

4.2 PART I GENERAL

I-I 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-I 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 that indicate the stability of the landfill site and may 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% ²
Subsidence rate	Below 2 cm per year ³

(3) Preceding and Precautionary Approach

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.

² "Guidance for Safety Management at Mining site" :Occupational Safety and Health Act (Japan) 1970

³ "Guidance for Forming of Appropriate Residential Estate" (Japan Society of Architectures and Ministry of Construction) 1975

(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 then 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 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 could 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 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 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 is 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 post 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 and 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.

- a. To implement appropriate operation and maintenance activities of landfill facilities such as providing the final cover soil
- b. To continuously operate the landfill facilities such as the leachate treatment plant
- c. To continue with the environmental monitoring work
- d. 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.

(1) 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.

- (2) From the evaluation, the closure priority of the landfill site and applied closure level should be setup.
- (3) 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

3. As for C3 and C4, in line with the semi-aerobic landfill concept, aerobic area of existing landfill site will be exoended by safe slocure measures.

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	++	+++		

Notes: +, ++, +++: 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 the Site Assessment

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).

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. In order to prevent soil erosions, gentler slope will be preferred.

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. 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.

b. 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.

c. 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.

d. 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.

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

d. Post closure management plan

- Operation plan
- Maintenance plan
- Monitoring plan

e. Implementation plan and schedule of safe closure

f. 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). <i>The concentration of the methane gas in the landfill gas mixture will have to be monitored regularly.</i> 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 ₂ S, 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 ₂ S 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 public hearing 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 OBJECTIVE 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 (Committee)
- Action 5: To establish a funding system for safe closure
- Action 6: To develop human resources for capacity building

Figure 5.1.1 shows the schematic diagram of the flow of the Action Plan, and Table 5.1.1 shows the proposed implementation schedule of the Action Plan.

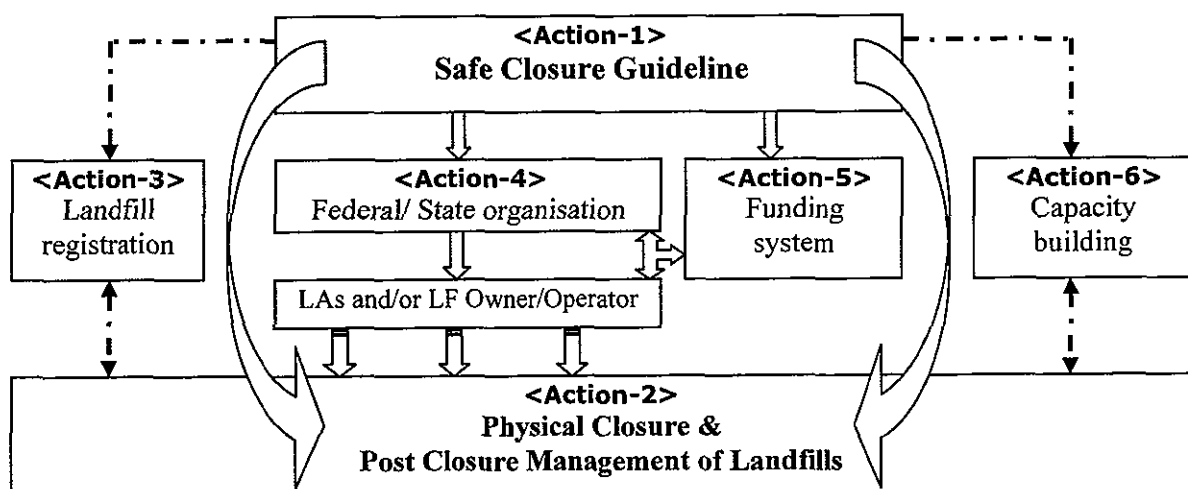


Figure 5.1.1 Schematic Flow of Action Plan

Table 5.1.1 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 5.1.2**.

Table 5.1.2 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 5.1.3 (i)** for the closed sites and **Table 5.1.3(ii)** for the operating landfills.

Table 5.1.3 (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 (Brckfield)	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 Sn 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	Lupat 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	Fikn	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								264.11	72,492,467	6,479,481

Table 5.1.3 (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 Kenan	TPS Jln 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	6,265,429	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 Kenan	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	Bakn	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 Sangiang	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 Tualiang	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								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.

5.3 ACTION 2: TO IMPLEMENT THE PHYSICAL CLOSURE AND POST CLOSURE MANAGEMENT INCLUDING THE SOCIAL CONSIDERATIONS

Based on the statement described in the safe closure guideline, procedure of landfill safe closure including physical closure and post closure management is shown in **Figure 5.3.1**.

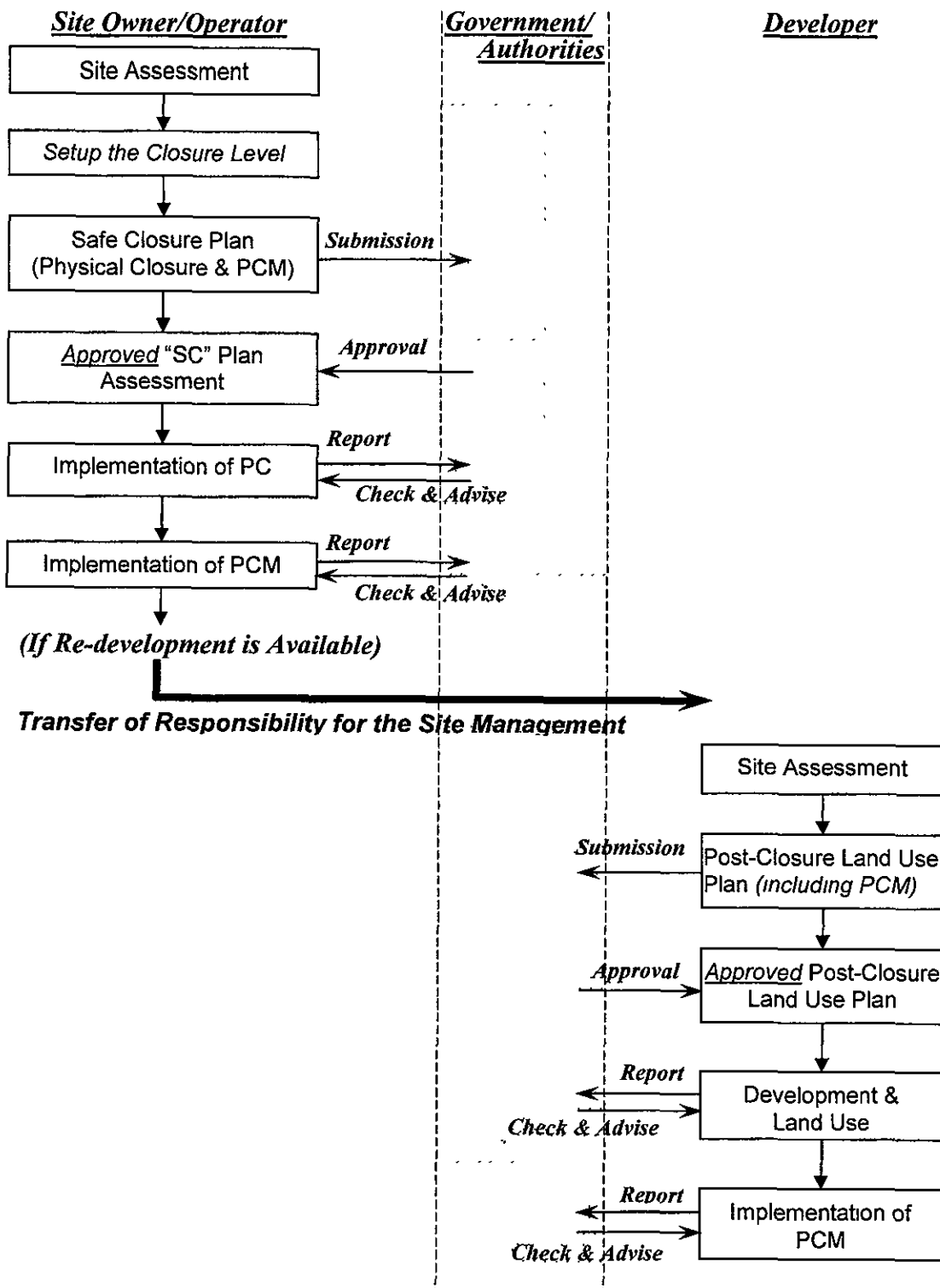


Figure 5.3.1 Process of Landfill Safe Closure

5.3.1 Physical Closure

(1) Physical closure plan

The Study has identified a total of 72 sites that require safe closure by the year 2010, and have been categorised into Groups A, B and C. The proposed implementation schedule should only commence from the year 2005, after the finalisation of the guideline and the necessary mechanisms.

The implementation schedule for the landfill safe closure is shown in **Table 5.3.1**. The table shows the annual breakdown of the number of sites, the closure levels and priority groups, which are to be closed from 2005 to 2010. The estimated CAPEX and OPEX have also been summarised in the table.

The required scope of works for physical closure should be determined on a case-to-case basis, including carrying out of the topographic surveys and soil investigations.

Table 5.3.1 Implementation Schedule for Landfill Safe Closure

(Unit of CAPEX & OPEX - RM)

1 CAPEX (Capital expenditure)	2005				2006				2007				2008				2009				2010				Total	
	C1	C2	C3	C4	C1	C2	C3	C4	C1	C2	C3	C4	C1	C2	C3	C4	C1	C2	C3	C4	C1	C2	C3	C4		Total
	Total	Total	Total	Total	Total	Total	Total	Total	Total	Total	Total	Total	Total	Total	Total	Total	Total	Total	Total	Total	Total	Total	Total	Total		Total
A Closed Sites																										
a) Group A																										
b) Group B																										
c) Group C																										
A Sub-total sites number																										
A Sub-total CAPEX																										
A Area of sites (ha)																										
B Operating Sites																										
a) Group A																										
b) Group B																										
c) Group C																										
B Sub-total sites number																										
B Sub-total CAPEX																										
B Area of sites (ha)																										
Total Sites Number																										
Total CAPEX																										
Total Area (ha)																										
2. OPEX (Operational expenditure)																										
A Closed Sites																										
a) Group A																										
b) Group B																										
c) Group C																										
A Sub-total sites number																										
A Sub-total OPEX																										
A Area of sites (ha)																										
B Operating Sites																										
a) Group A																										
b) Group B																										
c) Group C																										
B Sub-total sites number																										
B Sub-total OPEX																										
Total Sites Number																										
Total OPEX																										

(2) Cost of Safe Closure up to the year 2010

The estimated total cost of safe closure up to the year 2010 is tabulated in **Table 5.3.2**. The total CAPEX is estimated to be about RM 209 million and OPEX is about RM66.5 million. The total estimated cost for the entire Action Plan period is estimated to be about RM 275.5 million.

Table 5.3.2 Cost of Safe Closure up to 2010
(Unit of CAPEX and OPEX: RM)

Item	2005	2006	2007	2008	2009	2010	Total
1 CAPEX							
A Closed Sites							
a) Group A	16,750,000	-	-	-	-	-	16,750,000
b) Group B	-	19,541,000	-	-	-	-	19,541,000
c) Group C	-	-	36,200,000	-	-	-	36,200,000
Sub - Total	16,750,000	19,541,000	36,200,000	-	-	-	72,491,000
B. Operating Sites							
a) Group A	24,926,000	2,839,000	2,268,000	11,179,000	14,289,000	-	55,501,000
b) Group B	24,108,000	9,444,000	14,546,000	3,230,000	8,058,000	9,167,000	68,553,000
c) Group C	3,879,000	3,871,000	3,878,000	-	775,000	-	12,403,000
Sub - Total	52,913,000	16,154,000	20,692,000	14,409,000	23,122,000	9,167,000	136,457,000
Total CAPEX (Annual)	69,663,000	35,695,000	56,892,000	14,409,000	23,122,000	9,167,000	208,948,000
2 OPEX							
A. Closed Sites							
a) Group A	-	1,278,000	1,278,000	1,278,000	1,278,000	1,278,000	6,390,000
b) Group B	-	-	1,626,000	1,626,000	1,626,000	1,626,000	6,504,000
c) Group C	-	-	-	3,574,000	3,574,000	3,574,000	10,722,000
Sub - Total	-	1,278,000	2,904,000	6,478,000	6,478,000	6,478,000	23,616,000
B. Operating Sites							
a) Group A	-	2,409,000	2,596,000	2,837,000	3,917,000	4,958,000	16,717,000
b) Group B	-	2,421,000	3,580,000	4,575,000	4,883,000	5,544,000	21,003,000
c) Group C	-	447,000	868,000	1,259,000	1,259,000	1,366,000	5,199,000
Sub - Total	-	5,277,000	7,044,000	8,671,000	10,059,000	11,868,000	42,919,000
Total OPEX (Annual)	-	6,555,000	9,948,000	15,149,000	16,537,000	18,346,000	66,535,000
Total CAPEX + OPEX (Annual)	69,663,000	42,250,000	66,840,000	29,558,000	39,659,000	27,513,000	275,483,000

5.3.2 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 post closure management includes the operation and maintenance of installed landfill facilities such as the leachate treatment facility, gas ventilation system, maintenance of the top cover, surface drainage system, groundwater monitoring wells and the other supporting facilities (i.e. the access road and the vegetation growth).

The typical example of the maintenance items of the landfill facilities, method and scale/frequency are shown in **Table 5.3.3**.

Table 5.3.3 Summary of Maintenance Items

Facilities	Items	Methods	Scale/ Frequency
Top cover & dykes	Cracks, pools and soil erosion on the surface, State of plants	Periodical 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

Meanwhile, the post closure management also includes the monitoring of environmental pollution and stabilisation of water. The typical example of the monitoring items, parameters and frequency of monitoring are shown in **Table 5.3.4**.

Table 5.3.4 Summary of Monitoring Items

Monitoring media/parameters	Item and parameters	Frequency	Location
Preliminary site inspection	4) The surrounding environment 5) The condition of the facility 6) 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

5.3.3 Social Considerations

The social aspects/issues on scavengers and/or nearby households should be taken into consideration for each of the pre-closure, closing and post-closure stages of the landfill sites. The main issues are as follows:

(1) Scavengers

1) Pre-closure stage

- Surveys: Site surveys on the situation of the scavenging activities at the landfills that are to be closed should be carried out.
- Clearing/eviction of scavengers: For the safety reasons, no unauthorised personnel should be working at the site, especially the scavengers. The Local Authorities or operators of the landfill sites should formulate plans to prevent or evict the scavengers from the site.
- Notices for the closures: The preparations of relevant information for the notices of the closures should be carried out.
- Briefing the scavengers on the closures: In addition to preparations of the printed notices, on-site briefings may be provided by the LAs. Such briefing should include the reasons for their eviction, the health and safety aspects, etc.

2) Closing/post closure stage

- Warning Notices: In the closing/post closure stage there is the possibility that scavengers may try to gain entry to the landfill sites. Warning notices should be installed around the site informing of the closure.
- Construction of fences: In order to demarcate the physical boundary of the site and to deter trespassing, fences or hoardings should be constructed around the site.
- Inspections, monitoring and patrols: In order to ensure no further scavenging activities are being carried out at the site after the scavengers have been evicted, it is necessary for the LA or operator of the site to perform regular inspections and patrols to check on the activities at the site.

(2) Nearby and Surrounding Households

1) Pre-closure stage

- Surveys: The surveys on the number and types of properties, especially the households, nearby and surrounding the sites should be carried out and including interviews with the occupants of the premises.
- Notices for closures: The preparations of relevant information and notices for the closure are necessary, including the provision of notice signboards and printed literature materials on the closures, similar to those used for the scavengers.
- Public briefings on the closures: Public briefings or education programmes should be provided to those working or staying around the landfill site. The briefing should include all relevant subject matters such as the environmental issues related to the

site, the health and safety issues and also the proposed post-closure utilisation of the site.

- Setting up of Public Complaints/Information desk at the LA: It may be necessary to set up the public complaints/information desk at the LA to deal with complaints or the request for more information by the public.

2) Closing/post closure stage

- Warning Notices: Warning notices similar to those used for the scavengers should also be provided here.
- Construction of fences: Similar to the above, for the scavenger control, perimeter fencing should be provided to deter trespassing.
- Regular inspection, monitors and patrols: To make sure the prevention of further entering by children and others at specific landfill sites, LA and/or construction contractors are required to conduct regular inspection, monitors and patrols at the specific landfill sites.
- Public briefing: Public briefings on the proposed post-closure utilisation should be carried out by LA.

5.4 ACTION 3: TO ESTABLISH THE LANDFILL REGISTRATION SYSTEM

The landfill registration system is essential for the proper management and control of landfilling activities in the country. The registration provided up to date information on the landfill from the first day of operations through to the closure stage and continued over the post-closure period. The registration system should be carried out and the registration database should be maintained and updated regularly. Items need to be registered are shown in **Volume 3**.

In addition, the registration system should be used to check and monitor the post-closure utilisation of the sites and to prevent any over exploitation of the site for purposes not suitable for the area.

The landfill registration system should be carried out by and managed by the State Government under the guidance of the Federal Government. The Local Authorities should be responsible for providing the updated information to the State, together with reporting of any infringements or irregularities that may occur. The introduction of the landfill registration system will be the first step towards preventing illegal waste dumping. The flowchart for the landfill registration and management system is shown in **Table 5.4.1**.

Table 5.4.1 Flowchart of Landfill Registration and Management System

Landfill stages	Plan/Const. Stage			Operating Stage		Post-closure stage	
	Plan	Construction	Operation	Physical closure (PC)	Post-closure management (PCM)	Post-closure land use	
New site	▲ Registration		Checking of landfill operation	Checking of PC works	Checking of PCM		
	Management of Landfill site		Safe closure plan approval				
Operating site			Registration	Checking of PC works	Checking of PCM		
	Management of post-closure land use		Safe closure plan approval		Post-closure land use plan (1 year) approval	Checking of land use works	
Closed site	Management of landfill site			Safe closure plan approval	Checking of PC works	Checking of PCM	
	Management of post-closure land use				Post-closure land use plan (1 year) approval	Checking of land use works	
		Site not yet in use			Registration	Checking of PC works	Post-closure land use plan (1 year) approval
Site already utilised				Review of post-closure land use			

5.5 ACTION 4: TO ARRANGE THE FEDERAL AND STATE ORGANISATIONS

5.5.1 Landfill Sites Management Committee (LSMC)

Since all land matters are under the control of the State Government, it is appropriate that the related authorities of the State Government should be responsible for implementing and maintaining the Landfill Registration System. It is understood that, even after the proposed privatisation of landfill sites, no specific agency will be responsible for the closed landfill sites or illegal dumping grounds, as the State Government should continue to be responsible for such sites.

It is proposed that the Landfill Sites Management Committee (LSMC) should be set up at the State Government level, as the main player in the management/monitoring of the safe closure of landfill sites. The main roles of the committee are:

- i To carry out the registration of the landfill sites
- ii. To provide approval for the “Safe Closure Plan”, including physical closure and post-closure management plan
- iii. To manage and monitor the activities of landfill operators/owners for the safe closure. The committee should also be responsible for the post-closure land-use of the closed landfill sites; i.e. approval and monitor the “Development Plan of Closed Site” which includes development plan, PCM and safety control plan.

The LSMC should comprise of members from the following departments or offices;

- The Local Government Unit, State
- The State Land Office
- The State Economic Planning Unit (UPEN)
- The State Department of Environment
- The State Health Department
- The State Land and Country Planning Department

The State Local Government Unit should also assist the LSMD.

However, it is noted that many State Governments lack the technical expertise and human resources to administer these tasks. As such, MHLG is expected to develop human resources needs and provide technical advises to the State Government. It is also recommended that the Technical Committee for Management of Landfill (TCMLS) should be set up at the Federal level and to provide technical support to the State Government.

5.5.2 Technical Committee for Management of Landfill Site (TCMLS)

The committee members should comprise of representatives from institutions related to landfill management and including academicians. The members should include the following:

- Representatives from the Local Government Department of MHLG (Chairperson)

- Representatives from the Ministry of Health
- Representatives from the Ministry of Natural Resources and Environment
- Representatives from the Economic Planning Unit, Prime Minister's Department
- Academic Scholars from local universities and institute of higher educations
- Representatives from private landfill sites

5.5.3 Role of Major Stakeholders for Landfill Safe Closure

The flowchart outlining the role of the major stakeholders for landfill safe closure; i.e. Federal government, State government, Local authority and site owner/operator, is shown in **Figure 5.5.1**.

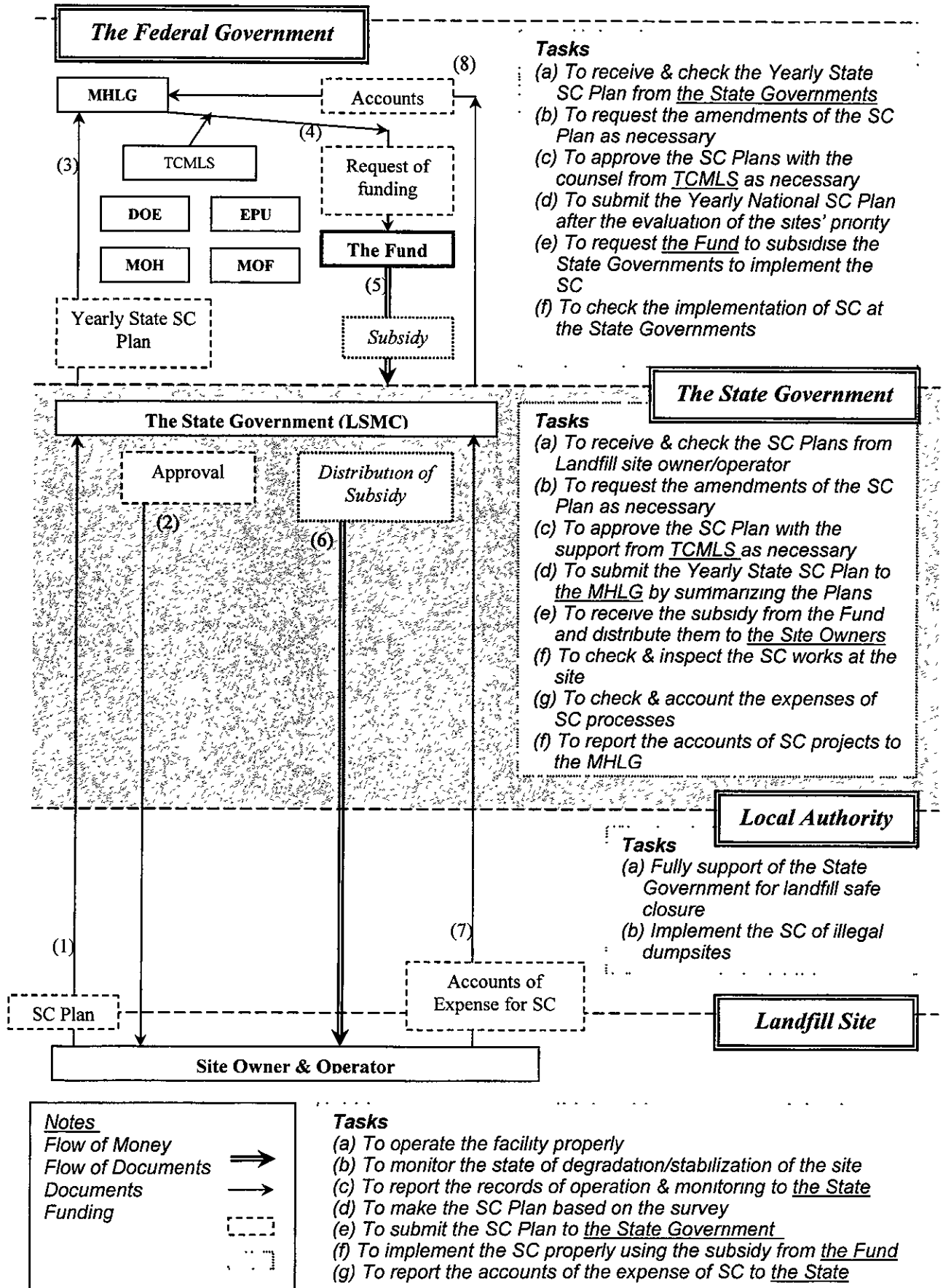


Figure 5.5.1 Roles of the Stakeholders for the Landfill Safe Closure Process

5.6 ACTION 5: TO ESTABLISH A FUNDING SYSTEM FOR SAFE CLOSURE

The Study made a preliminary financial analysis of the long-term plan on safe closure of landfill sites during 2005-2020. Taking into account this long-term perspective, the Study hereby recommends the funding system for implementation of the action plan with the target year of 2010.

(1) Basic Principle of Financing Safe Closure of Landfill Sites

Since the safe closure of landfill is an integral part of landfill operation, the cost for safe closure should also be included as a part of the cost for landfill operation.

The SWM collection services in Malaysia are in the midst of privatisation and some Local Authorities have contracted out their waste collection services to the concessionaire companies under an interim agreement. Similarly, some LA have also contracted out their disposal services to private companies to operate the transfer stations and some of the landfill sites.

The Federal Government, under BP 500, annually allocates budget for improvement of the existing landfills. Referring to the annual report by MHLG, the total budget allocations for SWM were approximately RM264 million for 2001, which accounts for about 10% of the total budget for MHLG. However, there has been virtually no budget allocation made for closure of waste landfills so far in Malaysia.

The draft NSP recommended that the cost of municipal solid waste management should be covered by those who generate wastes in accordance with the “Polluter Pays Principle” (PPP). The draft NSP also estimated the proposed fee for SWM services to be levied to the households and business premises to cater for the SWM costs. However, the cost for closure of landfills has not been fully identified in the draft NSP.

(2) Fund Raising Options for Safe Closure in Other Countries

The options for raising the funds for safe closure can be learned and adopted from examples of funding in some of the developed countries. For Japan and the Netherlands, the reserve fund have been set up for closure and post-closure management, and as for the USA, the landfill owners/operators are responsible to reserve the fund by themselves for their landfills. The funding mechanism should be adopted in Malaysia considering the developed country’s experiences but with some modification to suit the local conditions.

(3) Establishment of the National Fund for Landfill Closure

To secure availability of the fund, the Study recommends creation of the national fund for landfill closure in Malaysia. The fund mainly consists of:

- Additional allocation of national budget specifically used for landfill closure,
- Additional tipping fees collected from those who bring waste into the landfills including public and private SW haulers.

The percentage of each fund source will be determined based on the availability of national budget and also examination on the affordability of SW haulers. It is also

important to examine the possible increase of current SW collection fee rates levying to each household as well as other business establishments that generate solid waste.

In addition, the government should also make every possible effort of raising the fund from other sources including acquisition of certified emission reduction (CER) under clean development mechanism (CDM) of Kyoto Mechanism. If the safely closed landfill can be sold to the third party with strictly requirement of continuous environmental monitoring and specified land use, its income will also be added to the fund.

However, since the income from trading CER or selling of the closed landfill is not expected especially in the early years of the action plan period, allocation of national budget and collection of additional tipping fee will be the major sources of the fund.

(4) Recommended Fund Raising Plan

The Study here recommends the fund raising plan for safe closure of the landfill in accordance with the action plan. Primary sources of the fund are additional allocation of national budget and additional collection of tipping fees.

Considering the difficulty in obtaining the acceptance of citizens about the increase of the current rates of SWM services, additional tipping fee collection needs to be gradually applied to all the landfill sites, starting from metropolitan areas, subsequently to urbanized ones, and finally to other remaining areas. It means that governmental budget allocation is especially required in the early years of the action plan. Based on this recognition, the Study establishes the fund raising plan in accordance with the following preconditions.

- Fund raising from additional tipping fee collection will be carried out in accordance with the schedule shown in **Table 5.6.1**.

Table 5.6.1 Schedule of Additional Fee Collection

2005-2006	2007-2009	2010-
Additional fee collection will be carried out in KL	Additional fee collection will be gradually extended to other urbanized areas	Additional fee collection will be extended to the whole country.

- The shortage of the fund for implementing the action plan during 2005-2010 will be covered by additional allocation from the national budget.
- From 2010 onward, the fund for safe closure will be mostly covered by additional fee collection.

Table 5.6.2 below estimates the amount of the fund raised from additional fee collection and additional National budget allocation required for safe closure of the landfill sites in accordance with the action plan and the above preconditions.

Table 5.6.2 Estimated Amount of Fund with the Required Fund for Safe Closure of Landfill Sites during 2005 to 2010 (72 sites)

(Unit. RM thousand)						
Item	2005	2006	2007	2008	2009	2010
National budget required	55,750	55,750	29,610	29,610	0	0
Collection of tipping fees	3,602	3,795	12,199	24,988	39,348	40,760
Required fund for closure	69,663	42,250	66,840	29,558	39,659	27,513
Balance	-10,311	17,295	-25,031	25,040	-311	13,247

Figure 5.6.1 shows the estimated trend of CAPEX and OPEX in accordance with the action plan for safe closure of landfill sites (72 numbers).

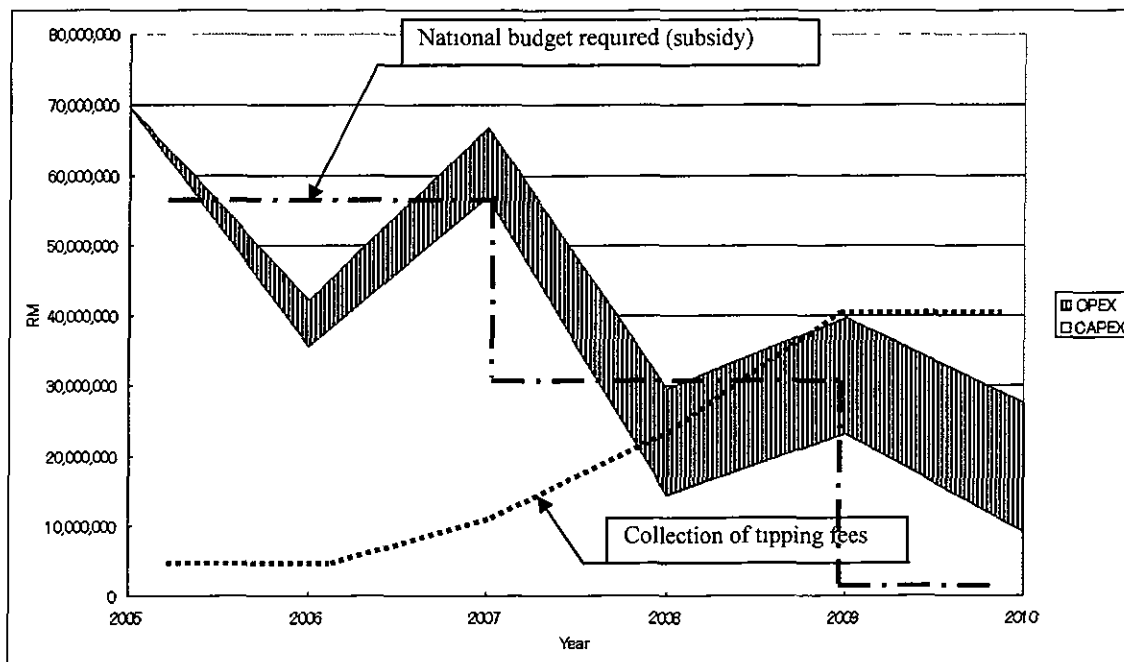


Figure 5.6.1 Trend of CAPEX and OPEX for Landfill Closure Action Plan (2005 - 2010)

The above fund raising plan may need to be adjusted to meet with the possible amount of the additional fee that can be collected and also the additional national budget that can be allocated by the Federal Government. Be that as it may, the percentage of the allocation of fund between the national budget and additional tipping fee collection will depend on availability of budget and affordability as well as willingness-to-pay of those who receive SWM services.

(5) Key Issues to be addressed for establishment of the National Fund

As to the budget allocation for the National Fund, it depends on the decision of the government while collection of additional tipping fee may entail several complex issues in relation to the SW collection fee rates, privatisation of SW collection and haulage services, and operation of the existing landfills. SW collection fee rates have to be carefully designed in consideration of equality among the peoples and their affordability and willingness to pay. With the collection of additional tipping fee for safe closure of landfills, the current contracts between private SW collection and haulage service

providers may need to be amended. The method of additional tipping fee collection will be another critical issue to be addressed. Taking into account the characteristics of the National Fund, the additional tipping fee should go to the fund and be managed by the government, in this case, MHLG, and provided to each landfill operating body at the time of landfill closure. The landfill owners and/or operators may be required to submit their landfill closure plan to the State authority while the state authority will submit these plans to MHLG for its approval of providing the fund.

As for the option for the allocation of the National Fund, it will be given to LAs taking into account the financial capability of targeted LAs. Range of subsidy from the fund might range between 50% to 100%.

As for the financial management of the reserve fund, the government financial institutes (GFIs) under the Ministry of Finance may take the main roles.

Initial seed money for the reserve fund may be required to be provided from the federal budget. In this regard, MHLG stated that it would consider some amount of budget to be earmarked for closure and post-closure of landfills in the Ninth Malaysia Plan.

5.7 ACTION 6: TO DEVELOP HUMAN RESOURCE FOR CAPACITY BUILDING

In order for the proper implementation of safe closure of landfill sites, it is necessary to identify the responsible organisations, operators and managers who will handle the management and/or carry out the actual safe closure works. However, due to the lack of suitably trained managers or operators in this field in Malaysia at present, the Federal Government must ensure that proper training and technical assistance must be provided.

To develop the human resources in Malaysia, appropriate training programme should be prepared and carried out. It is recommended that bi-annual one-week training course be provided for this purpose for training of the personnel from the States, Local Authorities and also for the related private companies. The proposed contents of the training course are shown in **Table 5.7.1**.

Table 5.7.1 Proposed Content of Training Courses for Safe Closure of Landfill Sites

	Training courses	State officials	LAs	Operator/owner
1	Administration, management and finance	+++	+	+
2	Guideline	+++	+++	+++
3	Laws and enforcement	+++	++	+
4	Registration of landfill sites	+++	+	+
5	Inventory survey/priority and closure level set-up	+++	++	+
6	Physical closure and post-closure management	++	++	+++
7	Environmental risk and monitoring	++	+	+++
8	Re-development of closed landfill site	++	+	+++

Note. (+ Recommended, ++. Should Attend, +++ Compulsory)

5.8 ACTION PLAN SCHEDULE

The implementation of landfill safe closure in accordance with the Action Plan has been determined by the consideration of the priority and closure schedule of operating sites. The implementation schedule for safe closure of landfill sites up to the year 2010 is shown in **Table 5.3.1** above.

(1) Outline

In order to implement the safe closure of landfills properly, the guideline for safe closure will have to be set up together with the “action plan for implementation of the guideline”, and must be approved by the Government of Malaysia.

The Guideline and the Action Plan are supposed to be approved for implementation by the end of 2004. The Malaysian Counterparts are encouraged to expedite the approval process by making the necessary adjustments to the institutional set up and to obtain the Government’s final approval for the Guideline and the Action Plan.

As for the approval of the guideline and the Action Plan, the setting up of the institutional mechanisms for landfill management and the special fund for safe closure are required, together with the collective approval by the Economic Planning Unit (EPU) and the Department of Environment (DOE).

(2) Implementation Schedule

In order to carry out the safe closure of landfill sites, the setting up and enactment of the safe closure guideline, the approval of the Action Plan, and budget allocation are urgently required to be completed. It is proposed that the Guideline and Action Plan should be set up in the year 2004. It is also desirable that the division for landfill management and fund for landfill safe closure should also be set up during this period.

The implementation schedule for the Action Plan is shown in **Table 5.8.1**. The main activities necessary to be carried out for the implementation of the Action Plan have been considered, they are;

- 1) Physical closure and post closure management
- 2) Enacting the safe closure guideline
- 3) Landfill registration system set-up
- 4) Completion of landfill sites list
- 5) Funding system set-up
- 6) Implementation of human resource development

Table 5.8.1 Implementation Schedule for Action Plan

	Activities	Agencies in charge	2003	2004	2005	2006	2007	2008	2009	2010
	JICA study for safe closure of Landfill sites									
	1. Preparation of guideline	JICA, MHLG, TWG								
	2. Preparation of action plan	JICA, MHLG, TWG								
	3. Pilot project and monitoring	JICA, MHLG, LAS								
	4. Human resources development	JICA, MHLG, TWG, States, LAS								
I.	Physical closure and post closure management									
	1. Instruction or public notice of landfill closure project	State								
	2. Preparation of safe closure plan	Operator/ owner or contractor State (and MHLG)								
	3. Approval of safe closure plan	Operator/ owner or contractor								
	4. Physical closure	Operator/ owner or contractor								
	5. Post closure management (aftercare and monitoring)	Operator/ owner or contractor								
II	Enacting the safe closure guideline									
	1. Approval of the guideline	Federal gov. (MHLG and DOE)								
	2. Publicizing/enacting the guideline	MHLG								
III	Landfill registration system set-up									
	1. Design of landfill registration system	MHLG								
	2. Publication of landfill registration system	MHLG								
	3. Set-up of landfill registration system	States								
	4. Registration of landfill sites	States and LAs (⇄ MHLG)								
IV	Completion of landfill sites list (additional inventory)									
	1. Data collection and survey of remaining landfill sites	LAs and States								
	2. Classification and closure level set-up	Sates and LAs								
	3. Completion/ data base of additional landfill sites	States and MHLG								
V	Funding system set-up for landfill safe closure									
	1. Design of funding system	Federal gov. (EPU and MHLG)								
	2. Authorization of funding system	Federal gov. (EPU and MHLG)								
	3. National budget allocation for the fund	Federal gov. (EPU and MHLG)								
	4. Establishment of fund collection system from tipping fee	MHLG and States								
	5. Implementation of fund collection from tipping fee	LAs, States and MHLG								
	6. Budget allocation for physical closure/ aftercare of landfills	Federal gov. (EPU and MHLG)								
VI	Implementation of human resource development									
	1. Set-up training program	MHLG								
	2. Implementation of the program	MHLG								

5.9 ACTION PLAN EVALUATION

This section evaluates the financial and economic impacts of implementing the action plan on safe closure of landfills sites based on the analysis of cost and benefit arising from the action plan.

(1) The ratio of the cost for safe closure of landfills to the total SWM cost

According to the cost estimation made in this Study, the total cost required for implementing the action plan is shown in the below **Table 5.9.1**.

Table 5.9.1 The Cost of Implementing the Action Plan

Description	Unit	Cost (RM)
1. Rehabilitation of Closed Landfills	Per tonne of waste generated	1.50
2. Safe Closure of Landfills in Operation	Per tonne of waste generated	4.10
Total Incremental Cost Required	Per tonne of waste generated	5.60
Total Incremental Cost Required (Urban household)	Per household per month	0.77
Total Incremental Cost Required (Rural household)	Per household per month	0.38

Notes:

- Amount of waste generation used in the table above is the total generation during the period of action plan from 2005 to 2010.
- The amount of household waste generation is estimated at 1.5 tons per urban household and 0.75 ton per rural household.

On the other hand, the draft NSP estimated the total cost for its implementation and currently levied assessment rate for SWM is shown in **Table 5.9.2**.

Table 5.9.2 The Cost of Implementing the Strategic Plan

Description	Unit	Cost (RM)
1. Current Cost of SWM Levied	Per tonne of waste generated	60 - 120
	Per household per month	7.5 - 15
2. Total Cost of Implementing the NSP	Per tonne of waste generated	227
	Per household per month	28

Source: MHLG, 2003

According to the cost estimations given above, the cost of implementing the safe closure of landfill sites up to 2020 only increases the rate of current levied cost of SWM by more or less 5.0%, or only 2.5% of the total cost required for implementing the NSP. It implies that the impacts of the cost for safe closure of landfills would be small enough to be included in the total SWM cost.

(2) Willingness and Affordability to Pay of the household

Although there is no prior survey on willingness-to-pay (WTP) of household for the safe closure of landfills, there was a similar WTP survey carried out in 1998 by EPU-DANCED entitled "A Contingent Valuation Study of Solid Waste Management in Kuala Lumpur & Petaling Jaya". It estimated that the sampling households are willing

to pay on average about RM 15.17 per month or about 0.45% of their monthly household income.

In general, in Malaysia, the monthly cost per household for safe closure of landfills is mostly less than 0.1% of the gross monthly household income except for the lowest income category in rural area, which is just about 0.1%. It seems that the increase in the cost of less than 0.1% will be affordable to most of the households in Malaysia.

(3) Potential Economic Benefits Obtained from Implementation of the Action Plan

There are many benefits of great importance that the Federal Government should pay attention to in terms of public health, environmental conservation, as well as sustainable development of the country.

a. Prevention and minimization of the risks upon human health and environment through safe closure.

The primary objective of safe closure of landfills is to prevent and minimise the risks to human health and the environment that may otherwise be realised some time in the future. Such risks to the human health and the environment may include:

- Surface/ground water pollution due to leakage of leachate from landfills
- Washing out of waste from landfills due to heavy rains if proper final soil cover has not been provided
- Potential impacts of landfill gas on the nearby area if proper action has not been taken to vent the gases.

b. Maximisation of the development potential of the post closure landfill sites

Generally, the higher the closure level of the landfill site will result in the higher development and land use potential of the site. The development potential of the land can be represented by its market value, which usually varies with types of land use and development potential. The value of land will be lower if it can be used only for the limited purposes due to existence of potential risks to human health and the environment resulting from improper closure and post closure management of landfills. Implementation of landfill safe closure and post closure management will have a significant influence upon the future land use and development potential of the closed landfills.

CHAPTER 6 PILOT PROJECTS

6.1 PURPOSE

The three Pilot Projects (PP) for safe closure of landfills have been implemented at the Ampang Jajar Landfill Site, Pekan Nenasi Landfill Site and the Ampang Jaya Closed Landfill Site. The purpose and the scope of work of the Pilot Projects are as follows;

- To develop and to analyse/examine the standards as set out in the Guideline for landfills under different conditions.
- To consider the suitability of construction methods and materials.
- To estimate the necessary construction costs.
- To identify the issues associated with the construction programme and the project period.
- To ascertain the capability of local engineers and contractors with regards to design, construct and monitoring.
- To show and learn from the progress and results of the safe closure and rehabilitation of landfills.
- To establish standard monitoring and maintenance requirements in the post safe closure phase.
- To provide actual pilot project case study and implementation examples for future references.

An outline of the pilot projects is shown in **Table 6.1.1**.

Table 6.1.1 Brief Description of the Pilot Projects

Item	Pilot Projects		
	Ampang Jajar Landfill	Pekan Nenasi Landfill	Ampang Jaya Closed Landfill
Status of landfill	Closed (2003)	In Operations	Closed (1998)
Key points in safe closure consideration	Safety closure of landfill that has been operated under improved conditions	Model for rehabilitation of landfill located on wetlands	Safety closure of landfill previously operated as an open dump site and poorly located
Targeted safe closure levels	Landscaping and safety closure to Level C3	Safety closure to Level C3	Safety closure to Level C2
Brief description of the pilot projects	Improvement of the slopes and installation of storm water drains, leachate collection pipes and gas vents	Upgrading to semi-aerobic landfill with leachate collection pipes, recirculation system and gas vents	Provision of leachate collection pipes and gas vents Installation of surface storm water drainage system

Major works carried out	<ul style="list-style-type: none"> • Topographic and geological survey • Re-forming 250m stretch of slopes from 3.2m to 7m high • Applying 8,000m² cover soil (150mm thick) • Plant 11,400m² turfing & 240 trees • Installing 275m of 450mm dia. leachate collection pipes • Installing 600m of 150mm dia. Leachate/gas pipes • Installing 900m of pre-cast surface / stormwater drains 	<ul style="list-style-type: none"> • Topographic and geological survey • Install 84m of 450mm dia leachate collection pipe • Install 330m of 225mm dia branch pipes • Excavation of 100m x 10m x 2m(deep) leachate collection pond • Installation of one 7.5kw surface aerator c/w control systems • Installation of one 5kw recirculation pump c/w piping and control panel 	<ul style="list-style-type: none"> • Topographic and geological survey • Construct 1km, 7m wide access road • Install 1km stormwater drains alongside access road • Install 126m of 450mm dia HDPE leachate collection pipe • Install 500m of 100mm dia leachate / gas collection pipes • Install 500m stormwater drains • Excavation of wetland area for leachate pond
Environmental monitoring	Before and after PP <ul style="list-style-type: none"> • Surface & groundwater • Leachate • Landfill gas 	Before and after PP <ul style="list-style-type: none"> • Surface & groundwater • Leachate • Landfill gas 	Before and after PP <ul style="list-style-type: none"> • Surface & groundwater • Leachate • Landfill gas

6.2 SELECTION OF PILOT PROJECT SITES

The pilot project (PP) sites were selected based on the landfill inventory data for both operating and closed landfill sites prepared by MHLG, and the site reconnaissance survey carried out by the JICA study team. A total of 19 landfill sites in the Peninsular Malaysia were identified as candidate sites for the pilot projects. The two main factors for the selection considerations were, i) their geographical locations, and ii) their closure stages, i.e. in operations, about-to close or closed sites.

The general procedures for the selection of the PP sites are shown in **Figure 6.2.1**.

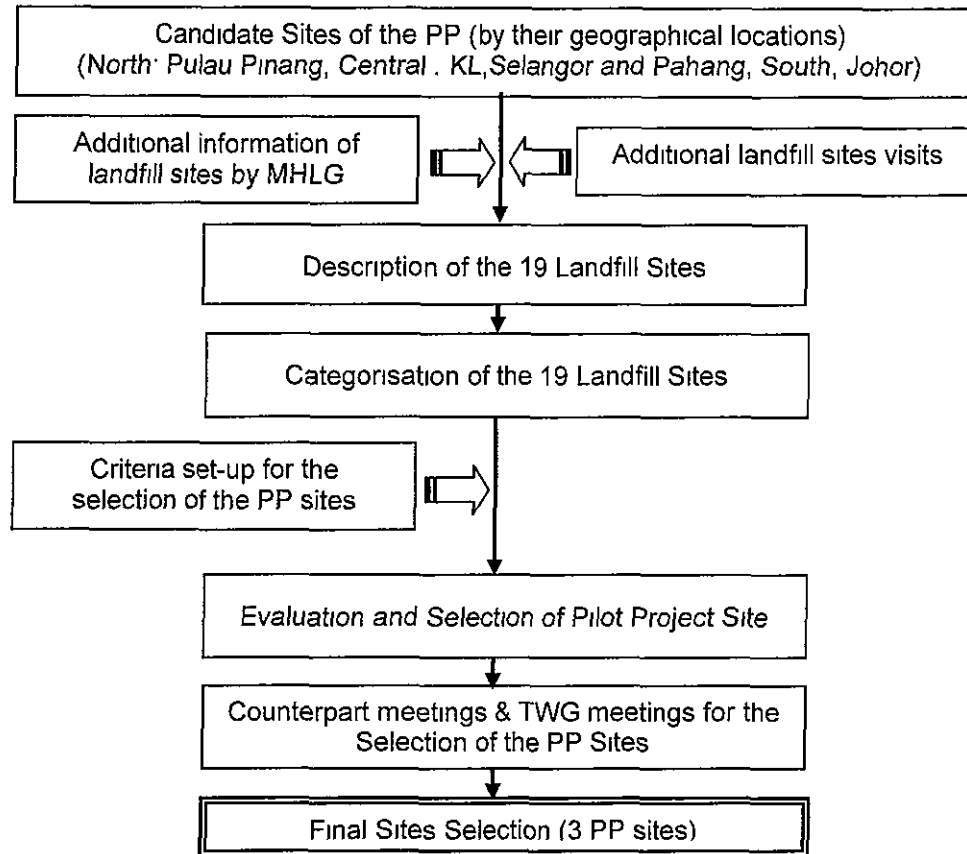


Figure 6.2.1 Site Selection Procedure for the Pilot Projects

In order to examine and to evaluate the characteristics of the 19 pilot project candidate sites, they were categorised into the following parameters;

- i. Closure stage of landfill
- ii. Risk to the environment
- iii. Potential for post closure utilisation
- iv. Landfill facility level

From the evaluation the candidate sites were presented to the Technical Working Group (TWG) for discussion and their consideration. As a result of the discussions, the 3 Pilot Project sites were selected. They are;

- i. Ampang Jajar Landfill site (Pulau Pinang)
- ii. Pekan Nenas Landfill site (Pahang)
- iii. Ampang Jaya Closed Landfill site (Selangor)

6.3 PILOT PROJECTS IMPLEMENTATION PROCESS

6.3.1 Implementation Flowchart

The implementation flowchart for the Pilot Project is shown in **Figure 6.3.1**.

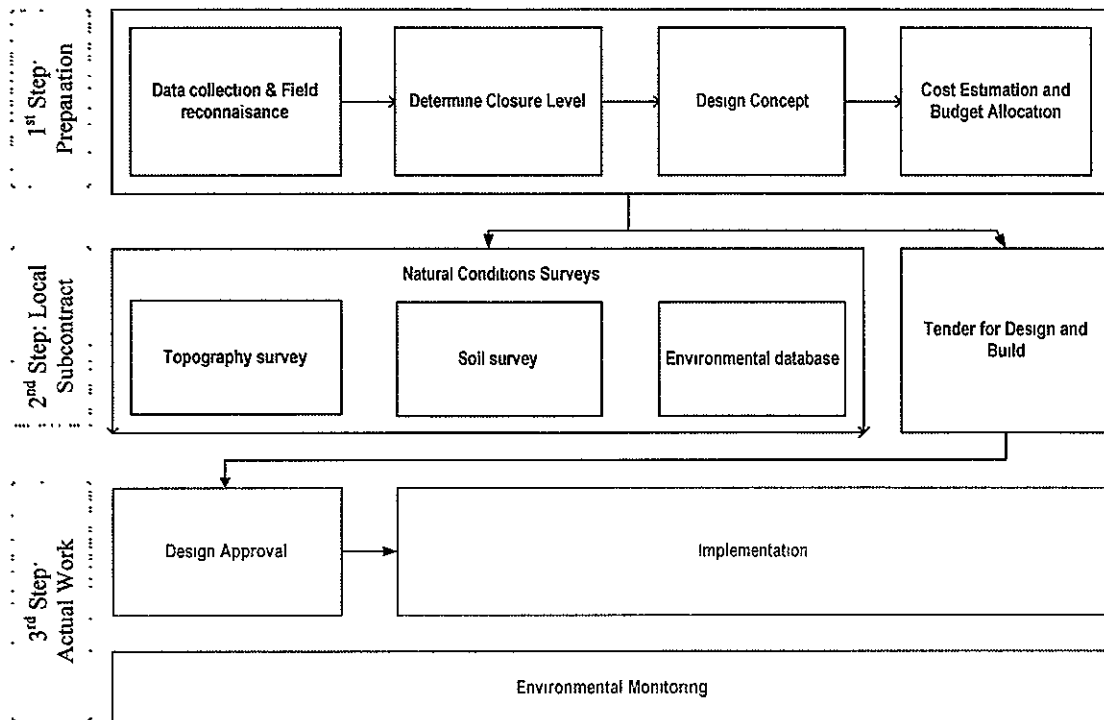


Figure 6.3.1 Implementation Flow

Once the 3 Pilot Project sites have been identified, as a 1st step, detailed site investigations were carried out to gather site specific data for each of the sites. Examples of the data gathered were as follows:

- Records of previous operations and previous improvement projects
- Records on previous leachate testing and analysis results
- The land use and development surrounding the site
- The effects of the new transfer station adjacent to the landfill site
- Carry out surface water, groundwater, leachate and gas sampling for the preparation of the environmental database
- Information on the tidal conditions for the sites that are situated on a swamp land or near to the coast

Prior to the commencement of the Pilot Projects, as a 2nd step, the topography surveys and soil investigations of the existing natural condition were carried out. The topography survey plans provide an up-to-date representation of the landfills that were later used for the detailed designs for the construction works. The soil investigations data were used to study and determine the groundwater flow both upstream and downstream of the closure works.

Once the detailed designs have been approved, as a 3rd step, the Pilot Projects were implemented and construction work commenced at each of the 3 sites.

6.3.2 Monitoring Programme for the Pilot Projects

The main objective of the monitoring programme under the pilot project is to evaluate the effect of the landfill improvements. Some components of the improvements, such as leachate water quality, landfill gas composition, etc., can be evaluated only on a long-term basis. It is expected that significant effects of improvement may not be observed for some components during the short period of these pilot projects. Therefore, for such components, this monitoring program will provide short-term observation but also it should be considered as an example of how the monitoring shall be continued by the own effort of MHLG or the Local Authorities until completion of the stabilisation process of the site.

Water quality parameters for monitoring of leachate, surface water and groundwater are based on the effluent standard applied to the landfill site in Malaysia (standard B). Water quality parameters and gas composition parameters, as well as their analytical method are as shown in Table 6.3.1.

Table 6.3.1 Analytical Parameters

(a) Water Quality

Water Quality Analysis			Method
1	Water temperature	°C	APHA 2550B
2	pH	-	APHA 4500 H+ B
3	Electric conductivity (EC)	mS/cm	APHA 2510 B
4	Dissolved oxygen (DO)	mg/l	APHA 4500-O G
5	Turbidity	NTU	APHA 2130B
6	Oxidation-reduction potential (ORP)	mV	APHA 2580B
7	BOD5 at 20degree C	mg/l	APHA 5210 B
8	COD	mg/l	APHA 5220 D
9	Suspended solids (SS)	mg/l	APHA 2540 D
10	Total nitrogen	mg/l	APHA 4500
11	Mercury (Hg)	mg/l	APHA 3112 B
12	Cadmium (Cd)	mg/l	APHA 3112 B
13	Hexavalent chrome (Cr+6)	mg/l	APHA 3500- Cr D
14	Arsenic (As)	mg/l	APHA 3120 B
15	Cyanide	mg/l	APHA 4500 CN C
16	Lead (Pb)	mg/l	APHA 3120 B
17	Trivalent chrome (Cr+3)	mg/l	APHA 3500 Cr D & 3120 B
18	Copper (Cu)	mg/l	APHA 3120 B
19	Manganese (Mn)	mg/l	APHA 3120 B
20	Nickel (Ni)	mg/l	APHA 3120 B
21	Tin (Sn)	mg/l	APHA 3120 B
22	Zinc (Zn)	mg/l	APHA 3120 B
23	Boron (B)	mg/l	APHA 3120 B
24	Iron (Fe)	mg/l	APHA 3120 B
25	Phenol	mg/l	APHA 5530 D
26	Chloride ion	mg/l	APHA 4500 Cl G
27	Sulphide	mg/l	APHA 4500 S2- D
28	Oil and grease	mg/l	APHA 5520 B
29	Ammonium-nitrogen	mg/l	APHA 4500 NH3 G
30	Nitrate-nitrogen	mg/l	APHA 4500 NO3- H
31	Nitrite-nitrogen	mg/l	APHA 4500 NO2- B

(b) Gas Quality

Gas Quality Analysis			Method
1	Oxygen (O ₂)	%	Galvanic cell sensor
2	Nitrogen (N ₂)	%	Computation as residual gas
3	Methane (CH ₄)	%	Infra-red absorption
4	Carbon dioxide (CO ₂)	%	Infra-red absorption

Note: APHA = American Public Health Association)

For each sampling location, samples will be taken four times (once before the pilot project improvement and three times after the project) according to the schedule shown in the following **Table 6.3.2** (⊙ indicates sampling timing).

Table 6.3.2 Sampling Schedule

Sample type	2003					2004							
	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Surface water	⊙						⊙			⊙		⊙	
Leachate	⊙						⊙			⊙		⊙	
Groundwater	⊙						⊙			⊙		⊙	
Landfill gas	⊙						⊙			⊙		⊙	

6.4 PILOT PROJECT - AMPANG JAJAR LANDFILL SITE (PULAU PINANG)

6.4.1 Outline of the Site

The Ampang Jajar landfill site started operations in the 1980s on a wetland beside the Prai River. The site was used as an open dumping site and it was improved to level L3 sanitary landfill in 1988 with advice and cooperation from the JICA experts. For the improvement works, leachate collection pipes, gas ventilation pipes, leachate pond and leachate re-circulation system were provided. With the leachate re-circulation system, the site was operated as a semi-aerobic landfill site. The landfill site is operated by MP Seberang Perai and is considered to be one of the best landfill sites in Malaysia. About 400 tonne per day of municipal waste were disposed at the site and for the past 15 years, more than 2.2 million tonnes of waste has been disposed.

The site occupies an area of about 17 ha and the final height of the waste layers is about 20 m. Ever since its closure in November 2003, all the waste are now sent to the neighbouring new transfer station and hauled to the Pulau Burung landfill site for disposal, about 40 km south of Ampang Jajar. Currently, MP Seberang Perai is providing the final cover on the top layer as part of their safe closure work.

The site is about 5 km from the MP Seberang Perai Council building and sandwiched between the riverside park on the West and the North-South Highway on the East. There are some housing development projects planed for at the neighbouring lot to the South. At present, the site has been earmarked for development as an “urban forest/park” after closure.

The brief description of the landfill operations and site characteristics are summarised in **Table 6.4.1**.

Table 6.4.1 Ampang Jajar Landfill Operations and Site Characteristics

Operational Characteristics	Site Characteristics
⇒ Started operations in 1980s and scheduled for to closure in June 2003 but was later closed in November 2003.	⇒ Located on a wetland area
⇒ Upgraded to a Level 3 landfill in 1988 with the installation of leachate collection pipes, pond, recirculation system, and gas vents	⇒ The site occupied and area of about 17 ha and the landfill height is about 20m
⇒ After the upgrading, it was operated as a semi-aerobic landfill	⇒ The western side of the landfill was developed as a riverside park
⇒ About 2.2 million tonnes of waste has been disposed at the landfill(about 400t/d)	⇒ The North-South Highway passes along the eastern side

6.4.2 Ampang Jajar Pilot Project Implementation

The entire site occupied an area of about 17 ha but for the purpose of Study, the Pilot Project area only concentrated on a certain area that is along the eastern slopes, covering the southern portion of approximately 250m of the slopes. The PP area is about one-third the entire stretch alongside the North-South Highway.

The main activities of the Ampang Jajar Pilot Project were:

- (1) Reformation of the slopes, provision of cover soil and planting of grass and vegetation along the slopes.
- (2) Provide improvements to the drainage system along the slope by the installation of surface drains and leachate drainage pipes
- (3) Installation of gas venting pipes
- (4) Provide improvements to the access road alongside the slopes.

Brief description and bill-of-quantities (BQ) of the Pilot Project is summarised in. **Figure 6.4.1** and **Figure 6.4.2** shows plan & design drawing of the pilot project and the photographic records of the progress of the work and the main facilities are shown in **Plate 6.4.1** and **Plate 6.4.2**.

At present, the site has been earmarked for development as an “urban forest/park” after closure.

Table 6.4.2 Ampang Jajar PP Description

No	Item/Description	Quantity
1	Slope Re-formation and Final Cover	
	Re-formation of the 1 st Step Slope and final cover <i>Improvement of the lowest slope to 1.2, and supply and compaction of impermeable clayey soil on the slope. Height of the step varies from 3.2 to 7.1m</i>	1,580m ³
	Application of cover soil on the upper layer of the 2 nd Step Slope (t = 300mm) <i>Supply and compaction of clayey soil on the slope and steps with a thickness of 300mm to improve the existing slope Number of steps above the first step range from 2 to 5 steps.</i>	8,000m ²
	Vegetation cover (t = 150mm) <i>Application of rich organic field soil</i>	11,385m ²
	Turfing (slope protection) <i>Spot turfing for protection of the slope.</i>	11,385m ²
	Planting (1 tree/25m ²) <i>Selected tree type should be able to grow under the landfill conditions</i>	240 trees
2	Leachate collection system (Main Pipe)	
	Blind (buried) leachate collection pipe (dia. 450mm) <i>Supply and installation of perforated spun concrete pipe class H, of nominal diameter 450mm including placing of gravel around the pipe, partial excavation and laying with crusher-run of 200mm thickness, on wooden sleeper/wedge.</i>	275m
3	Gas venting system	
	Vertical gas venting pipe (150mm) <i>Supply and installation of vertical gas venting perforated HDPE pipe, of diameter 150mm in pits surrounded by gravel (50 to 150mm), to a depth of 3.5m penetrating the solid waste. Locations were selected mostly midway of the slope Connecting pipes were installed at heights of about 1.5m above ground</i>	6 units
	Gas at slope (HDPE, 150mm) <i>Supply and installation of inclined vents (perforated 150mm HDPE) to vent the gas and collect leachate. Pipes are located at four (4) sections along the slope and connect with vertical and horizontal pipes for leachate and gas Pipes are laid below ground in trenches of 50 x 50cm and surrounded by gravel.</i>	185m
	Horizontal gas and leachate collection branch pipes (150mm) <i>Supply and installation of horizontal gas venting perforated HDPE pipe, diameter 150mm buried in trenches of 500mm x 500mm and surrounded by gravel of size 25mm. These pipes are laid along the upper two steps</i>	600m
4	Improvement of existing perimeter roads	
	Crusher-run pavement (t = 200mm) <i>Supply, level and compaction of the crusher-run for pavement of width 3.5m and thickness of t=200mm, including bed grading, along the road running adjacent to the foot of the slope.</i>	192.5m ³
5	Slope storm water drainage	
	Drainage at steps <i>Supply and place RC pre-cast type drainage ducts of dimensions 300 x 300mm along the steps.</i>	700m
	Drainage at slope (sloping part) <i>Supply and placement of RC pre-cast type cascading drainage ducts of dimensions 600 x 600 mm, at 5 locations along the slope.</i>	190m
	Drainage pipes at step crossings and under perimeter road (dia. 300mm) <i>Supply and installation of pipe culvers of spun concrete, diameter 300mm under the steps and the perimeter road</i>	50m
	Earth drain (300 & 900 wide) <i>Earth drain of 300 x 300mm shall also be laid along the top of the slope.</i>	214m
	Drainage pits at steps and perimeter road. <i>Square brick drainage pits of base dimensions S1=750x750mm and S2=900x900mm are installed at the intersections of leachate main and branch pipes and at the intersections of horizontal and cascading drains and the main drainage pipe.</i>	14 units

No	Item/Description	Quantity
	Rip Rap (3000mm x 2500mm x 900mm depth) with cement mortar <i>Riprap is installed at the 5 locations where the concrete drainage pipe connects with the wide earth drain to drain the collected storm water to the existing earth drain</i>	5 units
	Drainage at toe (600 x 450 pieces U Drain) <i>RC pre-cast drains of dimensions 600 x 450mm are laid along the foot of the slope to receive</i>	275m

