

CHAPTER 3 ISSUES OF SAFE CLOSURE OF LANDFILL SITES

As a result of baseline survey in the first stage of the Study, the following issues caused by the landfill sites were observed. They include institutional and financial aspects as well as environmental and technical aspects. It was confirmed that guideline which provides regulations and action plans should be formulated, and landfill safe closure should be implemented in line with them in order to overcome the issues and implement appropriate measures for landfill safe closure. The guideline for safe closure and action plan are shown in **Chapter 4** and **Chapter 5** respectively. Outline of the pilot projects, which are implemented in order to verify the technical requirements to be regulated in the guideline for safe closure, is shown in **Chapter 6**.

3.1 LANDFILL SITES IN MALAYSIA

3.1.1 Findings and Issues of Landfill Sites in Malaysia

Approximately 170 landfill sites are in operations and about 60 landfill sites have been closed. The list of existing/operating landfill sites as prepared by MHLG is summarised in **Table 3.1.1**. The list of closed landfill sites is summarised in **Table 3.1.2**.

The followings are a summary of the findings and issues of the landfill sites in Malaysia.

- Of the 171 landfill sites, 48% of them (83 sites) are operated as so called “open dumping” grounds. These sites have been attributed as the main source of environmental pollution. Such includes waste scattering, offensive odour, insect infestation, surface and groundwater pollution, leachate problems, etc.
- Measures for the collection and treatment of leachate have not been addressed for 90% (155 sites) of the existing landfill sites. Only about 10% of them are classified as sanitary landfill with some degree of environmental protection and consideration toward the facilities and operations.
- In the States of Johor, Negeri Sembilan, Kelantan, Sarawak and Sabah, most of landfill sites are categorised below Level 1. The ratios are 89%, 91%, 92%, 94% and 95%, respectively.
- During the last 10 years, about 50 landfill sites (or about 80% of the total number of closed sites) were closed without consideration for safe closure or any environmental countermeasures. Therefore, the environmental pollution and risk to the surroundings of the closed landfill sites are wide spread.

- It is reported that about 46% of the existing landfill sites will exceed their capacity soon and shall be closed within the next 5 years.
- Based on the *National Strategic Plan for Solid Waste Management*, landfill sites in Peninsular Malaysia shall be rationalised. Therefore, most of existing landfill sites shall be replaced or closed in the near future.
- There is no guideline published by MHLG officially on the planning, design and operation, and safe closure of landfill sites. Most Local Authorities applied their own procedures and techniques and thus resulted in poorly operated and managed landfill sites.

Examples of some of the poorly managed sites are;

- ❖ In Ampang Jaya landfill site in Selangor, landslide occurred in 1998 and two workers lost their lives. This was due to bad site location and improper operation techniques.
- ❖ In the Paka I closed landfill site in KL, long houses were constructed on the closed site for post closure utilisation. Due to uneven land settlement, the houses subsided and the drains damaged. This was due to the improper utilisation of closed landfill site.
- The financial capability of Local Authorities for landfill construction and operation is very limited; therefore, majority of the landfill sites operated by the Local Authority are in rather poor conditions. Similarly, landfill closures were not carried out properly.

In order to prevent environmental pollution, to maintain a healthy environment and introduce the proper post-closure utilisation of landfill sites, the safe closure of existing landfill sites and rehabilitation of closed landfill sites are two main issues in Malaysia that should be addressed urgently.

Table 3.1.1 Existing Landfill Sites in Malaysia

| No | States | Number of landfill | Average area (ha) | Waste received (ton/day) | Landfill level | | | | |
|----|-------------|--------------------|-------------------|--------------------------|----------------|---------|---------|---------|---------|
| | | | | | Level 0 | Level 1 | Level 2 | Level 3 | Level 4 |
| 1 | Johor | 18 | 5.6 | 1,082 | 10 | 6 | 2 | 1 | 0 |
| 2 | Melaka | 4 | 18.5 | 1,065 | 2 | 0 | 1 | 1 | 0 |
| 3 | N. Sembilan | 11 | 10.9 | 727 | 7 | 3 | 1 | 0 | 0 |
| 4 | Selangor | 14 | 10.6 | 2,285 | 0 | 7 | 1 | 1 | 5 |
| 5 | Pahang | 14 | 8.7 | 895 | 5 | 3 | 2 | 3 | 1 |
| 6 | Terengganu | 8 | 5.6 | 707 | 2 | 4 | 1 | 0 | 1 |
| 7 | Kelantan | 12 | 5.6 | 424 | 10 | 1 | 1 | 0 | 0 |
| 8 | Perak | 19 | 10.3 | 1,450 | 9 | 6 | 3 | 1 | 0 |
| 9 | Kedah | 10 | 7.7 | 893 | 3 | 2 | 4 | 0 | 1 |
| 10 | P. Pinang | 2 | 22.3 | 1,400 | 0 | 0 | 1 | 1 | 0 |

| | | | | | | | | | |
|-------|---------|-----|------|--------|-----------|-----------|-----------|---------|---------|
| 11 | Perlis | 1 | 4.0 | 100 | 0 | 0 | 0 | 0 | 1 |
| 12 | Sarawak | 36 | 2.9 | 1,000 | 20 | 14 | 2 | 0 | 0 |
| 13 | Sabah | 20 | 21.7 | 851 | 15 | 4 | 1 | 0 | 0 |
| 14 | KL | 1 | 12.0 | 600 | 0 | 0 | 1 | 0 | 0 |
| 15 | Labuan | 1 | 12.1 | 12 | 0 | 1 | 0 | 0 | 0 |
| Total | | 171 | 9.1 | 13,491 | 83 48% | 51 30% | 21 12% | 8 5% | 9 5% |

Notes: Level 0: Open dumping
 Level 1: Controlled tipping
 Level 2: Controlled landfill with bund and daily cover soil
 Level 3: Sanitary landfill with leachate recirculation system
 Level 4: Sanitary landfill with leachate treatment system

Source: MHLG, 2001

Table 3.1.2 Closed Landfill Sites in Malaysia

| No | States | Number of closed landfill site | Average operation period (years) | Operation start year | | | Landfill closed year | | |
|-------|-------------|--------------------------------|----------------------------------|----------------------|-----------|-----------|----------------------|-----------|-----------|
| | | | | 1970' | 1980' | 1990' | - 1994 | 1995-1999 | 2000 - |
| 1 | Johor | 7 | 7 | 2 | 2 | 3 | 0 | 4 | 3 |
| 2 | Melaka | 4 | 20 | 2 | 2 | 0 | 1 | 0 | 3 |
| 3 | N. Sembilan | 1 | n.a. | 0 | 1 | 0 | n.a. | n.a. | n.a. |
| 4 | Selangor | 9 | 8 | 0 | 4 | 5 | 1 | 7 | 1 |
| 5 | Pahang | 9 | 8 | 0 | 2 | 7 | 0 | 1 | 8 |
| 6 | Terengganu | 7 | 13 | 1 | 3 | 3 | 2 | 4 | 1 |
| 7 | Kelantan | 5 | 12 | 0 | 3 | 2 | 0 | 2 | 3 |
| 8 | Perak | 4 | 9 | 1 | 1 | 2 | 1 | 2 | 1 |
| 9 | Kedah | 5 | 8 | 3 | 1 | 1 | 3 | 0 | 2 |
| 10 | P. Pinang | 0 | -- | -- | -- | -- | -- | -- | -- |
| 11 | Perlis | 0 | -- | -- | -- | -- | -- | -- | -- |
| 12 | Sarawak | 5 | 12 | 1 | 4 | 0 | 1 | 2 | 2 |
| 13 | Sabah | 5 | 13 | 2 | 2 | 1 | 3 | 1 | 1 |
| Total | | 59 | 9.3 | 12 20% | 25 41% | 24 39% | 12 20% | 23 39% | 24 41% |

Source: MHLG, 2001

The list of landfills prepared through the *National Strategic Plan for Solid Waste Management in Malaysia* is shown in **Table 3.1.3**.

Table 3.1.3 Existing Landfill Sites in Peninsular Malaysia

| No | States | No. of landfill | Landfill level | | | | | Lifespan of landfills (years) | | | | |
|----|-------------|-----------------|----------------|---------|---------|---------|---------|-------------------------------|------|-------|-------|------|
| | | | Level 0 | Level 1 | Level 2 | Level 3 | Level 4 | 0-5 | 6-10 | 11-15 | 16-20 | > 20 |
| 1 | Johor | 24 | 11 | 8 | 4 | 1 | 0 | 11 | 5 | 5 | 1 | 1 |
| 2 | Melaka | 3 | 2 | 0 | 1 | 0 | 0 | 2 | 1 | 0 | 0 | 0 |
| 3 | N. Sembilan | 10 | 6 | 3 | 1 | 0 | 0 | 2 | 3 | 0 | 2 | 3 |
| 4 | Selangor | 11 | 0 | 7 | 1 | 1 | 2 | 5 | 0 | 1 | 4 | 1 |
| 5 | Pahang | 14 | 5 | 3 | 2 | 3 | 1 | 8 | 2 | 1 | 0 | 1 |
| 6 | Terengganu | 8 | 2 | 4 | 1 | 0 | 1 | 2 | 3 | 1 | 0 | 2 |
| 7 | Kelantan | 12 | 10 | 1 | 1 | 0 | 0 | 5 | 4 | 1 | 0 | 1 |

| | | | | | | | | | | | | |
|-------|-----------|--------------|-----------|-----------|-----------|---------|---------|-----------|-----------|-----------|-----------|-----------|
| 8 | Perak | 18 | 9 | 5 | 2 | 1 | 1 | 12 | 2 | 0 | 1 | 1 |
| 9 | Kedah | 9 | 3 | 2 | 3 | 0 | 1 | 1 | 3 | 2 | 1 | 1 |
| 10 | P. Pinang | 2 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 |
| 11 | Perlis | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| Total | | 112 (105) | 48 43% | 33 30% | 17 15% | 7 6% | 7 6% | 48 46% | 23 22% | 12 11% | 10 10% | 12 11% |

Note: These data were obtained through questionnaire survey. Only 90% Local Authorities have responded at the date of compilation.

Source: MHLG, 2003

It was noted that during the survey carried out by the Study Team, the assignment of the landfill levels were different from those provided by MHLG, those indicated in the NSP and those determined by the Study Inventory. The MHLG list was prepared in 2003, based on data collected the Local Authorities and compiled by MHLG. The list was provided to the Study Team at the start of the Study. The strategic Plan (NSP) list was prepared based on MHLG data collected in 2001 and augmented by the data collected by NSP Study through questionnaire survey to Local Authorities and visits to State Governments. In both cases the facility and operation levels were provided by the LAs. On the other hand the JICA inventory was prepared based on actual site visits and evaluation of the level by the Study Team. **Figure 3.1.1** shows the comparison of landfill facility/operation level between the 3 sources. It should be highlighted that the Study Team concluded the landfill levels are lower than that of MHLG and NSP with more than 50 % of the visited sites classified as level 0, and did not assign the highest Level 4 to any of the landfills in Malaysia.

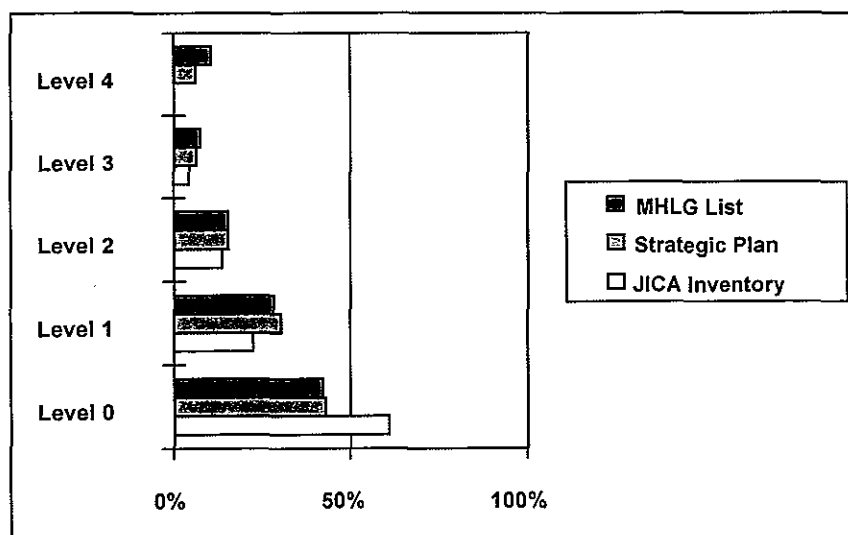
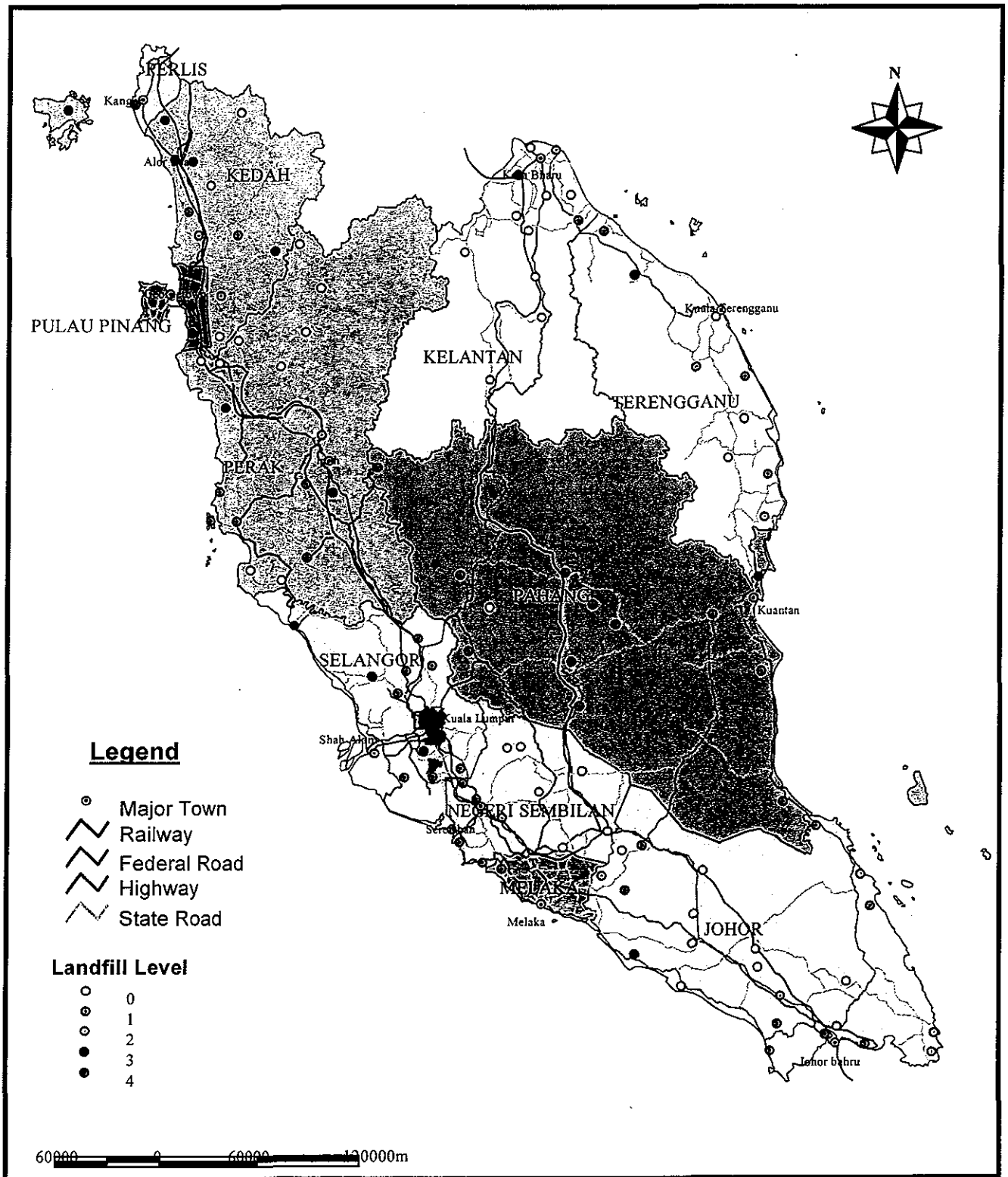


Figure 3.1.1 Comparison of the Landfill Level in Peninsular Malaysia

The location and the level of the landfill sites in the Peninsular Malaysia as prepared by the *National Strategic Plan for Solid Waste Management in Malaysia in 2003* is shown in **Figure 3.1.2**.



Source: National Strategic Plan for Solid Waste Management in Malaysia 2003

Figure 3.1.2 Location and Level of Landfill Sites in Peninsular Malaysia

3.1.2 Photographs of landfill sites in Malaysia

The photographs of some of the operating and closed landfill sites are shown in **Plate 3.1.1**. The photographs were taken during the site survey exercise.

Plate 3.1.1 Photographs of Landfill Sites in Malaysia



Paka 1 Closed Landfill (FTKL)



Kelana Jaya Landfill (MP Petaling Jaya, Selangor)



Telok Kapas Landfill (MP Klang, Selangor)



Sungai Kembong Landfill (MP Kajang, Selangor)



Taman Beringin Landfill Site (DBKL)



Kuala Sawah Closed Landfill (MP Nilai, N. Sembilan)



Sikamat Landfill Site (MP Seremban, N. Sembilan)

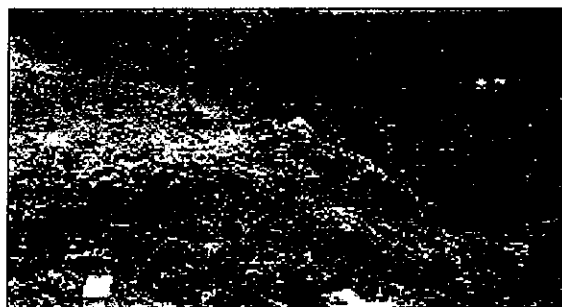


P. Kempas Closed Landfill (MP Port Dickson, N. Sembilan)

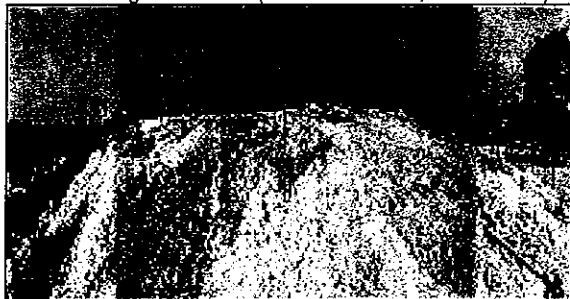
Plate 3.1.1 - Continued



Sua Betong Landfill Site (MP Port Dickson, N. Sembilan)



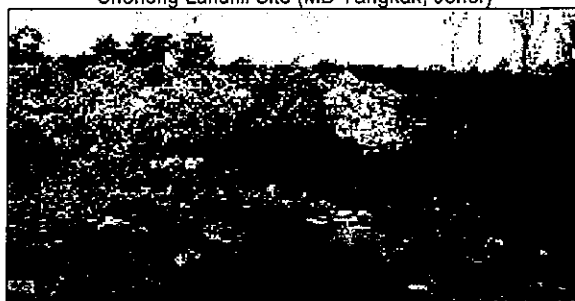
Pulau Sebang Landfill Site (MD Alor Gajah, Melaka)



Chohong Landfill Site (MD Tangkak, Johor)



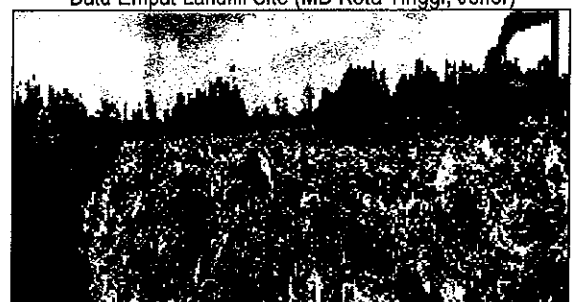
Ulu Tiram Landfill Site (MP JB Tengah, Johor)



Batu Empat Landfill Site (MD Kota Tinggi, Johor)



Jemaluang Landfill Site (MD Mersing, Johor)



Sri Pantai Landfill Site (MD Mersing, Johor)



Pekan Nenasi Landfill Site (MD Pekan, Pahang)



Taman Bandar Closed Landfill (MP Kuantan, Pahang)

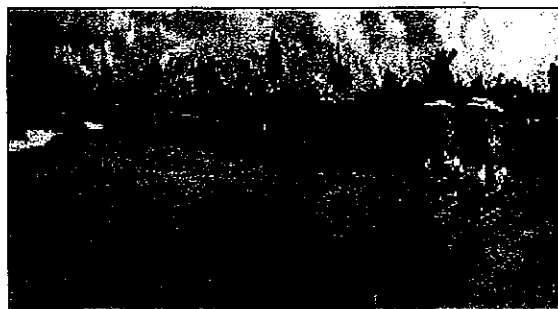


Jabor Jerangau Landfill Site (MP Kuantan, Pahang)

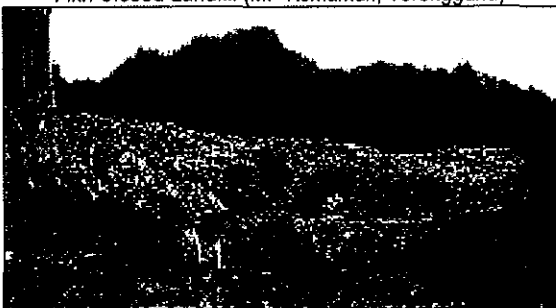
Plate 3.1.1 - Continued



Fikri Closed Landfill (MP Kemaman, Terengganu)



Tok Jembal Closed Landfill (MP K.Terengganu, Terengganu)



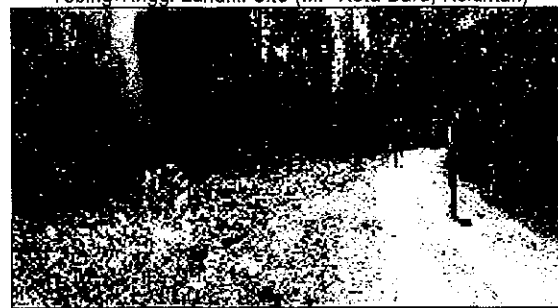
Kubang Ikan Landfill Site (MP K.Terengganu, Terengganu)



Tebing Tinggi Landfill Site (MP Kota Baru, Kelantan)



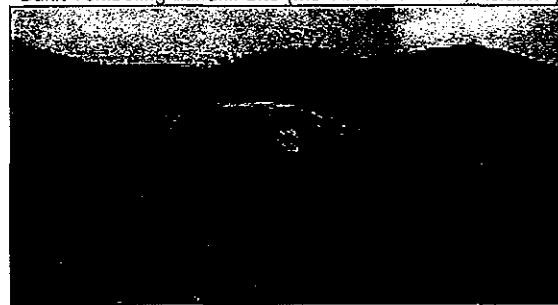
Sungai Sam Landfill Site (MD K.Krai Selatan, Kelantan)



Bukit Tembeling Landfill Site (MD K.Krai Selatan, Kelantan)



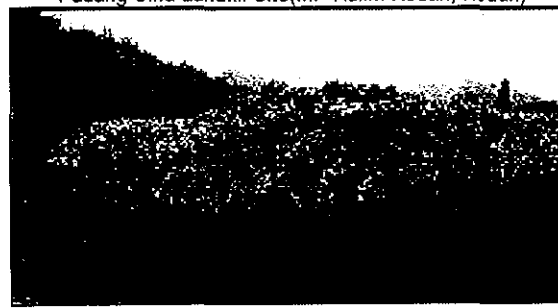
Bidor Landfill Site (MD Tapah, Perak)



Padang Cina Landfill Site (MP Kulim Kedah, Kedah)



Pulai Landfill Site (MD Baling, Perak)



Paya Kemunting Landfill Site (MD Kubang Pasu, Kedah)

3.1.3 Post-closure Land Use Practices and Issues

During the survey, it was noted that several closed landfill sites and areas adjacent to operating landfill sites have been redeveloped as residential areas, for example;

- A 23 storey low cost apartment building is currently under construction at the Kelana Jaya closed landfill site in Petaling Jaya , Selangor.
- A 5 storey apartment building is under construction at the West side of Taman Beringin landfill site in FTKL.
- Long houses were constructed at Paka-1 closed landfill site in FTKL in 1998.

With such developments around the sites, it seemed that consideration on the risk of hazard and environmental pollution caused by the closed landfill sites are not appreciated; i.e. the hazards caused by gas explosion/migration, landslide, landfill fire, health problem etc.

It is imperative that these issues should be highlighted to the Local Authorities and to the developers on the risks of redevelopment of the closed landfill sites.

Some of the photographs taken from the closed landfill site in Kuala Lumpur and Petaling Jaya are shown in **Plate 3.1.2**. Examples of hazardous incidents experiences in other countries are tabulated **Table 3.1.4**.

Plate 3.1.2 Redevelopment of Closed Landfill Sites in Malaysia

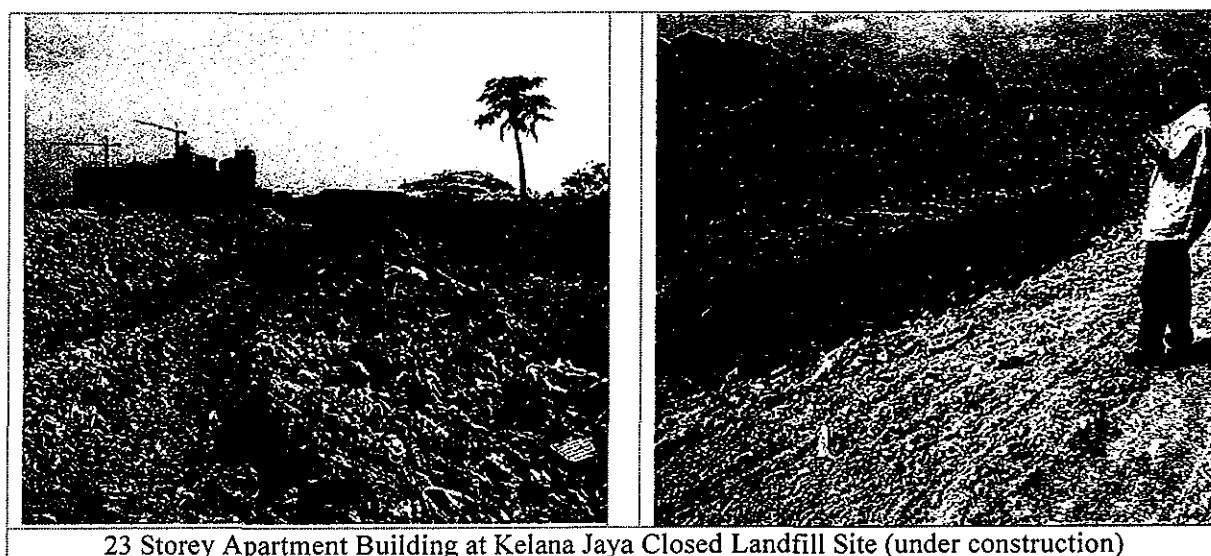


Plate 3.1.2 - Continued

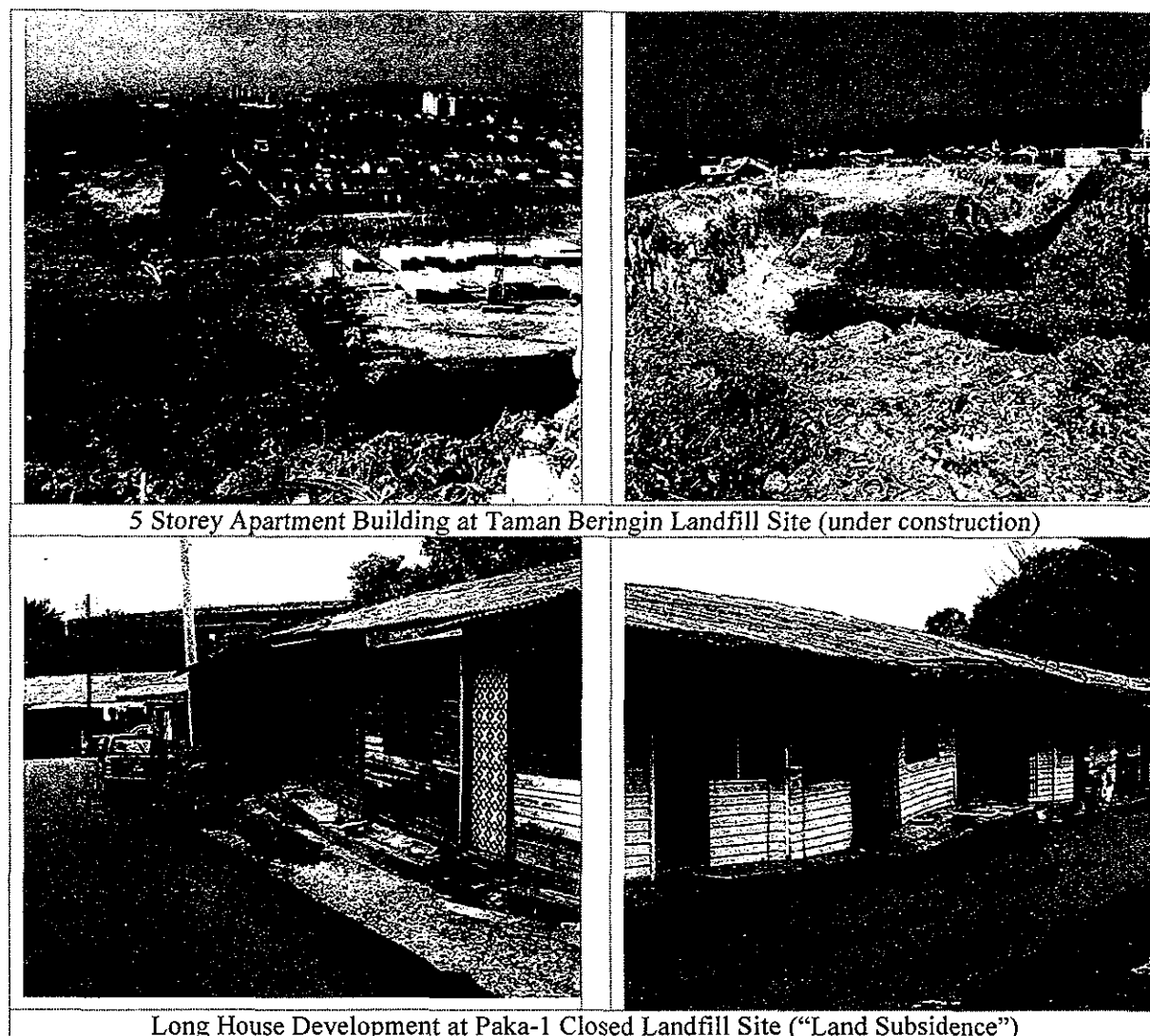


Table 3.1.4 Hazard Experiences Caused by the Landfill Sites in Several Countries

| No | Location | Year | Hazard Types | Outline of the Hazards |
|----|----------------|------|---------------|---|
| 1 | Kobe, Japan | 1977 | Gas explosion | 2 gas explosions occurred in a school in Kobe. As a result of site investigation, the land was found to be an ex-landfill site. The school was closed for half a year to ensure the area was safe for the pupils to return. |
| 2 | Chiba, Japan | n.a. | Gas migration | A carrot farm situated next to the landfill was exposed to the escaping methane gas. The gas and also a rise in temperature caused some damage to the crops. |
| 3 | Fukuoka, Japan | 1999 | Gas breakout | 3 workers were killed when they were exposed to a gust of hydrogen sulphide gas whilst carrying out some digging/boring work at the landfill site. |

| | | | | |
|----|-----------------------|------|--------------------|--|
| 4 | Okinawa, Japan | 2002 | Landfill fire | A fire occurred at a landfill site in Miyako Island which resulted in the release of several types of toxic gases. The local residence experienced and suffered irritations to their eyes and throat. |
| 5 | Selangor, Malaysia | 1998 | Landslide and fire | Landslide occurred at a landfill site in Ampang Jaya, Selangor. It was reported that two people were buried alive. After the incident, the site was immediately closed. |
| 6 | Atlanta, USA | 1999 | Gas explosion | A gas explosion caused an 8-year-old girl to suffer burns on her arms and legs while playing in a playground. The area was later discovered to be an illegal dumping ground many years ago. |
| 7 | North California, USA | 1994 | Gas explosion | A woman was seriously burned by a methane gas explosion while playing soccer in a park that was built over an old landfill site in Charlotte, North Carolina. |
| 8 | Pittsburgh, USA | 1987 | Gas explosion | Off-site gas migration from the landfill caused an explosion in a housing area in Pittsburgh, Pennsylvania. |
| 9 | Ohio, USA | 1984 | Gas explosion | Off-site gas migration from the landfill caused an explosion and destroyed a house in Akron, Ohio. |
| 10 | Cincinnati, USA | 1983 | Gas explosion | Gas explosion caused by the landfill destroyed a house across the street from the site in Cincinnati, Ohio. Some injuries were reported. |
| 11 | Colorado, USA | 1975 | Gas explosion | In Sheridan, Colorado, a gas explosion occurred near the storm drain laid across the site. The explosive gasses accumulated in the drain pipe ignited when a group of children were playing and lighting candles near the drain. The children all suffered serious injuries. |
| 12 | North California, USA | 1969 | Gas explosion | Methane gas migrated from the adjacent landfill leaked into the basement of an armoury in Winston-Salem, North Carolina. The gas ignited when a cigarette was lit thus killing three men and seriously injuring five others. |
| 13 | New York, USA | n.a. | Health problem | On the request from the community near the landfill site, an American agency conducted a public health assessment of the area. The assessment report concluded that there is a potential health risk to the community and may of cause respiratory damage due to hydrogen sulphide gas emitting from the sites although Further study is required. |
| 14 | Philippine | 2000 | Landslide | Heavy rainfall triggered an avalanche at a waste dumping site in the suburb of Quezon City. At least 68 people died and 800 were evacuated to emergency shelters. |
| 15 | Nantygwyddon, UK | n.a. | Health problem | More than 120 residence living near Nantygwyddon landfill site suffered major health problems. At the court, the residence group won a major compensation claim. |

| | | | | |
|----|-----------------------|-------|-----------------------------|---|
| 16 | Bogota, Colombia | 1997 | Landslide | It was reported that 80ha of avalanche at a waste dumping site occurred in Bogota. |
| 17 | Ghemme, Italy | 1992 | Gas explosion | Underground gas migration from the closed landfill site caused an explosion at the nearby industrial plant. |
| 18 | Carate-Brianza, Italy | 1981 | Gas migration | Gas migration from operating landfill sites seeping into nearby industrial facility was reported. |
| 19 | Casate, Switzerland | 1981- | Gas migration | Gas migration from landfill seeping into a home was reported. |
| 20 | Sarajevo, Yugoslavia | 1977 | Landslide and gas explosion | About 200,000 m ³ of avalanche occurred at the landfill site due to stability failure and gas explosions. Horizontal movement was recorded to be over 1 km and a number of nearby houses were burnt. |
| 21 | S. Augustin, Germany | 1981 | Gas migration | Gas migration from nearby landfill site occurred in the subsoil layer resulting in the neighbouring houses had to be evacuated. |
| 22 | Biella, Italy | 1981 | Gas explosion | Gas migrated via the subsoil layer penetrated into the neighbouring house resulting in an explosion that caused the death of the resident. |
| 23 | Cavenago, Italy | 1996 | Gas migration | Landfill gas migrated over a distance of 1 km and caused damage to the vegetation in nearby area. |
| 24 | Los Angeles, USA | 1982 | Landslide | A residential area built on a closed landfill showed cracks on the ground and experienced land movement. |
| 25 | Sacramento, USA | 2002 | Landfill fire | A fire occurred at a landfill site in Sacramento. |
| 26 | West Valley, USA | 2002 | Landfill fire | A fire occurred at a landfill site. It is reported that the fire produced some toxic gases such as carbon monoxide. |
| 27 | Vancouver, Canada | 2000 | Landfill fire | A fire occurred in a landfill site in Vancouver. The total damages and loss by the fire was estimated to be about at \$80,000. |

Note: The above list is in random order.

Sources: Information retrieved and collected from the "Agency for Toxic Substances and Disease Registry (USA)", CNN, BBC, Encos SA (Switzerland), Fire Department in Sacramento & West Valley (USA), MP Ampang Jaya etc.

3.2 NUMBER OF LANDFILL SITES IN MALAYSIA

Based on the landfill inventory survey carried out by the JICA Study Team in March 2003, it was discovered that amongst the 64 landfill sites visited by the JICA team, 29 sites (about 45%, 9 operating and 20 closed sites) were not registered in the official MHLG list of landfill sites, which is tabulated and included in *Volume 7, Data 2*. The summary is shown in **Table 3.2.1**. The landfill sites that were not recorded in the MHLG list are tabulated in **Table 3.2.2**.

Table 3.2.1 Number of Landfill Site visited by Study Team (2003)

| Landfill sites | Number of Landfill Sites visited by the Study Team | | |
|---------------------------|--|----------|----------|
| | Operating | Closed | Total |
| Listed in MHLG's list | 29 (76%) | 6 (33%) | 35 (55%) |
| NOT listed in MHLG's list | 9 (24%) | 20 (77%) | 29 (45%) |
| Total | 38 | 25 | 64 |

Since the inventory survey only managed to visits the landfill sites operated by only 35 out of the 91 Local Authorities in the Peninsular Malaysia, there are still a large number of landfill sites that may not be officially registered with MHLG. Therefore, in order to have a more complete landfill registration and to take necessary action for proper guidance to the Local Authorities, it is recommended that MHLG continue the inventory survey to cover the other sites in Malaysia presently not covered by the Study.

Table 3.2.2 Landfill Site List Not Recorded in MHLG List (as of 2003)

| No | State | Local Authority | Name of Landfill | Status | JICA Inventory No. |
|----|------------|-------------------|-------------------------------|-----------|--------------------|
| 1 | N.Sembilan | MP Nilai | Kuala Sawah | closed | NS-02 |
| 2 | N.Sembilan | MP Port Dickson | Quarters MPPD | closed | NS-04 |
| 3 | N.Sembilan | MP Port Dickson | Pengkalan Kempas | closed | NS-06 |
| 4 | N.Sembilan | MP Port Dickson | Sua Betong | operation | NS-07 |
| 5 | Melaka | MB Melaka | Krubong A | closed | ML-04 |
| 6 | Melaka | MB Melaka | Kota Laksamana | closed | ML-05 |
| 7 | Johor | MP JB Tengah | Kempas | closed | JH-05 |
| 8 | Johor | MD Kota Tinggi | Batu Empat | operation | JH-07 |
| 9 | Johor | MD Kota Tinggi | Sungai Rengit | operation | JH-08 |
| 10 | Johor | MD Kota Tinggi | Bandar Kota Tinggi | closed | JH-09 |
| 11 | Pahang | MP Kuantan | Taman Bandar | closed | PH-03 |
| 12 | Pahang | MP Kuantan | Gambang | closed | PH-04 |
| 13 | Pahang | MP Kuantan | Indera Mahkota | closed | PH-05 |
| 14 | Terengganu | MP Kemaman | Fikri | closed | TR-01 |
| 15 | Terengganu | MP Kemaman | Gelugor | closed | TR-02 |
| 16 | Terengganu | MP Kemaman | Gelugor | operation | TR-03 |
| 17 | Terengganu | MP K.Terengganu | Wakaf Tok Keh | closed | TR-06 |
| 18 | Kelantan | MP Kota Baru | Panji | closed | KL-01 |
| 19 | Kelantan | MP Kota Baru | Tebing Tinggi | operation | KL-02 |
| 20 | Kelantan | MD K.Krai Selatan | Sungai Sam | closed | KL-03 |
| 21 | Kelantan | MD K.Krai Selatan | Bukit Tembeling | operation | KL-04 |
| 22 | Perak | MD Kinta Selatan | Kg. Batu Putih (Kg. Tersusun) | closed | PR-02 |
| 23 | Perak | MD Kinta Selatan | Taman Sri Kampar | closed | PR-03 |
| 24 | Perak | MB Ipoh | Buntong | closed | PR-05 |
| 25 | Perak | MB Taiping | Jebong | operation | PR-06 |
| 26 | Perak | MB Taiping | Tekkah Jaya | closed | PR-07 |
| 27 | Perak | MD Tapah | Pekan Getah | operation | PR-08 |
| 28 | Kedah | MD Baling | Pulai | operation | KD-02 |
| 29 | Kedah | MD Baling | Kuala Pegang | closed | KD-03 |

3.3 ENVIRONMENTAL ISSUES OF LANDFILL SITES

3.3.1 Surface Water

During the site visits in March, 2003, conducted by members of the JICA Study team, it was learned that approximately 16 sites, or 10%, of the landfill sites surveyed are located upstream of the water intake points to the drinking water treatment facilities. These poses a potential risk to the drinking water system and contamination of the water supply. Furthermore, some of the sites discharge and spills their waste material into the river and creates unsightly landscape and environmental problems. It was also learned that a number of such sites were recommended for closure by the Department of Environment. However, there are no specific guidelines or specific instruction for water treatment dealing with the pollution measure such as leachate treatment and cut off.

In the Northern region of the Peninsular Malaysia, there are a number of prawn and shrimp farms that uses the ponds and water from the river sources that have been contaminated. Some of these ponds are situated nearby the landfill site whereby the prawns and shrimps are exposed to the contaminants and may bio-accumulate traces of the hazardous material, such as heavy metals. Thus, the leachate problem is affecting the potable water supply and also presence in our food supply.

3.3.2 Groundwater

There is currently no environmental standard set by the Department of Environment with regards to groundwater conditions. However, the potable water standards as set by the Ministry of Health are commonly used as the benchmark for groundwater monitoring. The parameters for the National Guidelines for Drinking Water Quality are as follows;

Table 3.3.1 National Guidelines for Drinking Water Quality

| Chemical | | Benchmark |
|-----------|-------------------|-----------|
| Sulphate | SO ₄ | 400mg/l |
| Hardness | CaCO ₃ | 500mg/l |
| Nitrate | NO ₃ | 10mg/l |
| Coliform | | 10 MPN |
| Manganese | Mn | 0.2mg/l |
| Chromium | Cr | 0.05mg/l |
| Zinc | Zn | 1.5mg/l |
| Arsenic | As | 0.05mg/l |
| Selenium | Se | 0.01mg/l |
| Chloride | Cl | 250mg/l |
| Phenols | | 0.002mg/l |

| | | |
|------------------------------|----|-----------|
| Total Dissolved Solids (TDS) | | 1500mg/l |
| Iron | Fe | 1mg/l |
| Copper | Cu | 1mg/l |
| Lead | Pb | 0.1mg/l |
| Cadmium | Cd | 0.005mg/l |
| Mercury | Hg | 0.001mg/l |

Source. Ministry of Health

Majority of the landfill sites do not have any countermeasures for groundwater protection such as bottom liners and installation of monitoring wells. Groundwater monitoring conducted by the Department of Environment around the landfill sites reported significant level of contamination. For example, 31% of the samples taken around the landfill site exceeded the benchmark limit for the presence of arsenic, which is a highly toxic chemical.⁸

Fortunately, raw water supply for Malaysia is not heavily dependent on the groundwater sources and thus such sources have minimal risk. However, it is usually the case that such groundwater contamination is not being realised and treated with great urgency until the very late stage of the problem. Proper integration of groundwater protection measure for the landfill site construction, operation, and closure should be looked into urgently and is highly recommended.

Vulnerability of the aquifer system against contamination is dependent on the hydrogeological conditions. For example, thick impervious clay layer near the surface will prevent the penetration of contaminants into the aquifer system. Most of the swampy areas have such clay layers. Flatlands have very little hydrogeological gradient and hence allow slow movement of the groundwater. In contrast, sandy soil profiles near the surface are more pervious and allow contaminants to seep through and the subsequent spreading of the contaminant will be much faster. Many of the former tin mining sites exhibits such characteristics. Therefore, when considering implementing groundwater protection measures, priority must be given to the areas that possess such vulnerable conditions.

The presence of heavy metal also poses a significant problem. As many of the landfill sites are on disused tin mines, there is already the presence of high levels of heavy metals that may have originated from natural source rather than from the leachate. Such heavy metals detected include arsenic, iron, manganese, etc. Such heavy metal presence could have been derived from the dissociation of arsenic present in ferric hydroxide and/or manganese hydroxide by the reductive/anoxic condition caused by the organic decomposition at the landfill sites. Such phenomena

⁸ Department of Environment, "Malaysia Environmental Quality Report 2001", P 49

were discovered in a number of sites in Bangladesh and in Southern Thailand. Further investigation into the course of such contaminants and its reaction should be carried out.

3.3.3 Sanitary Condition (Vector and Odour)

The Local Authorities have received large numbers of complaints from the residents and surrounding communities around the landfill sites regarding the unpleasant odour, fly infestation and large packs of stray dogs around the site. Flies are the main carrier and transmitter of contagious disease and stray dogs have been observed to attack others and possess the risk of spreading of diseases, such as rabies.

There are more complaints from the urban areas whereby the odour problem is the more serious. It was observed that some of the landfill sites have very little fly infestation problem and this could be due to the possibility of the use of insecticides to eradicate the problem. Excessive use of insecticides also possesses an environmental contamination risk.

3.3.4 Land Subsidence and Landfill Gas

There are numbers of closed landfill sites that have been used for housing development. If the landfill closure has not been carried out properly there is the possibility of uneven land settlement and subsidence. Such occurrences are fairly common and are generally unpredictable. Such problems must be taken into consideration when planning to utilise the closed landfill site for redevelopment purposes, especially for building. If proper countermeasures are not taken, land subsidence may result in damages to the buildings and structures. The built up of landfill gas could also pose a hazard and may cause explosions. Similarly, precaution should also be taken against prevention of occupational hazards that may result from the land subsidence and landfill gas during the construction period.

3.3.5 Landslide/Collapse and Fire

The Ampang Jaya landfill site experienced a fire and the subsequent landslide resulted in the death of 2 workers at the site. It was observed that a number of landfill site have waste piled very high and with very steep slopes. With the heavy rainfalls and the absence of embankment in most sites, landslides and slope collapses are very likely to occur. Such landslides are extremely dangerous and will affect the safety of the workers nearby and cause damage to the surrounding area such as spillage of the waste into the valleys and rivers.

Any fire at the sites will produce thick hazardous smoke and releases dioxin and toxic gases into the atmosphere. With the present increasing quantities of plastic and composite material being disposed of at the landfills, the toxic gas problem as the result of fire will become more serious.

3.3.6 Effects to Natural Drainage System

When a landfill is located on a swampy area, it may affect the natural flow of the drainage and surface water flow. This may lead to the destruction of existing plant life and vegetation, and also affects the natural eco-system of the area.

3.3.7 Necessity for Monitoring

To evaluate and manage the environmental effects and impacts caused by the landfill site, systematic monitoring of the leachate, surface water, groundwater, landfill gas and other ambient environment should be carried out. At present, majority of the landfill sites do not have any monitoring plan and it is highly recommended that such plan should be implemented.

3.3.8 Environmental Liabilities – Necessity for Good Record Keeping -

From the site visits, it was noted that a number of closed landfill sites have been transferred to private ownership. There were no records outlining the exact boundary and the characteristic of the sites.

For the closed landfill sites, especially the newly closed sites, the environmental and hazardous incidents may occur. The countermeasure to tackle such incident should be the legal responsibility of the developers or owner of the site. However, in order for the developers to take proper measures and control of the site, precise record of the landfill history and condition should be readily available and information shared. Without such measures and defined responsibilities, complicated legal issues may arise if and when environmental hazard occurs.

In addition to land subsidence and landfill gas problems, soil and groundwater contamination will have serious effects in the future. Such issues are increasingly being realised in Japan and in other industrialised developed nations. Liability for the soil and groundwater contamination may be imposed retroactively. Good record keeping is essential to avoid such serious legal problem in the future.

3.4 RISKS OF REDEVELOPMENT OF THE CLOSED LANDFILL SITES

For the post-closure re-utilisation of the closed landfill site, safety and environmental issues should be considered and counter-measures be formulated with the relevant authorities and agencies in order to prevent future hazards and any undue environmental effects. The issues of concerned are as follows.

- i. Risk of landslide or collapse of filled layer due to new ground loading imposed by the development plan.
- ii. Damage to the infrastructure or sanitation lifelines caused by the subsidence.
- iii. Discharge of leachate into the surrounding ground caused by the development.
- iv. Risk of explosion or fire from landfill gas.
- v. Significant damage to plant life on the site and surroundings, by the landfill gas or soil contamination.
- vi. Risk of unintentional chemical reaction of substances that may be introduces into the site as a result of the development works or the preventive measures works.
- vii. Diversion and prevention of gas migration and rainwater seepage that may be caused by the new land cover put in by the development.

The post closure land use should comply with regulations related to both the solid waste management regulations and the housing and building regulations. Alternatively, during the post-closure management phase, with careful consideration and preparation, the closed landfill site may be used for constructing a playground, park or for agricultural cultivations. Nevertheless, the land user/developer must comply with the landfill site management regulations since the site may still active and not completely stabilised.

3.4.1 Risk of Landslide or Collapse

The planners and developers should always plan and design their development by taking into account the stability of the shape of the site, the waste & soil coverings, and the additional surface load imposed by the new development. The bearing load

of the ground should be determined together with assessing the load balance and physical stability of the slopes.

Where buildings are to be constructed near the slopes, the risk of landslide or collapse must be considered. Developers should design the structures adequately and carry out any slope or ground stabilisation and improvement measures if necessary. Such measure may include the provision of ground anchor system, soil improvement of the dikes and foundations, additional fill at the dike, etc.

3.4.2 Problems of Subsidence

The degree and rate of subsidence at the landfill sites are always uneven and heterogeneous, i.e. differential subsidence from an area to another. On the built-up areas, such uneven settlement will exert enormous stresses on the foundations and may cause the building structures to crack and become unstable. This will also affect underground piping systems such as the water supply pipes, sewerage pipes, electricity supply conduits, etc. All these will cause disruption to supplies and inconvenience to the residents and users.

Continuous monitoring should be carried out to ensure that areas exhibiting major subsidence should not be used for any building purposes.

3.4.3 Risk of Groundwater Pollution

The developers of the landfill site should take careful preventive measures to minimise the groundwater and soil contamination. The recommended measures are to provide baseliners and leachate collection systems. These systems should be maintained regularly during the post-closure management period and continued long after the complete closure of the site. The leachate collection systems should be in operations for as long as necessary in order to lower the leachate quantity and maintain the stability of the site.

During the post-closure period, the leachate will remain a risk to groundwater pollution. The baseliners and leachate collection system should be maintained regularly and they should not be damaged or removed.

In order to prevent landslides, the water table in the filled layers should be kept as low as possible. The leachate drainage system should be in constant use and the leachate flow to the collection and treatment facilities. At the early stages, the leachate may contain heavy pollutants but the leachate quality will improve in time as the waste will have been decomposed and degraded. The leachate quality will eventually be

stabilised. As precautionary measures, the owner or operator of the site should ensure and maintain the following;

- i. The quality of the leachate effluent discharge to the surrounding should not cause further surface water pollution.
- ii. The quality of the leachate effluent should always improve and should not revert to bad again.

It is common for the leachate present inside the waste layers to have high concentrations of pollutants even though the quality of the leachate has been stabilised and maintained low. However, the quality of the leachate may worsen if the site has been disturbed, i.e. by excavations, drilling, loaded, etc.

Therefore, special care should be taken when excavation work or drilling of the site is required.

3.4.4 Risk of Gas Explosion or Fire

The landfill gas contains highly explosive and combustible material, i.e. methane (CH_4), hydrosulphide (H_2S), hydrogen (H_2), etc. These gases are mostly vented to the atmosphere through the ventilation pipes and through the soil top cover. The most hazardous gas present is methane and is highly explosive at the concentration of 5% to 15% by volume in normal atmosphere, and is combustible when it is over 15% in concentration.

The owner or operator should ensure that the concentration of methane gas in the ventilation pipe should be maintained below the 5% level. The concentration of methane and other hazardous gases will eventually decrease due to the decomposition and degradation of the waste with time.

As precautionary measures, the following should be maintained,

- i. The quality of the landfill gases should be monitored so that it should not cause any explosions or fire.
- ii. The quality of landfill gas should always improve and should not revert to bad again.

The quality of the gasses should improve with the decomposition and degradation of the waste. Hence, in order to evaluate the progress of the decomposition and degradation processes, it is particularly useful to monitor the change in the quality of

the leachate and gases together with observations of the ground subsidence, temperature fluctuations, etc.

3.4.5 Damages to the Plant life on the Site and Surroundings

Generally it can be observed that the plant life and vegetation tend not to grow well in and around the landfill site. Majority of the plant life found nearer to the site is either dying or dead due to exposure to landfill gases and soil contamination.

The landfill gases may contain certain phytotoxic substances such as ethylene, acetylene, hydrosulphide that tend to inhibit germination and growth.

The contaminated soil that contains traces of copper (Cu), cadmium (Cd), arsenic (As) and selenium (Se) tend to inhibit plants growth and may even destroy the plant when present at high concentration.

3.4.6 Appropriate Measures against the Pollution and Hazards

The decomposition and degradation processes of the waste in the landfill are exothermic, i.e. heat is generated. During the initial stages of active decomposition, the heat generated within the waste layers could be very high. In some cases the temperatures may reach up to 60°C. With time, as the decomposition and degradation reaction has been stabilised, the temperatures will also decrease.

The fluctuations in the temperature inside the waste layer are a good indicator to evaluate the progress of the decomposition and degradation of the waste. The temperature inside the waste layer should be monitored and recorded through the gas ventilation pipes or at other observation wells at the site. Monitoring and recording the temperature of the leachate is also useful.

3.4.7 Unintentional Chemical Reaction

The waste layers generally contain various concoctions of chemicals from the different types of household waste disposed of at the landfill site. During the rehabilitation or post-closure utilisation of the site, construction works may introduce some other material into the waste layers, such as lime, steel, concrete, etc. The chemical present in the waste layers may react with the chemical present in the construction material. For example, in the case of ammonia stripping, strong alkali such as lime or cement may come in contact with the liquid ammonium ions at the site. The reaction may cause the ions to be liberated as gaseous ammonia, and the ammonia rich gas will escape into the atmosphere. Ammonia is a hazardous gas and can cause irritation to the eyes and causes breathing problems. Similarly, hydrogen

gas may also be generated by the reaction of certain metals with the acids present in the waste.

Generally, with small scale construction works, such chemical reactions may not generated much gas and may not be disastrous. Nevertheless, it is advisable that the developers to ensure they have considered suitable precautionary steps in their construction material selection to prevent unintentional chemical reactions. The steps may be achieved by carrying out simple laboratory test to evaluate the compatibility of the materials.

3.4.8 Change of Surface Covers

After the physical closure of the site, there may still be some landfill gas generated in the waste layer. The gas will migrate and release through the cover soil into the atmosphere. Fresh air may also flow into the waste layer through the cover soil. However, if the top cover is impermeable, i.e. made from material such as concrete or asphalt pavement put in during the re-development work, then the gases will not be able to escape through the top and have to seek other more permeable escape routes. This will cause the gasses to migrate further to other parts of the site and escape through other surfaces, such as grass and vegetation fields, flower garden, etc. The diversion of gas flow may result in the built up of high concentration pockets of the gases and thus may cause damage to the plant life and in some cases even catches on fire.

In order to minimise gas migration that may result in accidents, it is advisable that the developers should consider the use of more diverse surface covering that are more permeable. If such alternative material cannot be used then, adequate gas ventilation system should be provided.

3.5 LEGISLATION, INSTITUTIONAL AND FINANCIAL ISSUES

3.5.1 Legislation Issues

Almost all the landfill sites in Peninsular Malaysia are operated below the Level 2 standard. Of these, about 48% are just open dumping sites. Only 10% of the landfill sites are classified as sanitary landfill where some environmental protection measures such as leachate collection and treatment facilities have been provided.

One of the main factors that contributed to such poor landfill conditions is the lack of official legislation and control on the “landfills”. There are no officially published guidelines for landfill planning, design and operations or safe closure. In recent years, the draft guideline entitled the “*Technical Guideline on Sanitary Landfill*”

(Design and Operation)” was adopted in 1990 and is widely referred to by the Local Authorities. However, the guideline is still in the “draft” status and is in need of review and authorised for full publication.

3.5.2 Institutional and Financial Issues

The safe closure and rehabilitation of landfill sites have not been implemented properly in Malaysia. Since all land matters are under the State Government control, when the landfill site that was operated by the Local Authority is closed the entire site is revert to the State Government. In most cases, majority of the records and documentations pertaining to the operations of the landfill site were never handed over to the State and were usually misplaced and lost. This makes the tasks of tracking and investigation of closed landfill sites very difficult and sometimes impossible.

In 2003, MHLG prepared the “National Strategic Plan for Solid Waste Management” to address issues pertaining to SWM in Malaysia. The National Strategic Plan is still in the draft stages and its contents have not yet made public. Nevertheless, the main objective of the Plan is its attempts to address and to set out the proper direction for the privatisation of the SWM sector, including investments and operations of landfill sites.

One of the main issues for the lack of interest in implementing the safe closure and rehabilitation of landfill sites is solely due to insufficient funds. Without sufficient funds, the Local Authorities are unable to set aside the necessary resources to carry out the operations and maintenance or close the landfills properly.

CHAPTER 4 GUIDELINE FOR SAFE CLOSURE AND REHABILITATION OF MSW LANDFILL SITES

4.1 INTRODUCTION

The main objectives of the study on The Safe Closure and Rehabilitation of Landfill Sites in Malaysia are to formulate the relevant guidelines and setting up of the action plan for the safe closure and rehabilitation of landfill sites that accept predominantly municipal solid waste.

The Guideline is divided into two sections, viz. Part I and Part II. Section I addresses the issues with regards to the general procedures for safe closure, and the legislation, institutional and financial aspects. Section II explains the technical requirements in more details.

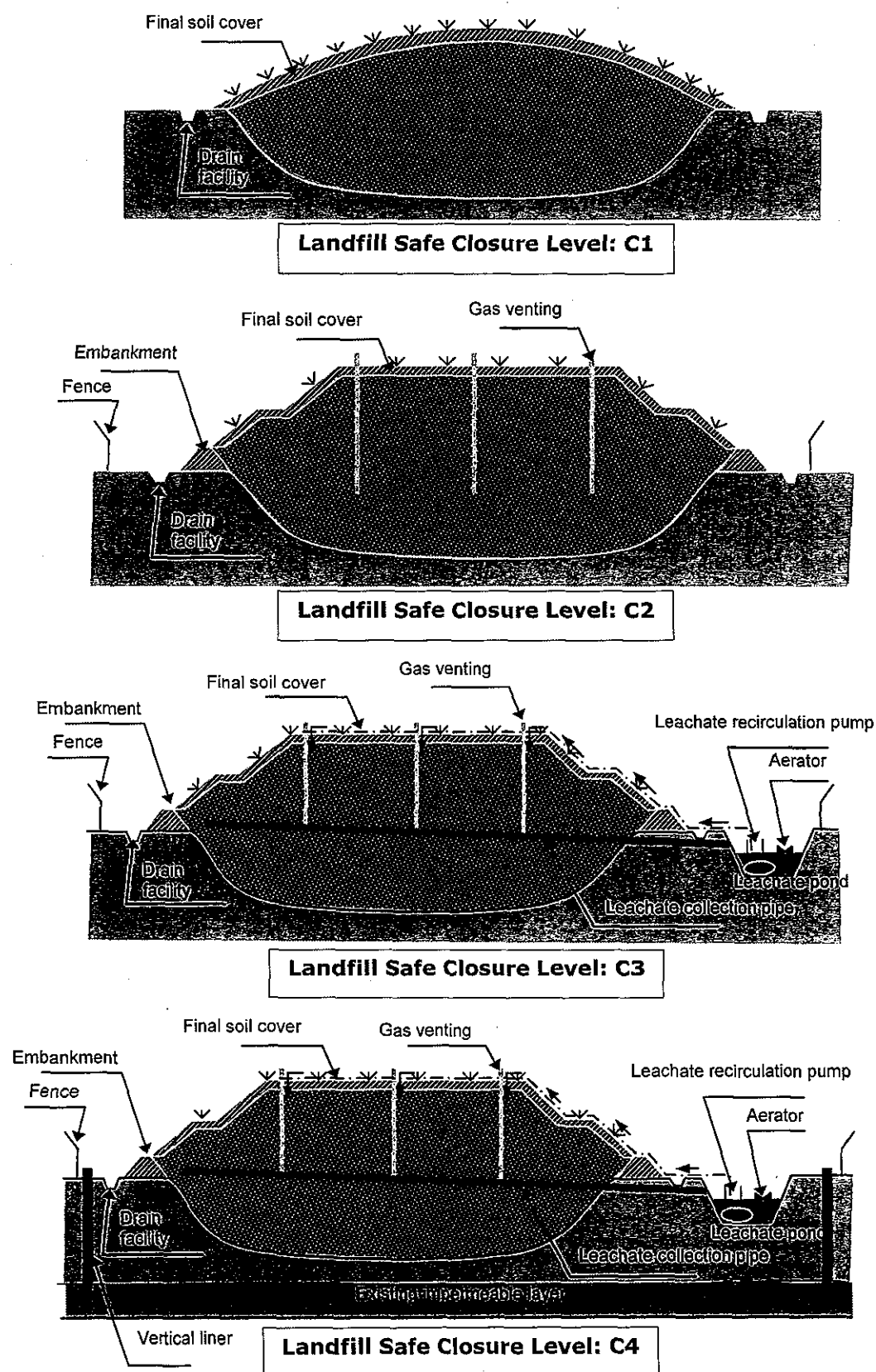
The Guideline recommends that for all landfills, that accept municipal solid waste including abandoned sites, where waste-filling work has been completed should be closed properly for the safe storage of the wastes and to prevent pollution to the surrounding environment. The “Safe closure plan” should be formulated to include the physical closure (PC) and the post-closure management (PCM) activities. The safe closure plan should be prepared based on the priority and the closure level of the landfill site.

The closure-levels are classified into 4 categories as follows.

- | | |
|-----------|---|
| Level C1: | Minimal closure level (to provide final cover and drainage system around the site) |
| Level C2: | Low closure level (similar to C1, but with the addition of dike, controlled slope and gas ventilation system) |
| Level C3: | Middle closure level (similar to C2, but with the addition of semi-aerobic landfill system with leachate re-circulation) |
| Level C4: | High closure level (similar to C3, but with the addition of groundwater pollution control measures with leachate treatment) |

The schematic diagrams of the landfill closure levels are shown in **Note: For C3 & C4**, aerobic area of existing landfill site will be expanded by safe closure measures

Figure 4.1.1.



Note: For C3 & C4, aerobic area of existing landfill site will be expanded by safe closure measures.

Figure 4.1.1 Schematic Diagrams of Landfill Closure Levels

The technical requirements included such activities as the installation of the necessary facilities, i.e. the leachate treatment facility; the provision of adequate protection, i.e. top covering; and the environmental monitoring activities and schedule. The PCM (operation and maintenance of the landfill facilities and monitoring) will have to be continued even after the new land use has been implemented for the closed landfill site.

The “Post-closure Land Use” is also addressed and it recommends that all future post-closure land use of closed landfill sites should be carefully considered based on the clear understanding of the landfill during its term of operation and closure as well as the impacts it has had on the surroundings. The proposed land use should not endanger the lives of the public and the users.

The Guideline also addressed the necessity of setting up the relevant advisory and regulatory bodies at both the Federal Government and the State Government. All these are to ensure the necessary legislations are in place, and to streamline the inter-departmental or cross-ministerial bureaucracy by the dissemination and mutual understanding of the procedures as set out in the guideline. In general, The Federal Government, as it has continued to do so in the past, shall ensure that the waste management activities are in compliance with the current laws, and the Federal Government will provide the State Governments and the Local Authorities with necessary technical advises and assist them in the development of their human resources. The individual State Government is responsible for all land management issues and should be responsible for registration of landfills, management and monitoring of landfill safety closure and post-closure land use. The landfill owner/operator shall be responsible for implementation of physical closure and post-closure management of the sites.

Another key issue that is addressed in the Guideline relates to the financial resources and funding structure. The Guideline recommends that a strategic funding system be set up at the Federal Governmental level to cater for the implementation of the sustainable landfill safe closure. The Federal Government will then manage the *Fund* and apportion the funds accordingly upon the requests from the State Governments and by taking into account of the landfill closure priorities.

4.2 PART I GENERAL

I-1 Purpose of the Guideline

The purpose of the landfill safe closure is as follows.

- (1) Protecting public health and the environment by proper management of landfill safe closure and post closure land use,
- (2) Prevention of environmental pollution and risks from the closed landfill sites,
- (3) Prevention of environmental pollution and risks from the uncontrolled development of closed landfill sites.

Municipal solid waste landfills generate environmental pollution and hazards long after the waste landfill ceases in operation. Degradation of the waste layers takes a long time whilst they continue to produce leachate and landfill gases. It is necessary to manage the site properly after the operations and to manage the post closure land use in order to protect the public health and preserve the environment. These problems are further

aggravated by the fact that majority of landfills in Malaysia have not been managed and closed properly.

In order to achieve a safe closure of the landfill, it is important that the various measures for safe closure have been considered even at the initial stages, from planning through to design and construction, and eventually throughout the operations.

This guideline provides the recommended steps necessary to close the landfill in a safe manner, including steps to rehabilitate the closed landfills and on how to manage the closed landfill site properly. This guideline also provides the recommendations for the post closure land use of closed landfill sites.

This guideline is to be used in conjunction with the “Technical Guideline on Sanitary Landfill, Design and Operation (Revised draft)”, and should cover the entire lifespan of the landfill site. It should be noted that for landfills with proper facilities and operation, the burden on the safe closure might be significantly reduced. In other words, in order to reduce the risks of pollution and hazards caused by the landfill and reduce the safe closure cost, improper operating landfill sites are necessary to be rehabilitated in accordance with the *Technical Guideline*.

I-2 Scope of the Guideline

I-2.1 Landfill Sites Covered by the Guideline

This guideline shall cover the landfill sites that accept municipal solid waste. These are categorised as follows:

- a. Closed landfills and open dump sites
- b. Existing landfills in operation
- c. New landfills

According to the existing Government policy, all new landfill should be sanitary landfill and requires EIA approved from DOE.

I-2.2 Landfill Closure Stages Covered by the Guideline

This guideline mainly covers the following landfill closure stages.

- a. Physical closure (PC) of landfill sites
- b. Post-closure management (PCM) of landfill sites
- c. Post-closure land use of closed landfill sites

In this guideline, the “Safe Closure (SC)” process shall include the “Physical Closure (PC)” and the “Post-closure Management (PCM)”. The “Post-closure land use” is regarded as part of PCM.

I-3 Definitions of Terms

Landfill site: The site where municipal wastes are disposed off by land filling. Such sites may be provided with various landfill facilities. In accordance with the “Technical Guideline on Sanitary Landfill, Design and Operation (Revised draft)”, the landfill sites can be categorised into 4 types; i.e. from Level 1 (L1) to Level 4 (L4). Open Dumpsite is categorised as Level Zero (L0.)

Closed landfill site: The landfill site where the waste filling activities have been completed.

Abandoned site: The landfill site where the owners/operators could not be identified “Illegal dump site” will be included in this category.

Safe closure (SC): “Safe closure” consists of the activities of “Physical closure (PC)” and “Post-closure management (PCM)”.

Physical closure (PC): The action by which the necessary measures for safe closure has been applied to the entire landfill area.

Closure levels (C1, C2, C3, C4): There are 4 closure levels, i.e. from C1 to C4. These closure levels indicate the countermeasures necessary to control the environmental pollution and hazards from the landfill sites. Each landfill site should be assigned with a targeted closure level at the initial stages of the safe closure process.

Post-closure management (PCM): The management activities necessary to operate, maintain and monitor the landfill facilities such as the leachate treatment, landfill gas treatment, cover soil etc. The activities also include the environmental monitoring, landfill stabilization monitoring and management of information/records of the closed landfills.

Post-closure land use: The re-utilization of closed landfill sites for purposes other than for waste filling. The PCM activities should be continued through out the post-closure land use.

I-4 Related Regulations and Legislations

The related laws, regulations and guidelines on the safe closure of landfill site are as follows.

(1) Land and Sanitation Cleansing

- Local Government Act 1976 (LGA)
- Town & Country Planning Act 1974
- Land Acquisition Act 1965
- Street, Drainage and Building Act 1974 (SDBA)
- By-laws under the LGA on collection and disposal of solid waste

(2) Environment

- Environmental Quality Act 1974 (EQA)
- Environmental Quality Order (Prescribed Activities Environmental Impact Assessment) 1987

(3) Guidelines

- Guiding Principles for the Design of a Municipal Solid Waste (MSW) Sanitary Landfill, DOE (draft)
- Technical Guideline on Sanitary Landfill, Design and Operation (revised draft)
- The Environmental Impact Assessment Guideline for Municipal Solid Waste, Sewerage Treatment and Disposal Project, DOE

(4) Others

- Action Plan for Beautiful and Clean Malaysia (The ABC Plan)

I-5 Basic Concept of the Guideline

I-5.1 “Safe Closure”

- (1) A landfill where waste-filling activities have been completed shall be closed properly for safe storage of the waste and prevention of pollution to the surrounding environment.
- (2) When a landfill is being closed, appropriate measures shall be taken to prevent environmental pollution caused by leachate or landfill gas resulting from the decomposition and degradation of the waste. Even long after closure of the landfill, post-closure management (including environmental monitoring) should be carried out continuously.

Parameters to measure the stability of the landfill site which way lead the termination of the post-closure management are shown in **Table 4.2.1**.

Table 4.2.1 Parameters to Measure the Landfill Stabilization

| Parameter | Target value |
|--------------|--|
| Leachate | Below DOE Standard A or B (depend on location of the landfill) <Mainly for BOD, COD, SS and Heavy Metals> |
| Landfill gas | Methane (CH ₄): below 1.0% |
| Subsidence | Below 2 cm per year |

- (3) When a landfill site ceases in operation and closed, it is necessary to formulate a “safe closure plan” that which comprises of the physical closure (PC) and the post-closure management (PCM) for submission to the relevant authorities for approval. This also applies to the abandoned sites.
- (4) **Appropriate Technology**
In order to minimize the risks of pollution and hazards caused by the landfill, *the Appropriate Technology* should be applied to close the site safely and to manage the closed site.
- (5) **Site-specific approach**
In order to determine the “safe closure” requirements, the conditions of each individual site shall be investigated. Their risks to environmental pollution/ hazards and potential for post-closure land use should be evaluated based on the site-specific conditions. From the evaluations, the proper countermeasures can than be applied ranging from the basic level (C1) to the advanced level (C4).

I-5.2 “Post-closure Land Use”

- (1) The type of post-closure land use of closed landfills should be carefully considered based on the clear understanding of the landfill conditions during operations,

closure, and together with impacts it may have had on the surroundings. The post closure land use should also take into consideration the aspects pertaining to environmental protection and the health and safety of the users and the public.

- (2) The “Post-closure land use plan” (including the land use plan, safe measures and post-closure management) will have to be formulated and submitted to the relevant authorities for approval. Once approval has been obtained, then only the new land use for the closed landfill can be implemented.
- (3) Operation and maintenance of the landfill facilities should be continued throughout the post closure land use redevelopment. Those facilities that may have been affected by the redevelopment works, such as the gas ventilation pipes and surface drainage, must be re-installed at suitable locations in order to preserve their functions.
- (4) The stabilization period of landfill site after waste filling has completed is expected to be minimum 10 years. Therefore, post-closure land use shall be considered and can be preceded after this period. This is to minimize the effects of land subsidence and landfill gas generation on the development site.

However, for the landfill sites 5 years has past after waste filling has completed, provisional land-use might be applied under the following conditions.

1. Utilization of only surface layers of the closed landfill site and access of the people to the site shall be very limited; such as green space, parking etc.
2. Prior to the utilization, monitoring of environment and landfill stabilization shall be carried out and then the landfill condition shall be clarified.

I-5.3 Legal Framework of Landfill Safe Closure

In order to implement and manage the sustainable landfill safe closure efficiently and effectively, institutional and legal systems will have been set up in accordance with the following principles.

- (1) The registration system of landfill sites will have been established to ensure better enforcement of the required measures and long-term operation and maintenance of the closed landfills in accordance with the appropriate safe closure measures.
- (2) The State Governments will be responsible for registration of the landfills, management/monitoring of landfill safe closure and post-closure land use.
- (3) The Federal Government will set up a new funding system to subsidize the additional financial expenditure necessary to implement the safe closure of landfills.
- (4) The landfill management activities will have to be managed by the State Governments and Local Authorities complying with the relevant regulations and laws. The Federal Government will provide the necessary technical advice and assistance with the human resources development.

I-5.4 Roles of Stakeholders

The roles of the main stakeholders are as follows.

(1) Federal Government

The Federal Government will provide technical advice and assistance to the State Governments for the management of the landfill safe closure and post-closure land use. The Federal Government will prepare and allocate sufficient financial resources for the physical closure and post-closure management of the landfills.

An inter-ministerial committee or advisory board may be established in the Federal Governmental level to manage and oversee the safe closure and post closure activities.

The Federal Government will be responsible for the following major tasks:

- a. To provide the Guideline for safe closure of landfills. (MHLG)
- b. To provide technical support and assistance to the State Governments and LAs. (MHLG and DOE)
- c. To set up the landfill registration system and determine the priority of each operating and closed site based on the information obtained from the State Governments and LAs. (MHLG)
- d. To set up and manage the specific funding system for the landfill safe closure, and allocate funds to the State Governments and LAs. (Economic Planning Unit (EPU), Ministry of Finance (MOF) and MHLG)
- e. To set up a technical advisory committee to determine and provide technical assistance to the State Governments and LAs
- f. To monitor and verify the re-development plan for the closed site with regards to the technical issues and to assist the State Governments when required

(2) State Governments

State Governments should play the main role in the registration of landfill sites in their boundary and management monitoring activities of the landfill safe closure and past closure land use.

A new committee could be established in the State Governmental level to handle these roles.

The State Governments should be responsible for the following:

- a. To collect information and data on the landfills in their respective boundaries (through landfill registration) and to evaluate and determine the priority and closure level for each site, and forward the data to MHLG
- b. To review the Safe Closure Plans (PC plan and PCM plan) and provide approval to the site owner/operator, and monitor the activities with the cooperation of LAs
- c. To manage/control the PC and PCM for the abandoned sites
- d. To request funding from the Federal Government for implementation of the PC and PCM of landfills
- e. To monitor the funds and verify the expenses for the SC
- f. To review the post-closure land use plan and provide approval to the developer, and monitor/the activities with the cooperation of the LAs

- g. To collect the portion of the tipping fee which is to be paid into the specific Fund for the landfill closure with the cooperation of LAs
- h. To set up a working committee to oversee the landfill safe closure in the State Government.

(3) Local Authorities (LAs)

The Local Authorities shall support the State Government in carrying out the duties and activities on safe closure of landfills.

For the “*abandoned site*”, the LAs should assume the role of the site owner or operator, with support from the State Governments and the Federal Government.

The LAs are in the forefront of waste management and landfill site management. The roles of the LAs are as follows.

- a. To collect the information and data on the landfills in their respective jurisdictions and forward to the State Government, and assist in the registration, evaluation and clarification of landfills
- b. To monitor/supervise the activities of operation and closure of the sites carried out by the landfill owner/operator and/or developer with the cooperation of the State Government
- c. To implement the PC and PCM for the abandoned sites
- d. To collect the portion of the tipping fee which is to be paid into the specific Fund for the landfill closure under the instruction of the State Government

(4) Site Operator/Owner

The operator/owner of the landfill site should construct and operate the landfill in accordance with good practices as set out in the “Technical Guideline on Sanitary Landfill, Design and Operation (revised draft, 2004)”. When the waste filling activities have been completed, the site operator/owner should implement the physical closure (PC) work and commence on the post-closure management (PCM), and with support from the State Government.

The site owner/operator are major players for landfill site operation/management and their roles are as follows.

- a. To document and manage the information and records of their landfill site properly (i.e. the geological survey report, EIA report, construction records, operation and monitoring records, etc)
- b. To operate the site properly and to keep daily records of the operations (i.e. the tonnage of waste accepted, cover soil work, leachate treatment, etc)
- c. To inform the LAs and the State Government on the schedule of final waste acceptance (more than one year but less than two years in advance).
- d. To prepare the SC plan (PC and PCM) with the cooperation of the State Government and other relevant parties
- e. To implement the SC properly by using the subsidies from the specific Fund
- f. To pay the additional tipping fee to the specific Fund of landfill safe closure, under the instructions of the Federal Government, State Government and the LAs

(5) Developers and Land Owner

Developers and/or the landowners planning to use a closed landfill site for other development purposes will have to consider the necessary measures for environment protection and hazards control as for a past closure management.

The major role of the developers and landowner are as follows.

- a. To collect the information and records of the landfill from the relevant parties
- b. To investigate the site from the aspects of environmental pollution and possible hazards
- c. To prepare the post closure land-use (i.e. the re-development plan, PCM plan and safe plan) of the site and to obtain the approval from the State Government
- d. To take over the obligation for PCM from the site owner/operator
- e. To inform the future land users on the conditions of the site and any other issues that may have arisen.

I-5.5 Landfill Registration System and Record Management

All operating and closed landfill sites should be registered and the records should be kept and managed by the relevant authorities of the State Government.

The relevant authorities of the State Government should collect the information of all the landfills within their boundary and generate a database and registering the sites. This information will be opened to the land authorities and planning authorities at the State level. This information will be collated and managed by the Federal Government, i.e. by MHLG.

I-5.6 Financial Resources and Funding

The strategic funding system will be set up at the Federal Governmental level for implementing the sustainable landfill safe closure. The general concepts for the funding system are as follows.

- (1) The setting up of a specific *Fund* for implementing the safe closure of the landfill sites.
- (2) During landfill operation, a necessary fee should be added to the tipping fee to allow for contributions towards the *Fund*.
- (3) The Federal Government will manage the *Fund* and apportion the funds accordingly upon the requests from the State Governments and by taking into account of the landfill closure priorities.

I-6 Process of Landfill Safe Closure

The processes of landfill safe closure are as follows.

- (1) The operator/owner of landfills should assess their respective sites in order to clarify the environmental pollution potential and land use potential.

- (2) Based on the assessment, the operator/owner should setup a closure level of the landfill site.
- (3) The operator/owner of landfills should prepare the “Safe Closure (SC) Plan” for submission to the State government for approval. The SC plan should be submitted one year before closure of the landfill site.
- (4) After the approval, the operator/owner of landfills will implement the physical closure works and post closure management activities. These activities should be informed to the related authorities periodically.
- (5) State government should examine the SC plan and approve if it meet the requirement. Safe closure activities (PC and PCM) carried out by the operator/owner should be managed/monitored by the State government.
- (6) The developer should prepare the “Post-closure Land Use Plan” and submit to the relevant authority in the State government for approval.
- (7) The developer can implement the post-closure land use after obtaining the approval. Implementation activities including PCM shall be informed to the related authorities periodically.

I-7 Human Resources Development

Regarding to the landfill management including landfill safe closure, it is necessary to establish and continue with the “human resource development” exercises for all the stakeholders.

MHLG will organize and provide the necessary training courses regularly.

4.3 PART II TECHNICAL REQUIREMENTS

II-1 Technical Requirements for Safe Closure of Landfill Sites

The technical requirements for safe closure of landfill sites are as follows.

- (1) Landfill sites should be closed safely and the post-closure management should be carried out properly.
- (2) Measures for safe closure of landfill sites.
 - a. To prevent wastes from littering or overflowing from the landfill site
 - b. To prevent fire or explosion that may be caused by landfill gases
 - c. To minimize offensive odours emitting from landfill site
 - d. To provide storm water run-off and drainage facilities
 - e. To minimize environmental pollution caused by leachate from landfill site
 - f. To prevent groundwater contamination
 - g. To take measures for wastes stabilization

- (3) Measures for post-closure management of landfill sites.
- To implement appropriate operation and maintenance activities of landfill facilities such as providing the final cover soil
 - To continuously operate the landfill facilities such as the leachate treatment plant
 - To continue with the environmental monitoring work
 - To continue with the waste stabilisation monitoring
- (4) Appropriate measures and activities required to achieve safe closure should be determined based on the conditions of the site including operation level, existing facilities, surrounding environment and post closure land use.

II-2 Determination of Priority and Safe Closure Level

All landfill sites should be assigned with the targeted safe closure level at the initial stages of the safe closure of landfill sites. The procedure to clarify the safe closure level for each landfill site is as follows.

- Site assessment survey should be carried out in order to determine the general conditions, environmental conditions and land use conditions of the site. From the results of the survey, the environmental pollution potential and land use potential can be evaluated.
- From the evaluation, the closure priority of the landfill site and applied closure level should be setup.
- The proper safe closure plan should then be formulated and the physical closure works and the post closure management activities should be carried out.

II-2.1 Priority of Landfill Sites for Safe Closure

All the landfill sites should be evaluated and ranked according to their priority for safe closure implementation. From the priority list, the sites requiring urgent remedial actions can be identified and the necessary funds can be allocated to the site. The evaluation and priority of each site that has been identified for safe closure should be determined by the State Governmental and approved by the Federal level lead by MHLG. The ranking will be based on two criteria, i.e. the environmental pollution potential and the land use potential.

The sites can be classified into 4 groups, namely Group A, B, C and D, as shown in **Table 4.3.1**.

Table 4.3.1 Grouping of Landfill Sites for Safe Closure Priority

| | Priority | Environmental Pollution Potential | Land use Potential |
|---------|----------|-----------------------------------|--------------------|
| Group A | High | High | High |
| Group B | Middle | High | Low |
| Group C | Middle | Low | High |
| Group D | Low | Low | Low |

II-2.2 Closure Level Applied for the Landfill Sites

The appropriate closure level should be assigned and applied for the prevention of environmental pollution and hazards. The relevant authorities at the State level should be responsible to determine target closure level for each landfill site within their jurisdiction. The closure levels are classified into 4 categories as follows.

- Level C1: Minimal closure level (to provide final cover and drainage system around the site)
- Level C2: Low closure level (similar to C1, but with the addition of dike, controlled slope and gas ventilation system)
- Level C3: Middle closure level (similar to C2, but with the addition of semi-aerobic landfill system with leachate re-circulation)
- Level C4: High closure level (similar to C3, but with the addition of groundwater pollution control measures with leachate treatment)

The measures necessary to be taken for each of the closure levels are tabulated in **Table 4.3.2**.

Table 4.3.2 Closure Levels and Required Measures/Facilities

| Measures | Safe closure Level | | | |
|-----------------------|--------------------|-----|---------------------|-----|
| | C1 | C2 | C3 | C4 |
| Final cover soil | ++ | +++ | +++ | +++ |
| Storm-water drainage | + | ++ | +++ | +++ |
| Safely storage | + | ++ | +++ | +++ |
| Gas vent | | ++ | +++ | +++ |
| Leachate | | + | +++ | +++ |
| Groundwater | | | ++ | +++ |
| Early stabilization | | + | +++ | +++ |
| Post closure measures | | + | +++ | +++ |
| Monitoring | + | ++ | +++ | +++ |
| Landfill system | | | Semi-aerobic System | |

Notes: 1. The methodology of closure level set-up is described at the Appendix, Chapter 5, Volume 2.

2. +: minimum equipped/ operated, ++: fair, +++: Fully equipped/ operated.

The landfill sites identified for safe closure that has been assigned with the higher priority should be given the higher closure level. The relationship between the landfill closure levels and the priority groups are tabulated in **Table 4.3.3**.

Table 4.3.3 Relationship between Landfill Closure Priority and Safe Closure Level

| Group | Priority for closure | Safe closure Level | | | |
|---------|----------------------|--------------------|-----|-----|----|
| | | C1 | C2 | C3 | C4 |
| Group A | High | | | +++ | ++ |
| Group B | Middle | | + | +++ | + |
| Group C | Middle | | +++ | ++ | |
| Group D | Low | ++ | +++ | | |

Note: +, ++, +++: magnitude of the relation (+: low, ++: medium, +++: high)

II-3 Site Survey for Evaluation and Design

The landfill site should be evaluated properly based on the site survey/investigation. The following items will be required to evaluate the landfill site and to provide the proper measures for safe closure.

Table 4.3.4 Survey Items for Evaluation of the Site

| Items | Proposed Measures |
|--|--|
| (1) Topographic and Geological survey | The topographic and geological data of the sites should be collected and further surveys be carried out where necessary. |
| (2) Structures and facilities of landfill site | The details of the landfill facilities and records of the landfill operations should be collected. All the landfill facilities should be clearly identified and indicated on the plan. |
| (3) Shape and stability of filled waste | The shape of the site should be clarified in order to evaluate the stability of the landfill site. |
| (4) Total amount of disposed waste | The total amount of the filled waste should be estimated based on the operation record and topographic profile of the site. |
| (5) Degradation of the filled waste | The information and data of the following should be collected and/or measured; a. The amount and quality of the leachate b. The amount and quality of the landfill gas c. The temperature of the waste layers d. The physical composition of the waste (if available) The variation in the leachate and gas concentration should be used to determine the rate of decomposition, degradation and the stabilisation of the landfill waste. |
| (6) State of the surrounding environment | The conditions of surrounding environment should be surveyed and/or measured. All relevant information including the monitoring data should be collected. |
| (7) Surrounding land use | The surrounding land use should be identified and the land use plan of the site should be collected (if any). |

Note: As for items to be surveyed and/or identified related to (6) and (7) above are shown in Appendix 18, Volume 3.

II-4 Requirements of Safe Closure

In order to implement the safe closure of landfill site, proper physical closure and post closure management should be carried out.

- (1) The Physical Closure (PC) consists of the measures or facilities necessary for the safe storage of waste, prevention of environmental pollution and early stabilization of waste.
- (2) The Post Closure Management (PCM) consists of the operation of landfill facilities such as leachate treatment plant, the maintenance of the facilities including covering soil, and the monitoring of environment pollution and stabilization of waste.

II-4.1 Requirements of Physical Closure

The closed landfill should be provided with the necessary facilities for the safe storage of waste, to prevent environment pollution and to accelerate early stabilization of waste. Also the facilities for post closure management, such as control building for operation and maintenance and the monitoring facilities should be provided.

The facilities required for landfill safe closure should be planned, designed and implemented based on the following requirements.

(1) Reformation for Landfill Shape/ Slope and Waste Storage Facility

The shape or slope of the filled waste should be modified if they are deemed to be unstable and/or when the waste has been overfilled. The gradient of the slopes should be less than 1:2.

The waste storage bank and/or retaining wall should be constructed if the shape of the filled waste is not stable, and if the boundary of the site is limited. The proposed modification and improvement works should be described in details in the safe closure plan.

(2) Final Cover Soil

The final cover soil should be provided for environmental protection measures, i.e. to minimise the leachate production, prevention of waste scattering, minimize odour and prevention of fire. The recommended thickness of the final cover soil should be more than 750mm. In areas where trees and scrubs are to be planted, the thickness should be increased to be more than 1500mm. Regular maintenance of the cover soil will be necessary.

(3) Storm Water Drainage

Storm water drainage system should be installed at the upper part, at the slopes and at the surroundings of the landfill site. This is to prevent the water from seeping into the waste layers and reduce the leachate production amount and protect the landfill site. Regular maintenance of the storm-water drainage will be necessary.

(4) Gas ventilation Facility

Gas ventilation facility should be provided and the venting pipes should be installed at 50m intervals. The purpose of the venting pipes is to allow the landfill gas to be released into the atmosphere and thus preventing gas explosion. This facility will also assist the acceleration of the landfill stabilisation by enhancing the waste decomposition process.

(5) Leachate Collection Pipes and Leachate Re-circulation Facility

The leachate collection pipes and leachate re-circulation facilities should be installed in order to provide semi-aerobic conditions to the landfill waste layers. The effects of these facilities to the landfill site are as follows.

- To minimize the groundwater contamination by removal of leachate accumulated in the waste layers
- The improvement of leachate quality through contact with air and aeration

- Promote early stabilisation of the landfill waste by accelerating the waste decomposition process
- Reduction in the generation of methane gas

(6) Leachate Treatment Facility

The leachate treatment facility should be installed to treat the leachate in order to comply with the DOE standards prior to discharging the effluent into the public water bodies via the drainage system. The purpose of the facility is to prevent contamination of the public waterways and the groundwater sources.

(7) Groundwater Protection Facility (liner)

The groundwater protection facility, such as artificial liner systems, should be installed in order to prevent leachate seeping into the groundwater sources and contaminating the groundwater.

II-4.2 Requirement of Post Closure Management

The facilities installed for safe storage of waste, prevention of environmental pollution and accelerating early stabilization should be operated and maintained properly, up until the closed landfill site has stabilised.

The monitoring of the environmental pollution and stabilisation of waste should be carried out continuously.

The result of the monitoring and record of the operation and maintenance should be reported to relevant authority periodically.

(1) Operation and Maintenance of Landfill Facilities

a. Leachate treatment

The proper operation and maintenance of the leachate treatment facility is very important to prevent any further environmental pollution that may occur after the physical closure.

The concentration and the amount of the leachate will eventually decrease and improved gradually with time, and it may take a long time to do so. When the concentration of leachate has improved and comply with the relevant environmental effluent discharge standards and will not cause serious damage to the surroundings, then the leachate treatment process may be changed or even terminated. However, it should be noted that the Nitrogen levels in the leachate could remain at high concentration for a long time.

b. Gas ventilation

The landfill gas ventilation system should be operated for a long time to prevent the build up of toxic gases and to prevent fire/explosion hazards.

The gas ventilation pipes will also act as air pipes and provide air (oxygen) to the waste layers and accelerate the waste degradation process. Therefore, the gas ventilation pipes should be maintained over the long term and new ventilation pipes be installed where necessary.

c. Top cover

Major subsidence may occur during the first two years after completion of waste filling works, therefore, special care for landfill facilities shall be taken into considered of this period.

After a period of time, major subsidence may not occur, but risk of minor subsidence and damage to the top cover will still remain. It is necessary to maintain the top cover to prevent the percolation of rainwater into the waste layers and to protect the landfill site.

d. Surface drainage

The surface drainage system should be inspected and maintained regularly over the long period of time. This facility will channel the surface water to the drains and resulting in the reduction in leachate production and also protecting the landfill site.

e. Groundwater monitoring wells

The groundwater monitoring wells should be maintained over a long period of time in order to preserve the well for use periodic monitoring activities.

f. Other supporting facilities

Other supporting facilities like the access road and the vegetation growth on the top/slopes should be maintained where necessary for a long period of time.

The typical example of the maintenance items of the landfill facilities, method and scale/ frequency are shown in **Table 4.3.5**.

Table 4.3.5 Summary of Maintenance Items

| Facilities | Items | Methods | Scale/ Frequency |
|-----------------------------------|--|--|--|
| Top cover & dykes | Cracks, pools and soil erosion on the surface, State of plants | Periodic visual inspections | The entire site, weekly |
| Surface drainage on the top cover | Clogging by soil/leaves, Damage by sedimentation | Periodical visual inspections | The entire site, weekly (more frequent during the rain season) |
| Cut-off drainage around the site | Clogging by soil/leaves, Damage by traffic | Periodical visual inspections | The entire site, weekly (more frequent during the rain season) |
| Gas ventilation pipes | Clogging, damage to pipes, corrosion | Periodical visual inspections | all pipes, weekly |
| Leachate collection pipes | Clogging, damage to pipes, corrosion | Periodical inspections & comparison of the effluent quantity data | daily |
| Leachate treatment facility | Quality of treated effluent | Daily inspections (colour of effluent) Periodical effluent analysis | daily monitoring frequency |
| Monitoring facility | Conditions of the monitoring wells | Periodical inspections | all wells, weekly |

(2) Monitoring of Environmental Pollution and Early Stabilisation

The monitoring of the environment and the waste stabilisation process should be carried out periodically.

a. Items and Frequency of Monitoring

The typical examples of the monitoring items, parameters and frequency of monitoring are shown in **Table 4.3.6**.

Table 4.3.6 Summary of Monitoring Items

| Monitoring media/parameters | Item and parameters | Frequency | Location |
|-----------------------------|--|--------------------------|----------------------------|
| Preliminary site inspection | 1) The surrounding environment 2) The condition of the facility 3) Nuisance condition | Once (before monitoring) | - |
| Leachate | <ul style="list-style-type: none"> • pH • BOD • COD • Nitrogen (Ammonia, Nitrate, Nitrite) • ORP • EC • TOC | 4 times per year | 1 point per leachate pond |
| Landfill gas | <ul style="list-style-type: none"> • Oxygen (O₂) • Nitrogen (N₂) • Methane (CH₄) • Carbonic anhydride (CO₂) • Hydrogen sulphide (H₂S) • Temperature | 2 times per year | 2 points per site |
| Soil subsidence | Topographic level at the top of the landfill | Once a year | 1 point per landfill block |
| Groundwater | Groundwater benchmark parameters | Once a year | 3 points per site |
| Surface water | Effluent standard parameters | Once a year | 2 points per stream |

b. Period

The duration of the monitoring period depends on the bio-degradation and stabilization of the filled waste layers. In practice, the monitoring should be continued a long term after the PC. However, the monitoring items and frequency may vary depending on the conditions of the filled waste layers.

c. Recording and reporting

The data and records of the monitoring activities should be submitted to the relevant authorities in the State Government periodically and should be documented and kept.

II-5 Safe Closure Plan

The safe closure plan for the landfill site should be prepared based on the priority and the closure level. The plan should include:

- a. General information of the landfill site
 - Name of the landfill site
 - Owner and operator of the landfill site
 - Location of the landfill site
 - Area and height of the landfill site
 - Brief descriptions of the landfill facility with plans or site maps and cross-sections
 - Period of waste acceptance (date of start of operation and final waste acceptance)
 - Tonnage and volume of the filled waste
- b. Priority and closure level
- c. Physical closure Plan
 - Stable shape plan
 - Covering soil and other facilities
 - Vegetation plan
 - Tentative land use
- e. Post closure management plan
 - Operation plan
 - Maintenance plan
 - Monitoring plan
- f. Implementation plan and schedule of safe closure
- g. Costs estimation for safe closure
 - Physical closure
 - Post closure management

II-6 Post-closure Land Use

The closed landfill site may be used for other purpose if proper counter-measures have been taken in order to develop the site. The post closure management (PCM) activities should be continued after the post-closure land use.

II-6.1 Required Counter Measures

When the closed site has been earmarked for be redevelopment, the appropriate counter-measures should be carried out. These counter-measures can be categorized into four functions as follows.

(1) Succession and/or Improvement of Landfill Facilities

The landfill facilities and/or safe closure facilities should be properly operated and maintained at all times even if no major problems are apparent in the closed site. Existing facilities like the gas ventilation and the surface drainage systems that may be affected by the development works should be moved and reinstalled at the appropriate new locations.

(2) Safety Measures for Development and Land Use

The safe control of the post closure land use comprises of followings.

Table 4.3.7 Safety Control Items

| Item | Remark |
|---|---|
| a. Landslide / collapse | The stabilisation of the slopes should be checked regularly. The weight of the equipments or facilities exerted on the site should also be monitored. |
| b. Fires / Explosion | Landfill gas contains highly flammable and explosive mixture of gases. Methane gas is highly explosive and volatile when the concentration in air is between the ranges of 5% to 15% (by volume). The concentration of the methane gas in the landfill gas mixture will have to be monitored regularly. It is also necessary to control the migration paths of landfill gas to prevent it from accumulation in dangerous quantities. As precautionary measures, fire protection and prevention facilities should be installed near the gas discharge points. |
| c. Damage to the plant life and vegetation at the sites | Landfill gas and certain waste may damage the plant life and vegetation. The top cover soil layer should be sufficiently thick to support and promote plant growth and the roots not exposed to the filled waste. Certain type of plants or vegetation are susceptible to various compounds found in the landfill gas, i.e. H_2S , NH_4 , Ethylene, etc. Therefore, the selection of suitable plants for planting at the closed landfill sites should be considered carefully. |
| d. Damage to the equipments and facilities | Landfill gas mixtures contain various corrosive gases such as H_2S and NH_4 , that may corrode and damage metallic objects and concrete structures installed at the site. Therefore, the selection of construction materials for the equipment and facilities must be carried out diligently. Ground subsidence may also damage foundations and infrastructures such as pipelines, drains and the access roads. |
| e. Chemical reactions | The decomposing waste layers contain large amount of hazardous chemical compounds such as ammonium (NH_4^+). The ammonium will react with the alkaline compounds in the cement and limestone present in the discarded construction waste. The resulting unintended chemical reaction will produce ammonia gas (NH_3), which is extremely toxic. This process of de-nitrification is also known as "Ammonia Stripping". |

(3) Measures to Control and/or Prevent the Environmental Pollution and Hazards

The development work at the closed landfill site will definitely cause some environmental pollution and hazards. The excavation work will expose the waste layers and resulting in dust pollution and emission of offensive odour. Road surface paving works may prevent the landfill gas migration to the surface and trapped the gasses in pockets that may cause the gas explosion. Appropriate counter-measures must be provided to ensure such occurrences are prevented.

Development works of post closure land use at the closed landfill site may affect/destroy the existing environment pollution control measures. Some of the possible effects are as follows:

Table 4.3.8 Environmental Control Items

| Items | Remarks |
|---------------------------|--|
| a. Landfill gas migration | The developer may have constructed floors or road surfaces that are impervious and prevents the gas from escaping through the surface. This will cause the gas to migrate and seep into the neighbouring grounds and into the houses where the gas accumulates and may cause damage or explosions. |

| | |
|--------------------------|---|
| b. Leakage of leachate | Development works may damage the existing landfill facilities such as the leachate collection and treatment system and the soil cover. Care must be taken when preparing such works at the site. |
| c. Groundwater pollution | Development works may puncture and damage the impermeable layer of the bottom soil liner. Care must be taken to ensure the layer is not damaged and regular groundwater monitoring should be carried out during and after the development works. |
| d. Excavated waste | The excavated waste during development works should be disposed of in a safe and proper manner and should not be left exposed on the site. |
| f. Liner | Development works that require extensive excavation or piling should not be permitted on closed sites that have been previously provided with artificial bottom liner system. The construction works may puncture and damage the liners. Such work should only be allowed when alternative counter-measures to the liner have been installed around the site. Such measures may include providing sheet piles to acts as vertical liners to contain the flow of leachate etc. |

(4) Facilities to Minimise Effects to the Public

If the post closure land use resulted in the increase in the population and human traffic to the developed site, then the future land use plan must include appropriate counter-measures to protect and minimise the harmful effects that may occur. Such measures may include the installation of gas collection system around the buildings to control gas migration.

II-6.2 Post-closure Land Use Plan

The developer should prepare the post closure land use plan and submitted to the relevant authorities in the State Government for approval. The content of the plan should include the following.

- (1) General information/condition of landfill site and its surroundings
- (2) Status of stabilisation of the filled waste
- (3) Post-closure land utilisation
- (4) Alteration plan of landfill facilities
- (5) Safe control measures
 - Construction and development
 - Land utilisation
- (6) Environmental pollution control measures
- (7) Post closure management (PCM) plan
 - Operation and maintenance of facilities
 - Monitoring of environment and stabilization
- (8) Implementation schedule of the above items

II-7 Social Considerations on Closure of Landfills

There are many reasons for closing a landfill and the main reason is usually due the inherent negative social impacts it has on the surrounding population. The main health

risk and impact are on those working at the landfills, i.e. the operators and scavengers, and the residents living around the sites. The social considerations on the closures should be implemented at each stage as follows.

(1) Social Consideration for the Scavengers

a. Before landfill closure

- a-1. Carry out a survey on the scavengers and their activities
- a-2. Preparation of relevant information on the landfill closure
- a-3. Preparation of information on environmental health issues affecting the scavengers
- a-4. Preparation of the scavengers evacuation plan
- a-5. Organize briefings and explanatory meetings on the landfill closure
- a-6. Set up an information desk on the landfill closure at the LA

b. After landfill closure

- b-1. Preparation of signboards to prohibit trespassing and entry to the landfill sites
- b-2. Construction of fences and/or barbed wire structures at landfill sites
- b-3. Carry out regular patrols to check for illegal entries into the landfill sites

(2) Social Consideration for Surrounding Households

a. Before landfill closure

- a-1. Carry out a survey on the surrounding households
- a-2. Preparation of relevant information on the landfill closure
- a-3. Preparation of information on environmental health issues
- a-4. Organizing explanatory meetings on the landfill closure
- a-5. Setting up of an information desk on the landfill closure at LA

b. After landfill closure

- b-1. Preparation of signboards to prohibit entering at landfill sites
- b-2. Construction of fences at landfill sites
- b-3. Carry out regular patrols to check for illegal entries into the landfill sites
- b-4. Carry out to gather public opinions and reactions to the utilisation of closed landfill sites

CHAPTER 5 ACTION PLAN ON SAFE CLOSURE OF LANDFILL SITES

5.1 OBJECTIVES OF ACTION PLAN

The degradation and stabilisation of the landfilled waste will take a long period of time. All landfill sites should be closed in a safe manner and post closure management should be carried out in order to secure the safe storage of the waste and to prevent further environmental pollution. The proper post-closure management will include operation of leachate treatment facilities and performing the environmental monitoring.

To conduct the physical closure and post closure management, as described earlier, it is crucial that the landfill registration and control system are in place. The funding mechanism and allocations must also be set up together with the setting up of the training programme for human resources development activities.

The Action Plan aims to set the proceedings and schedule to implement the safe closure for all the priority sites and to establish the required institutional mechanism and financial support by the year 2010. The major “Action” activities are as follows:

- Action 1: To authorise the safe closure guideline
- Action 2: To implement the physical closure and post closure management including the social considerations
- Action 3: To establish the landfill registration system
- Action 4: To arrange the Federal and State Organisation
- Action 5: To establish a funding system for safe closure
- Action 6: To develop human resources for capacity building

Figure 5.2.1 shows the schematic diagram of the flow of the Action Plan, and Table 5.2.1 shows the proposed implementation schedule of the Action Plan.

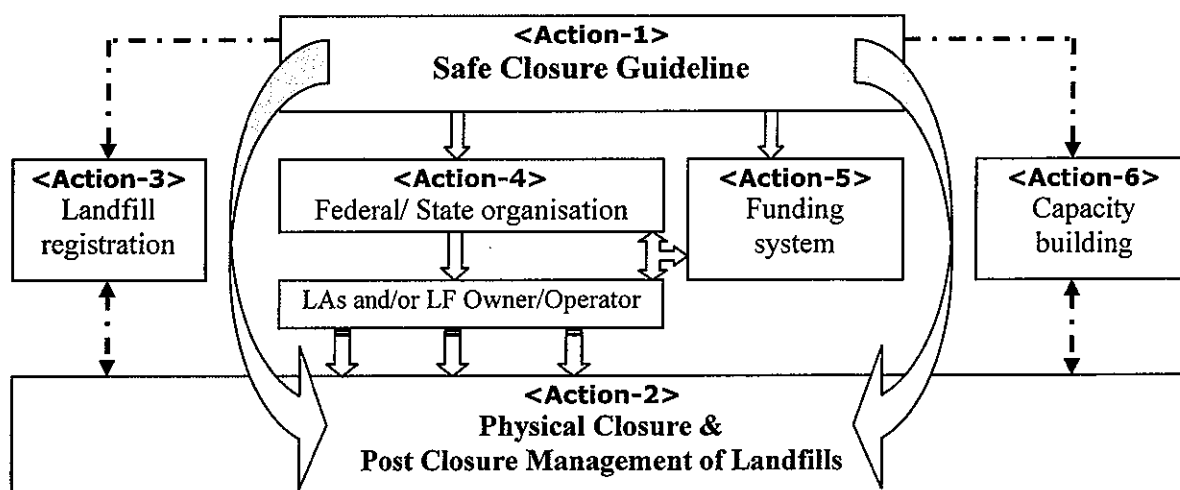


Figure 5.2.1 Schematic Flow of Action Plan

Table 5.2.1 Implementation Schedule of Action Plan

| Actions | Item | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|----------|---|------|------|------|------|------|------|------|
| Action 1 | Authorise the safe closure guideline | ++++ | | | | | | |
| Action 2 | Implement the landfill safe closure | | ++++ | ++++ | ++++ | ++++ | ++++ | ++++ |
| | - Closed sites (High Priority: 7 sites) | | ++++ | | | | | |
| | - Closed sites (Medium Priority: 9 sites) | | | ++++ | | | | |
| | - Closed sites (Medium-Low Priority: 17 sites) | | | | ++++ | | | |
| | - Operation sites (High-Med-Low Priority: 39 sites) | | | ++++ | ++++ | ++++ | ++++ | ++++ |
| Action 3 | Establish the landfill registration system | ++++ | | | | | | |
| Action 4 | Arrange the Federal/ State organization | ++++ | | | | | | |
| Action 5 | Establish a funding system | ++++ | ++++ | | | | | |
| Action 6 | Develop the human resources | ++++ | ++++ | ++++ | ++++ | ++++ | ++++ | ++++ |

5.1.1 Target Year and Target Sites

Inline with the above proposed action, the preliminary analysis established that there should be about 111 landfill sites, comprising of 55 closed landfill sites and 56 operating sites that have to be closed by 2010. There are 72 sites identified as the priority sites and classified under Groups A, B and C, and 39 sites under Group D, with lesser priority in terms of their *environmental risk potential* and *land use potential*. There is the urgent need to develop the Action Plan that addresses the priorities and to establish the OPEX and CAPEX that are realistic and viable.

The target-year and target-sites of the Action Plan are as follows:

- a. Target year : 2010
- b. Target sites : 72 landfill sites in Groups A, B and C

The breakdown of the number of sites in their respective groups is shown in **Table 5.2.2**.

Table 5.2.2 Target Sites for Action Plan

| Item | Target sites | | | | Group D | Total |
|----------------|--------------|---------|---------|-------|---------|-------|
| | Group A | Group B | Group C | Total | | |
| Closed site | 7 | 9 | 17 | 33 | 22 | 55 |
| Operating site | 13 | 18 | 8 | 39 | 17 | 56 |
| Total | 20 | 27 | 25 | 72 | 39 | 111 |

The lists of the identified landfills together with the CAPEX and OPEX are tabulated in **Table 5.2.3 (i)** for the closed sites and **Table 5.2.3(ii)** for the operating landfills.

Table 5.2.3 (i) List of Closed Landfill Sites for the Action Plan (2005-2010)

| No. | State | No. | Name of LA | Name of Site | Closure Level | Group | Year end | Area (ha) | CAPEX RM | OPEX RM/yr |
|---------------------|-------------|-------|----------------------|--------------------------|---------------|-------|----------|-----------|------------|------------|
| Closed Sites - 2005 | | | | | | | | | | |
| 1 | Johor | JH-09 | MD Kota Tinggi | Bandar Kota Tinggi | C3 | CL-A | 1988 | 1.62 | 612,532 | 86,476 |
| 2 | Johor | JH-26 | MD Simpang Renggam | TPS Simpang Renggam | C3 | CL-A | 1995 | 0.50 | 231,216 | 58,020 |
| 3 | Kelantan | KL-09 | MD Bachok | Kg. Hujung Repek | C4 | CL-A | 1995 | 2.53 | 2,909,658 | 190,255 |
| 4 | Selangor | SL-07 | MD Kuala Langat | TPS Banting | C4 | CL-A | 1998 | 3.00 | 3,248,768 | 219,016 |
| 5 | Melaka | ML-08 | MD Jasin | Kesang Pajak* | C4 | CL-A | 2002 | 9.16 | 7,119,527 | 479,989 |
| 6 | DBKL | DB-06 | DB Kuala Lumpur | Paka 1 | C3 | CL-A | 1994 | 6.50 | 1,482,991 | 167,230 |
| 7 | DBKL | DB-07 | DB Kuala Lumpur | Kp. Semarak (Brickfield) | C3 | CL-A | 2003 | 5.00 | 1,146,036 | 135,138 |
| | | | | | | | | 28.31 | 16,750,728 | 1,336,124 |
| Closed Sites - 2006 | | | | | | | | | | |
| 1 | Perak | PR-03 | MD Kinta Selatan | Taman Sri Kampar | C4 | CL-B | 1970 | 4.00 | 3,982,662 | 267,321 |
| 2 | Johor | JH-24 | MD Simpang Renggam | TPS Machap | C3 | CL-B | 1996 | 3.00 | 1,078,622 | 120,777 |
| 3 | Kelantan | KL-13 | MD Tanah Merah | KG. Cat Rimau | C4 | CL-B | 1999 | 5.80 | 5,133,048 | 342,142 |
| 4 | Johor | JH-01 | MD Tangkak | Chohong | C4 | CL-B | 2000 | 1.01 | 1,675,381 | 132,233 |
| 5 | Melaka | ML-06 | MD Jasin | Lipat Kajang | C3 | CL-B | 2000 | 3.24 | 748,359 | 97,104 |
| 6 | Melaka | ML-02 | MD Alor Gajah | Pulau Sebang | C2 | CL-B | 2002 | 0.81 | 124,070 | 33,395 |
| 7 | Pahang | PH-08 | MD Bentong | Sungai Sematut | C4 | CL-B | 2002 | 2.00 | 2,236,372 | 147,517 |
| 8 | N. Sembilan | NS-02 | MP Nilai | Kuala Sawah | C3 | CL-B | 2003 | 10.12 | 2,294,631 | 244,213 |
| 9 | Selangor | SL-12 | MP Kajang | Ampang Jaya | C3 | CL-B | 1997 | 10.00 | 2,268,032 | 241,699 |
| | | | | | | | | 39.98 | 19,541,177 | 1,626,401 |
| Closed Sites - 2007 | | | | | | | | | | |
| 1 | Melaka | ML-05 | MB Melaka | Kota Laksamana | C2 | CL-C | 1973 | 5.80 | 1,259,919 | 131,744 |
| 2 | Terengganu | TR-01 | MP Kemaman | Fikri | C2 | CL-C | 1985 | 2.02 | 416,405 | 57,605 |
| 3 | Terengganu | TR-06 | MP K. Terengganu | Wakaf Tok Keh | C2 | CL-C | 1985 | 4.05 | 883,066 | 96,252 |
| 4 | Pahang | PH-03 | MP Kuantan | Taman Bandar | C2 | CL-C | 1986 | 2.02 | 416,405 | 57,605 |
| 5 | Perak | PR-05 | MB Ipoh | Buntong | C2 | CL-C | 1986 | 20.00 | 4,296,114 | 378,906 |
| 6 | Kelantan | KL-01 | MP Kota Baru | Panji | C2 | CL-C | 1987 | 4.05 | 883,066 | 96,252 |
| 7 | Pahang | PH-05 | MP Kuantan | Indera Mahkota | C1 | CL-C | 1993 | 50.00 | 5,155,896 | 450,109 |
| 8 | Terengganu | TR-05 | MP K. Terengganu | Tok Jembal | C2 | CL-C | 1994 | 8.09 | 1,751,188 | 168,146 |
| 9 | Melaka | ML-04 | MB Melaka | Krubong A* | C2 | CL-C | 1994 | 5.80 | 1,259,919 | 127,461 |
| 10 | Pahang | PH-14 | MD Jerantut | TPS Batu 57 | C2 | CL-C | 1996 | 2.00 | 411,754 | 57,220 |
| 11 | Selangor | SL-01 | MP Petaling Jaya | Kelana Jaya | C2 | CL-C | 1996 | 8.09 | 1,050,713 | 110,136 |
| 12 | Perak | PR-07 | MB Taiping | Tekkah Jaya | C3 | CL-C | 1999 | 40.00 | 8,557,008 | 731,775 |
| 13 | Pahang | PH-12 | MD Cameron Highlands | TPS Sisa Pepejal MDCH | C2 | CL-C | 2001 | 0.40 | 76,125 | 29,424 |
| 14 | Perak | PR-02 | MD Kinta Selatan | Kg. Batu Putih | C2 | CL-C | 2002 | 2.00 | 411,754 | 57,220 |
| 15 | DBKL | DB-03 | DB Kuala Lumpur | Sri Petaling | C3 | CL-C | 1991 | 21.00 | 4,725,485 | 473,592 |
| 16 | DBKL | DB-04 | DB Kuala Lumpur | Sugai Bersi | C3 | CL-C | 1995 | 14.00 | 3,162,753 | 326,281 |
| 17 | DBKL | DB-05 | DB Kuala Lumpur | Paka 2 | C3 | CL-C | 1994 | 6.50 | 1,482,991 | 167,230 |
| | | | | | | | | 195.83 | 36,200,562 | 3,516,956 |
| Total | | | | | 33 sites | | | 264.11 | 72,492,467 | 6,479,481 |

Table 5.2.3 (ii) List of Operating Landfill Sites for the Action Plan (2005-2010)

| No. | State | No. | Name of LA | Name of Site | Closure Level | Group | Year end | Area (ha) | CAPEX RM | OPEX RM/yr |
|-------------------------------|------------|-------|----------------------|-----------------------|-----------------|-------|----------|---------------|--------------------|------------------|
| Operating Sites - 2005 | | | | | | | | | | |
| 1 | Penang | PP-01 | MP Pulau Pinang | Jeti Jelutong | C3 | OP-A | 2003 | 20.00 | 4,502,733 | 452,614 |
| 2 | Perak | PR-19 | MD Kerian | TPS Jin Dnnistown | C4 | OP-A | 2003 | 0.81 | 1,470,537 | 112,222 |
| 3 | Perlis | PL-01 | MP Kangar | Kuala Perlis | C3 | OP-A | 2003 | 8.00 | 2,921,250 | 279,363 |
| 4 | Johor | JH-22 | MD Tangkak | TPS Batu 16 Sengkang | C3 | OP-A | 2004 | 7.00 | 2,559,972 | 248,407 |
| 5 | DBKL | DB-01 | DB Kuala Lumpur | Taman Beringin | C3 | OP-A | 2004 | 12.00 | 3,063,887 | 294,899 |
| 6 | Terengganu | TR-07 | MP K.Terengganu | Kubang Ikan | C3 | OP-A | 2004 | 13.30 | 4,823,821 | 441,755 |
| 7 | Perak | PR-08 | MD Tapah | Pekan Getah | C3 | OP-A | 2004 | 21.50 | 4,836,842 | 484,076 |
| 8 | Kedah | KD-09 | MD Padang Terap | TPS MDPT | C3 | OP-A | 2004 | 2.02 | 747,925 | 96,320 |
| 9 | Perak | PR-23 | MP Manjung | TPS Sungai Wangi | C4 | OP-B | 2003 | 10.12 | 6,285,429 | 407,801 |
| 10 | Johor | JH-16 | MD Pontian | TPS Rimba Terjun | C3 | OP-B | 2003 | 12.00 | 4,357,896 | 402,064 |
| 11 | Johor | JH-03 | MP JB Tengah | Ulu Tiram | C3 | OP-B | 2003 | 17.40 | 4,421,718 | 411,712 |
| 12 | Kelantan | KL-02 | MP Kota Baru | Tebing Tinggi | C3 | OP-B | 2003 | 19.00 | 6,863,738 | 615,144 |
| 13 | Johor | JH-07 | MD Kota Tinggi | Batu Empat | C3 | OP-B | 2004 | 6.00 | 2,200,072 | 217,506 |
| 14 | N.Sembilan | NS-03 | MP Seremban | Sikamat | C3 | OP-C | 2003 | 5.26 | 1,204,132 | 140,686 |
| 15 | Penang | PP-02 | MP Seberang Perai | Ampang Jajar | C3 | OP-C | 2003 | 17.00 | 2,675,112 | 307,051 |
| | | | | | | | | 171.41 | 52,915,064 | |
| Operating Sites - 2006 | | | | | | | | | | |
| 1 | Perak | PR-20 | MD Kerian | TPS Alor Pongsu | C4 | OP-A | 2005 | 2.43 | 2,839,279 | 186,378 |
| 2 | Pahang | PH-13 | MD Jerantut | TPS Kg.Mat Lilau | C3 | OP-B | 2005 | 4.37 | 1,135,517 | 127,385 |
| 3 | Kedah | KD-07 | MD Kubang Pasu | Paya Kemunting | C3 | OP-B | 2005 | 5.03 | 1,303,017 | 142,081 |
| 4 | Melaka | ML-03 | MB Melaka | Krubong | C3 | OP-B | 2005 | 27.70 | 7,005,647 | 632,886 |
| 5 | Perak | PR-24 | MP Manjung | TPS Teluk Cempedak | C3 | OP-C | 2005 | 2.02 | 581,364 | 82,526 |
| 6 | Johor | JH-02 | MP Muar | Bakri | C3 | OP-C | 2005 | 14.57 | 3,290,416 | 338,327 |
| | | | | | | | | 56.12 | 16,155,240 | 1,509,582 |
| Operating Sites - 2007 | | | | | | | | | | |
| 1 | DBKL | DB-02 | DB Kuala Lumpur | Jinjang Utara | C3 | OP-A | 2006 | 10.00 | 2,268,032 | 241,699 |
| 2 | Johor | JH-17 | MD Pontian | TPS Sanglang | C4 | OP-B | 2006 | 1.21 | 1,862,544 | 142,203 |
| 3 | Pahang | PH-09 | MD Bentong | Chamang | C4 | OP-B | 2006 | 3.00 | 3,248,768 | 209,856 |
| 4 | Perak | PR-13 | MD Kuala Kangsar | TPS MDKK | C4 | OP-B | 2006 | 13.42 | 9,435,589 | 642,868 |
| 5 | Terengganu | TR-04 | MP Kemaman | Mak Cili Paya | C2 | OP-C | 2006 | 5.00 | 1,088,099 | 113,232 |
| 6 | Pahang | PH-10 | MP Temerloh | TPS Ulu Tualang | C2 | OP-C | 2006 | 7.28 | 630,932 | 75,371 |
| 7 | Terengganu | TR-03 | MP Kemaman | Gelugor | C2 | OP-C | 2006 | 10.00 | 2,159,387 | 201,951 |
| | | | | | | | | 49.92 | 20,693,350 | 1,627,180 |
| Operating Sites - 2008 | | | | | | | | | | |
| 1 | Perak | PR-04 | MB Ipoh | Bercham | C3 | OP-A | 2007 | 50.00 | 11,179,310 | 1,079,558 |
| 2 | Selangor | SL-05 | MD Kuala Langat | TPS | C3 | OP-B | 2007 | 6.07 | 2,224,521 | 219,610 |
| 3 | Johor | JH-27 | MD Yong Peng | TPS MDYP | C4 | OP-B | 2007 | 0.40 | 1,006,086 | 88,180 |
| | | | | | | | | 56.47 | 14,409,917 | 1,387,348 |
| Operating Sites - 2009 | | | | | | | | | | |
| 1 | Perak | PR-17 | MD Selama | TPS MDS | C3 | OP-A | 2008 | 4.04 | 1,492,479 | 156,517 |
| 2 | Perak | PR-06 | MB Taiping | Jebong | C4 | OP-A | 2008 | 20.00 | 12,797,470 | 884,770 |
| 3 | Pahang | PH-11 | MD Cameron Highlands | TPS Sisa Pepejal MDCH | C4 | OP-B | 2008 | 0.40 | 998,191 | 87,286 |
| 4 | N.Sembilan | NS-07 | MP Port Dickson | Sua Betong | C3 | OP-B | 2008 | 3.24 | 1,201,656 | 131,318 |
| 5 | Selangor | SL-03 | MP Kajang | Sungai Kenbong | C3 | OP-B | 2008 | 16.19 | 5,858,364 | 529,757 |
| 6 | Pahang | PH-18 | MD Raub | TPS Cheroh | C3 | OP-C | 2008 | 4.85 | 775,619 | 106,963 |
| | | | | | | | | 48.72 | 23,123,778 | 1,896,611 |
| Operating Sites - 2010 | | | | | | | | | | |
| 1 | Perak | PR-16 | MD Pengkalan Hulu | TPS Sisa Pepejal | C4 | OP-B | 2009 | 8.40 | 6,684,102 | 449,819 |
| 2 | Kedah | KD-06 | MP Kota Setar | Bukit Tok Bertandok | C3 | OP-B | 2009 | 9.70 | 2,483,716 | 244,781 |
| | | | | | | | | 18.10 | 9,167,818 | 694,600 |
| Total | | | | | 39 sites | | | 400.74 | 136,465,167 | 7,115,320 |

5.1.2 Basic Policies and Strategies

The safe closure process requires long-term post closure management and hence proper institutional and financial arrangements. In the formulation of the Action Plan, the following concepts were considered, which are;

- a. The operators and/or owners of landfill sites should be responsible to carry out the safe closure and post closure management activities with assistance from the Local Authorities, State Governments and the Federal Government.
- b. The State Governments are responsible for the registrations and control of all landfill sites within their boundary and including the development activities of the sites. All registration and control procedures should be established in accordance with the guideline and under the control of the State Governments.
- c. In principal, the major source of funding should be from the incremental tipping fee from the solid waste managing activities. Subsidy from the Federal Government should be used to establish and to maintain the new funding system for safe closure of landfills.
- d. The Federal Government should be responsible to manage the new funding system and allocate the fund for safe closure based on the request from the State Governments.
- e. The Federal Government should also be responsible to provide technical assistance, capacity building and human resources development.

5.2 Action 1: To Authorise the Safe Closure Guideline

As previously stated in Volume 2, Chapter 4, in order to achieve a safe closure of the landfill, it is important that the various measures for safe closure have been considered even at the initial stages, from planning through to design and construction, and eventually throughout the operations. The safe closure guideline provides the recommended steps necessary to close the landfill in a safe manner, including steps to rehabilitate the closed landfills and on how to manage the closed landfill site properly. This guideline also provides the recommendations for the post closure land use of closed landfill sites. Thus it is important that the safe closure guideline is authorised by the relevant Governmental authorities and adopted as the official guideline for all future landfill safe closure requirements.

This guideline is to be used in conjunction with the “Technical Guideline for Sanitary Landfill, Design and Operation (Revised draft 2004)”, and should cover the entire lifespan of the landfill site.