaction in the RFT. This may consist of a minimum compaction rate or through stipulation of the characteristics of equipment to be used to achieve a reasonable level of compaction.



**Landfill gas well head.**



**Landfill liner seam test.**

### **Landfill Cover**

Landfill covers are engineered barriers designed to prevent or minimize landfill fires, odors, human and animal access to waste, precipitation infiltration, scavenging, erosion, and other potential negative situations. Typically landfill cover is classified as daily, intermediate, or final. The thickness and type of soil or other material used in each case varies depending on the function that the cover is to serve. Specific functions of the various types of cover are described below.

**Daily Cover:** The primary function of daily cover is to reduce odors, vector access to waste, fires, litter, and the unsightliness of the landfill workface. The application of suitable daily cover can:

- Reduce litter, odors, vectors, and other nuisances.
- Reduce leachate generation.
- Provide better access to the workface.
- Increase the safety of waste haulers and operating personnel.
- Minimize fire danger.
- Improve the landfill aesthetics, thereby improving public perception of the operation.
- Prevent scavenging.

In some countries, the application of cover of a minimum thickness is required by solid waste management regulations. In Egypt, the regulations require the daily application of at least 15 cm of soil as a daily cover.

**Intermediate Cover:** Intermediate cover provides essentially the same functions as daily cover, only for a longer period of time. In the US, solid waste management regulations call for at least 30 cm of uniformly compacted material over all sides and working faces of any portions of the landfill that will not be receiving waste for a period of 6 months or more.

**Final Cover:** After all of the airspace at a landfill has been used, final cover should be applied. The type of final cover material to be used should be specified in the landfill design and operating plan. Site specific elements such as climate, rainfall, etc., have a significant impact on selecting materials that can provide surface stability. The RFT should stipulate the required performance of the final cover system. This required performance may be related to the ultimate use of the landfill site after the facility has closed.

Soil is commonly used for cover at landfills. This can include soil excavated from the disposal area site or soil shipped in from an off site location. Alternative daily cover (ADC) such as C&D, certain forms of industrial waste, and commercial ADC products have been used around the world.

### **Landfill Maintenance**

Effective operations can only be sustained if there is effective maintenance of the equipment, systems, and structures required for operations. This includes any mechanized equipment as well as fixed landfill site structures such as the completed landfill areas, access roads, and systems such as leachate control equipment. The RFT should stipulate a minimum level of maintenance that the contractor will be required to provide on each element to assure the long term function and effectiveness of the landfill and its operating systems and equipment.

### **Health and Safety**

Landfill workers are exposed to many potentially dangerous materials and situations as they supervise and direct the disposal of waste. Landfill staff must

be properly trained and equipped to safeguard themselves from the dangerous properties of the waste materials placed in the landfill. Universally, the most common basis for health and safety procedures is to minimize the contact between the waste and the people whose health could be affected by contact. The RFT should stipulate that the contractor will operate the disposal facility in a manner that assures the health and safety of operating staff and others who must visit the landfill for any reason.

### **Environmental Monitoring**

Landfills are intended to perform an important environmental function. The simple act of getting the waste to the landfill accomplishes the most important part of that function since it separates most of the population from direct contact with the waste. However, the design and operation of the landfill must attempt to control the environmental effects of the material after it is deposited there. Landfill environmental monitoring includes, among other things, the placement and sampling of groundwater monitoring wells to determine that the landfill is not damaging groundwater. The technical specifications of the RFT should stipulate the minimum level of environmental monitoring that the contractor will be required to perform. This level of performance should at a minimum address any and all EEA monitoring requirements.

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## **Rural Considerations**

*Solid waste generated in rural areas still must be disposed safely. Often the best alternative will be to collect and transfer rural solid waste to large, regional, landfills that have the disposal volume to justify the safeguards that assure that the waste is effectively managed. In some situations, however, it may be impractical to transfer rural solid waste because of the long distances involved. In these cases, small disposal areas may be established or existing disposal sites improved to manage the small amounts of solid waste generated. If this does occur, the rural disposal area should still be actively managed, particularly in control of site access and waste placement. If daily cover is not feasible, equipment may be brought in periodically to cover disposed wastes and/or excavate a new area for waste placement.*

*In locating such small rural landfills, many of the same considerations should be included as would be the case in locating a larger urban disposal area. The intensity of the site evaluation process should be based on the expected quantity and type of solid waste to be placed in the rural disposal area. Typically, rural areas will not generate large amounts of industrial waste that might pose a unique disposal problem. Conversely, there may be small amounts of untreated medical waste that are brought to the disposal area because of a lack of collection and treatment services in the rural area. Such waste may be generated by small clinics or medical care practitioners located in the rural area. This is one of the reasons why controlled waste placement needs to be practiced and care needs to be taken to reduce potential exposures to dangerous properties.*

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The procedures described in this chapter may be part of a process to procure a contractor to provide a comprehensive integrated solid waste management service or one of securing a contractor who will provide a service solely aimed at managing a disposal area.

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*The following general steps should be taken in developing the landfill component of the contracted solid waste service:*

- Step 1:** *Define and Evaluate Existing Disposal Practices.*
  - Step 2:** *Assess New Landfill Site Options.*
  - Step 3:** *Identify Potential Landfill Sites.*
  - Step 4:** *Compile Findings in an Assessment Report.*
  - Step 5:** *Select the Preferred Site.*
  - Step 6:** *Close Existing Open Dump Site.*
  - Step 7:** *Start Operations at a New Landfill.*
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**Landfill liner repair patch.**

# STEP 1: DEFINE AND EVALUATE EXISTING DISPOSAL PRACTICES

*Current relevant laws and regulations that affect solid waste management are shown in Appendix A of this chapter.*

**T**he first step in the process of securing a private contractor must attempt to define and evaluate existing disposal practices in the service area. This will form the basis for much of the information that will be necessary to make informed decisions about new disposal locations or the continued use of an existing disposal site. It will also be the basis for providing information to prospective contractors so that they can submit detailed proposals in response to the disposal elements of the RFT. Typical technical specification content for the disposal component of an effective RFT is presented in Appendix B.

## **Review Legal, Policy, and Regulatory Framework**

New disposal areas must be managed within the context of the laws and regulations that exist at the national, governorate, or local level at the time that a new landfill is developed. The basic foundation for the laws and regulations that affect solid waste management in general in Egypt is Law 4/1994 and its Executive Regulations.

Reviewing current laws and regulations governing disposal area development and operation is an important preliminary step in defining planning activities as well as the regulatory process that the contractor will have to follow in developing all elements of their program. Since these are apt to evolve in the future, the timing of the review must correspond with the development of the RFT.

The RFT should place the responsibility for knowing and meeting all of the regulatory requirements for new disposal areas on the contractor. However, enough information should be made available in the RFT for prospective contractors to understand the level of work that they will have to undertake to secure all approvals for their work. This should also include some indication of evolving legislation at all levels that could influence the contract during the procurement process or during its operational term.

## **Determine Full Cost of Current Disposal Operation**

The full cost of current disposal practices should be determined and analyzed. This will facilitate understanding the increased costs associated with improved disposal standards established in the RFT. This analysis should include all costs of permanent staff and equipment as well as costs associated with any temporary services used at the disposal site. Full cost accounting



Landfill liner extrusion welder.

principles for solid waste management described in Chapter 3 should be applied to your service area. Knowledge of the full existing current costs will be important in explaining the benefits and value of the contractor's service to the public and political officials.

A detailed evaluation of all staffing currently involved in the existing solid waste management program should be included in the cost analysis, as it is likely that the contractor will seek to hire some of the current solid waste management staff.

### **Determine Environmental Impact of Current Disposal Site**

A clear understanding of the environmental impact of the current disposal site is critical for explaining the reasons behind the new contracted service or for the need to develop a new disposal area. It will also be important in determining whether the current site can continue to be used. It is particularly important if the cost of a new facility developed and operated to a better standard of performance is higher than the perceived cost of the current facility and practices. The content of an environmental assessment of the current disposal area should look at all of its potential effects. Recommended content for a full Environmental Impact Assessment (EIA) is shown in Appendix C. Many of the criteria shown for an effective environmental impact analysis may be applied to the evaluation of the current disposal site as well as to any new potential sites.

### **Evaluate the Amount and Type of Solid Waste to be Managed at the Disposal Area**

The amount and type of solid waste currently received at the existing disposal site and that which will be received after implementation of the full ISWM program must be determined. This can be accomplished through a waste generation and composition survey which attempts to answer the following questions:

- How much waste is being produced in the service area and how much of it actually reaches the disposal site?
- What is the general composition of waste from residential areas?
- What is the composition of wastes, including hazardous waste, from the other main sources of production (industrial, etc.)?
- How might the quantity or general composition of the waste change in the future?



**Leachate collection pond.**

The waste generation and composition survey should also attempt to generate information that will be relevant to the design and function of the disposal facility. Some of the important characteristics for the different types of solid waste that should be investigated include:

- Moisture content.
- Biodegradability.
- Calorific value.
- Densities.

The amount of MSW received at a disposal site is generally based on the population of the landfill service area. An increase in the quantity of waste placed into the landfill in the future will be due to increases in population or the expansion of the landfill service area thereby increasing the effective population served by the landfill. The amount of solid waste generated in the service area may be different than the amount actually received for disposal. The difference between generation and collection rate is the result of informal disposal, animal feeding, and recycling that occurs within the service area. As the collection rate increases, the quantity of solid waste reaching the disposal area will also increase. An increase in the collection/generation ratio will lead to a faster depletion of the designed landfill capacity. Generation of waste receipt data as solid waste is received at the landfill will become an important planning tool to estimate the time remaining before the site will be completely filled. Keeping track of this data is an important part of planning expansions or implementing new disposal sites. Consider starting to collect this type of information at the existing disposal area so that more detailed information is available to the contractor in the RFT.

The design of the industrial waste management element of an ISWM program should be based on an inventory of industrial waste sources within the service area. As outlined in Chapter 10, industrial waste recycling and reuse opportunities should be optimized so that a minimum amount of this waste ultimately reaches the disposal site. This may even include a requirement that the contractor accomplish a set minimum amount of waste diversion to recycle and reuse opportunities.

The characteristics and amount of industrial waste that may be received at the disposal site is a function of the type, size, and number of industrial facilities generating the waste. The nature of industrial waste received at the landfill will be very important in determining the environmental performance of the landfill as well as potential health and safety hazards for operators who must handle these materials as they are received at the disposal area. Many forms of industrial waste are hazardous and pose a danger to both the environment and to operators who must handle them. The physical (quantity, particle size gradation, etc.) and chemical (leachability of heavy metals and other substances, etc.) characteristics of some forms of industrial waste will determine the environmental and operational effects of disposing this material in the landfill.

Other waste types (treated medical waste residue, etc.) in the service area will need to be identified. The waste forms that require special handling should be identified so that operation of the disposal area provides the means for effectively managing these materials. This information should definitely be included in the RFT since it will help to define the level of effort needed on the part of the contractor to handle these waste forms and still achieve the overall performance requirements of the RFT.



## STEP 2: ASSESS NEW LANDFILL SITE OPTIONS

In many cases, an upgrade of solid waste management practices will require the development of a new disposal area. While there are a number of advantages to continuing operations at a current disposal area, this should only occur if the characteristics of the existing site allow environmentally sound conditions to be maintained. There are also a number of advantages of siting a new landfill facility on the same property as or adjacent to an existing dump, including the following:

- A site with an existing solid waste management identity may be more acceptable to the general public than a new site.
- The collection system is already designed to transport solid waste to the existing location.

Whether a new landfill facility is located at a current solid waste management site or a new site, locating a landfill in the right hydrogeological setting can often avoid the significant expense of a liner system to protect groundwater. However, economic concerns such as haul costs and the cost of land often dictate where a new landfill may be located. Therefore, site conditions define what steps must be taken in terms of design to limit the environmental impact of a landfill facility. A poorly situated disposal site can lead to a number of problems including:

- High costs associated with the transport of solid waste to the disposal area.
- Environmental damage as a result of insufficient isolation from surface and subsurface conditions.
- Poor access and configuration that makes it difficult to control operations.

Selecting a good site to develop a new disposal area is one of the most important issues in developing and implementing a new solid waste management program. Key considerations include:

1. **Haul distance:** Haul distance should be kept as short as possible to keep cost down. If a new landfill can be located within an economic haul distance that allows direct haul by collection vehicles, the cost of transfer can be avoided.
2. **Location restrictions:** Location restrictions must be understood and complied with. Restrictions to protect aircraft from collisions with birds often associated with landfill facilities must be adhered to. Bird collisions have caused extensive damage to aircraft and can lead to aircraft crashes during takeoffs and landings. EEAA has established guidelines for required offset distances.
3. **Available land area:** In the siting process, available land area is a key consideration. In order to minimize the costs associated with design, permitting, siting, and closure and post-closure activities, it is desirable to have a facility that will operate for a reasonably long time period. Ideally, a site should be sought with sufficient capacity for a minimum of 10 to 20 years of operation for the quantity of waste to be received for disposal.



Liner deployment.

### Form a Landfill Siting Committee

The first task in the siting process is the formation of a landfill siting committee. This committee should include representation from all interested parties in the landfill siting process. In addition to political representation, the siting committee should also include representatives of any other entity that

may be affected by the new landfill site. This may include representatives of citizen groups, non-governmental organizations (NGOs), and local or regional planning agencies, as well as current solid waste management agencies.

### **Establish Criteria for Site Identification**

After the Landfill Siting Committee has been formed, they can begin establishing criteria for identifying potential landfill sites. The physical, demographic, and political knowledge required to find and secure a new disposal site cannot usually be grasped in a short time by a private contractor that may not be familiar with local conditions, and so experience has shown that the governorates themselves are best equipped to select a site.

Identifying a suitable site for a new disposal site can be very difficult. People's perception of any new landfill application will, unfortunately be based on their visual images of existing or past practices. The suitability depends on numerous technical, environmental, economic, social, and political criteria. When selecting a site, a balance needs to be achieved among multiple criteria that might have competing objectives. The relative weight given to each criterion used in selecting a suitable site will vary based on the community's concerns, needs, and expectations.

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*The siting process should include upfront and continuous public participation. Establishing credibility and trust with the public is as important as addressing environmental, social, and economic concerns about the facility. The public must be a legitimate partner in the landfill siting process to integrate community needs and concerns and to influence the decision-making process. Planners and decision-makers should read Chapter 7, Public Awareness and Communications, for guidance on best practices for communicating and building support with the public.*

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In evaluating new potential landfill sites, a range of criteria may be applied to qualify different general locations and specific potential sites. These criteria can be grouped into the following categories which also show reasonable performance parameters:

1. Transportation related criteria:
  - Within 2 kilometers (km) from a suitable main road.
  - Within an economic travel distance from point of origin of waste.
2. Geotechnical, hydrological, and hydrogeological criteria:
  - Outside of flood plains or other areas liable to flooding.
  - Away from steep slopes that are liable to fail.
  - Areas without high or seasonally high groundwater.
  - Outside of wetlands or other areas of ecological significance.
3. Land-use criteria:
  - Outside of designated groundwater recharge areas, significant aquifers, or surface water collection areas for water supply systems.
  - Areas without incompatible current or future land-use.
  - Areas outside of a military exclusion zone.
4. Public acceptance criteria:

- Areas away from existing residential development.
- Areas outside of a designated distance from historical, religious, or other important cultural sites.

5. Safety criteria:

- Areas at least 5 km from an airport runway in the direction of approach and take off.
- Outside of areas of former military activity where buried ordnance may be present.
- Areas known to contain unstable soil conditions.

Every potential site should be reviewed within the context of the above criteria. The process used to evaluate potential disposal sites needs to be as objective as possible based on carefully developed and transparent criteria. These criteria should be influenced by input from the public and all other interested parties affected by the development of the new disposal site. In addition to defining the level of effort and the time that will be required to develop the new site, this step will help to define the work and schedule required to close the existing site once the new landfill has been developed. The contractor will probably be required to operate the existing disposal area until the new landfill site has been developed. If this is the case, the RFT should stipulate the manner in which contracted operation of the current site is to be accomplished. Operational parameters for the interim contracted operation of the current disposal area as well as improvements that will be implemented by the contractor should be spelled out in the technical specifications of the RFT.

It may also be possible for the selected contractor to be actively involved in the disposal area siting process. Some of the following tasks may be assigned to the contractor as the process of developing a new disposal area proceeds.

### **Prioritize Criteria**

To make the process truly objective, site selection criteria should be determined by the landfill siting committee prior to investigating any physical sites within the service area. In this way, the committee responsible for the siting process can establish the criteria that are important based on their knowledge of the general area in which the sites may be located. In addition, the site selection criteria should include any requirements stipulated in the EEAA rules and regulations governing landfill sites in Egypt.

Three categories or sets of criteria are applied during various stages of the siting process. It is unlikely that any site will meet all the criteria, in which case, each criterion's relative weight and importance must be considered. The three categories are:

- Exclusionary.
- Technical.
- Community-specific.

### **Define Exclusionary Siting Criteria**

Siting a disposal area in areas with preclusive siting criteria may be prohibited by federal laws or regulations. Even when siting in excluded zones is allowed, the added engineering designs or strong public opposition can significantly increase construction costs. In general, it is best to avoid siting in these areas. Exclusionary criteria might include areas such as:

- Protected sites of historical, archeological, or cultural significance.
- Prime agricultural land.

- Parks and preserves.
- Land reserved for military uses.
- Wetlands.
- Endangered and protected flora and fauna habitats.

### **Define Technical Siting Criteria**

The second category of criteria to develop includes technical parameters that help define the best potential sites. These criteria provide guidance on specific engineering, operation, and transportation conditions that should be considered to ensure that potential sites are feasible from technical, environmental, and economic perspectives. Examples of technical siting criteria include the following:

- **Proximity to waste generators:** To maximize waste collection efficiency, disposal areas should be within a reasonable distance from waste generators. As the distance that waste must be transported to the disposal area increased, transfer stations may be necessary to manage system efficiency and cost (see Chapter 13).
- **Site size requirements:** Locating a site of sufficient size is critical to assure that sufficient disposal area will be available for use for a length of time sufficient to justify the cost of developing the disposal site in the proper manner. Engineering input can establish preliminary size criteria based on a conceptual design.
- **Ability to expand:** When selecting a site, its expansion potential should be considered. It is frequently less expensive (and significantly less difficult) to expand an existing disposal area than to develop a new site due to the ability to use existing operations staff, traffic control systems, office space, and buildings. It is important to note that this expansion potential is better realized if the existing site is operated to a good standard.
- **Buffer space:** To mitigate impact on the surrounding community, disposal areas should be located in an area that provides separation from residences or sensitive areas.



**Liner installation team.**



### **Define Community-Specific Criteria**

The third category of criteria to consider is the impact of the facility on the surrounding community. These criteria are more subjective than technical in nature and incorporate local, social, and cultural factors. Examples of these criteria include:

- Impact on air quality.
- Odor and noise.
- Impact on traffic, aesthetics, and quality of life.
- Impact on the local land use and infrastructure.

### **Apply the Criteria**

Apply the criteria in the following order. Note that it is likely every site will have some shortcomings.

1. Plot the exclusionary criteria on constraint maps. This will help the planning team visualize the impact of exclusionary criteria.
2. Once unsuitable areas are eliminated, apply technical and community-specific criteria to all remaining options. Information for each potential site should be developed so the planning team can rank the sites.
3. Based on the team's ranking, the top two to four sites should undergo more rigorous analysis to determine technical feasibility and compliance with environmental, economic, and other community objectives.

The following is a general description of how to develop a new disposal area. The initial decisions regarding the design of each task should include whether you will be asking your contractor to participate in the process.

### **Develop Constraint Mapping**

Constraint mapping identifies areas where restrictive siting criteria would not allow location of a new disposal site. Use a base map of the service area (or area of evaluation if the new disposal site can be located outside of your service area) as a starting point, and eliminate portions of the evaluation area where siting criteria cannot be met. For example, selected siting criteria may identify any area within a certain distance from a natural waterway such as a river as unacceptable. If this is the case, the area within the stipulated distance of any major waterway can be shaded as unacceptable on the constraint map. By applying all siting criteria to the base map, the areas that do conform to the siting criteria will become evident. These areas will then serve as the focal point for evaluating specific sites that may exist within the acceptable area.



**Open dump fire.**

While many of the following criteria are not a basis for totally eliminating a potential site, they do provide a basis for screening the best sites and verifying that they conform to EEAA guidelines.

1. Proximity to residential areas, major highways, industrial parks, and environmental sensitive areas (rare and endangered species breeding areas or protected habitat, etc.). Care should be taken that structures and sensitive areas are not within the site boundaries.
2. Prevailing wind direction and velocity. If at all possible, the site should be located down wind from residential areas, industrial parks, and business areas.
3. Proximity to airports and air traffic. The site should be at least 3 km away from a turbojet airport and at least 1.6 km for piston powered aircraft.

4. **Visibility.** If possible, the site should be located out of view from major highways and business/residential centers.
5. **Socio-politically sensitive sites.** The site should be located away from sites such as mosques, National Parks, memorials, and other areas that would not be acceptable to the public.
6. **Sufficient land area** should exist to provide enough landfill capacity based on the expected amount of waste to be received from the service area.
7. A site should be sought that is within a minimum time travel for collection vehicles. The location of a disposal area can have a significant influence on the efficiency of a solid waste collection program. Collection programs work best when the majority of the time is spent actually collecting solid waste from waste sources rather than in over the road transport to disposal areas. For example, the site selection criteria may stipulate a maximum of 30 minutes travel time from points of collection to the disposal area.
8. Remote sites may require the development of transfer stations within the service area. These transfer stations will allow for more economical transport of the solid waste from points of collection to remote disposal areas if the distance to the disposal area from collection zones is excessive.
9. Potential areas may be excluded from consideration as a result of a high seasonal water table or as a result of the critical aspects of groundwater beneath a particular site. For example, if groundwater underneath a potential site serves as a source of drinking water then the potential contamination associated with a new disposal area may preclude the use of that location.
10. The best location for landfill is on a site with relatively impermeable soils. Conversely, a site with permeable soils that could contribute to significant migration of leachate from the landfill may be a poor location. Soils characteristics may become an important siting criterion that may be reflected in the constraint mapping.



Open dump scavengers.

11. There should be no private or public wells, irrigation or livestock water supply wells near the proposed site if they are at risk of contamination from the new facility.
12. There should be no underlying limestone, carbonate, or other porous rock formations that would be ineffective as barriers to leachate or gas migration.
13. There should be no such significant seismic risk associated with the potential site that may require costly engineering measures to stabilize the landfill mass after it has been placed.
14. Proposed landfill sites should be located in areas that are accessible and can accommodate additional truck traffic that will be associated with waste delivery to the new disposal area.

Sources of information that may be available in your area by which to develop constraint mapping include:

- Local government or governorate planning and transport departments.
- Water supply authorities.
- Military sources.
- Mining companies.
- Geological institutes.
- Aviation authorities.
- Hydrology and meteorology institutes.
- Government ministries.
- Universities and university research projects.

### **Develop Site Ranking System**

Once priority criteria has been defined and accepted by the siting committee, a numerically-based ranking system should be developed that will allow each site to be evaluated and ranked in an objective manner. The numerical system should give added weight to crucial siting criteria. The greater the level of objectivity in establishing of the numerical criteria and subsequent site ranking, the better the siting process will achieve the desired result. To the degree possible, the site ranking system should be developed and defined prior to the initial evaluation of any sites. This will help to keep the entire process of site evaluation as objective as possible.



**Public awareness and communications.**

## STEP 3: IDENTIFY POTENTIAL LANDFILL SITES

General areas that may contain potential sites can now be identified. Of particular interest should be areas under single ownership that have been in a state of neglect or non-use for an extended period of time. If the list of sites contains the existing dumpsite, it could have some advantages since:

- The site is already available.
- It already has solid waste identity.
- The site is familiar to waste collection agencies and will not require a significant change in the collection system configuration.

### Perform Initial Surveys

An initial walkover survey of each potential site should be conducted. The objective is to identify specific site features that may be favorable or unfavorable to the development of a disposal site, and to identify sufficient constraints resulting in a reduction of the number of potential sites to a maximum of three.

### Rank Sites

After the surveys, the characteristics of the identified potential sites can be evaluated and ranked in accordance with the predetermined criteria, preferably resulting in a shortlist of three sites for more detailed evaluation. By short-listing sites, the cost of the detailed site evaluation can be kept to a minimum as further evaluation requires some field analysis of conditions such as site hydrogeology.

### Develop Conceptual Designs and Plans

To further assist in the identification of a preferred site, conceptual designs for each candidate short listed site should be prepared. These conceptual designs should allow for an approximate estimate of the following:

- Site capacity in m<sup>3</sup> of waste.
- Volume of daily and final cover required.
- Resources needed to install an adequate leachate control system.
- The extent of work required to provide access to the site.
- The costs associated with all the above.
- The impact on the service area waste collection system on use of the site (vehicles, transfer stations, etc.).

### Perform Detailed Site Investigations

A detailed site investigation should, at a minimum, include a subsurface exploration and topographic survey. The subsurface exploration should be aimed at defining the following:

- Groundwater hydrogeology.
- Baseline quality of ground and surface water (if it exists on the site).
- Quantity of soil material available for cover purposes.
- Permeability of the base of the landfill and of the material to be used for final cover.
- Bearing capacity of the base of the landfill.
- Stability of any slopes to be cut.

The detailed site evaluations should make use of the above surveys and the conceptual design to determine the conformance of the sites to the developed criteria. These tasks may be delegated to your contractor after execution of the contract. This work may be accomplished by the contractor with your input to provide all of the information necessary for final decisions relative to the selection of a new site. During the time that they are assisting in the site selection process, the contractor may be required to operate the existing disposal site. This interim operation could also include required improvements that are defined in the RFT.



Sandbags holding down final cover.



## **STEP 4:**

# **COMPILE FINDINGS IN AN ASSESSMENT REPORT**

**T**he assessment report should present the findings of the site selection committee for the short-listed sites and show whether the sites are viable in the five following areas:

1. Physical and environmental.
2. Technical.
3. Economic.
4. Social and cultural.
5. Legal.

The economic justification of the new landfill site needs to consider all of the financial implications to the waste management system including:

- The current cost of waste disposal at the existing site.
- The current cost of collecting and transporting waste of the existing site.
- Closure of the existing site.
- The expected cost of the design, construction, operation, completion, and aftercare of the new sanitary landfill.
- The expected cost of collecting and transporting waste to the new sanitary landfill.

The feasibility report will serve as the primary supporting document by which decisions can be made on the development of the new disposal area. The feasibility report must clearly demonstrate that:

- There is a need to improve current waste disposal practices.
- The most appropriate way will be by developing and operating a long-term landfill.
- The site chosen is the best available in the area.
- The new landfill can and will be developed and operated to satisfactory environmental and performance standards.
- The impact of its introduction on the waste collection system has been fully accounted.
- The cost of the changes to the waste management system is reasonable and affordable.

Based on the evaluation criteria selected by the siting committee, the feasibility report should make a recommendation as to which site best fits the ranking criteria previously established.

*A preliminary EIA should be prepared for each short-listed site and a detailed assessment completed for the site that will be recommended. Suggested EIA criteria are presented in Appendix C.*



**Uncontrolled open dump fire.**

## **STEP 5: SELECT THE PREFERRED SITE**

**O**nce all the required information has been gathered and all of the accompanying analyses have been completed, a final decision can be made as to the preferred site. Since owner permission would have been required to do some of the detailed testing in the steps above, conversations relative to the potential purchase of the site should have already begun.

The objective of the site selection program is to identify and secure a proposed site that can be described in detail in the RFT. The location of a new disposal area will be very important in defining collection and transfer facilities and equipment required for all of the wastes to be managed within the service area. Provide sufficient detail to enable contractors to develop their proposals. This detail may require that a specific disposal location be identified. If site identification and procurement has not been completed, consider designating a preferred site to give the contractor a basis to submit their tender for the planning committee to evaluate proposals received from a number of prospective contractors.

### **Solicit Stakeholder Input**

Public opposition to any new disposal area can be significant. Because of this, you must be prepared to involve potentially affected people and communities in the siting process as soon as possible. This requires establishing a working relationship with representatives of the affected communities to address their concerns about the new proposed site. All of the questions that they will have concerning the design, implementation, and operation of the landfill must be fully and clearly addressed.

Key communities should be represented on the siting committee. Throughout the siting process, public participation should be sought so as to accomplish the following objectives:

- Promote understanding of the need for a new landfill site and the principles of operations involved in sound practice. You need to demonstrate the new landfill will not be operated in the manner that an open dump may have been in the past.



**Continuous staff training is part of landfill operations.**

- Keep the public informed as to the features of the proposed landfill and its status through public hearings and announcements.
- Solicit public opinion of the siting process and the decisions to be made in developing the new site.
- Promote consciousness of the public in their role as waste generators thereby enhancing their ownership of the solid waste management issue.

Key issues that should be addressed during the public involvement process include the following:

1. The landfill staff will monitor waste haulers and inspect incoming waste loads to ensure that hazardous wastes and other unacceptable materials are not inadvertently disposed in the landfill.
2. Training will be provided for landfill staff in waste identification and safe waste handling practices.
3. The proposed landfill will have a groundwater monitoring plan.
4. A lining system may be employed to minimize leachate and landfill gas migration depending on soil conditions.
5. Daily cover will be used.
6. Measures will be taken to reduce fugitive dust emissions from roads around the landfill.
7. Steps will be taken to control landfill gas properly.
8. The facility design provides adequate sound attenuation measures to reduce noise pollution.
9. The facility has procedures in place to control vectors and litter.
10. The facility plan has provisions for closure and post-closure care.



**Desiccation cracks in soil.**

## **STEP 6: CLOSE THE EXISTING OPEN DUMP SITE**

**D**epending on the pace of activities associated with establishing the contracted services, your contractor may have to operate the existing disposal area at the start of their contract. This will be the case if the new site selection process has not been completed but the collection elements (MSW, industrial waste, etc.) are ready to be implemented.

If it is determined that the existing disposal location meets the necessary criteria for effective disposal, the contractor may undertake operations while improving conditions to the level of performance required in the RFT. The performance requirements for interim operation of the existing disposal area should be specified in the technical documents. These specification should include the improvements that the contractor is expected to implement in their interim operation.

If providing interim operation of the current disposal area, the contractor may also undertake planning and other physical activities aimed at ultimately closing the existing disposal area site. Some of these activities are described in the following tasks.

### **Define Physical Characteristics of the Site to be Closed**

The manner in which an existing open dumpsite is closed is a function of its overall characteristics and the way that it has been historically used for solid waste disposal. Evaluation of an existing dumpsite closure should include the identification of any specific environmental issues that may have to be addressed through effective closure planning and design. Some of these may require ongoing monitoring activities after the facility has been formally closed.

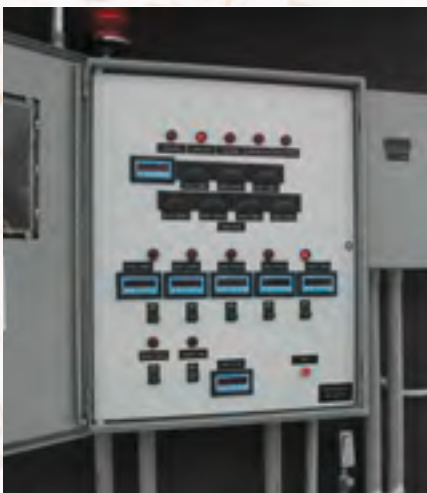
The open dumpsite to be closed should be surveyed to determine the extent of the area requiring closure. This survey may help to determine if it is practical to consolidate the solid waste that has been placed in the disposal area so as to reduce overall closure cost. Closure should include placement of final cover to isolate the solid waste from its surrounding environment. The intent of final cover is listed below:

- Control surface erosion.
- Control landfill gas and leachate migration.
- Support planned after closure land use.
- Maintain all of the above while the landfilled waste continues to decompose and settle.

Depending on the initial environmental evaluation of the existing disposal site, a decision will need to be made as to whether environmental monitoring will continue to occur during a post-closure period. Environmental monitoring may be required if there is a possibility that the closed disposal area will have a damaging effect on groundwater, particularly if receptors are apt to be affected (through pollution of a down-gradient well, for example).

### **Define Land Use After Closure**

The intended land-use after closure is very important in defining closure design. For example, in some industrialized countries, closed landfill sites have been converted to active recreational use. This has required that the closure design be sufficient to prevent any health and safety effects for the people who will use the site after it has been closed and recreational facilities have been developed. If the site is not to be used and is to remain idle, it should be covered, stabilized, and isolated through fencing that will keep people and animals away from the disposal site after it has been closed.



**Leachate monitoring system.**



## Prepare Closure Plan

The closure of an existing disposal area must be coordinated with the opening of a new replacement facility. Throughout the planning process for the new site, there needs to be close coordination with those responsible for collecting solid waste and transporting it to the disposal area. This is especially crucial at the time that an existing disposal site is closed. Collection crews must then begin to transport their solid waste to the new facility. Because of this, all infrastructure required to begin receiving trucks at the new landfill must be ready to use at the time the old disposal area is closed.

The closure of the old disposal area should occur at a time when the site can be secured from access by unauthorized people who may still seek to place solid waste at the existing disposal site. A new location may mean that waste suppliers in proximity to the old site may need to transport waste further away than they are used to. If not properly monitored and enforced, they may still attempt to dump their waste at the old site in any location that they can get access to. This may require around the clock guards to prevent unauthorized dumping for a period of time after closure. It should also be noted that an old disposal area that will be closed for disposal may still serve as a good location for development of a transfer station or waste drop-off location (see Chapter 13). This may help to assure that unauthorized disposal at the old site ceases upon closure.

If all of the solid waste brought to the disposal site is on the control of an ISWM contractor, coordination can be streamlined. This will be the case if the contractor is also responsible for management of the collection system and management of the other components (industrial and medical waste collection) as well as development, construction, and operation of the disposal area.

A list and schedule should be developed of all closure activities that will be required before the existing disposal site can be officially closed. This will form the basis for your closure plan. This can be developed for inclusion in the RFT or developed by the selected contractor during their interim operation of the existing disposal area in anticipation of starting operations in a



Landfill signage aids in public awareness.

new location. The closure plan will seek to coordinate all activities among the various entities that will be affected by the site closure. This coordination will include providing the proper notices including the date the old site will be not available and that the new site ready to receive solid waste.

### **Establish Post-Closure Monitoring Requirement**

Depending on the possible effect of the closed landfill site on potential receptors, some monitoring of the closed site may be required. If monitoring wells exist at the site, post-closure monitoring could consist of continued testing of the wells to determine whether leachate is migrating from the site. You should determine this when you evaluate the environmental impact of the existing disposal area.

If there is concern that landfill gas may migrate from the site to nearby residences or other adjoining land-uses, ongoing testing for landfill gas may also be required. If landfill gas and leachate migration monitoring is not required, you should plan to, at a minimum, periodically visit the site to make sure that all waste remains covered and that there are no other specific issues that have arisen at the disposal area that must be addressed. Examples of such a situation would be the breaching of security fencing or the erosion of landfill surfaces that expose the solid waste contained in the landfill.



**Leachate control station.**

### **Close the Existing Landfill**

Once the landfill closure plan has been developed and the required infrastructure for the new disposal site has been completed and is available for receipt of solid waste, the existing site may be closed. Sufficient notice must be give to all parties who will be affected by the closure if they must then transfer their operations to bring their collected waste to the new disposal site. Once waste is not coming to the old site, the remaining elements of the closure plan (final cover, fencing, etc.) can be implemented.



## **STEP 7: START OPERATIONS AT A NEW LANDFILL**

**T**he proper function of any controlled landfill requires both effective design and operations. In a basic sense, the principal goal of developing a controlled landfill must be to allow effective disposal of solid waste in manner that can be achieved at the lowest cost while mitigating environmental damage and safety hazard potential. Key objectives must be achieved to realize the above goal. The key objectives require that the landfill design and operations:

1. Eliminate all fires and manage disposal activities to minimize fire potential in the future.
2. Develop sustainable landfill design and operational procedures that minimizes environmental and, in particular, damage to groundwater resources.
3. Develop landfill design and operational procedures that safeguard the health and safety of operators and others visiting the site for any purpose.
4. Establish a sustainable landfill configuration that allows the site to be developed and used as a cost effective, environmentally sound and safe solid waste disposal site for as many years as possible.

These objectives, if achieved, will improve site conditions and allow for the proper solid waste management at the site. One of the key decisions that will need to be made is the level of technical and performance standards that will be required for the landfill design and operations. The landfill standards will determine both the level of health and environmental protection that will be met and the overall costs associated with the facility.

### **Establish Minimum Design Standards**

1. Groundwater and surface water protection (liners, etc.).
2. Leachate management.
3. Landfill gas management.
4. Access roads.
5. Waste receipt facilities (truck scales, etc.).
6. Mobile equipment maintenance facilities.
7. Access control structures (fencing, etc.).
8. Environmental monitoring.



**Leachate control system.**

### **Establish Minimum Operational Standards**

1. Access control.
1. Waste placement and compaction.
3. Application of daily cover.
4. Intermediate and final cover and cell construction.
5. Mechanical landfill equipment.
6. Surface water management (if at all required).
7. Fire control.
8. Litter control.
9. Leachate control and monitoring.
10. Landfill gas control and monitoring.
11. Record keeping.
12. Prevention of scavenging.
13. Personnel protective equipment.

These standards will form the basis for the technical specifications associated with disposal in the RFT.

### **Construct all Required Infrastructure**

After all final plans and specifications have been developed by the contractor and approved by any appropriate agencies with jurisdiction over the process; the required landfill infrastructure can be constructed. Infrastructure components should not be placed into service until they have been properly constructed and meet all quality control standards required under the contract.

### **Develop Landfill Operations Plan**

The RFT technical specifications should require prospective contractors to submit a draft operations plan for the landfill element of their ISWM program. This operations plan should be submitted as a draft during the tender process, refined during the contract development period, and finalized soon after contract execution. The operations plan should define in detail the manner in which the contractor will accomplish the disposal function. The required content of the draft operations plan should be clearly defined in the RFT technical specifications.

### **Coordinate with all Solid Waste Operators**

When the new disposal area has been constructed and is ready to receive waste, there must be close coordination with the entities responsible for solid waste collection. This coordination is required to assure that there is an orderly transition for the collection service integration at the new disposal site. During planning, consideration will have already been given to the effect that the new disposal area are will have on the efficiency of the collection system.

### **Begin Operations at the New Disposal Location**

Once all construction has been completed and all approvals have been granted, operations can begin at the new disposal site. The RFT should stipulate that it will be the contractor's responsibility to assure that all designs and construction are completed in accordance with the RFT technical specifications. It should also be the contractor's responsibility to operate the new disposal facility in accordance with the approved operations plan.





## APPENDIX A: LAWS AND REGULATIONS RELATED TO LANDFILLS

The legal and regulatory framework for solid waste management in Egypt is based on existing bylaws, ordinances, and regulations. These include inspection and enforcement responsibilities and procedures at national and local levels. The main legislation relating to solid waste management is Law 38/1967 and amended by Law 31/1976 and Law 129/1982. Law 38/1967 and its implementing regulations (Minister of Housing Decree 134/1968) govern the collection, transport, and disposal of non-hazardous solid waste in Egypt. It also imposes a cleanliness tax on all housing units equivalent to 2 percent of the rental value. Some of the key provisions of these laws and regulations include the following:

- Article 6/1938 prohibits storing or dumping solid wastes in locations not specified by the local councils.
- Law 31/1976 defines “garbage and solid wastes” as including domestic and industrial waste. It also specifies garbage containers, means of transportation, and the frequency of solid waste collection.
- Law 38/1967 requires that wastes be disposed of in sanitary landfills surrounded by a 1.8 m high fence.
- Article 17 of the implementing regulations require that the waste be disposed of in piles or trenches that are compacted, covered with no less than 15 cm of sand, and sprayed with water.

Other relevant laws affecting solid waste management include:

- Law 106/1976 regarding the organization of construction works and construction and demolition debris (C&D).
- Law 66/1977 regarding traffic and transport of litter and similar materials.
- Law 43/1979 regarding the local governing body which deals with the responsibilities of the local officials in public services and their authorities in levying charges and gate fees.
- Law 137/1981 deals with occupational safety. It only has peripheral relevance to solid waste management, but includes Article 117 which requires that employers inform their workers of the hazards associated with non-compliance with safety measures. The law also requires that personal safety equipment, together with training on its use, should be provided to the worker.
- Presidential Decree 284/1983 established the Cairo and Giza Beautification and Cleansing Authorities. The mandates of these authorities include the collection of garbage and solid wastes and their disposal in special areas. By 1990, the Cairo and Giza Governorates have forbidden waste transportation by the use of donkey carts and formalized the subcontracting of door-to-door waste collection. As a result, many Zabbaleen, (traditional, informal private small-scale waste collection and recycling enterprises) formed co-operatives to be able to buy pick-up trucks to continue their waste collection services.

Law 4/1994 (the Environmental Protection Law) is comprehensive environmental control legislation and has a major influence on solid waste management. The Prime Ministerial Decree 338/1995 promulgates the Executive Regulations of Law 4/1994, and the Executive Regulations cover many areas of environmental protection. Law 4/1994 requires environmental impact assessments of new developments, including industrial projects. It established the Environmental Protection Fund to fund various relevant environmental projects. The Fund is supported financially by the government, donor agencies, and proceeds from fines paid by those who do not follow the environmental regulations. It also advocates setting up a system of incentives to be offered to organizations, individuals, and others, to carry out projects for environmental protection; and covers the protection from pollution of the land, water, and air environments.

In terms of solid waste management, the most specific stipulations of Law 4/1994 deal with the identification and management of hazardous materials, including wastes, and the prohibition of the installation of facilities for treating hazardous waste without a license. The conditions of any such license are to be

determined by the Ministry of Housing after consultation with the Ministries of Health and Industry and the Egyptian Environmental Affairs Agency (EEAA). In particular, Law 4/1994 stipulates the following:

- Article 30 states that management of hazardous wastes shall be subject to the procedures and regulations stated in the Executive Regulations of this Law. The Executive Regulations shall designate the competent authority, which, after consulting EEAA, will issue the tables of dangerous wastes to which the provisions of this Law shall apply. These tables form the basis for identifying the waste forms that will not be acceptable waste at the disposal facility unless components and systems have been installed that are designed for the disposal of hazardous waste.
- Article 31 forbids construction of any establishment for treating dangerous wastes without a permit from the competent administrative authority and before consulting EEAA. Disposal of dangerous wastes shall be according to the norms and conditions stated in the Executive Regulations of this Law. The Minister of Housing, Utilities and New Communities shall assign, after consulting with the Ministries of Health, Industry and EEAA, the disposal sites and the required conditions to authorize the disposal of dangerous wastes.
- Article 37 prohibits the burning, disposal or treatment of solid waste except in designated areas far away from housing or industrial or agricultural areas as well as from waterways.
- Article 38 permits the incineration of infectious waste generated from medical care in hospitals and health centers, with certain provisions. Article 38 also requires that local authorities allocate specific places for waste disposal after conducting a topographical study to identify the area, the amount and nature of waste that may be disposed of every 24 hours.
- Article 39 requires that collectors of garbage and solid waste maintain their garbage bins and vehicles in a clean state. Garbage bins shall be covered tightly so that no offensive odors shall emit, and also to avoid becoming a source for attracting and growing flies and other similar insects, or a focus for attracting stray animals. The garbage contents shall be collected and transported at suitable intervals according to the conditions of each area. The quantity of garbage shall not exceed the capacity of any of these bins at any time. This standard affecting collection can implicitly affect the disposal area since the nature of the collection system can have a major influence on the effectiveness of the disposal area.

Law 4/1994 also presents disposal area specifications that include:

- Lower level than the surrounding area.
- Not less than 1,500 m from the nearest residential areas.
- Enough space for waste disposal and other activities, e.g. waste separation.
- Available water for emergency and other usages.
- Available equipment for waste disposal, turning, and ash disposal so waste is not wind blown nor leached into groundwater.
- Local units, in coordination with EEAA, are mandated to allocate sufficient space for solid waste disposal, treatment and incineration.
- Article 41 of the Executive Regulations requires similar conditions for the disposal of construction waste.

## APPENDIX B: INSTRUCTIONS AND EXAMPLES FOR TECHNICAL SPECIFICATIONS

The technical specifications of the Request for Tender (RFT) are intended to define the service to be provided by the contractor. For an effective RFT process, sufficient detail should be provided to the contractor as to how they are expected to perform their services. Technical specifications must define the responsibilities that will exist on each side of the contract. They should spell out your ultimate responsibilities as well as those that will be required of the contractor.

With sufficient information, prospective bidders can prepare detailed proposals that are responsive to your intent. The process by which you should develop the tender process is outlined in the previous chapters of this manual. This section is intended to focus on the recommended technical requirements and documents that cover the disposal function of a contracted integrated solid waste management program in your service area. Appropriate technical specifications content relative to the disposal function should include the following sections:

1. Definitions.
2. General Background.
3. Service Specifications.
4. Minimum Technical Requirements.
5. Performance Standards.
6. Performance Monitoring.
7. Measurement and Payment.
8. Penalties.

The information included in each section should be based on the solid waste management improvements that will be accomplished through the contract. The following presented a recommendation on the standards that should be applied to the technical specifications of the RFT. The basic intent of the RFT is to apprise the contractor of what you expect in their RFT response as well as in their provision of services if they are successful in getting the contract. The following is a recommended approach to the information provided.

### General Background

Though the general background section, you should provide information to the contractor relative to current disposal facilities and practices in the service area. This section should also clearly state what you expect of the contractor in general terms that will then be supported by the detailed requirements stipulated in the service specifications and performance standards.

Though the RFT, you should make the contractor responsible for the design, construction, and operation of a new engineered landfill for disposal of all solid waste derived from the service area. If there is an existing disposal site that will be used in the near term future, you should stipulate in the technical specifications the point in time when the new landfill facility must come into service.

The contractor should be required to provide disposal capacity that complies with all applicable requirements of the RFT and the contract. The technical specifications should stipulate the solid waste that will be brought to the disposal site. At a minimum, this waste stream will include: MSW, industrial waste, treated medical waste residue, and any other waste type that you designate and define in the RFT.

Other information presented in this section should include discussions on the following issues:

**Waste Quantity:** An estimate of the amount of solid waste that will be brought to the disposal area on a regular basis should be provided. This estimate should include a breakdown of the various types of waste that must be managed. If possible, the data should include any peak levels and other variation in quantity that is expected.

**Waste Source:** The technical specifications should present information concerning the various sources of waste that will generate the waste brought to the new disposal area. If the landfill component is part of a more comprehensive integrated solid waste management contract, the contractor may already know



the generators from other data that you present on the waste collection systems that will also be covered in the technical specifications.

**Existing Facilities:** If you want the contractor to use an existing disposal area during the initial period of its operating contract, you should describe that facility. This description should include any information that will assist the contractor to define contract operations at the site including an estimate of remaining life and physical limitations concerning site utilization.

### Example Statement on Waste Source

*“The governorate intends to procure one or more contractors to collect municipal solid waste, industrial waste, and medical waste, and to process and/or treat the wastes as appropriate. The governorate will allow private haulers to deliver acceptable waste to the engineered landfill. Therefore, the traffic flow to the engineered landfill will include transfer trailers, waste collection vehicles, dump trucks, private cars, and pick-up trucks.”*

**New Engineered Landfill Site:** If the contractor is to develop a new engineered landfill, you should prepare and present the criteria for that development in the technical specifications. The data that you prepare to help the contractor should, at a minimum, include the following:

- **Location and Setting:** The location of the new engineered landfill site may not be known at the time that the RFT is developed. If that of the case, you should provide basic assumptions to the contractor to allow them to prepare their proposals. For example, you may tell the contractor that it is assumed that disposal will be in the vicinity of the existing disposal site. For example, you may state to the contractor that the new engineered landfill site will be within 10 km of the existing landfill. A map that will be used as an exhibit to the RFT to show the location of the existing disposal site.
- **Site Topography:** If the contractor will be required to utilize an existing disposal site, you should provide detailed information concerning that site. For example, a site topographical plan for the existing disposal site may be presented as an exhibit of the RFT. If you are in the process of locating a new disposal site that the contractor will eventually run, you should provide the contractor with technical information including a topographical plan as soon as it becomes available.

**Environmental Impact Assessment:** You should state who is responsible for preparing, submitting and obtaining approval of the Environmental Impact Assessment (EIA) for the new engineered landfill from the Egyptian Environmental Affairs Agency (EEAA). If the contractor will be made responsible, the governorate should still plan to assist with the coordination of this effort with the EEAA.

**Preparation Period:** In the RFT, you should give the contractor a minimum (9 to 12 months, for example) preparation period beginning with the contract signing date and the remaining life of the existing disposal area (if it is to be used by the contractor) to establish the new engineered landfill. Through the contract documents, you should, at a minimum, make the contractor responsible for the following activities during the preparation period:

- Finalize site field data collection and analysis.
- Prepare and receive EEAA approval of the final EIA.
- Prepare a project schedule for obtaining permits, finalizing the engineered landfill design and construction, equipment and personnel procurement, and start-up of operations.
- Initiate the final engineered landfill design and engineering drawings.
- Order, receive, and mobilize all equipment including a scalehouse.
- Locate and equip operations and customer service offices.
- Recruit and train management and operations personnel.

In conjunction with the preparation period, you should require that the contractor prepare and submit a preparation work plan and monthly preparation reports describing in detail the progress made in preparing to implement the contract and any potential impediments to implementation in the specified time period.

**Summary of Intent:** The introduction of the RFT should include a summary of intent that defines your overall intent in issuing the landfill unit RFT.

### Service Specifications

Through the service specifications, you will begin the process of providing detailed information concerning the service that will be covered by the contract. A good set of service specifications includes the following important elements:

### Draft Work Plan

All pre-qualified bidders need to submit a draft work plan (DWP) as part of the technical proposal with the tender offer. You should define the minimum requirements of the draft work plan that you desire in the RFT. The draft work plan will be used for the purpose of evaluating the technical adequacy of the tender offers. It should include information on the continued operation of the existing disposal area if this is going to be required of the contractor and the new engineered landfill. The draft work plan should provide detailed descriptions of the following:

- Project schedule showing completion dates for acquiring permits, completion of design engineering, construction of all facilities, and start-up of commercial operations.
- Plans and procedures to acquire all construction and environmental permits.
- Site plan.
- Preliminary new engineered landfill design, construction, and operations plans.
- Equipment list.
- Staffing plan.

Some of the specific requirements for the above draft work plan elements are as follows:

1. **Site Plan:** The draft work plan should include site plans with a recommended scale of 1:2,000. The site plans should include a vicinity map that shows the location, access road, and street address for the facilities. The site plan should also delineate the following:

- Existing and final elevation contours.
- Property boundary.
- Access roads.
- Perimeter fencing area and entrance gates.
- Major structure locations including the scalehouse.
- Drainage facilities.
- Maintenance yard.

2. **New Engineered Landfill Preliminary Design, Construction, and Operations Plan:** A preliminary design, construction and operations report should be provided in the draft work plan. The report should, at a minimum, include the following information in the form of a narrative description and preliminary design drawings for the new engineered landfill:

- Executive summary including descriptions of the design, construction, phased operation, and closure of the existing disposal site and the new engineered landfill.
- Design criteria for construction of the engineered landfill including landfill volume and capacity.
- Daily and annual design capacity.
- Design disposal density including methods of measurement.
- Design assumptions for waste volume, daily soil cover, intermediate soil cover, and final cover requirements.
- Calculations indicating total landfill volume required for the contract operations period as well as the ultimate site capacity.

### Example Summary of Intent

*"The intent of the governorate as prescribed in the RFT is to provide its citizens with an engineered landfill at the best price and with the highest quality of service. It is the sole responsibility of the pre-qualified bidder to exercise due diligence in assessing all existing work conditions, and ultimately to rely on its own analysis of the work in the calculation of prices submitted in the tender offer. The contractor shall not rely on the information provided herein related to the projections of population and waste quantities in determining the price of its bid."*

- Type of liner and liner placement method for the new engineered landfill.
- Design assumptions and calculation for the leachate collection and treatment system for the new engineered landfill.
- Scalehouse operation procedures and description of the data collection and management system.
- Description of the site security system.
- Preliminary facility and equipment maintenance schedules.
- Animal and vector management plan.
- Cover management plan.
- Dust management plan.
- Fire control plan.
- Groundwater management plan.
- Landfill construction and quality control plan.
- Landfill gas management plan.
- Leachate management plan.
- Surface water management plan.
- Waste monitoring plan.
- Noise control measures.
- Contingency plans detailing corrective or remedial actions to be taken in case of environmental contamination or other emergency events.
- Closure plan.
- List of required permits and schedule for obtaining permits.

Conceptual drawings associated with the above should specifically include the following information:

- Bottom of excavation.
- Liner details.
- Top of liner details.
- Final cover and elevation.

The draft work plan needs to include sufficient design information to obtain EIA approval from the EEAA to design, construct, and operate the engineered landfill. The draft work plan should include appropriate text as well as engineering drawings. Upon reviewing the draft work plan, you should have the right to request clarifications, additional information, and drawings.

Upon contract award, the contractor must meet with you to discuss and resolve any required changes to the draft work plan. Based on these discussions, you should then give the contractor a maximum length of time (within 150 days, for example) after the contract signing date to finalize all design and construction details and submit a final work plan to you. Again, you should maintain the right to request additional design information including revisions to the engineering plans and drawings.

### **Preparation Work Plan**

You should require that the contractor submit a preparation work plan (PWP) within a certain time after the signing the final contract (within 45 days, for example). This preparation work plan should describe in detail the contractor activities during the preparation period stipulated in the RFT. Your RFT should require that the preparation work plan provide schedules for the initiation and completion of all preparation period activities including, but not necessarily limited to, the following:

- Overall project schedule.
- Existing landfill operations (if required) and closure plan.
- Final engineering design schedule.
- Recruiting and training labor and supervisory personnel.
- Procurement of supplies and equipment.
- Construction of facilities.

### **Final Work Plan**

Through the technical specifications, you should require that the contractor submit a final work plan (FWP) within a certain time frame following the contract signing date (within 150 days, for example).

The final work plan should include the final landfill design, construction, operations, and closure plan, the final operations and closure plan for the existing disposal, and incorporate refinements and modifications discussed and agreed upon between you and the contractor prior to execution of the contract. In addition, the final work plan should include a copy of the preparation work plan, including any revisions to the preparation work plan agreed upon by you and the contractor after its initial submittal.

### **Environmental Permitting**

You should make the contractor should be made responsible for all necessary permitting. An EIA should be required for the new engineered landfill. Through this process, you should require that the contractor obtain all necessary approvals of the EIA. This EIA should meet all EEAA permitting regulations necessary for design, construction, and operation of the engineered landfill.

In addition to completion of the EIA and in conjunction with the Executive Regulations for Law 4/1994 (Law of Environment, 1994, Article 28), you should also require that the contractor assist you in obtaining necessary project approvals from the Ministry of Housing, Ministry of Health, and the Ministry of Industry.

### **Engineered Landfill Design**

Through the technical specifications, you should clearly state that the contractor will be responsible for design of the engineered landfill that shall be designed to accept a designated quantity of acceptable solid wastes on a 7-day per week basis for a minimum period (15 years, for example).

### **Engineered Landfill Construction**

Through the technical specifications, you should require that the contractor take the responsible for construction of the engineered landfill, and all associated appurtenances and facilities, including, but not limited to: access roads, site fencing, scalehouse, office building(s), utilities, utility hook-ups, and environmental control systems. The contractor should be required to conduct appropriate quality assurance and quality control (QA/QC) procedures during all construction activities, and should provide record or "as-built" drawings of all facilities constructed. The contractor should also be made responsible for the procurement and maintenance of all equipment and supplies necessary for construction.

### **Engineered Landfill Operation**

You should hold the contractor responsible for providing all manpower, equipment, supplies, etc. required to manage and operate the engineered landfill after it has been designed and constructed.

### **Environmental Monitoring**

You should make the contractor responsible for all required environmental monitoring including, at a minimum:

- **Groundwater:** Require that the contractor prepare a groundwater management plan that describes in detail the proposed location of the groundwater monitoring wells, as well as the proposed well installation and groundwater collection and analytical procedures, and submit the plan to you for approval.
- **Landfill Gas:** Require that the contractor prepare a landfill gas management plan that describes in detail the proposed types and locations of both on-site structure and off-site migration monitoring devices. The landfill gas management plan also should describe monitoring procedures, and meter and detector maintenance and calibration. It should also state mitigation measures to be used in the event landfill gas migration is detected. Through the RFT, stipulate to the contractor that they must submit the plan to you for approval.

### **Closure**

Through the RFT, give the contractor the responsibility for closure of the existing disposal area and, eventually, the new engineered landfill. The contractor should be required to prepare closure plans describing in detail the closure activities that will take place. The closure plan should include the following considerations:

- Final cover contours and type of material.
- Settlement of solid waste layers.
- Leachate management.
- Final cover design.
- Surface water management.

- Landfill gas management.
- Environmental Monitoring Plan.
- On-going post-closure site maintenance and security activities.
- Removal of unnecessary equipment, materials, buildings and structures.

The closure design should be required to result in a closed site as a useful parcel of land.

### **Public Disturbance, Nuisance, and Safety Hazards**

Require that the contractor take all reasonable steps to minimize off-site disturbances, nuisances, and public safety hazards during performance of all aspects of landfill services that they will be required to provide as a result of the contract.

### **Reporting Requirements**

The following are example terms that relate to what you should require of the contractor's reporting process for the project:

- **Monthly Preparation Reports (MPRs):** During the preparation period the contractor should submit monthly preparation reports to the governorate project administrator describing the progress made on the preparation work plan during the preceding month, as well as any potential impediments to implementation in the specified time period. The reports should be in a form acceptable to you and submitted no later than the 15<sup>th</sup> day of the following month.
- **Monthly Operations Reports (MORs):** During the operation period, require that the contractor submit monthly operations reports to the project administrator. Each monthly operations report should include detailed information concerning the performance of the landfill service and provide a breakdown of the type and quantity of waste delivered to the landfill. The reports should be in a form acceptable to you and submitted no later than the 15<sup>th</sup> day of the following month.
- **Annual Operations Reports (AORs):** During the operation period within a month from the end of the operational year, require that the contractor submit annual operations reports to you. Each annual operations report should include a detailed summary of the monthly operations reports for the previous year. Again, the reports should be in a form that is acceptable to you.

### **Handling of Complaints**

Through the service specification, stipulate that all complaints that cannot be handled directly by the contractor's landfill manager during working hours should be referred to and managed by the contractor's customer service office.

### **Minimum Technical Requirements**

The minimum technical requirements provide your definition of the minimum standards that must be met in the equipment, personnel and processes used in providing the contracted landfill service. Some of the key minimum technical requirements that you should require are shown below:

### **New Engineered Landfill Final Design**

The final design of the new engineered landfill will be critical in defining how the facility will prevent environmental damage. Recommended minimum technical standards for the landfill design are described as follows:

1. **Design Drawings:** The contractor should prepare the final design and engineering drawings during the preparation period. At a minimum, require that the contractor provide the following engineering drawings:
  - **Location and Vicinity Maps:** These should show the site location and vicinity. The vicinity map should include the site boundary and all major roads, structures, industries, commercial and residential areas within a 2-km radius of the site.
  - **Site Boundary Surveys:** These should show the boundary conditions and a legal description of the site.
  - **Site Layout with Topographic Contours:** These should show locations and dimensions of all proposed site structures including roads, buildings, fencing, scales, utilities, etc. Topographic contours with a minimum of 1 m intervals should also be depicted.
  - **Construction Phasing Plan:** These should show the ultimate use of the site in a planned phasing approach. Interfacing of construction and operation should be noted. At a minimum you

should require an overall drawing (recommended scale 1:1,000) as well as construction phasing drawings (recommended scale 1:100) showing the construction phasing details. The construction phasing details should include details on phasing of cells, leachate collection system, landfill gas collection system, roads, and all other components of the new engineered landfill.

- **Excavation and Grading Plans:** These should show the excavation and base grading for the cells and required earthwork for construction. At a minimum overall drawing (recommended scale 1:1,000) as well as other drawings (recommended scale 1:100) showing the excavation and grading plans should be required.
  - **Cell Construction Details:** These should show cell profiles with liner, leachate collection pipe lateral drainage layer, ditches, access roads and final cover tie-in to the bottom liner at the edge of the fill area (recommended scale 1:500).
  - **Leachate Management Plan:** You should require that the contractor provide a drawing (recommended scale 1:500) that shows the leachate collection, transport, and treatment system. This plan should include all inverts of the collector pipes, transport pipes, manholes, tanks, etc.
  - **Landfill Gas Management Plan:** This plan should show landfill gas migration control and monitoring measures, and concepts for passive or active venting system (recommended scale - 1:500).
  - **Final Cover Contours:** You should require that the contractor provide a drawing (recommended scale 1:500) showing bench terraces, berms, drainage swales, etc.
  - **Construction Details:** These should show liner anchorage details, leachate management system, roadways etc. (recommended scale 1:500) when required.
  - **Cross Sections:** These should show typical sections through the fill area, bottom of cells, sideslopes, and final cover elevations. Detailed cross sections showing the construction of solid waste lifts and slopes should be required (recommended scale 1:500).
2. **Bottom Liner:** The site characteristics of your new disposal will help to determine if a bottom liner is required. The RFT technical specifications should require that the contractor evaluate site conditions to determine if a liner is required. Your EIA may show that a liner is required. If this is the case, the technical specification may stipulate the type of liner required and criteria by which it should be designed. Any liner design will need to conform to ECAA guidelines in effect at the time that the line is designed.
3. **Construction:** Through the RFT, you should establish minimum technical standards for construction of the engineered landfill. At a minimum, you should require the following:
- **Quality Control:** During all construction activities, make the contractor responsible for monitoring quality control over all suppliers, services, site conditions, and workmanship. Require that the contractor prepare a landfill construction and quality control plan that describes the QA/QC measures that will be employed during construction. Require that the contractor should submit the plan to you for approval. QA/QC plan procedures and requirement should include the following:
    - Continuous inspection and field supervision by qualified personnel provided by the contractor.
    - Laboratory testing of construction materials.
    - Utilizing experienced contractors and workers having a minimum of 5 years of experience in their profession or trades.
    - Conformance to manufacturers' installation QC procedures.
  - **Cell Construction:** The RFT should state that the contractor must construct waste cells and related facilities in strict accordance with the approved design drawings. They should also be advised that any changes of the approved design will require your approval.
4. **Construction Phasing Plan:** For each phase, you should require that the contractor prepare engineering drawings that will be presented to your project administrator for review and approval. These drawings should clearly delineate the landfilling phasing sequence from initial waste disposal through closure, airspace requirements, volume of compacted waste, and volume utilized for daily

cover. The construction phasing plan should demonstrate that the site has sufficient disposal capacity for the contract period. The phasing plan should show how interfacing of the landfill construction and operation will take place.

Make the contractor responsible for providing appropriate engineering drawings (recommended scale 1:100) showing cell construction details including profile of the cell, leachate collection pipes, lateral drainage layers, perimeter roads, and access roads when applicable.

5. **Final Cover:** You should further require that the contractor design a final cover system to provide stability of the landfill surface after closure and to allow for gas venting, if it is required.
6. **Leachate Management:** The engineered landfill design should include a leachate management system consisting of a drainage and leachate conveyance layer on top of the bottom and sideslope liners, sumps and/or tanks, and a system to treat the collected leachate. You should require that the leachate collection system should be placed directly above the liner. The leachate collection system should be designed to ensure that the maximum allowable leachate head above the liner is 20 cm. Leachate head should not exceed 20 cm at any point on the lining system with the exception of collection wells. The lateral leachate drainage layer should be designed with a minimum slope of 2 percent.

The leachate collection system should be designed for the maximum estimated loading of solid waste material and equipment during landfill construction. The contractor should use high density polyethylene (HDPE) SDR 11 or better piping, or a geosynthetic equivalent for leachate collection. Sufficient gravel, sand, and/or soil should be placed on the leachate collection system so that the integrity of the leachate collection system is maintained at all times during construction and operation of the engineered landfill.

The collected leachate should be routed to an individual manhole, lined leachate pond or lagoon, or a central storage tank.

The contractor should be responsible for meeting all permitting requirements for leachate treatment. If allowed by regulatory authorities, the leachate could be concentrated in an evaporation pond or recirculated into the landfill.

7. **Office Building:** You should require that the office building should be a permanent structure (temporary structure(s) in case of the landfill). It should be equipped with an office area for landfill management and supervisory staff and also include the following:
  - Office for the landfill manager.
  - Office to accommodate working space and desks for at least three contract monitors.
  - Office to store landfill drawings and records.
  - Washrooms and shower area.
  - Bathroom facilities.
  - Lunch room for employees.
  - First aid station.
  - Visitor reception area.
8. **On-Site Utilities:** Through the RFT, make the contractor responsible for design and construction of on-site utilities including the following:
  - **Water:** The facility should be equipped with potable drinking water as well as water for fire fighting and dust mitigation.
  - **Electricity:** The facility should be equipped with sufficient electrical capacity to power all electrical equipment located on the site.
  - **Sanitary Facilities:** The permanent office building should be equipped with a shower area, washrooms, toilets, and a change area to handle all landfill employees.
9. **On-Site Access Road:** You should also require that the contractor's engineered landfill design include an appropriate access road from the site entrance to the landfill working face. This access

road should be designed to accommodate vehicles having a minimum 40 ton gross weight. The access road should be a minimum of 15 m wide to handle two-way transfer trailer traffic from the scalehouse to the face of the landfill. The access road should be designed and constructed to include ditching and drainage.

10. **Scalehouse:** You should require that the engineered landfill design include a scalehouse located at the entrance to the site. The scalehouse should be equipped with a minimum of two platform truck scales and a computerized system for billing and tracking incoming waste. The platform scales should have the capability of accurately measuring tare and net weights of a range of vehicles from pick-up trucks to transfer trailers. The scales should have a minimum designated level of accuracy (e.g., +/- 100 kg). The scalehouse should be a permanent structure furnished with appropriate space to maintain and operate the computerized weight recording system, store historical records, and have sufficient room for two scalehouse operators.
11. **Separation Barrier:** Require that the landfill design include provisions for a minimum 2 m separation between the maximum groundwater elevation and bottom of the landfill liner (if required). The design should include a separation barrier to ensure that water does not penetrate or destroy the integrity of the bottom and sideslope liners. Design documentation should include details on the materials, permeability, strength, thickness, and physical characteristics of the separation barrier.
12. **Sideslope Liner:** As a minimum service specification, you should require that the sideslopes with a slope less than 20 percent have a liner hydraulic barrier performance equal to that of the bottom liner, if one is required. The contractor should be responsible for the design of any sideslope lining system required within the landfill design.
13. **Site Access Road:** Through the service specification, you should require that the access road design allow for two-way traffic to and from the facilities and be designed to accommodate vehicles having a minimum 40-ton gross weight.
14. **Site Fencing:** You should require that the entire boundary of the site should be fenced. The fencing should, at a minimum, consist of chain link fencing topped with barbed wire, or a similar material and should be a minimum of 1.8 m high.

### Landfill Operations

You should establish minimum technical standards for operation of the engineered landfill. At a minimum, these should include the following:

1. **Acceptable and Unacceptable Waste:** Require that the contractor dispose only acceptable waste at the engineered landfill, and not dispose any unacceptable waste. Acceptable waste may include MSW, industrial waste, treated medical waste residue, C&D, and residues from waste composting and/or recycling facilities, as well as any other waste type designated by you in the RFT. Unacceptable waste should be all other wastes including, but not limited to, hazardous waste, chemical liquid wastes, and radioactive wastes. Require that the contractor implement a waste monitoring plan approved by you to inspect loads to detect and prevent the disposal of unacceptable waste. The plan should, at a minimum, include:
  - Inspection frequency.
  - Inspection personnel.
  - Identification of an inspection area located away from the tipping area.
  - A training program for the facility employees in the identification of unacceptable waste.
2. **Access Control:** You should require that the ability for trucks to access the disposal site at any time when the landfill is not staffed be limited. Locking gates should be installed that would prohibit trucks from entering the site outside of designated hours of waste receipt. If possible, the landfill access road should be configured so that trucks or any other vehicles cannot get into the disposal area when the facility is closed. Strategically placed and maintained rock or soil piles could aid in this purpose.



3. **Animal Vector Control:** Stipulate that the contractor should not allow the presence of livestock or other domestic animals on the site, and should take measures to discourage and minimize the presence of rodents, birds, insects, feral animals, and any other potential disease vectors.
4. **Cover and Cover Material Management:** Require that the contractor place daily, intermediate, and final covers on the new engineered landfill. Give the contractor the responsibility for developing a cover management plan and verifying that sufficient cover material is available on site for continued landfill operation, as well as closure. The cover management plan should provide details on quantity, storage, and management of cover material, including a total site soil balance and plan for soil storage. It should be the contractor's responsibility to ensure that sufficient cover material is available at the site. If not, it is the contractor's responsibility to procure and transport to the site the cover material from another source at the contractor's expense. The cover management plan also should describe what will be done with excess soil, if there is an excess of soil at the site.
  - **Daily Cover:** Require that the contractor cover the active face of the landfill at the end of each working day to suppress fires at the landfill face, control litter and odors, and discourage the presence of animal vectors. The daily cover material should consist of a minimum of 15 cm of soil or an approved alternative material. The contractor should maintain a daily cover stockpile management area containing sufficient cover material. A minimum of a 10-day supply of daily cover material should be continuously available on site.
  - **Intermediate Cover:** If the contractor does not intend to place additional waste material over an area of the landfill that already has received wastes for a time of 6 months or more, require that the contractor place an intermediate cover over this area. The intermediate cover should consist of a specified minimum thickness of soil.
  - **Final Cover:** After any area of the landfill has reached its final elevation, and no more waste will be placed on the area, you should stipulate in the RFT that the contractor should place final cover.
5. **Dust Management:** Require that the contractor incorporate measures to mitigate dust generation during landfill operation. At any time dust is observed at 1 m or more above the ground surface, the contractor should proceed with dust control measures. At a minimum, the contractor should water any unpaved access road in use at least four times a day. Other dust control measures may include paving of access roads, use of additional water on access roads, and minimizing excavation on windy days.
6. **Environmental Monitoring:** The minimum technical requirements should stipulate the manner in which the environmental performance of the new engineered landfill can be monitored. This should, at a minimum, include the following:
  - **Groundwater Monitoring:** Make the contractor responsible for construction of a minimum number of groundwater monitoring wells. At least one well should be located up-gradient of the engineered landfill site and the rest down-gradient of the site. The actual number and location of the wells should be determined by a qualified hydrogeologist. The contractor should prepare, and provide to the governorate, boring logs and well construction details for each of the monitoring wells. Require that the contractor obtain groundwater samples from these wells at least quarterly. During sampling the groundwater should be analyzed in the field for temperature, pH, and conductivity.

The collected groundwater samples should be sent to an independent, governorate-approved laboratory for analysis of the following parameters:

- *pH.*
- *Conductivity.*
- *Volatile Organic Compounds (VOCs).*
- *Hydrocarbons.*
- *Lead (Pb), Cadmium (Cd), Mercury (Hg), and Zinc (Zn).*

The RFT should require that the contractor should report the results of the field and laboratory analyses to the project administrator. All groundwater collection and analytical procedures should be conducted in accordance the approved groundwater management plan. Make sure that the contractor is aware that they are responsible for all installation, sampling and laboratory costs throughout the duration of the contract.

- **Landfill Gas Monitoring:** Require that the contractor install a landfill gas migration monitoring system. The system should be used to monitor for the migration of landfill gas into on-site structures as well as for off-site subsurface migration. The contractor should monitor on-site structures daily and should monitor the off-site migration system monthly. All monitoring data should be reported to the project administrator. All landfill gas monitoring device installation and monitoring sample collection and analytical procedures should be conducted in accordance the approved landfill gas management plan.
7. **Equipment:** Make the contractor responsible for procurement and maintenance of equipment sufficient to effectively operate the landfill, including back-up equipment. Such equipment should include, but not be limited to, the following:
    - Earth moving equipment.
    - Graders.
    - Compactors.
    - Front-end loaders.
    - Pick-up trucks.
    - Water trucks.
    - Sweepers.
    - Communications equipment.
  8. **Facility and Equipment Maintenance:** Make the contractor responsible for establishing a scheduled equipment maintenance program and conducting routine maintenance on all equipment throughout the duration of the contract. The contractor should maintain all facilities in a manner that does not negatively impact daily operations, site security, or worker health and safety. The contractor should maintain the following items in good working condition capable of performing their intended function:
    - Buildings and other structures including, but not limited to, perimeter fencing, gates, scalehouse, paved surfaces, un-paved surfaces, drainage structures and yard piping, leachate collection and storage facilities, utilities, and truck scales.
    - Mobile equipment including, not limited to: earth moving equipment, graders, front-end loaders, sweepers, dump trucks, water transport trucks, and fire fighting equipment.
  9. **Fire Suppression:** Your RFT should stipulate that the operating site should be equipped with appropriate fire fighting and fire retardant equipment to suppress any fires on the site. This should also require that all buildings located on the site be constructed of fire resistant/retardant materials and maintain fire extinguishers.
  10. **Hours and Days of Operation:** You should stipulate that the days of the week and time the landfill must be open and/or closed.
  11. **Landfill Entrance:** The RFT should stipulate that only one vehicle entrance will be provided. All vehicles should enter and leave the site from this entrance.
  12. **Landfill Gas:** Require that the contractor install and operate a landfill gas control system if it has been determined that landfill gas generation is occurring at the site, or when required by regulation.
  13. **Litter Control:** You should make the contractor responsible for collecting and properly disposing of litter inside the site and along the access road to the landfill and any wind blown litter originating from the landfill. The site should have appropriate fencing to prevent wind blown litter from leaving the site. On a daily basis, require that designated contractor personnel inspect the entire perimeter of the facility and collect all litter within the first 50 m outside the site boundary and along the

access road. The RFT should require that the contractor keep the access road, entrance area, office area, and the scalehouse area free from litter at all times.

14. **Regulatory Compliance:** Stipulate that the contractor will be required to construct, operate, and close the existing disposal area and the new engineered landfill in compliance with all permitting and environmental regulations and health and safety regulations at all times throughout the duration of the contract. In case of non-compliance, make it necessary for the contractor to notify you and the appropriate regulatory authority within 24 hours.
15. **Safety and Communications:** Require the contractor to develop a site-specific safety and communications plan. At a minimum, this should require that all contractor staff should receive training in health and safety, and emergency response procedures. Require that the site be equipped with telephone service to call for emergency medical assistance in the event of a serious worker injury. The contractor should stock and provide emergency first aid kits for use in an event of an injury. The contractor's employees should be required to wear, personal protective equipment including, but not limited to, foot protection, hard hats, visual safety vests, and dust masks. The contractor also should provide hard hats and dust masks for site visitors. The contractor should conduct a monthly safety inspection of the entire facility and inspect the condition and upkeep of all required personal protective equipment in use and in storage.
16. **Scalehouse:** Require that all incoming waste collection vehicles be weighed prior to dumping their waste load. Vehicles also should be weighed after emptying their loads if a previous certified empty weight has not been established for that vehicle. At the scalehouse, vehicles should be directed utilizing a manual flagging system or an automated traffic signal. Require that the contractor ensure that vehicle queuing time at the scalehouse is kept to a minimum, especially during peak delivery times. Make the contractor be responsible for timely scheduled maintenance and calibration of the platform scales throughout the term of the contract. All maintenance and calibration procedures should conform to manufacturer specifications.
17. **Scavenging:** Require the contractor to forbid all employees, subcontractors, or the general public from informally scavenging any waste delivered to the engineered landfill. Give the contractor the right to isolate and sort out bulky items for recycling from the delivered waste. Bulky items include large appliances, furniture, and large metal objects. Any contractor activity associated with on-site sorting or recycling should be confined to a dedicated area of the site located away from the landfill face. Salvaged and sorted items should be removed, sold, or landfilled within 2 months of its recovery. The contractor should not permanently store any waste or recovered waste items at the site.
18. **Security:** Whenever the landfill areas are closed for holidays or for any other reason, require that the entrance gate be closed and locked to prevent vandalism and uncontrolled dumping of waste at the landfill. Security should be provided 24 hours per day at the landfill entrance gate. Contractor security personnel should be responsible for preventing unauthorized entry to the site.
19. **Site Life:** You should require that the design and operations be prepared and undertaken in a manner that will maximize the life of the engineered landfill site. The design criteria that you should stipulate should include a  $700 \text{ kg/m}^3$  or better in-place average compaction density.
20. **Site Signage:** Require that the contractor post a sign(s) at the site entrance identifying the site name, address, telephone number, and the contractor's name. The sign(s) also should list acceptable and unacceptable wastes, hours and days of operation, and the 24-hour telephone number of the customer service office.
21. You should also require that the contractor post a sign every 500 m along the site fencing stating the site name, that entry to the site is through the front gate only, that dumping outside the site is illegal, and providing the 24-hour telephone number of the customer service office. All lettering on all signs should be in both Arabic and English and a minimum of 8 cm in height.
22. **Source of Waste:** The RFT should clearly state that the landfill will only accept wastes generated in the defined service area.
23. **Staffing and Management:** Require the contractor to provide at a minimum the following staffing:

- Landfill manager.
  - Shift supervisors.
  - Scalehouse operators.
  - Equipment operators.
  - Mechanics.
  - Laborers.
24. **Training:** Through the technical specifications, require that landfill operators be trained on a number of matters for effective operation of the disposal site. These include:
- Operating responsibilities.
  - Identification of dangerous waste.
  - Effective management and handling of dangerous materials, if received.
  - Health and safety.
  - Waste control and receipt procedures.
  - Landfill administrative procedures (permit review, etc.).
  - Field mechanized equipment operation and maintenance procedures (for equipment operators).
  - Environmental monitoring primarily groundwater.
  - Fire elimination and prevention.
25. **Waste Compaction:** The technical document service specifications should stipulate that the waste placed in the landfill be compacted to an average in-place waste compaction density of 700 kg/m<sup>3</sup>, or greater.
26. **Waste Receipt Control:** The RFT technical specifications should require that waste control procedures be adopted at the landfill to minimize environmental and health/safety effects relating to some types of waste materials. You should stipulate that the contractor will be responsible for training landfill operators to identify particularly dangerous waste materials to limit exposure to their properties. At a minimum, the following waste receipt rules should be stipulated in the RFT:
- Only authorized waste transporters should be allowed to use the disposal facility. The current permit program should be expanded to require permit scrutiny and inspection of all loads received from industrial sources.
  - No liquids should be allowed to be deposited in the landfill including full or partially full containers.
  - Any loads with evidence of fire should be offloaded in the hot load area and the fire immediately extinguished using soil cover or water from the quarry.
  - Scavengers should not be allowed to forage for any materials deposited at the landfill.
  - All waste delivery vehicles should be required to leave the disposal site as soon as they have completed off-loading.
  - No waste should be allowed to be delivered at any time when the disposal site is not staffed.
27. **Weighing and Materials Classification System:** Require that the contractor should maintain a system for classifying, weighing, and recording all incoming waste and specific vehicle information. Incoming waste should be classified by the following categories:
- Residential and commercial waste.
  - Industrial waste.
  - Treated medical waste residue.
  - Residue from composting facility(s).
  - Residue from recycling facility(s).
  - Construction and demolition waste.
  - Accumulated waste.
  - Sludge or other special wastes.
  - Vehicle type.
  - Vehicle gross and tare weight.
  - Vehicle license number or truck number and contractor.

## Reporting

1. **Monthly Operations Report:** You should require that each monthly operations report be submitted no later than the 15<sup>th</sup> day of the following month. Require that each monthly operations report include, and not be limited to, the following information:

- Total quantity of solid waste landfilled during the month based on scalehouse records by type and tonnage.
- Volume of landfill used.
- Average in-place waste density.
- Percent of total airspace used.
- Areas of the landfill receiving waste.
- Areas of the landfill receiving intermediate or final cover.
- Groundwater and landfill gas monitoring results, and remedial actions taken, if any.
- Quantities of leachate collected and treated.
- Storm events, if any, and an assessment of the surface water management system's performance.
- Specific equipment problems during that month.
- An updated list of equipment and vehicles bought or disposed by the contractor.
- Staffing issues or changes.
- An updated list of supervisory personnel at the engineered landfill.
- Injuries or other labor problems during that month.
- Description of any non-compliance or violations of law or regulations and their resolution.
- List of complaints during the month and their resolution.

2. **Annual Operations Report:** Require that annual operations reports be submitted to the project administrator within a 30-day period following the end of the preceding contract year. Each annual operations report should include, and not be limited to, the following information:

- Total quantity of solid waste landfilled during the year based on scalehouse records by type and tonnage.
- Volume of landfill used.
- Average in-place waste density.
- Percent of total airspace used.
- Areas of the landfill receiving waste.
- Areas of the landfill receiving intermediate or final cover.
- A summary of annual groundwater and landfill gas monitoring results, and remedial actions taken, if any.
- Quantities of leachate collected and treated during the year.
- An updated list of equipment and vehicles bought or disposed by the contractor during the year.
- An updated list of staffing changes and labor problems or issues during the year.
- A summary of any non-compliance or violations of law or regulations during the year and their resolution.
- A summary of complaints during the year and their resolution.
- Proposals for contract changes that will increase operating efficiency.

## Landfill Closure

You should make the contractor responsible for closure of the engineered landfill and the existing disposal area. The contractor should conduct all closure activities in accordance with the approved closure plan.

# APPENDIX C: RECOMMENDED MINIMUM STANDARDS FOR ENVIRONMENTAL IMPACT ASSESSMENT

## Environmental Impact Assessment

An Environmental Impact Assessment (EIA) of existing or proposed disposal sites should address each phase of a landfill development project including:

1. Site preparation and construction (the construction phase).
2. Landfill operation (the operations phase).
3. Closure and post-closure care (the post-closure phase).

The EIA should specifically contain descriptions of the activities or information that relates to each of the above project phases. This appendix is intended to define the type of information that should be investigated or evaluated. Your specific circumstances should define the issues that are a high priority in your region. At a minimum, this should include the following:

### Construction Phase Activities

- Clearing, leveling, and/or excavating of the disposal site or new sections of an existing site.
- Construction of surface water control structures such as berms or drainage ditches.
- Construction of access and on-site roads.
- Construction or installation of soil or synthetic liners.
- Construction of leachate collection, retention, recirculation, or treatment facilities.
- Construction of landfill gas collection, ventilation, or treatment systems.
- Installation of monitoring systems for ground/surface water, air and noise pollution.
- Construction or installation of fences, gate, office, scales, water and power supplies, sanitation facilities, garage and workshop for heavy equipment and vehicles, cover soil storage, and other facilities.
- Estimate of the traffic volume to be experienced during site preparation and construction.

### Operations Phase Activities

- Projected airspace volume of the disposal area for the entire landfill operation period.
- Projected volume and composition of the various types of solid waste to be landfilled.
- Projected volume and type of cover material required to provide daily, intermediate, and final cover.
- Operational plan or schedule for waste placement.
- Cover and compaction of solid waste.
- Extension and construction of on-site roads to the landfill workface.
- Excavation of soil for use as cover material.
- Estimate of traffic volume to be experienced during the operations phase.

### Post-Closure Phase Activities

- Projected volume and type of final cover material including top soil to be used for final closure cover.
- Landfill closure process detailing final capping schedule, removal and abandonment of systems that will no longer be needed, establishing monitoring facilities for post-closure care, etc.
- Projected final topography of the site.
- Post-closure monitoring, inspection and maintenance plan.
- Post-closure land use plan.

### General Items and Activities for all Phases

- Projected cost of construction, operation and maintenance of the site and facilities referenced above.
- Contingency plan for emergencies.

- Project site plans and design drawings showing the site and facilities, and maps showing the location of nearby human settlements and other land uses.

## **Description of Existing Conditions**

As much as possible, existing information should be collected and used. However, site-specific field surveys may be required to supplement existing information. All data should be summarized through text and graphics. The following is a general listing of information that should be generated for the EIA:

### **Topography and Land Use**

- General and topographic map(s) showing the site, surrounding municipalities, water bodies, etc.
- Current land use.
- Photographs of the site and its relevant features.

### **Geology**

- Surficial geology of the site and surrounding areas.
- Soil characteristics of the site (e.g., permeability, porosity, density, profile, organic content, etc.).
- Geological hazards, slope stability, earthquakes and landslides history, seismological survey.

### **Meteorology**

- General description of the climate in the region.
- Meteorological data, including:
  - Temperature (monthly averages).
  - Rainfall (monthly averages), intensity (24-hour duration), number of rainy days.
  - Wind (frequency distribution of strength and direction, presented in wind roses, if possible).

### **Hydrology and Water Resources (when applicable)**

- Surface hydrology of the site and surroundings including:
  - Natural drainage patterns.
  - Definition of watershed areas.
  - Stream flow rates (if gauging stations are available).
  - Estimates of discharges or flow rates from the site, and seasonal changes in the flow rates.
- Hydrogeology of the site and surroundings:
  - Groundwater aquifer delineation.
  - Groundwater table depth.
  - Estimates of groundwater flow rates.
- Water resources and uses in the watershed or region:
  - Drinking water wells.
  - Springs.
  - Commercial and sport fisheries.
  - Irrigation canals or structures.

### **Air Quality and Noise**

- Ambient noise levels at and near the site.
- Ambient levels of primary air pollutants.
- Extent of odors at or near the site.

### **Socioeconomic Environment**

The EIA should include a socioeconomic profile of the municipalities, villages, or settlements adjacent to or near the proposed landfill site. The information that should be included in this profile includes the following:

- Administrative boundaries.
- Population, its distribution, density, and characteristics (age, sex, and education level).
- Industries, employment and productivity statistics.
- Transportation and traffic conditions.
- Health status data including morbidity and mortality rates available and health care facilities.
- Number of households that will be directly affected by the project.

The EIA should include a discussion on the future and developments of the site and surroundings if the implementation of the proposed landfill project did not go forward.

### **Assessment of Potential Environmental Impacts**

The potential environmental impacts of each of the above landfill project phases should be evaluated and presented quantitatively and qualitatively. Particularly important items to be addressed are shown below:

#### **Geology and Hydrology**

1. Construction and operation phases:
  - Erosion and sedimentation problems during and following site clearing and leveling, soil covering, etc.
  - Changes in drainage patterns which may affect water resources and wildlife habitat.
  - Likelihood of flooding and landslides due to changes in geomorphology and slope stability.
2. Post-closure phase:
  - Land subsidence due to decomposition of organic waste.

#### **Water Quality**

1. Construction phase:
  - Increase in turbidity of surface water due to surface soil erosion and airborne dust deposition.
2. Operation phase:
  - Increase in turbidity of surface water due to surface soil erosion and airborne dust deposition.
  - Increase in suspended solids, biochemical oxygen demand (BOD), and other pollutants due to solid waste entering surface water bodies.
  - Surface water pollution due to leachate from the site.
  - Groundwater pollution due to leachate from the site.
  - Residual impacts on water quality when leachate collection and treatment facilities are provided.
  - Impacts on water quality due to structural failure, surface drainage and leachate collection and treatment facilities.
3. Post-closure phase:
  - All the same items as defined for the construction and operation phases if final cover, surface drainage, and leachate collection and treatment facilities are not provided.
  - Impacts on water quality due to structural failure of final cover, surface drainage, and leachate collection and treatment facilities.

#### **Air Quality and Noise**

1. Construction phase:
  - Dust and particulates during site clearing, leveling, excavating, etc., and access road construction.
  - Sulfur and nitrogen oxides, carbon monoxide, etc. from vehicle emissions.
  - Noise due to traffic and heavy equipment works.
2. Operation phase:



- All the items as in construction phase.
  - Airborne or windblown particulates of solid waste.
  - Odor and biogas due to biodegradation of organic waste.
  - Toxic gas from chemical waste.
  - Particulates and toxic gas due to open burning.
3. Post-closure phase:
- All the items as in operation phase if final cover and appropriate gas extraction and disposal systems are not provided.

### **Flora and Fauna**

1. Construction and operation phases:
- Removal of vegetation and wildlife habitat due to site clearing, leveling, etc. general disturbance of wildlife in the surrounding areas due to increased traffic and heavy equipment works.
2. Post-closure phase:
- Site rehabilitation works.
  - Disturbance due to water quality degradation and gas emission.

### **Visual Impacts**

1. Construction and operation phases:
- Loss of green due to removal of vegetation.
  - Changes in landscape.
2. Post-closure phase:
- Final topography that may not be well matched with the surrounding landscape.

### **Socioeconomic and Cultural Impacts**

1. Construction and operation phases:
- Resettlement of people living on or around the project site.
  - Potential decreases in crop yields and fish catch, due to water pollution or decreased water availability.
  - Impacts of enhanced traffic: dust, noise, and safety.
  - Potentially increased risk of open and subsurface fire public health problems due to the breeding of flies and vermin.
  - Health and sanitation problems due to inadequate housing and sanitation structures of the laborers.
  - Compromised safety of workers due to inadequate provision of facilities and equipment.
  - Peace and order problems due to strong increase in the number of non-local laborers.
2. Post-closure phase:
- Post-closure land use and increase/decrease in land value.
  - Fire hazards and landfill gas emission.

### **Evaluation of Mitigating Measures**

The EIA should list and discuss all of the necessary mitigating measures to minimize the identified adverse impacts as outlined above. The structural and operational mitigation measures are normally incorporated in the design and operational management plan for the facility. Some commonly applied mitigation measures include:

### **Geology and Hydrology**

1. Construction and operation phases:
- Construction of dikes/berms and drainage channels to control hydrological impacts.
  - Vegetation cover, sediment control systems, and planting of disturbed areas to prevent erosion and siltation.
  - Design consideration for the slope of landfill, and contingency planning for landslides and flooding.

2. Post-closure phase:
  - Post-closure land use plan to prevent construction of heavy structures.

### **Water Quality**

1. Construction and operation phases:
  - Sediment control and vegetation of disturbed areas to prevent erosion and siltation.
  - Construction of a drainage system to collect polluted surface run-off.
  - Application of liners to intercept leachate.
  - Construction of leachate collection systems.
  - Construction of a wastewater/leachate treatment system to treat polluted surface run-off and/or leachate.
2. Post-closure phase:
  - Application of final cover to reduce surface water pollution design of final slope to reduce leachate production.
  - Contingency planning for structural failure.

### **Air Quality and Noise**

1. Construction phase:
  - Minimization of dust generation by sprinkling stockpiles of removed earth and dusty roads with water.
  - Choose working hours and use larger vehicles to reduce noise and air pollution levels due to traffic.
2. Operation phase:
  - All the same items presented for the construction phase above.
  - Application of daily cover to prevent odors and airborne waste.
  - Application of a mobile or permanent fence to capture windblown waste.
  - Construction of a gas collection and disposal systems.
3. Post-closure phase:
  - Application of final cover to prevent airborne waste.
  - Contingency planning for possible structural failure of the landfill mass.

### **Flora and Fauna**

1. Construction and operation phases:
  - Construction of buffer zones by planting trees, etc.
  - Construction of artificial wildlife habitat such as artificial wetlands.
2. Post-closure phase:
  - Revegetation of the site after closure or temporarily to prevent excessive erosion.

### **Visual Impacts**

1. Construction and operation phases:
  - Construction of buffer zones by planting trees, etc.
2. Post-closure phase:
  - Revegetation of the site.
  - Design of final topography considering the surrounding landscape and future land use.

### **Socioeconomic and Cultural Impacts**

- Compensation measures for affected or resettled people.
- Planning for the information campaign and dialogue with the population affected by the proposed disposal area.
- Improvement of working environment, including protection measures for employees such as the provision of training, and safety equipment, respiratory and hearing protection devices, first aid kits, etc.
- Contingency plan involving local communities and workers.









# SOLID WASTE TECHNICAL ASSISTANCE



Ministry of State for Environmental Affairs



U.S. Agency for International Development



Egyptian Environmental Policy Program