SOLID WASTE PLANNING AND DISPOSAL

Service Delivery Training Module 4 of 4

MINISTRY OF LOCAL GOVERNMENT AND
PROVINCIAL COUNCILS

GOOD GOVERNANCE FOR LOCAL DEVELOPMENT
SLILG

SOLID WASTE PLANNING AND DISPOSAL

Service Delivery Training Module 4 of 4

2008

MINISTRY OF LOCAL GOVERNMENT
AND PROVINCIAL COUNCILS

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PREFACE

The Asia Foundation (TAF) implemented the Transparent Accountable Local Governance (TALG) Program with financial support from the United States Agency for International Development (USAID) from January 2005 - September 2007. The Foundation's main counterparts were the Ministry of Local Government and Provincial Councils and the Sri Lanka Institute of Local Governance. The International City/County Management Association (ICMA) and Environmental Management Lanka (EML) provided additional technical assistance and support.

The TALG Program developed a number of training modules and publications as part of its institutional strengthening programme for Local Authorities (LAs) in Sri Lanka. Each of the TALG training modules was used to train officials in thirty-five LAs in Southern, Eastern, Central, North Western, North Central and Uva provinces. These were very successful in promoting effective, transparent and accountable local governance. Preparing the training modules was a painstaking process and support from the Australian Agency for International Development (AusAID) enabled The Asia Foundation to complete and publish this and the other publications in the series.

INTRODUCTION

Through the interventions made by the Foundation for the betterment of the Local Governance system in Sri Lanka, publications were developed in the following areas:

- Citizen Participation
- Local Planning
- Service Delivery
- Financial Management
- Policy and Regulations

These publications range from one-page documents of Leading Practices to Training Modules. Major categories of the publications are:

- Training Modules
- Guidebooks
- Reports and Documents
- Video Films
- Computer Applications

TALG developed many training modules mainly in the areas of Financial Management and Service Delivery. **Solid Waste Planning and Disposal** is Module 4 under Service Delivery Training. Other training modules in the series include:

Module 1: Solid Waste Collection and Transport

Module 2: Solid Waste Reduction

Module 3: Road and Drainage Maintenance

In addition to these training modules, TALG developed video films showing successful solid waste management (SWM) initiatives implemented by the Sri Lankan and regional LAs.

Users should note that there are a range of TALG publications including Technology of Participation and Resource Directory for Local Authorities that can be used by LAs to create an enabling environment for improved SWM.

About this Training Module

Module 4: Solid Waste Planning and Disposal

Many Sri Lankan LAs adopt environmentally and socially unacceptable approaches in SWM. In addition, LAs lack resources in order to implement proper disposal systems. This module deals with the methodologies that should be adopted by LAs in order to reduce the negative impacts of existing disposal methods such as open dumping. Further, the module contains steps to be followed to develop a long-term SWM plan with the assistance of different stakeholders.

What is Inside this Module

The publications developed by TALG can be used by different users, ranging from beginners to practitioners, those working in LAs and for those working as partners with LAs. This publication contains all of the resources developed for the delivery of a two-day workshop in Solid Waste Planning and Disposal.

This training module provides comprehensive and detailed learning materials on Solid Waste Planning and Disposal that can be used as reference material for practitioners in LAs and as background information for trainers. Interactive exercises have been included throughout the training module. Additional resources can be found in the annexures of this module, which includes supporting documents and useful materials such as checklists, templates and manuals.

Attached to this module is a CD, which provides a 'PowerPoint' version of the reference materials with a focus on the needs of LAs and an 'MS Excel' spreadsheet application developed to help LAs measure and monitor their performance in waste management.

The Main Objectives of this Module

- To provide guidance to LAs in Sri Lanka and officials who engage in SWM activities.
- To provide knowledge, skills and tools for planning LA waste management activities in a systematic manner.
- To assist LAs to practice waste disposal methods which minimize the impact on the environment and society, and to monitor and manage the workforce engaged in waste management.
- To assist LAs to ensure a satisfactory level of waste management that meets the needs and demands of citizens.

How to Use this Module

The resources in this publication may be used:

- To enhance knowledge in this specific area.
- To share the knowledge with others.
- To support a training programme and awareness campaigns.
- To improve the existing system and enhance performance monitoring.

Trainers and beginners can use these learning materials to obtain knowledge on present practices and issues of solid waste planning and disposal in LAs. The learning materials will provide guidance to all decision-makers and staff who are involved in waste management activities. It will also provide guidance on how to reduce waste management costs within LAs.

Trainers can use the prepared 'PowerPoint' presentations to conduct awareness programmes for LA staff, decision-makers and other individuals. Group exercises can be used to improve practical experience on waste planning and disposal.

User-friendly spreadsheets will help relevant officers to monitor daily activities associated with solid waste planning and disposal. This can be used not only for monitoring but also for the decision-making process.

SESSION 1: SOLID WASTE MANAGEMENT PLANNING

Introduction

Planning in the field of SWM is the process by which community needs regarding waste management are measured and evaluated, and workable alternatives are developed for presentation to decision-makers. Planning of SWM is both exciting and challenging because most of the technical, environmental, economic, social and political factors and the interrelationships that are involved, are not fully understood.

In general terms, the planning process involves the collection, transfer, transport, processing, disposal, evaluation and presentation of data relevant to issues in the SWM process.

Planning is the conscious process for meeting future requirements and objectives with full consideration of any likely contingencies. The plan should guide intended actions specifying the time and priorities for accomplishing these actions.

The planning process is a systematic method of:

1. Recognizing the areas to be changed and improved in the present system.
2. Collecting and analyzing data about the present status.
3. Suggesting actions to overcome/improve the existing situation.
4. Evolving a suitable strategy for implementation with respect to a timeframe.
5. Implementing the proposed plan.
6. Evaluating the actions taken in the light of their success or failure in achieving objectives, and if necessary, modifying the plan to meet changing conditions.

A LA plan for SWM, therefore, should be a written document outlining the activities that the local government intends to undertake during the life of the plan, coupled with a set of directives for achieving those objectives in a given timeframe.

In order to avoid problems due to a lack of coordination and passing responsibility to others, it is necessary to have at least one person responsible for SWM on the LA staff. The overall control in relation to collection, transport, processing and disposal of all wastes, including shop facilities, should rest with this person. This person could either be the Chief Municipal Engineer or a separate manager of the SWM department. However, the stakeholders of a SWM planning and disposal process would be the Chairman or the Mayor of the council, the Secretary or Municipal Commissioner, other officials of the SWM department such as supervisors and labourers who are engaged in the collection, transportation and disposal of solid waste, and most importantly, the residents and business owners of the area.

1.1 Why LAs Need a Solid Waste Management Plan

SWM is a part of public health and sanitation; therefore, it falls within the purview of LAs. The LAs undertake the task of SWM with their own staff, equipment and funds. In some cases, part of the work is contracted to private sector companies, although the responsibility for proper management lies with the LA. Therefore, before implementing any SWM programme, it is very important to have developed a proper plan with community participation, to resolve the community needs within the framework of:

1. Available resources.
2. Staff, equipment and facility utilization.
3. Environmental protection.
4. An effective and efficient management system.

1.2 Benefits of Planning for LAs

- Comprehensive strategies to deliver an efficient and cost effective SWM system.
- Well-identified alternatives and preferred solutions to community needs with regards to SWM.
- Well-identified approaches that improve the health and sanitation conditions of the area.
- Help to utilize the available resources more efficiently.
- Help to implement the 3R system (Reduce, Reuse, Recycle) more effectively and thereby reduce the quantities of waste needing collection, transport and disposal.
- Can identify potential resources to urban development and LA revenues.
- Could achieve social and economic benefits by reducing the marginalization of poor people. Unplanned disposal of waste generally takes place in areas where poor people live. Therefore, a properly planned disposal site will help to identify suitable land and provide neighbours with buffering from SWM activities.
- Improve the aesthetic values of the area and make it more attractive to private investment and more liveable for area residents.
- Can identify strategies that rely less on landfills or dumping sites and focus on improved resource recovery processes.

1.3 How to Develop a Solid Waste Management Plan

Guidelines for Trainers

Objective

To explain the 1st step in planning, Initial Organization Process.

a) Leadership commitment
b) Importance of planning team
c) Identifying leader/facilitator for the team
d) Work planning

Preferred technology to be used - 'PowerPoint' presentations and interactive discussions with participants.

Materials to be used - Whiteboard can be used to draw a simple organizational chart of the planning team.

1.4 Initial Organization Process (Step One)

a) Leadership Commitment

The success of the LA planning process greatly depends on the strong commitment and support of the Mayor or Chairman and an active and effective planning team. Therefore, the level of success of the planning process will depend on:

a. Commitment of the Chief Executive Officer (Mayor or Chairman) of the LA, senior staff members responsible for SWM and other stakeholders.
b. Developing a rapport among the key persons mentioned above.
c. Gaining approval of the Council for the planning process, the timeline, budget and the planning work agenda before work begins.

b) Organizing the Planning Team

The success of participatory planning will depend on a dynamic and effective team. It is therefore necessary to form an effective team among elected members, staff members and community representatives. The community representatives should be selected from community based organizations, religious leaders and the business community. Ideally, the main planning team will have about 8-10 members. Clearly describing the role and responsibility of the planning team and the Council approval of the process, is critical in avoiding misunderstandings later on in the process. Members of the public in the planning committee are advisory, and their scope and responsibility is to advise the LA decision-makers of recommended decisions. They should communicate with the other members of the team regularly, both formally and informally, at committee meetings coordinated by the team leader.

Some of the suggested criteria for the members of the planning team are:

1. Knowledge, skills, attitudes and commitment to contribute to the process.
2. Willingness to participate in the planning process.
3. Availability to participate in the process.

c) Identifying a Facilitator

The Facilitator is the person who coordinates the activities of the LA planning team and keeps the planning process going without any interruptions, even when some of the members are busy. The facilitator could be one of the following:

a. A staff member of the LA who has received TOP (Techniques of Participation) training.
b. A council member who has good facilitation and organizational skills, preferably with TOP training.
c. An external facilitator from a government organization or from a professional consultancy firm.

The facilitator should:

- Be able to coordinate the planning team's activity regularly.
- Have a good understanding of the objectives and steps of the planning process.
- Have good facilitation skills and be able to encourage adequate participation.
- Be able to identify the decision-makers within the council and community and should build up a good rapport with them.
- Be neutral on which approach is selected, but insist that the process move forward.

d) Orientation and Work Planning for the Team

- The planning team needs to become motivated for the task and develop a work plan, which will guide them to complete the SWM plan for the LA.
- The LA could invite resource people to help explain the process and encourage the team to follow the process to derive benefits. The planning process for medium-term development, developed by the Sri Lanka Institute of Local Governance under TALG, is a good planning model to follow.
- Identification of the major issues in relation to SWM at present.
- Time period for planning should be identified.

Design Period

Municipal SWM involves activities associated with generation, storage, collection, transfer, transport, processing, recovery and disposal of solid waste. It encompasses planning, organizational administration, financial, legal and engineering aspects involving inter-disciplinary relationships.

While preparing a municipal SWM plan, the following design periods should be used in determining the focus of the SWM planning effort, based upon the necessity of SWM objectives.

I. Short-term plan 2-5 Years
II. Medium-term plan 5-15 Years
III. Long-term plan 15- 25 Years

The planning process involves close collaboration with other planning agencies at local, provincial and national levels, as well as the general public, to ensure better coordination in allocation of priorities and resources. The collection, transportation, processing and disposal aspects; the facilities, augmentation and replacement of the equipment and sites; allocation of priorities and resources, should all invariably be decided keeping in view the design period of municipal SWM plan. Under normal situations this period is normally between 2- 5 years, which is short-term.

Population Forecast

The future population growth will have to be estimated with due regard to all the factors governing the future growth and development of the project area in the industrial, commercial, residential, educational, social and administrative sectors. Special factors causing sudden influx or outflow of population should be forecast to the extent possible.

A judgment based on these factors would help in selecting the most probable trend for the population growth in the area or areas of the project from the mathematical model given in Annexure 1.

SESSION 2: COLLECTION OF EXISTING DATA, ANALYSIS OF RESULTS AND ISSUES IDENTIFICATION

Guidelines for Trainers

Objective

1) To explain the 2nd step of the planning process.

   Outputs

   a. List of key stakeholders
   b. A resource profile
   c. Socio-economic and financial analysis
   d. List of other issues and concerns

2) Explain what is expected from the planning team.
3) Analysis of data and issues identification.
4) Collection of data available – primary/secondary information, composition, technical information, transfer stations, disposal etc.

Preferred technology to be used - 'PowerPoint' presentation and exercises.

Materials to be used - Use data collection sample formats from TALG Solid Waste Collection and Transport Training.

2.1 Collection of Existing Data, Situation Analysis and Issues Identification (Step Two)

This is a preparatory step to be carried out by the planning team members of the LA.

This step is intended to:

a. Make a rapid assessment of the existing situation of the SWM process.
b. Make an initial list of issues and a preliminary resource assessment.
c. Review the implications of the planning legislation and development of proposals.
d. Identify key stakeholders to consult and involve in the process.

This step includes gathering primary and secondary data required for the analysis of the existing situation, and initial identification of issues in the form of a list. Data collected from original sources are known as primary data; whereas the data obtained from published documents or processed by secondary sources are known as secondary data. The internal and external stakeholders will be identified and consulted in order to: validate the initial list of issues prepared by the planning team of the LA; and to generate other issues and concerns.

The objectives of this step are:

- To develop an analysis of the LA situation and create an initial list of issues.
- To identify the stakeholders to be involved in the planning process.

- To conduct multi-stakeholder consultations to validate the initial list of issues, generate other issues and concerns and develop suitable recommendations.

The outputs of this step are:

1. List of key stakeholders.
2. A list of issues to be addressed in the new proposal.
3. List of available resources.

2.2 Identification of Stakeholders

Conduct a stakeholder survey through personal contact and, if required, set up informal interviews to identify key stakeholders to be involved in the planning and consultation activities. The following options can be used for identifying the stakeholders' representation in the advisory committee.

- Invite several community representatives to join the core planning team.
- Create sub-committees with several community representatives on each sub-committee.
- Create a citizen advisory committee with a large number of citizens representing different constituent groups to assist the core team.

The planning team of the LA will identify individuals, relevant groups, organizations and institutions to be represented on the advisory committee for the planning process.

SUGGESTED STAKEHOLDER GROUPS	
• LA staff	• Community based organizations
• Provincial Council	• Business and trade associations
• Divisional Secretary	• NGOs
• Grama Niladhari	• Women's groups
• National Government Agencies	• Youth Groups
• Academic Institutions	• Religious leaders
• Donors	• Village-level committees

The following areas are to be considered by the planning team:

- Identify the mandate or activities of each stakeholder.
- Consider what might be included in the action plan.
- Identify what resources and skills the stakeholders should contribute to the planning and implementation of the plan. (Financial, human, physical, goodwill and/or political support).
- Consider what might prevent full participation of the stakeholders in the planning process or project implementation.

- Consider what strategies the LA can take to meet the constraints and to ensure the active and appropriate involvement of the stakeholders in the process.
- Consider ensuring wide representation so that all interested constituent groups are involved, so as to avoid complaints when the plan is adopted.

2.3 Determination of Decision Criteria

The Planning Committee, with the input from the Advisory Committee, needs to determine what criteria they will use to find the best solution. They need to define how they will know a good solution when they see it. This criterion will be used at the end of the process to select the best alternative or set of alternatives.

2.4 Collection of Existing Data

In this step an inventory is made of all pertinent factors about the community, and data are collected as needed to meet the problem specifications. The main purpose of the inventory is to define the existing solid waste system as completely and as accurately as possible and to collect certain other basic information such as population data. This is an important step in planning, because all subsequent recommendations for action will be based on the findings of this step.

The following general information should be collected and updated from time to time in order to prepare the SWM plan.

Salient Features of the LA:

1. Area of the LA.
2. Population of the LA.
3. Decadal growth of population.
4. Number of wards, their area and population.
5. Ward-wise information in regards to:
    - Population density in different wards.
    - No. of households, shops and establishments.
    - No. of vegetable/fruit//meat/fish markets.
    - No. of slaughter houses.
    - No. of educational institutions.
    - No. of theatres/meeting halls.
    - No. of office complexes.
    - No. of temples - religious places.
    - No. of hotels and restaurants.
    - No. of hospitals and nursing homes.
    - No. of industries, large/medium/small.
    - Number of slums and their population.
    - Road length and width.
    - Area covered with underground sewage system.
    - Area having surface drains.
    - Total number of public toilets.

It is important to calculate the waste generation rates (per capita or other factor) for each of these categories. Without these data the forecasting of future waste generation will not be possible and proper planning cannot be undertaken successfully. Module 1 will give the details on how to determine the waste generation rates within the council area. The above list can be modified to reflect the waste generation rates that are available.

2.5 General Information on SWM

Waste Generation

It is important to have the waste generation information amounts and composition collected, as this will have a major impact on the planning process. Information that needs to be collected can be found in Module 1. Determination of Solid Waste Generation and Collection Rates is given in Annexure 2, at the end of this module.

Composition of Waste

Determination of composition of waste is very important in selecting the appropriate technology.

1. Physical characteristics (% by weight or volume). Paper, plastics, metal, glass, organic matter, rubber, coconut shells etc.
2. Chemical characteristics. Moisture content, bulk density, calorific value, pH value, organic carbon, N, P, K %, C:N Ratio etc.
3. Heavy metals content.

Details of composition analysis is given in Module 1. A 'Sample Format for Waste Generation and Composition Determination Data Collection' sheet is given in Annexure 3. Annexure 3a gives the results of a recent SW composition analysis carried out in an Urban Council.

Determination of Chemical Characteristics and Heavy Metal Content

Information on the chemical components that constitute metal solid waste (MSW) is important in evaluating alternative processing and recovery options.

Because of the diverse mixture of solid waste, determination of the composition is not an easy task. Strict statistical procedures are difficult to implement. For this reason, more generalized field procedures based on common sense and random sampling techniques have evolved for determining composition. In determining composition of residential MSW it has been found that a measurement made on a sample size of about 200lb is sufficient.

To obtain a sample for analysis, the load (mixed load of MSW from a tractor/compactor) is first quartered. One part is then selected for additional quartering until a sample size of about 200 lb is obtained. This sample can now be separated manually into its components and measured. Similar processes on several additional loads should be carried out before finalizing the results.

For chemical analysis of major elements and heavy metals, random moisture content samples of about 500g should be sealed in polythene bags and sent to an analytical laboratory as soon as possible after collection.

An exercise on determination of solid waste generation rates is given in Annexure 4.

Staff Position in SWM Department

- Number of sanitation workers deployed in the LA for collection of waste.
- Number of sanitation workers deployed for transportation of waste (loading).
- Ward-wise allocation of sanitation workers.

- Sweeper/Population ratio in each ward.
- Sweeper/Road length ratio in each ward.
- Sweeper/Supervisor ratio in each ward.

Waste Storage Facilities

- Number of sites designated/notified as temporary collection points (dustbins, open collection points, skips).
- Type and size of each of the above in each ward.
- Ward-wise average amount of waste generated each day.

Solid Waste Transportation

- Number of vehicles available within the local body for the transportation of waste, their type, size and age.
- Number of trips made by each vehicle in one shift.
- Number of vehicles used in first trip, second trip, third trip, etc.
- Quantity of solid waste transported in each shift.
- Quantity of solid waste transported by each vehicle.
- Total quantity of solid waste transported each day.

Waste Processing and Disposal

- Number of solid waste processing and disposal sites in the city.
- Number of solid waste recycling centres.
- Quantities of recycled products.
- Distances from the centre in the built-up area, to the disposal sites.
- The area of these sites.
- The quantity of waste treated/disposed of at each site/day.
- The expected life of each landfilled site.

Refer to Annexure 5, Method of Calculation of Life Span of a Landfill (see Module 1 for further details).

Financial Aspects

Operational costs for each item shall be collected separately.

- Cost for collection/ton or volume.
- Cost of transportation/ton or volume.
- Cost of disposal/ton or volume.
- Allocation of revenue and capital budget for SWM annual budgets.

Usually, LAs do not have weighing facilities at disposal sites. Therefore, the weight has to be estimated by determining the approximate volume of each waste transport vehicle, recording the number of loads delivered a day and considering the bulk density of the solid waste.

Primary Collection

Collection is the first and prime activity in SWM. For planning and designing an effective, sustainable, cost effective and efficient primary collection system, the following information will need to be determined and forecast for the planning period for each Ward of the LA.

Population and Composition of Waste

- Present and future growth of population.
- Solid waste generation per capita/day.
- Quantity of solid waste generated per day.
- Area to be covered.
- Population density.
- Physical characteristics.
- Chemical characteristics.

Source of Generation

- Residential.
- Commercial.
- Industrial.
- Hospital.
- Institutional.
- Waterways - rainwater drains.
- Construction waste.

Manpower and Implements

- Manpower - Sanitation workers in local body.
- Contract workers.
- Voluntary agency workers.
- Implements, tools and plant.
- Primary collection vehicles.
- Handcarts.
- Wheelbarrows.
- Temporary storage depots.
- Welfare measures for workers. (Uniforms, Housing, Healthcare, Loans for education etc.)

(Refer to Module 1 for more details)

Monitoring of Primary Collection Services

Individual sections of the SWM department may collect, compile and analyze data to monitor daily, weekly and monthly SWM activities, with the aim of providing effective management services.

Reports to be sent daily by SW supervisors to the person responsible for SWM:

a. Quantity of waste collection.

b. Inspection reports by supervisors on street sweeping and primary collection.

c. Inspection of solid waste storage sites.

d. Inspection of silt removal sites and building waste disposal sites.

e. Recovery of additional cleaning charges, if any.

(Please refer to Module 1 for more details on reports to be sent on primary collection.)

Legal Matters

A number of cases are filed in the courts each month for violation of sanitation laws. For the effective monitoring of SWM services, the information collected should be carefully analyzed and corrective measures taken promptly.

There should be route maps and duty charts with each of the supervisory staff. They should check whether work on the site is going as per schedule and whether vehicles and manpower are working at their optimum level. Motorcycles and mobile phones for effective communication and supervision are good options for effective monitoring of service delivery. Ensuring timely follow-up (next day) on complaints or complaint book notations are important.

Secondary Collection

Transfer Stations

The second activity in SWM service is the transfer of waste to a larger transport vehicle, prior to dumping at the disposal site. The method and data requirements to design and establish an ideal transfer station is given below:

- Location
- Area
- Capacity
- Type of transfer station
- Mode of unloading
- Types of vehicles
- Sources of collection
- Reception facility
- Weighing bridge
- Sanitation impact aspects
- Segregation facility
- Rainwater drain facility
- Public resistance

(For further details please refer to Module 1)

Transportation

Secondary collection (transportation) plays a vital role in SWM services. To enable designing a cost effective and efficient secondary collection system to synchronize with the operation of primary collection and transfer system, information that needs to be collected is given below:

a. Transportation of waste

b. Quantities of waste transported

c. Record of trips made by vehicles to disposal sites

d. Route Schedule

e. Machinery

f. Manpower

g. Monitoring of vehicles/machinery

h. Workshop performance: monthly statement

2.6 Disposal of Solid Waste

Disposal is the last and most important activity in SWM practices. In order to have an effective planned operation of disposal and a design that is engineered and scientifically sound, the following aspects have to be taken into consideration.

Processing/Treatment

To plan an effective solid waste processing technique, the following areas need to be considered and evaluated for applicability in the local situation.

1. Physical Conversion - Refuse Derived Fuel Pellets

Refuse Derived Fuel - Power Generation

Refuse derived fuel refers to solid waste that is processed to serve as fuel for boilers producing steam or electricity.

2. Thermal conversion or energy recovery - Incineration, Pyrolysis and Gasification Thermal processing of solid waste can be defined as the conversion of solid waste into gaseous, liquid and solid conversion products, with the concurrent or subsequent release of heat energy.

Gasification

Gasification is the partial combustion of solid waste in the presence of oxygen, to generate a combustible gas containing carbon monoxide hydrogen and gaseous hydrocarbons.

Pyrolysis

Pyrolysis is the thermal processing of waste in the complete absence of oxygen.

3. Bio-Conversion for energy recovery - Anaerobic Digestion/Bio-Methanation

Biogas Production

- During the decomposition of organic substances, highly flammable gases are generated. It has been observed that anaerobic digestion of organic matter is responsible for this gas generation, which is known as Biogas.

- Biogas is composed of highly flammable methane gas (55-70%), carbon dioxide (25-35%) and traces of hydrogen sulphide and nitrogen sulphide.
- Biogas is produced by anaerobic digestion by the decomposition of organic matter in the absence of oxygen by a special group of bacteria (anaerobic bacteria).

Benefits of Biogas Production

- The cost of energy generation is reduced through the use of a low-cost renewable source.
- It is an effective waste treatment method.
- The sludge by-product is used as a soil fertilizer.
- Environmental problems associated with waste dumping are avoided.
- Less fossil fuel is consumed.

4. Bio-Conversion for compost production - Aerobic Composting, Vermicomposting

Objectives

- To transform the biodegradable organic materials into a biologically stable material, and in the process, reduce the original volume of waste.
- To destroy pathogens, insect eggs and other unwanted organisms and weed seeds that may be present.
- To retain the maximum nutrient content.
- To produce a product that can be used to support plant growth and as a soil amendment.

Composting of organic waste occurs in three stages.

a) Preparation of Waste for composting

- Screening of waste to remove non-suitable materials.
- Shredding.
- Other conditions necessary for the aerobic decomposition of organic waste.

b) Composting Organic Matter

- Usually the waste is piled into heaps with a base of about 2.5 - 3.5m, and a height of 1.75m.
- In addition to humidity, aeration must be adequate for decomposition to occur.
- Humidity is controlled through watering and aeration is controlled through rotation.

c) Preparation of Compost

- Sorting the compost raises its quality and value, creating only soft and uniform compost. Nutrients that plants require for growth are sometimes added. Usually 350 - 500kg of manure can be produced from one ton of municipal waste, according to the location of the factory and weathering conditions.

- Good compost must be free of any pathogens, grass seeds, toxic substances such as ammonia, heavy metals and bad odour. This will not be achieved unless sorting of the original municipal waste takes place, and the rules of the production process are perfectly followed.

Sanitary Land Filling

Sanitary landfill is a physical facility used for disposal of solid waste in surface soil, with engineered facility to minimize public health and environmental aspects.

For a landfill design, selection and operation, the following aspects should be considered to ascertain which is least costly and most environmentally sound. A balanced approach will cause trade-offs to these conflicting goals.

1. Site Topography, Location and Land Use

   Because it is necessary to cover solid waste placed each day in the landfill and to provide a final cover layer after the land filling operations are complete, data must be obtained on the amounts and characteristics of soil in the area. The local topography must be considered because it will affect the type of landfill operation to be used, the equipment required, and the extent of work necessary to make the site usable.

2. Ownership

   Collection of data on the ownership of the land is important in getting the necessary approvals from the appropriate authorities such as, Urban Development Authority (UDA), Sri Lanka Land Reclamation and Development Corporation (SLLRDC), and Central Environmental Authority (CEA) etc.

3. Extent

   In selecting a potential land disposal site, it is important to ensure that sufficient land area is available to maintain the landfill throughout the proposed time period in the plan. Although there are no fixed rules concerning the area required, it is desirable to have sufficient area, including an adequate buffer zone. For shorter periods of planned use, the disposal operations become considerably more expensive, especially with respect to site preparation, provision of auxiliary facilities and completion of the final cover. For preliminary planning purposes, the amount of land area required can be estimated as illustrated in the example given in Annexure 6.

4. Habitation

   Information on the habitation is important as there are certain local restrictions with respect to siting landfills near airports, in wetlands, low lying areas (floodplains) close to water bodies such as rivers, lakes etc.

5. Access

   Information should be collected on access roads to, and within the site, to ensure they are suitable for a large compactor and other heavy equipment.

6. Hydrology - Ground Water Level

   The local surface water hydrology of the area is important in establishing the existing natural drainage and runoff characteristics. Other conditions of flooding must also be identified. These data will also be required to assess the pollution potential of the proposed site and to establish what must be done to ensure that the movement of leachate or gases will not impair the quality of local ground water.

7. Lifetime of the Site

   The useful life of the site will depend on the area of the site, the method of filling, compaction adopted and the amount of soil used in the daily cover.

8. Leachate and Methane Protection

   Among the more important physical changes in landfills are lateral diffusion of gases in the landfill and emission of the landfill gases to the surrounding environment, movement of leachate within the landfill and into underground soils. Landfill gas movement and emissions and leachate control are particularly important considerations in landfill management. Determination of the amount of methane gas production and the amount of leachate production is complicated and it is beyond the scope of this manual.

9. Infrastructure

   Information on infrastructure available at the existing site or operation will be useful for the planning process.

10. Personnel and Training

    Information on trained staff available and the level of training will need to be collected.

11. Machinery

    Number and kinds of machinery available at the dumpsite needs to be recorded. Further, their age, capacity, availability of operators will also need to be recorded.

12. Monitoring - Operation and Maintenance

    Monitoring, operation and maintenance procedures should be recorded. The record sheets maintained for this purpose must be reviewed regularly by the person responsible for SWM at the LA.

13. Public Resistance

    Public opinion, comments, criticism and any resistance shown by them during the operational process, needs to be recorded.

14. Nature of Disposal
    a. Open dumping
    b. Controlled dumping
    c. Engineered landfill
    d. Sanitary landfill
    e. Any other method - Specify

More details on site selection, liner systems, leachate collection in sanitary landfills is given in Annexure 13.

2.7 Analysis of Data and Issues Identification

This step also involves the detailed evaluation and analysis of the data collected. It is during this phase of the process that the plan begins to form. In some cases it may be necessary to collect additional data and information, because a problem can have more than one solution. It is beneficial for decision-making purposes to develop alternatives of one or more programmes. In developing alternatives, it is especially important that all functional elements be coordinated to ensure an integrated system from on-site storage, through to processing and final disposal. Since a wide variety of alternative programmes and technologies are not available for the management of solid waste, the analysis of data can be carried out by considering the questions given below.

It is preferable if the data collected can be cross-checked and converted into a digital form e.g. Database format - Excel/Dbase.

1. The amount of waste generated within the LA.
2. The amount of waste collected in the present system.
3. The amount of solid waste separated for reusing and recycling.
4. The amount of solid waste being composted.
5. The amount of solid waste being combusted.
6. The amount of solid waste to be disposed of in landfill.
7. What technologies should be used for collecting solid waste separated at source?
8. What are the present deportation routes?
9. Time and motion surveys to study collection efficiency.
10. What technologies should be used for the compaction of solid waste at the landfill?
11. What are the changes in quantities and composition of different solid waste streams?
12. Changes in the specifications and the markets for recyclable materials.
13. What is the proper timing for the application of various technologies in a SWM system and how should decisions be made?
14. What are the social impacts already there and what could be the new problems?
15. Quality of the service provided by the LA.

The development of an effective SWM system will depend on the availability of reliable data in the characteristics of the solid waste stream, performance specifications for alternative technologies and adequate cost information.

SESSION 3: OBJECTIVES AND CONSIDERATION OF ALTERNATIVE ACTIONS FOR ACHIEVING OBJECTIVES

Guidelines for Trainers

Objective

1) To familiarize participants with the steps involved in identifying and designing programmes to achieve goals and objectives of the plan.
2) To familiarize participants with steps to identify the capacity development and policy requirements necessary to implement programmes.

Preferred technology to be used - 'PowerPoint' presentation and exercises.

3.1 Objectives and Consideration of Alternative Actions for Achieving Objectives

In this step, the objectives of the LA should be well defined. A limited number of alternatives are selected by the committee to be included in the plan. The committee reviews the alternatives. Once approaches have been selected, the appropriate capacity development and policy requirements are identifed to facilitate project implementation. This is essential to the success, sustainability and implementation of the plan.

The objectives of this step are:

1) To identify and design programmes and projects to achieve goals and objectives of the plan.
2) To identify the capacity development and policy requirements necessary to implement the programmes.

Documentation for each alternative, regardless of complexity, is necessary and should include a general description of the process or approach. Further, the description must encompass the following:

1. Performance
2. Cost/Benefit analysis
3. Environmental Impact Assessment
4. Administration and Management Schedule

Performance

Performance means getting the job done. The workforce and equipment required to provide the level of service desired by the community must be specified. The significant details that must be identified include:

1. Level of service.
2. Equipment reliability and flexibility.
3. Equipment and workforce expandability.
4. Programme compatibility with other environmental programmes (air and water) and future changes in technology.

Cost/Benefit Analysis

The analysis must include estimates of capital costs as well as operating costs. The cost of an alternate method can be expressed as an annual cost. The cost can also be expressed as unit costs (Rs per Ton). Unit costs can be used to compare the cost effectiveness of alternative methods.

When cost estimates are completed, financing methods can be identified. A financial analysis must be made for each programme alternative, but the details must be consistent with the planning level and available planning funds. The output from economic analysis are tables listing capital and operating costs; pro forma charts showing income, expenses and cash flow for the period of time under study.

Environmental Impact Assessment

The programmes of an integrated SWM plan will have an impact on a community in three ways.

1. Through the changes to the natural environment.
2. Through involvement of the human environment.
3. Through a re-ordering of the community's socio economic structure.

An attempt should be made to make quantitative estimates of each impact. However, this task is rather difficult due to the complex nature of the above interactions. Determining the impact of alternative programmes requires information from community agencies and groups not normally involved in SWM, including business and environmental groups, regulatory agencies for air and water quality control, legislative bodies and resource agencies.

Administration and Management Schedule

Administration functions and organizations for implementation must also be identified for each alternative. It is practical for the planner to develop details of administration only for the short-term planning period.

The final action in this step is the selection of a preferred set of programmes/actions to form the plan. The programme can be selected from a single alternative or they can be selected from various alternatives. The final selection has to be made by the committee, based on the decision criteria determined at the beginning of the process. For each of the projects, the team will need a brief description and a list of main activities. The group should discuss the benefits, risks and implementation challenges of each potential project.

3.2 Policy Requirements

Refer to the local legislation required to carry out the project. For some projects, by-laws may need to be drafted and passed by the LA in order for projects to be implemented. This would include cases such as those where fees would be levied for improved services or where new regulations are to be enforced (e.g. source separation).

3.3 Create an Action Plan

The purpose of this activity is to determine the actions and requirements to implement the preferred option or activity, and achieve the 'key result' in response to the question.

The steps involved are:

1. Choose a facilitator, timekeeper and a recorder for this exercise. The facilitator leads the process while the recorder lists the input of the participants.
2. Facilitator clarifies the activity instructions - steps, time and end result.

3. Brainstorm to identify potential activities that are required to implement the preferred option.
4. Determine the sequence of the first 3-4 activities to be undertaken over the next three months.
   a. Determine the target dates for completion of each task.
   b. Identify who should do the activity.
   c. Whose approval is required along the way?
   d. Whose support and help is needed?
   e. Who will oversee and monitor progress?
5. Complete the Action Plan Worksheet (see below).
6. Record any long-term directions that are required.

Action Plan Worksheet - Preferred Option/Activity

Short-Term Action Steps/Details and Resources	Who • Does it. • Oversees it. • Approves it.	When
1. Initial Organization: • Organizing the planning team. • Work Plan for the planning team. • Determination of the design period.	Chairmen/Mayor Commissioner Chief Municipal Engineer Senior staff members of LA	
2. Decision Criteria: • Collection of available existing data. • Situation Analysis and issue identification (list of issues to be addressed). • Validate the initial list of issues.	LA staff Planning team members	
3. Objectives and consideration of alternative actions: • Define objectives and the actions available. • Prioritize activities. • Assign responsibilities for each activity. • Set timeframes for each activity.	Planning Committee	
4. Plan Implementation: • To validate the draft proposals. • To obtain council approvals. • Develop an implementation schedule.	With stakeholders and other public parties involved. Planning Committee members	
5. Monitoring and Evaluation: • Identifying the monitoring team. • Prepare an evaluation plan. • Implementation of the evaluation plan.	Planning team or monitoring team appointed by the Planning Committee	
Long-Term Directions 1. Planning and implementation of the waste reduction programmes. 2. Monitoring of environmental pollution status at disposal sites. 3. Organizing public awareness programmes possibly with other private sector organizations.		

SESSION 4: MANAGING AND SUSTAINING IMPLEMENTATION OF SOLID WASTE MANAGEMENT PROGRAMMES

Guidelines for Trainers

Objective

1) To become familiar with establishing mechanisms to implement projects in the plan.
2) To become familiar with development of implementation schedules and their use.
3) To explain the processes to monitor and evaluate the SWM programme.

Proposed technology to be used - 'PowerPoint' presentation, discussions, and exercises.

4.1 Managing and Sustaining Plan Implementation

The last step in the planning process becomes the first step in plan implementation. The LA must now put their 'Action Plan' into action:

The objectives of this step are:

1. To validate the draft plan with the stakeholders and with other public parties involved.
2. To obtain Council approval for the plan.
3. To establish mechanisms to implement projects in the plan.
4. Develop implementation schedules.

The LA planning team will prepare a write-up of the plan components and present it to other stakeholders for validation. All parts of the plan; vision, objectives, plan of action, budget and resource mobilization strategy should be validated. The main document should be presented to the Council for its approval.

The Chairman/Mayor and Commissioner/Secretary will need to go through the activity schedule in the plan and assign the work to relevant persons or a special standing committee or task group. The project outline with activities, persons responsible, time frame and budget should be reviewed, finalized and initiated.

4.2 Development of an Implementation Schedule

The primary objective of an implementation schedule is to set a time sequence of actions and to establish an organizational structure to take action. Other elements important to implementation are fiscal management and administrative considerations. The implementation schedule must also contain the following details of fiscal management.

1. Capital formation.
2. Cash flow requirements.
3. Revenue programmes, such as service rates or taxes.

The primary objective of the implementation schedule is to set actions for short-term programmes. However, any integrated SWM plan will require periodic updating.

4.3 Implementation Schedule

The implementation schedule has to be developed task-by-task and year-by-year. Since a lengthy text is required to present the details of all tasks, the following activities are listed in a topical format for the functional elements of SWM.

Year .....

Task 1 Hold hearings and adopt the SWM plan by the Council.

Task 2 Improvements to the waste collection system.

a. Time and motion studies to be carried out in selected areas.
b. Revision of vehicle routines.

Task 3 Transfer station

a. Select a site.
b. Begin preliminary design.
c. Develop redesign cost estimates.
d. Begin environmental impact report.
e. Site approvals from CEA and other relevant authorities.

Task 4 Resource Recovery

a. Site selection.
b. Begin preliminary design.
c. Develop pre-design cost estimates.
d. Begin resource recovery study.
e. Implement house source separation trial programmes.
f. Prepare marketing programmes.

Task 5 Disposal

a. Develop and adopt disposal site policy.
b. Site selection.
c. Begin preliminary design.
d. Site approvals from CEA and other relevant authorities.
e. Design cost estimates.
f. Advertise and receive bids from private industries for construction and operation of facility.
g. Recommend and install appropriate monitoring systems for gas and leachate.

Task 6 Administration

a. Obtain required permits.
b. Review and update plan (from 2nd year).
c. Develop financing plan.
d. Hold planning committee meetings.
e. Set user rates for processing facility.
f. Renew permits.

4.4 Public Awareness and Training Programmes

Public Awareness

Public awareness is an important activity in SWM to keep the system sustainable. The information related to public awareness is necessary for a sustainable system

Mode of Implementing Public Awareness Programmes

Audio and Video Programmes

A School educational programme.

B Distributing leaflets.

C Educating community leaders.

Public Participation

A Conducting seminars for the people in the area.

B Organizing voluntary cleaning up sessions with the participation of people in the area.

C Educating people on the improvements carried out in the area over the last month.

D Community leaders must be included in the planning and management committees of the Council.

E Introducing solid waste reduction methods such as source separation and home composting into community level activities.

4.5 Policy Guidelines

Information and Policy Guidelines for SWM regarding administration, enforcement, solid waste processing concessions, hospital waste, handling of legal matters is essential for day-to-day management.

1. National Policy
2. LA's Policy
3. CEA Guidelines and Regulations
4. World Health Organization (WHO) Guidelines

4.6 Monitoring and Evaluation

The LA planning team itself may continue as the monitoring and evaluation team or the responsibility may be handed over to a specific LA staff person or organizational unit. The team may decide to select a sub-group from among themselves and committed stakeholders. The team may:

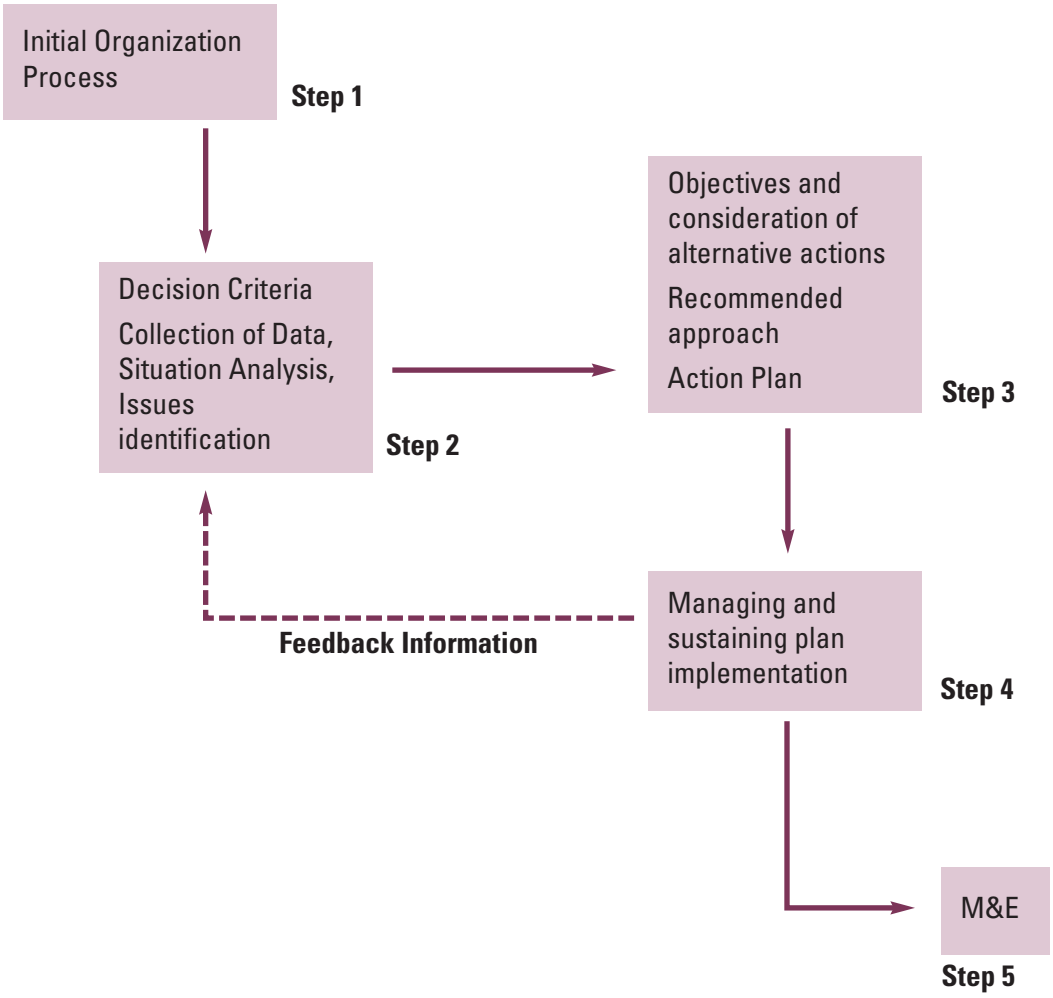
1. Draft the duties, responsibilities and competencies required of the monitoring and evaluation (M&E) team .
2. Identify potential members of the team, taking into consideration the structures and systems for M&E that are mandated or are currently in place.
3. Orient the team for M&E work.

NOTE: Final selection of the M&E team is the responsibility of either the Chairman/Mayor and/or the Council. In cases where the Council has delegated responsibility, the authority will reside with the Secretary or the Municipal Commissioner.

The M&E team should prepare evaluation plans using the following guidelines:

1. Design and adopt an M&E tool: drafting, validating and adopting.
2. Conduct quarterly assessments of project implementation and results.
3. Conduct annual assessments of overall plan implementation and achievements of the plan objectives.
4. Preparation of reports: quarterly, annual, reports for council, staff and public.

Figure 1. Basic Planning Model



Sample Format for Preparing Municipal SWM Plan

Corresponding Steps in the Model	Elements of the Report
1	Foreword or Preface (or both) Table of Contents Section I. Introduction (Purpose of the plan) Section II. Executive Summary (Note: This section should be written last and may come at the beginning of the report)
2	Section III. Background of the Planning Area 1. Jurisdictions a. National b. State c. LA d. Location Map e. Population (size and densities) f. Housing (types and locations) g. Land uses (residential, commercial, industrial, agricultural, recreational etc.) h. Transportation corridors 2. Physical Conditions a. Environmental conditions b. Geology and soils c. Climatology d. Drainage basins e. Financial status i. Tax base (assessed valuation) ii. Tax rates iii. Public finance practices iv. Economic base v. Other f. Status of legislation
2	Section IV. Existing SWM conditions 1. Arrange data according to specific needs of the information related to municipal SWM. 2. Describe and analyze all existing conditions affecting management of municipal waste.

Corresponding Steps in the Model	Elements of the Report	
		a. Storage, segregation and primary collection of waste. b. Quantities of waste generated with generation rates, collected and disposed of. c. Transportation and disposal practices. d. General management practices. e. Public awareness and knowledge about solid waste problems and willingness to pay for better services. f. Expenditure for SWM. 3. Environmental and health impact study carried out considering the potential adverse effects of SWM activities.
2	Section V	Future Conditions and problem definition 1. Relevancy for the future (from the analysis of data of existing conditions accumulated in sections iii and iv, determine which conditions will have a bearing on the future). 2. Future problems defined a. Types b. Locations c. Extent d. Persistence e. Others 3. All existing conditions and problems bearing upon the future should be forecasted at this stage.
3	Section VI	Objectives Objectives should be clearly stated and based upon need to solve problems defined earlier. Local Government might specify any of the following objectives to solve its solid waste problems. 1. Acceptable methods for storage, segregation of recyclable solid waste. 2. Acceptable methods for primary collection of solid waste. 3. Acceptable methods for bulk storage of solid waste at storage depots. 4. Acceptable methods of transportation of solid waste. 5. Acceptable solid waste processing practices. 6. Acceptable methods of solid waste disposal. 7. Development of SWM organizational structure.

Corresponding Steps in the Model	Elements of the Report
	8. Development of better trained SWM personnel (operating and management levels). 9. Better informed public regarding solid waste. Problems and service requirements. 10. Provision of sufficient financial support for SWM.
3	Section VII. Recommendations for solution (The Plan) 1. This section should specify what the LA intends to accomplish in order to solve its management problems. It should include designation of the following: a. System improvement. b. Timing and priorities of intended action (consider short and long-term objectives). c. Who should act. d. Estimated costs. e. Problems that will be solved. 2. It is suggested that the following steps be considered in the action plan. Proposals for these steps should be accompanied by procedures for accomplishment and a schedule of implementation. a. Establishment of SWM operating departments and identifying its jurisdictions. b. Recruiting, selecting and hiring of SWM operating personnel. c. Human resources development programme. d. Technical assistance to operating units. e. Provisions for inspection and enforcement. f. Licensing of facilities. g. Framing legislation, amendments to rules and regulations. h. Development of budgeting procedure, financing, cost-effectiveness, special charge features and other operating management features. i. Public information, education and communication programmes/systems.
4	Section VIII. Implementation (Occurs outside the plan document but guided by it)
5	Section IX. Monitoring and Performance (Evaluation of the Programme) This section of the report should include monitoring of various activities of municipal SWM and also evaluation of the performance of all the related activities with reference to the objectives/targets envisaged, once the programme is implemented.

Corresponding Steps in the Model	Elements of the Report
	Appendices This section of the report should include supporting materials and information used to develop the analysis, objectives and plan. Content of this section might include: a. Charts b. Additional tables c. References d. Legislation and regulations e. Definition of terms f. Methodologies of research and analysis

The text of the Municipal SWM plan for a LA should explain in detail all the above elements that are contained in the plan report, following the above outline.

Case Study- Example in Identifying Existing Operation and Administrative Problems

Functional Elements	Problems
Generation	Records on type of SW available. Location and quantity of waste are inadequate. Waste quantities are increasing.
Storage	Local standards are very poor. Containers are inaccessible, overflowing.
Collection	Collection service area records are incomplete. No proper route plan for collection.
Transfer	Existing transfer stations do not have capacity for increased quantities or for resource recovery operations. Regional need for transfer stations is not defined.
Processing and Recovery	Existing programmes do not identify diversion goals. Existing recovery methods do not meet materials reliability standards. There are no standards developed for products made from recyclable materials. Funding sources must be found to finance a recovery system.
Disposal	No data available on leachate movement. Capacity of the site is exhausted. No final land use plans are available for site/s.
Administration and Control	Local ordinances are uncoordinated and incomplete. Source separation to be imposed and legalized.

Four alternative programmes were put forward by the planning team for detailed analysis.

- Alternative 1: Basically an extension of the existing system, this alternative calls for the construction of transfer stations to replace exhausted landfills with transport of waste to City B landfill. Recoveries would be maintained at existing levels.
- Alternative 2: A significantly changed system, involving a central processing facility is proposed in this alternative. Most waste would be moved to the processing facility and then to the City B disposal site. Resource recovery facility would be expanded.
- Alternative 3: The major feature of this alternative is the addition of glass and aluminium recovery to facilities of alternative 2. The City B landfill would then be completely closed to unprocessed waste.
- Alternative 4: Energy recovery is the primary feature in this alternative. The energy recovery station would accept all organic waste from the processing station. The energy recovery conversion is to steam, and the steam would be sold in City A and used for heating and air conditioning of buildings.

Capital Cost of Facilities for all Alternatives are Summarized Below

Facilities	Alternate 1	Alternate 2	Alternate 3	Alternate 4
Transfer	3,989,000	3,989,000	3,989,000	3,989,000
Transport	1,066,000	1,806,000	2,698,000	2,698,000
Processing and Materials Recovery	_____	16,756,000	33,273,000	33,273,000
Energy Recovery	_____	_____	_____	(112,500,000)
Total Cost	5,055,000	22,551,000	39,960,000	(72,540)

(The above figures given are arbitrary figures)

Alternative 3 was recommended for implementation. The programmes of this alternative began the process of meeting waste diversion and resource recovery goals mandated by legislation and improving the landfill programmes of the region. The required facilities are expandable and can be used to produce a processed solid waste for most known resource systems. The benefits from the economies of large scale operations and from the resultant environmental improvements are significant. The two main criteria for the above decision was:

1. Cost involvement
2. Environmental impacts

The other alternatives were not recommended for the following reasons.

Alternate 1

Rejected because the added transfer station programme increased the disposal cost for all agencies and offered little or no opportunity for future cost reductions

Alternate 2

Rejected because the level of resource recovery was not sufficient from materials recovery sales to offset annual costs.

Alternate 4

Rejected because of the high capital costs and the uncertainties associated with the energy production.

The last step after the selection of an alternative was the development of a more detailed management schedule for implementation, financing and administration.

SESSION 5: IMPROVED METHODS OF DISPOSAL WHEN LANDFILLS ARE NOT AVAILABLE

Methods of Disposal with Special Emphasis on Dumping/Land Filling

Guidelines for Trainers

Objective

1) Emphasize the factors that need to be identified in deciding the method of disposal.
2) Highlight the present three commonly used methods of disposal.
3) Environmental problems created due to present methods of disposal.

Proposed technology to be used - 'PowerPoint' presentation with appropriate photographs.

5.1 Disposal - General

Disposal of solid waste can be carried out in several ways. However, before deciding the appropriate method for the LA, the following information should be collected:

- Quantity of waste generated within the LA area.
- Composition of waste generated.
- Economics of the methods available.
- Environmental impacts due to implementation.
- Public acceptance of the selected methods.

5.2 Principal Methods of Waste Disposal

There are four principal methods of disposal depending on the amount and the quality of the waste:

A. Incineration
B. Composting
C. Land filling
D. Waste to energy

A. Incineration

Incineration can range from open burning to latest methods of incineration such as plasma technology. Incineration is mainly for the energy recovery purposes. This technology is more appropriate for waste with high calorific value. The initial capital investments are very high and therefore may be out of reach for most Sri Lankan LAs.

B. Composting

Composting is suitable for waste consisting of high organic matter. Composting technologies haven't developed to a great extent and it could vary from in-vessel to open windrowing. Composting technologies are comparatively cheaper than energy recovery methods. Composting is most suitable for source-separated or post collection separation of solid waste. Composting on the site of generation is also viable in Sri Lanka.

C. Land filling

Land filling methods are still the most common methods used throughout the world. This could vary from open dumping to sanitary landfills. Operating a sanitary landfill would be rather expensive from Sir Lankan standards. Therefore, the most suitable method would be something in between open dumping and sanitary landfill.

D. Waste to Energy

Waste to energy technology is most suitable for waste with high calorific value and low moisture. However, with the production of Refuse Derived Fuel (RDF) these technologies can now be introduced to Sri Lanka. Again, the prohibitive factor would be the very high initial capital costs involved.

EXERCISE - Identify at Least Five Pros and Cons for Each Method of SW Disposal

Method of Disposal	Pros	Cons
1.	1. 2. 3. 4. 5.	
2.	1. 2. 3. 4. 5.	
3.	1. 2. 3. 4. 5.	
4.	1. 2. 3. 4. 5.	
5.	1. 2. 3. 4. 5.	

From the above data what are your suggestions for deciding on a method of SW disposal for your LA?

5.3 Present Problems of Environmental Pollution due to Existing Dumpsites

Under Sri Lankan LA conditions, the most common method of waste disposal is open dumping to a vacant piece of land, especially to low-lying land. To make the conditions worse, these dumps are set on fire either purposely to reduce the volume to extend the life cycle of the dump or accidentally. Under these conditions, environmental pollution is considerable.

1. Heavy lorry traffic - can give rise to nuisance, damage to road surface etc. The following guidelines are helpful to overcome these issues.
    a. Routing to avoid residential areas.
    b. Using one-way routes to avoid traffic congestion in narrow roads.
    c. Carrying out road improvements such as strengthening or widening of roads.
    d. Restrictions on traffic movement hours.

2. Noise pollution - Adverse impacts on the local community from noise may arise from a number of sources including through vehicles, both on the access roads and inside the dumpsite.

3. Odour problem - Offensive odours at landfill/dumpsites may result from a number of conditions including types of solid waste materials, which have decomposed significantly prior to land filling. Leachate treatment systems and landfill gas collection will help to overcome these issues. Other strategies include:
    a. Effective use of appropriate types and adequate material of daily cover.
    b. Speedy compaction of disposed waste.
    c. Progressive capping and restoration.
    d. Effective management of landfill gas.
    e. Effective leachate management.
    f. Consideration of wind direction when planning leachate treatment plants and direction of tipping.

4. Litter problem - Poor litter control both on and off site is particularly offensive to neighbours and is caused by wind and animals. Good operational practices should be followed to minimize the occurrence of wind blown and animal scattered litter. Measures for controlling the litter include:
    a. Consideration of prevailing wind direction and strength when planning the fill direction.
    b. Temporary banks or bunds immediately adjacent to the tipping area.
    c. Permanent catch fences and netting to trap wind blown litter.
    d. Restricting the incoming vehicles to covered vehicles.
    e. Fencing to restrict stray animals.

    Litter pickers should be employed to collect litter, which escapes the above preventive methods.

5. Ground water and surface runoff water contaminated with leachate - Leachate is the liquid that has percolated through solid waste and has extracted, dissolved or suspended material. In most of the landfills/dumpsites, leachate is composed of the liquid that has entered the landfill from external sources such as surface drainage water, ground water and the liquid produced from the decomposition of waste. Therefore, the best way to reduce leachate

contaminations of ground water and surface water would be to have a regular clay/soil cover in these already existing dumpsites. Other strategies include directing surface water AWAY from the dumpsite. Since most localities use low-lying land as dumpsites, water usually drains TOWARDS the dump location. Creating interceptor drainage to channel storm water around the dumpsite can help reduce leachate intrusion into the ground.

6. Vermin and other pests - Landfills have the potential to harbour flies and vermin and to attract other animals looking for food. Modern landfill techniques including prompt placement, consolidation and covering of waste in well-defined cells are effective in the prevention of infestation by rodents and insects. Rats and flies are the main pests, which require control. Fences and gates can control larger animals. In some cases where elephants or cows are problems, more substantial fencing can help.

7. Emission of toxic gases - Open burning of waste to reduce quantities has been extensively used in most parts of the country. This is the most unacceptable method of disposal of solid waste. The low temperature burning of polythene, plastics and PVC will emit highly toxic gases such as dioxins and nitrous oxides (NOX) to the atmosphere. Therefore, people should be educated through awareness programmes of the implications of burning waste materials and the practice by both citizens and the LA should be avoided.

8. Health Issues

Types of Environmental and Health Hazards Due to Solid Waste

Environmental and Health Hazards	Examples	Causes
Environmental Pollution	Air quality, water quality, land use and noise.	Emission of toxic gases, leachate and vehicle moment.
Communicable Diseases	Gastrointestinal disorders, diarrhoea, respiratory infections, skin disease, jaundice, trachoma etc.	Handling of waste by workers and scavengers. Air borne microbes.
Non-communicable Diseases	Poisoning, hearing defects and dust.	Contamination with toxic materials through gases and leachate.
Injury	Occupational injury by sharps, needles, glasses, metals, wood etc.	By direct handling of waste.

5.4 Other Important Issues with Landfill and Dumpsites

A. Waste Compaction

Compaction of the waste can be carried out by using the same tracked dozer or wheeled bucked loader used in spreading the solid waste. However, steel wheeled mobile landfill compactors are now available to use in the dumpsites. Compactors help to:

1. Chop and homogenize the waste.
2. Reduce the void fraction of the waste.
3. Produce an even and stable surface.
4. Pin down waste to minimize litter and make the site less attractive to birds and vermin.

B. Application of a Daily Cover

Once the waste is compacted to desired heights, a daily cover should be applied with soil up to a thickness of 6 inches using a dozer or a bucket wheel loader.

The advantages of using daily cover are:

1. Prevents windblown litter and odours.
2. Deterrence to scavengers, birds and vermin.
3. Improving the site's visual appearance.

Disadvantage:

1. Takes up valuable void spaces for primary waste.

C. Have a Plan for Final Use

D. Operate Site to Accommodate Final Use

E. Monitor Site After Closure to Assess Environmental Impact

Annexure 8 gives the impact identification due to existing methods of waste disposal.

SESSION 6: REMEDIATION OF EXISTING AND OLD LANDFILLS/DUMPSITES

Guidelines for Trainers

Objective

1) Sanitary landfills will be out of reach for most LAs in the near future. Therefore, the participants should be educated on improving the existing dumps to minimize the environmental impacts.
2) Site approval process.
3) Highlight the importance of public awareness and tsunami programmes.

Preferred Technology to be used - 'PowerPoint' presentation with appropriate pictures and 'Brief Course Content for Training Various Levels of Staff/Officers. See Annexure 8a.

6.1 Remediation of Existing and Old Landfill Sites

Under Sri Lankan conditions, LAs still dispose of their waste mainly by open dumping to vacant pieces of land, especially lowlands or marshy lands. Under these circumstances the environmental pollution due to disposal of waste is very significant. This mainly takes place through:

1. Surface runoff water.
2. Leachate contamination of ground water.
3. Emissions of toxic gases.

In more rural areas of the country where surface water is used for drinking, bathing and washing, as well as agricultural irrigation, improper disposal of solid waste is literally poisoning the population.

Therefore, it is important to rehabilitate these dumpsites as soon as possible to minimize the environmental pollution. The following course of action is suggested to rehabilitate the existing dumpsites, which are not properly managed.

1. Levelling of garbage hillocks with a dozer or drag. The level can be more than one. It could be in the form of a few steps if the hillocks are very high.
2. Covering with a layer of clay soils/gravel, either as the final cover or as an intermediate cover if the fill operation is to be continued in the future.
3. Cutting drains internally and around the landfill so as to collect all leachate and the surface run-off water into a collection pond made at one end of the landfill.
4. If the filling operation is to be continued, spreading a daily cover with soil has to be carried out without any hesitation.
5. If any insect and other infestations are present, it has to be controlled using recommended techniques applied by experienced operators. However, if pesticides are used, care must be given to ensure the cure is not more environmentally hazardous than the problem.
6. Construct diversion channels to intercept storm water and carry it away from or around the site.

Daily records to be maintained at the disposal site by the person in charge:

1. Inspection of waste disposal site.
2. Name and location of the site.
3. Whether all the staff were present on duty during the week.
4. Whether the required machinery was available on the site on all days.
5. Whether the approach road and internal roads are properly maintained.
6. Whether the weighbridge is functional and properly used.
7. Quantity of waste received at the site each day of the week.
8. Whether the solid waste has been spread and covered with soil properly.
9. Any deficiencies noticed.
10. Remedial action taken.

6.2 Closure Plans

A closure plan should be developed and adopted before the landfill is to stop receiving waste. The following elements must be addressed in a landfill.

1. Final cover design.
2. Surface water and drainage control system.
3. Control of landfill gases.
4. Control and treatment of leachate.
5. Environmental monitoring systems.
6. Potential uses for completed landfills to be identified.

CLASS EXERCISE - show pictures of problems and have each team describe improvements and fixes.

6.3 Final Cover Design

The final cover is the surface to be placed over a landfill after waste is received. The design of the final cover must satisfy two functions for the site.

1. Ensure the long-term post closure integrity of the landfill with respect to any emissions to the environment.
2. Support the growth of vegetation or other site uses.

Some of the important cover design parameters are:

1. Design configuration.
2. Final permeability.
3. Surface slope.
4. Landscape design.
5. Method of repair as land settles.
6. Slope stability.

Surface Water and Drainage Control Systems

The following features must be included in the design of water drainage control systems:

1. Collection and routing of surface waters off the landfill surface.
2. Selection of channel and drainage ways that will carry water at adequate velocities to avoid deposition.
3. Use of sufficient surface slopes.

1. Control of landfill gases

   Typical landfill gas control facilities include extraction wells, collection and transmission piping and gas flaring. However, under the old dumpsite rehabilitation process, nothing much can be done to control gases except insertion of pipes to collect some amount of gas and a good impermeable final cover layer.

2. Control and Treatment of Leachate

   The amount of leachate to be controlled and treated after the landfill is closed is a function of the final cover design, the type of waste placed in the landfill, and the climate, especially precipitation of the region. However, in the existing dumpsites there are only a few things that can be done to control the leachate:

   1. Final cover to prevent infiltration of surface run-off water.
   2. Establishing a leachate collecting drain system around the dumpsite with a collection pond for treatment.

6.4 Environmental Monitoring System

Environmental monitoring system to be developed to track the movement of any landfill emissions to the water, air, and soil environments.

6.5 Potential Uses of Completed Landfills

Because open space in urban areas is highly desirable, former landfill sites present a unique opportunity for land reclamation. Some possible uses for closed landfill sites include parks, recreational areas, nature reserves, botanic gardens, crop production, and even some commercial developments.

Selection of an end use is dictated by the needs of the community and the funds available for the reclamation project.

6.6 Site Management

Management of the dumpsite needs to maintain daily records of:

1. Monitoring of Landfill Operation - Annexure 9
2. Equipment Performance Record at the Disposal Site - Annexure 10
3. Disposal Site Labour Utility Report - Annexure 11

6.7 Site Approval Procedures

The regulations for the site approvals were Gazetted under the National Environmental Act, (NEA) No47 of 1980 as, amended by Act no56 of 1988 and no595/16 of 1990. (Annexure 12)

Under these regulations:

No person shall on or after the relevant date discharge, deposit or emit waste into the environment, which will cause

pollution, or cause noise pollution, except:

a. Under the authority of a license issued by the CEA and

b. In accordance with the standards and criteria specified in the Schedule of the same document.

The license issued under these regulations shall be known as the 'Environment Protection License'.

An application for the license shall be made:

1. Separately, in respect of each premises where dumping is to be carried out.
2. Application must be made in the specified form given in the above document.
3. Accompanied by a receipt for the payment of the fee specified.
4. At least 30 days prior to the relevant date of the commencement of the work at the site.

Under the provisions of Section 23Z of the NEA the Environmental Impact Assessment (EIA) apply only to prescribed projects, which have been specified in Gazette Extraordinary No.772/22 of 24.06.1993. Accordingly, construction of a solid waste disposal facility having a capacity exceeding 100Mt per day is a prescribed project and needs to go through an EIA.

Projects less than 100Mt per day may require an Initial Environmental Evaluation (IEE) as decided by the CEA.

6.8 Application Procedure

A written application shall be submitted to the Hazardous Waste Dept. of the CEA and shall provide to the CEA the following information and any further information as may be requested by the CEA for approval procedure. Sample basic questionnaire is given in Annexure 14.

1. A topographic map showing the location and boundaries of the proposed site and land use within one KM radius of the proposed site.
2. A clear layout plan with appropriate scale showing full details of the proposed locations for different activities.
3. The capacity of the facility, all machinery and equipment to be used in the facility, operational hours, number of working days and number of workers for each activity.
4. The details of the operation flow diagram for the proposed facility, origin, composition and expected weight or volume of solid waste to be accepted, as well as the projected waste quantity expected in future years.
5. Details of the post closure design, including details of closure procedures showing the existing topographic map and the final elevation of the landfill after closure.
6. Details of any pollution control systems to be implemented e.g. liner systems, leachate treatment systems, gas control systems etc.

The purpose of the EIA is to ensure that the development option under consideration is environmentally sound and sustainable and that environmental consequences are recognized and taken into account early on in the project design. EIAs are intended to foster sound decision-making.

6.9 Complaint Redress

Information on complaint redress of public grievances is essential to update, obtain feedback on the nature of the complaints, time taken to redress complaints and for taking positive steps to improve the services to the public.

The following are the steps for a complaint redress system:

1. Centralized complaint location.
2. Zonal level complaint data collection.
3. Ward level complaint data collection.
4. Norms for resolution of complaints.
5. Monitoring of complaint redresses and timelines.

The following specimen format can be used to collect the complaints received by the supervisory officers and should be maintained daily and sent to field managers for information and resolution.

Format Day/Week/Month

No.	Date	Name of the Complainant and Address	Nature of the Complaint	Details of Action Taken	Date Action Taken	Remarks
	Supervisors Signature			Field Manager		

EXERCISE - (by team) describe the complaints process in your LA

ANNEXURES

ANNEXURE 1: POPULATION FORCASTING MATHEMATICAL MODEL - AN EXAMPLE

Year	Population	Increase (X)	Incremental Increase (Y)
1921	40,185		
1931	44,522	4337	
1941	60,395	15,873 (+)	11,536
1951	75,614	15,219 (-)	654
1961	98,886	23,272 (+)	8,053
1971	124,230	25,344 (+)	2,072
1981	158,800	34,570 (+)	9,226
1991	204,650	45,850 (+)	11,280
Total		164,465	41,513

Average $\underline{X} = \frac{164,465}{7} = 23,495$ Average $\underline{Y} = \frac{41,513}{6} = 6,919$

$Pn = P_1 + n\overline{X} + \frac{n(n+1)\overline{Y}}{2}$

$n = p_2 - p_1$

Where P2 = Year of projection

P1 = Year of last census

P 2003 = $p1991 + 1.2 \times 23,493 + \frac{1.2 \times 2.2 \times 6,919}{2}$

= 204,650 + 28,194 + 9,133

= 2,41,977

P 2013 = $P1991 + 2.2 \times 23,495 + \frac{2.2 \times 3.2 \times 6,919}{2}$

= 204,650 + 51,689 + 24,355

= 2,80,694

ANNEXURE 2: DETERMINATION OF SOLID WASTE GENERATION AND COLLECTION RATES

Knowledge of the quantities of solid waste generated and collected for processing or disposal is of fundamental importance to all aspects of SWM.

Methods need to assess solid waste quantities

1) Volume and weight are used for the measurement of solid waste quantities. Unfortunately, the use of volume on a measure of quantities can be misleading. If the volume is needed; the measured volumes must be related to either the degree of compaction of the waste or the specific weight of the waste under the conditions of storage.

   Weight measurements are the only actual basis for records because tonnages can be measured directly.

Methodology commonly used to assess solid waste quantities are:

1) Load - count analysis
2) Weight - volume analysis
3) Material - balance analysis

1) Load Count Analysis

In this method the number of individual loads and the corresponding waste characteristics are recorded over a specified time period. If scales are available, weight data is also recorded. Unit generation rates can be determined by using filed data collected from a representative sample, which should cover more than 5% of the total number of units.

Example Estimation of unit solid waste generation rates for a residential area.

1) Number of residential homes - 1200
2) The observation period - 7 days
3) Number of compactor truck loads - 9
4) Average volume of a compactor truck - 20 yds^3
5) Number of flatbed truck loads - 7
6) Average flatbed truck volume - 2 yd^3
7) Number of loads for individual residential private vehicles - 20
8) Estimated volume per domestic vehicles - 8 ft^3

Using the above data, calculate the total weight per week.

Item	Number of Loads	Average Volume yd^3/load	Specific Weight lb/yd^3	Total Weight lb
Compactor truck	9	20	500	90,000
Flatbed	7	2	225	3,150
Individual privates vehicles	20	0.30	150	900
Total				94,050

Determine the net waste collection rate based on the assumption that each household is comprised of 3.5 people.

Unit rate = $\frac{94,050}{(1200 \times 3.5)(7)}$

= 3.2 lb/home/day

or = 1.45 kg/home/day

or if the estimation is carried out with field data collected from representative samples, the unit rate can be determined similarly to calculate total waste generated.

= per capital / day rate x total Population of the area.

ANNEXURE 3: SAMPLE FORMAT FOR WASTE GENERATION AND COMPOSITION DETERMINATION DATA COLLECTION

Category	Material	Weight (Kg)		
		Day 1	Day 2	Day 3
Organic	Food			
	Home garden waste			
	Cotton textile			
	Fish			
	Meat			
	Coconut shell			
	Coconut comb (comber)			
Plastic	PET bottle - transparent			
	PET bottle - non transparent			
	Plastic containers			
	Plastic items			
	PVC			
	Durable plastic items			
	HDPE - printed film			
	HDPE - non printed film			
	HDPE - high gauge			
	LDPE - film			
	LDPE - large bags and others			
	Poly/propylene			
	Aseptic			
Paper	Corrugated cardboards			
	Old cardboard boxes			
	Newspaper			
	Magazines/catalogues			
	Commercial and institution			
Glass	Clear			
	Green			
	Brown			
	Other Colours			
	Florescent tube/bulb			
Metal	Tin/steel can			
	Aluminium cans			
	Other ferrous			
	Other non ferrous			

E-waste	Computer related
	TVs and others CRTs
	Other small consumer items
	Battery
	Wire
Construction/Demolition	Concrete
	Asphalt paving
	Asphalt roofing
	Wood waste
	Rock, soil, fines
	Bricks
Highly Hazardous Waste	Paint
	Vehicle and equipment
	Used oil
	Batteries
Special Category	Ash
	Sewage solid
	Industrial sludge
	Treated medical waste
	Non treated medical waste
	Bulky items
	Tyres
	Mixed residue
	Rubber items

ANNEXURE 3A: RESULTS OF A SOLID WASTE COMPOSITION ANALYSIS CARRIED OUT IN AN URBAN COUNCIL

Composition Data

	Middle Income%	Low Income%
Organic	88	87
Plastic	03	03
Paper	03	04
Glass	01	0.5
Ash	03	03

	C%	N%
Composite sample	12 - 18	1.5 - 2

Physical properties of the municipal solid waste in an Urban Council.

Total Solids

Ts g/kg (Dry)	Moisture Solids g/kg	Ash g/kg	Volatile Solids g/kg
71%	61.8%	17.4%	8.2%

ANNEXURE 4: WASTE GENERATION RATES DETERMINATION

Important points to be considered:

1. Waste generation rates should be determined separately for different sources of origin e.g. household, commercial establishments, hotels etc.
2. Sampling size should be over 5% of the total number of each category of waste generation source.
3. Important to carry out a composition analysis at the same time.
4. Accurate population density data should be made available from a recent study.

Dated collected from a recent study carried out by a LA is given below.

- The total population 111,974
- The total number of households 6,895
- Average number of occupants per household 5
- Number of households selected for sampling 250

It is better to separate the households into 3 groups according to income levels. However, to make this exercise simple, all households are considered as one group.

The data collected are as follows:

Category	Material	Weight (Kg)		
		Day 1	Day 2	Day 3
Organic	Food	5700	5650	8500
	Home garden waste	11250	10,300	9460
	Cotton textile	390	350	285
	Fish			
	Meat			
	Coconut shell	150	185	210
	Coconut comb (comber)	600	580	420
Plastic	PET bottle - transparent	15.5	12.0	9.0
	PET bottle - non trance parent	5.6	5.2	4.9
	Plastic containers	18.2	16.2	15.9
	Plastic items	19.8	17.4	22.6
	PVC	48.5	40.6	50.3
	Durable plastic items	78.4	75.8	80.4
	HDPE - printed film	36.8	32.7	42.3
	HDPE - non printed film	14.5	18.2	16.1
	HDPE - high gauge	75.3	82.4	70.6
	LDPE - film	165	178	153
	LDPE - large bags and others	58.4	53.2	63.4
	Poly propylene	22.4	25.8	28.3
	Aseptic			

Paper	Corrugated cardboards			
	Old cardboard boxes			
	Newspaper	358	420	345
	Magazines/catalogues	26.4	28.0	34.2
	Commercial and institution	92.6	100.5	98.4
Glass	Clear	96.8	88.3	105.2
	Green	7.5	8.0	6.6
	Brown	8.3	6.4	7.8
	Other colours	0.2	0.4	0.4
	Florescent tube/bulb	0.8	0.6	1.2
Metal	Tin/steel can	18.5	20.2	14.5
	Aluminium cans	65.3	69.0	70.2
	Other ferrous	128.4	150.6	148.8
	Other non ferrous	28.6	25.8	32.3
E-waste	Computer related	0.4	0.8	1.5
	TVs and others CRTs	10.8	12.6	15.3
	Other small consumer items	0.8	0.6	0.7
	Battery	4.2	5.0	3.5
	Wire	1.2	1.5	2.3
Construction/Demolition	Concrete	108.6	125.6	150.4
	Asphalt paving	1.6	2.8	3.5
	Asphalt roofing	2.8	3.6	3.9
	Wood waste	15.6	16.5	20.5
	Rock, soil, fines	1.2	0.8	2.5
	Bricks	18.9	15.8	22.6
Highly Hazardous Waste	Paint	1.6	2.5	2.6
	Vehicle and equipment	0.6	0.8	0.5
	Used oil	Nil	Nil	Nil
	Batteries	4.5	4.9	3.6
Special Category	Ash	250	200.6	285.6
	Sewage solid	Nil	Nil	Nil
	Industrial sludge	Nil	Nil	Nil
	Treated medical waste	Nil	Nil	Nil
	Non treated medical waste	Nil	Nil	Nil
	Bulky items	15.5	20.3	24.5
	Tyres	12.8	25.6	30.6
	Mixed residue	5.3	4.8	5.8
	Rubber items	48.6	45.6	55.6

Questions:

I. Calculate the amount of waste generated per capita per day.

II. What is the total amount of waste generated per day?

III. How much waste will be reasonably generated by a new development of 100 average-sized homes?

ANNEXURE 5: METHOD OF CALCULATION OF LIFE SPAN OF A LANDFILL

Estimation of Landfill, Capacity Height of Area and Life Span

1. Current waste generation per year = W tons / year
2. Estimated rate of increase of waste generation per year = X%
   (Use rate of population growth if waste generation growth rates are not available).
3. Estimated life of landfill = N years
4. Waste generation after N years = $\frac{w}{100}(1=X)^{h}$ tons/year
5. Total waste generation in N years
   T = ½ [W+W (1+X^{h})] h tons
6. Total volume of waste in N years (Vw) (Assuming 0-.85t /CU.M density of waste)
   Vw = T/0185 Cu.M
7. Total volume of daily cover in N years (V dc)
   (Assuming on the basis 15 cm soil cover on top and sides for lift height of 1.5 - 2 m)
   $V\ d_c$ = 0.1 Vw Cu.M
8. Total volume required for corporate of liner system and cover system
   (Assuming 1.5m thick liner system and 1.0 m thick cover system.)
   V_c = K V w Cu.M.

   (K = 0.25 for 10 m height landfill, 0.125 for 20m high landfill. This is rated for landfills where width of landfill is significantly larger than the height).
9. Volume likely to become available within 10 years due to settlement/biodegradation of waste.
   Vs = m Vw

   (m = 0.10 for biodegradable waste; m will be less than 0.05 for incinerated/inert waste).
10. First estimate of landfill capacity (C i)
    $C_i = V_w + V_d + V_c - V_s$ (Cu.M)
11. First estimate of landfill height and area.
    a) Restricted area available = Av (Sq.m)
       Area required for infrastructural facilities = 0.15 Av
       Area available for land filling = 0.85Av

       Average landfill height required above base level
       $H_i = C_i / H_i$ (Sq.m)

b) Area required for landfill separators

$A_i = C_i / H_i$ (Sq.m)

Total area required (including infrastructural facilities)

$A = 1.15\ A_i$ (Sq.m)

ANNEXURE 6: ESTIMATION OF REQUIRED LANDFILL AREA - AN EXAMPLE

Estimate the required landfill area for a community with a population of 31,000. Assume that the following conditions apply:

Solid Waste generation = 6.4 lb/capita/day

Compacted density of solid waste in landfill = 800lb/yd^3

Average depth of compacted solid waste = 20ft

Solution

1. Determine the daily solid waste generation rate in tons per day

   Generation rate = $\frac{31{,}000 \times 6.4}{2000 \text{ lb/ton}}$

   = 99.2 ton/day

2. Computation of required land area

   Volume required = $\frac{99.2 \times 2000}{800}$

   = 248 yd^3/d = 190 M^3/d

   Area required/Year = $\frac{248 \times 365 \times 227}{20 \times 43560}$

   = 2.81 acre/ year = 1.14 Ha/ year

1 Ton	=	2000 lbs
1 Yd^3	=	227 ft^3
1 Yd^3	=	0.7646 M^3
1 Acre	=	43,560 ft^2
1 Acre	=	0.4048 Hectares

Comments: The actual site requirements will be greater than the value computed because additional land is required for a buffer zone, office and service building, access roads and so on. Typically, this allowance varies 20 - 40%.

ANNEXURE 7: GROUP EXERCISES

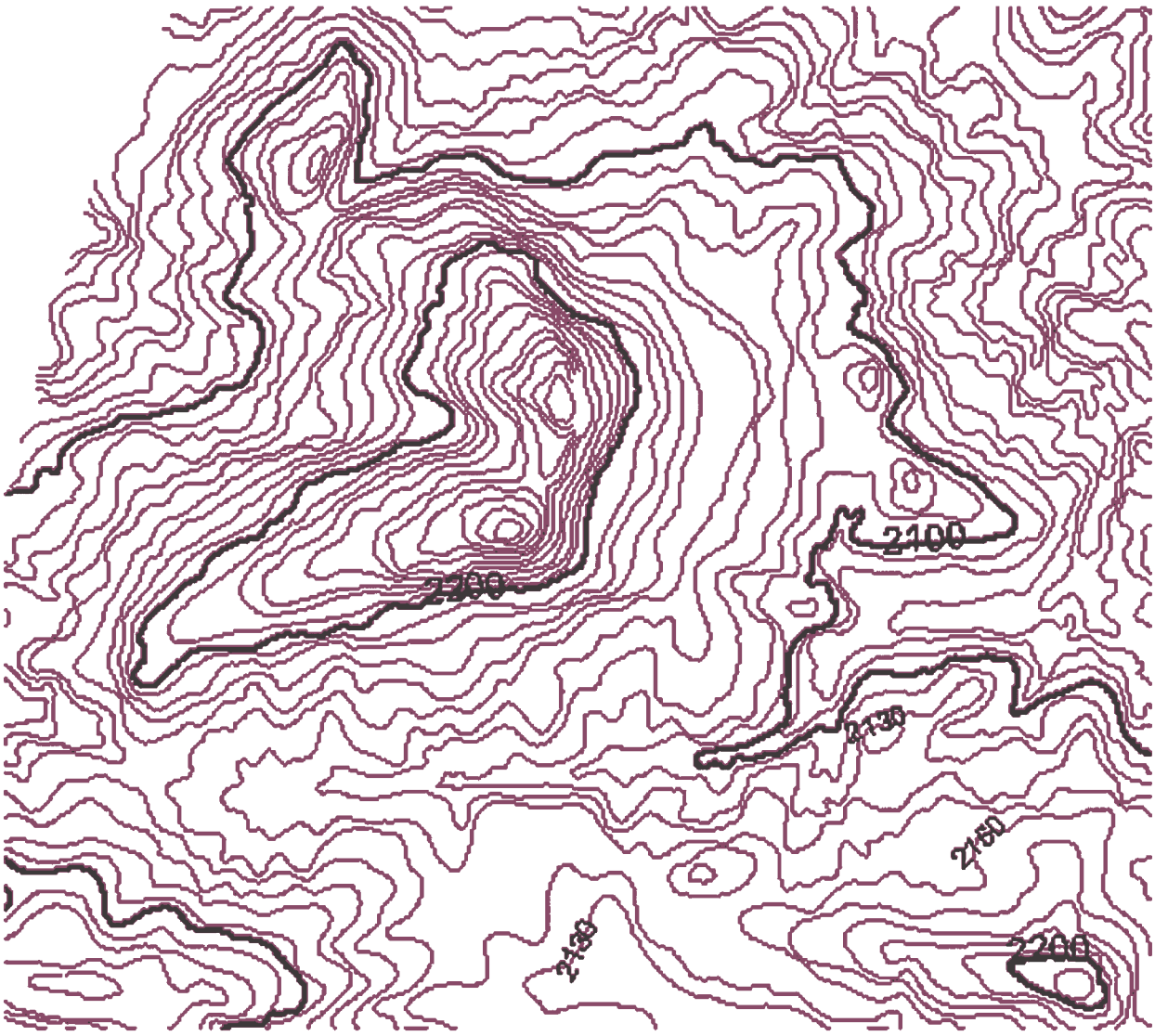
Exercise 1: Participatory Planning Process

1. Overview of the participatory planning process - by the Trainer.
2. Divide the participants into small groups.
3. Each group should summarize the present SWM operation in their LA area.
4. Each group should identify SWM issues as outlined in Session 2 of this module.
5. Generate comments and discussion among the participants on identified issues and priority areas.
6. Ask the participants to reach consensus and list the top 3-4 priority issues.
7. Ask the participants for proposals and suggestions to formulate a SWM plan achieving the objectives and goals of the LA.

Exercise 2: Improving Disposal Facilities

1. Divide the participants into small groups.
2. List out the ways of reducing waste.
3. What improvements can be introduced to the present dumpsite in the LA with respect to:
    a. Leachate contamination of ground and surface water runoff.
    b. Open burning of waste.
    c. Reducing the odour problem.
    d. Reducing wind-born litter.
    e. Preventing animals and other insect vectors breeding.
4. One member from each group to present results to the audience.
5. Panel discussion on the presentations.
6. Formulate a list of actions to be taken in improving the dumpsite.

Exercise 3: Selecting and Designing a New Dumpsite



Topographical Site Map Showing Available Area for a New Dumpsite with 10m Contour Lines

Problem: Let's assume that the LA has found 25 acres of land for a new dumpsite for waste disposal. A topographical site map is given above. Using the knowledge you have gained from this training course, list out the informations/details to be collected/studied to establish a dumpsite. Demarcate the most suitable block of 10 acres on the site map. Give reasons for your demarcation using the format given below.

Site selection
I. What are the local factors that should be considered in the surrounding area?
II. What are the local data that should be collected?
III. How would you assess the public reaction to establishing the dump?
IV. What are the approvals required to initiate the dumpsite?
V. What will be the criteria used in the final selection of the site?
VI. What are the most important factors considered in designing the landfill?

VII. According to the topography of the site what type of design do you recommend for adoption?

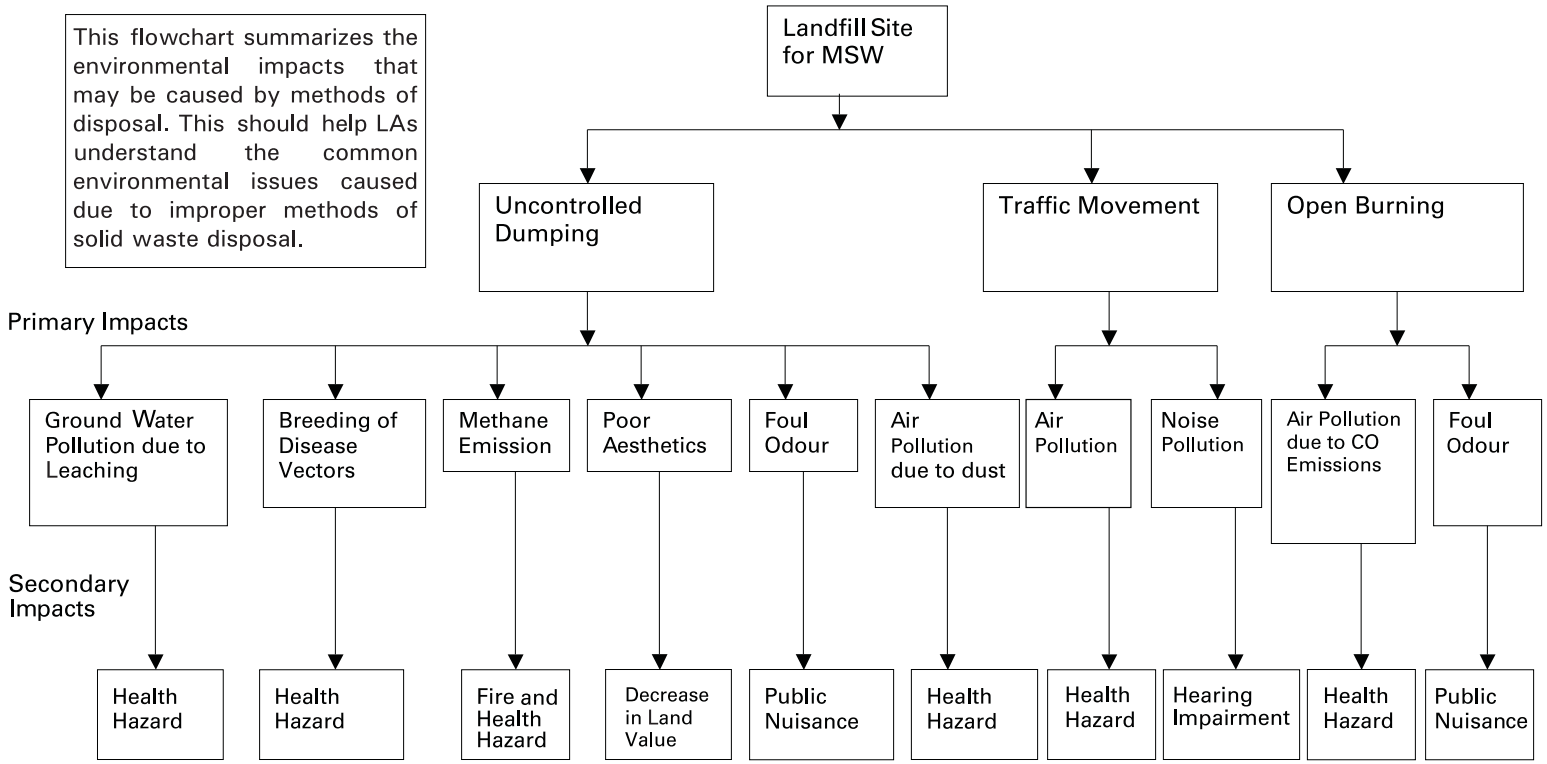
VIII. What are the precautionary measures you recommend for adoption:

1. To minimize leachate production and ground water contamination?

2. To minimize landfill gas release to the atmosphere?

IX. What type of filling method do you recommend for the operation of the site? (Briefly describe the method you suggest).

ANNEXURE 8: IMPACT IDENTIFICATION FOR NETWORK SYSTEM



ANNEXURE 8A: BRIEF COURSE CONTENT FOR TRAINING VARIOUS LEVELS OF STAFF / OFFICERS

A. Training Sanitation Workers

1. Importance of sanitation in urban areas.
2. Present scenario of SWM system in the urban areas, deficiencies in the system etc.
3. Impact of inefficient SWM services on health of sanitation workers.
4. Impact of inefficient SWM on community health and environment.
5. Inefficiency of tools and equipment used and loss of manpower productivity.
6. Need for modernization of SWM practices.
7. Options available for improving services.
8. Advantages of using improved tools and equipment for primary collection of waste and street sweeping.
9. Need for synchronization of storage at source, primary collection of waste and waste storage depots.
10. Proper upkeep of tools and equipment.

B. Training Sanitation Supervisors of Various Levels

Points 1 to 10 as above.

11. Need for synchronization of transportation of waste with solid waste storage depot.
12. Transportation of solid waste on a day-to-day basis.
13. Waste processing and disposal options, advantages and disadvantages of various technologies available.
14. Sanitary land filling.
15. Public and NGO participation in waste management.
16. Building public awareness.

C. Training Officers of the SWM Department

Points 1 to 16 as per A and B above.

17. SWM practices prevalent in other parts of the world, both in developed and developing countries.
18. Institutional strengthening, internal capacity building and human resources development.
19. Private sector participation in SWM.
20. Management information system.
21. Health and legal aspects.

ANNEXURE 9: MONITORING OF LANDFILL OPERATION

Daily Waste Disposal Record Sheet

Name of the disposal (dump) site: .....

Vehicle Reg. No.	Type of Vehicle Compactor/Tractor/ Tipper	Drivers Name and ID No.	Route No. (if available)	Time of Entry	Time of Leaving	Approximate Quantity Full Load 3/4 Load etc.	Remarks - special type of waste	Supervisory Officer's Signature

Summary of the Day's Operation

	Total Number of Vehicles Operated	Quantity of Waste Received/Mt
a. Compactors		
b. Tractors		
c.Trailers		
Quantity of waste disposed		
Quantity left over for next day		
Comments and reasons		
		..... Signature of the Supervisory Officer

Maintenance of daily waste disposal record sheets is an important aspect of the monitoring process. With this information, LAs will be able to monitor the amount of waste disposed of in day and the vehicle utilization efficiency can be maximized through this information. The efficiency of the disposal system will ultimately determine the waste collection and other cleaning services of the city.

ANNEXURE 10: RECORD OF EQUIPMENT PERFORMANCE AT THE DISPOSAL SITE

Name of Disposal Site : ..... Date.....

	Operation Duration			Breakdown Duration				Utility			
Equipment Details	Time of start	Time of Close	Duration (Hr)	Time of Break -down	Time of Re-start	Duration (Hr)	Nature of Break -down	Volume of Waste Compacted	Volume of Waste Cleared	Volume of Ground Cover Applied	Remarks

Supervisory Officer's Signature: .....

Daily equipment performance records at the disposal sites are important in improving the efficiency or the productivity of the site. This will also help to monitor the fuel usage at the site, which is one of the high cost factors at disposal sites. The machine utilization efficiency can also be improved by monitoring the performance records at the dumpsite.

ANNEXURE 11: DISPOSAL SITE LABOUR UTILITY REPORT

Name of Landfill Site : ..... Date.....

	Drivers			Sanitary Workers			Mechanics			Supervisors		
Shift	**Allocated**	**Present**	**Absent**	**Allocated**	**Present**	**Absent**	**Allocated**	**Present**	**Absent**	**Allocated**	**Present**	**Absent**
Day												

Maintenance of disposal site labour utility reports is useful for the overall management of the disposal site. The labour turn-out is an important aspect of the proper management of the site. Therefore, the daily records maintenance will facilitate the easy monitoring of labour outputs and necessary action can be taken if labour outputs are low.

ANNEXURE 12: NATIONAL ENVIRONMENTAL ACT 1980 (AMENDED)

The Gazette of the Democratic Socialist Republic of Sri Lanka

EXTRA ORDINARY
No. 595/16 - FRIDAY, FEBRUARY 02,1990

PART I: SECTION (1) - GENERAL
Government Notification
NATIONAL ENVIRONMENTAL ACT NO. 47 OF 1980

REGULATIONS made by the president under section 32 of the national Environmental Act, No 47 of 1980, as amended by Act No 56 of 1988, read with Article 44 (2) of the constitution.

R. Premadasa
President

Colombo 08.01.1990

Regulations

1. These regulations may be cited as the National Environmental (Protection & Quality) Regulations No. 2 of 1990.

2. No person shall, on or after the relevant date discharge, deposit or emit waste into the environment which will cause pollution, or cause noise pollution, except:

   a) Under the authority of a license issued by the Central Environmental Authority (hereinafter referred to as 'the Authority') and

   b) In accordance with the standards and criteria specified in Schedule I hereto:

      Provided that, where a licensee who does not conform to the standards or criteria specified herein, is at the discretion of the Authority directed to implement a programme of action within a specified period, so as to conform to the aforesaid standards and criteria and to observe certain conditions during such period such licence shall, so long as he observes such conditions, be deemed to comply with the preceding provisions of this regulation.

3. Notwithstanding anything contained in regulation 2, the Authority may, by a direction issued under regulation 13, impose more stringent standards and criteria than those specified in schedule I hereto in respect of any particular industry, operation or process, having regard to the need to protect the receiving environment.

4. Where an activity in respect of which an application for a license is made is not covered by the standards and criteria specified in Schedule I hereto, the Authority will decide on such application on its merits and the applicant shall comply with all such directions as may be issued to him by the Authority for the protection of the environment.

5. The license issued under these regulations shall be known as the 'Environmental Protection License' (hereinafter referred to as the license).

6. (1) An application for the license shall be made:
    a) Separately, in respect of each premises at which the acts authorized by the licences are carried out;
    b) Substantially in Form A in Schedule II hereto;
    c) Accompanied by a receipt for the payment of the fee specified in Schedule III hereto.
    d) At least 30 days prior to the relevant date or to the date on which applicant is required to have the license whichever is earlier.

    (2) For the purpose of these regulations 'Premises' means the totality of buildings and installations used separately or combination to carry out the acts authorized by the licence.

    (3) Every applicant shall furnish all such particulars as may be required to be stated in the aforesaid Form A and any other information that may be called for by the Authority for the purpose of deciding on the application.

7. Every License issued by the Authority shall be:
    a) In Form B in schedule II hereto:
    b) Valid for a period of one year, subject to any suspension of the license under section 23 D of the act: and
    c) Renewable.

8. The Authority shall issue the license only if it is satisfied that:-
    a) The license will not be used to contravene the provisions of the Act or these regulations.
    b) No irreversible damage or hazard to man and environment or any nuisance will result from the acts authorized by the license.
    c) The applicant has taken adequate steps for the protection of the environment in accordance with the requirements of the law.

9. (1) An application for a renewal of a license shall be made:
    a) At least one month before the date of expiry of the license or one month before effecting any changes, alterations, or extensions to the premises at which the acts authorized by the license are carried out, as the case may be;
    b) Substantially in Form C in Schedule II hereto;
    c) Accompanied by a receipt for the payment of the fee for the renewal of licence specified in schedule III hereto.

    (2) Every applicant for a renewal of the license shall furnish all such particulars as may be required to be stated in the aforesaid Form C and any other information that may be called for by the Authority for the purpose of deciding on the application.

10. The Authority may, before issuing an order suspending or cancelling a license under section 23 D of the Act give the holder of the licence an opportunity to show cause why such order should not be issued:

    Provided that, where, since the issue of the license, the receiving environment has been altered or changed due to natural factors or otherwise or where continued discharge, disposition or emission of waste into the environment under the licence will or could affect any beneficial used adversely, the Authority shall forthwith issue an order suspending the licence for a period to be specified in the order or cancel such licence.

11. (1) Any applicant for a license who is aggrieved by the refusal of Authority to grant a license, or any holder of a license who is aggrieved by the suspension or cancellation of a license or the refusal to renew a license may, within thirty days after the day of notification of such decision to him, appeal in writing against such refusal, suspension, cancellation or refusal to renew, to the Secretary for the ministry-in-charge of the subject of Policy Planning and Implementation.

    (2) Such applicant shall be given an opportunity of marking representations in person or by authorized representative in connection with his appeal.

    (3) The Secretary may set aside, verify or confirm the decision appeal form and the Authority shall give effect to the secretary's decision.

    (4) The decision of the secretary shall be final and conclusive.

12. The holder of a license shall forthwith notify the Authority of:

    (a) Any changes made or proposed to be made in the particulars furnished in connection with his application for a license.

    (b) Any decision to terminate any activity to which the license relates;

    And shall comply with any directions that may be issued by the authority to prevent or mitigate environmental pollutions and hazards.

13. Every applicant or every holder of a license shall comply with any direction given by or on behalf of the Authority for the purpose of protecting the environment.

14. Every person who acts in contravention of any regulations commits an offence punishable under section 31 of the Act.

15. In these regulations: "The act means the National Environment Act No. 47 of 1980 as amended by Act No. 56 of 1988.

ANNEXURE 13: LANDFILLS, PRELIMINARY SITE SELECTION AND DATA COLLECTION

The term landfill is used to describe a unit operation for final disposal of MSW on land designed and constructed with the objective of minimum impact on the environment. There are 7 essential components of a landfill.

1. A liner system at the base and sides of the landfill, which prevents migration of leachate or gas to the surrounding soil.
2. A leachate collection and control facility, which collects and extracts leachate within and from the base of the landfill and then treats the leachate.
3. A gas collection and control facility, which collects and extracts gases from within and from the top of the landfill, and then flares it or uses it for energy recovery.
4. A final cover system at the top of the landfill which enhances surface drainage, prevents infiltration of water and supports surface vegetation.
5. A surface water drainage system, which collects and removes all surface water runoff from the landfill site.
6. An environmental monitoring system, which periodically collects and analyzes air, surface water, soil gas and ground water samples around the landfill site.
7. A closure and post-closure plan which lists the steps that must be taken to close and secure a landfill site once the filling operation has been completed.

Site Selection

Selection of a landfill site usually comprises the following steps:

1. Setting up Locational Criteria
2. Data Collection
3. Environmental Impact Assessment
4. Final Site Selection

Locational Criteria

It is essential to locate the landfill in an appropriate area and with appropriate design measures and permission from the CEA. The following criteria are suggested in siting a new landfill site.

1. Lake or Pond: No landfill should be constructed within 200 metres of any lake, pond or lagoon. This is to avoid the contamination of water through runoff wastewater or the water body itself.
2. River: No landfill should be constructed within 100 M of a river or stream.
3. Flood Plain: No landfill should be constructed within a 100-Year flood plain. However, if a properly designed protection embankment is constructed around the landfill, the landfill could be build in flood plains.
4. Buffer Zones: A landfill site should be at least 500M away from the declared area.
5. Wetlands: No landfill should be constructed within wetlands.
6. Ground Water Table: A landfill should not be constructed in areas where the water table is less than 2M below ground surface.
7. Airports: No landfill should be constructed within the limits prescribed by the Aviation Authorities.

8. Water Supply Wells: No landfill should be constructed within 500M of any water supply well.
9. Unstable Areas: A landfill should not be located in potentially unstable areas such as areas prone to land slides.
10. Buffer Zone: A landfill should have a buffer zone around it, up to a distance of 200M minimum.

Searching for an Area

To identify potential sites for a landfill, a search has to be delineated. The search is usually governed by the economics of solid waste transportation.

Development of a List of Potential Sites

After demarcating the search area and studying the various restrictions listed in the local criteria, areas having potential for site development should be identified. In areas where land availability is scarce, degraded sites such as abandoned quarries or old dumpsites can be considered.

Data Collection

The following information needs to be studied before deciding the site.

1. Topographic Maps

The topography of the area indicates low and high areas, natural surface water drainage patterns, streams and rivers. A topographic map will help to find sites that are not on natural surface water drains or flood plains. Topographic maps can be obtained from the Survey Department for most of the areas.

2. Soil Maps

These maps, primarily for agricultural use, will show the types of soil near the surface. They are of limited use as they do not show types of soil a few metres below the surface. Soil maps can be obtained from the Land Use Department in Sri Lanka.

3. Land Use Plans

These plans are useful in delineating areas with definite zoning restrictions. These plans are used to delineate possible sites that are sufficiently away from certain localities and to satisfy zoning criteria within the search area. These maps are available at the UDA.

4. Transportation Maps

These maps, which indicate roads, railways and airports, are used to determine the transportation requirements in developing a site.

5. Water Use Plans

Such plans are usually not readily available. However, once potential areas are delineated, the water use in those areas must be investigated. A plan indicating the following items should be developed: private and public tube wells indicating capacity of each well, major and minor drinking water supply lines, water intake wells located on surface water bodies and open wells.

6. Flood Plain Maps

These maps are used to delineate areas that are within a 100-year flood plain. Landfill siting must be avoided within the flood plains of major rivers.

7. Geological Maps

These maps will indicate geological features and bedrock levels. A general idea about soil type can be developed from a geological map. These maps can be obtained from the Geological Surveys Department of Sri Lanka.

8. Ground Water Maps

Ground water contour maps are available in certain regions, which indicate the depth of ground water table and regional ground water flow patterns.

9. Rainfall Data

The monthly rainfall data for the region can be collected from the Meteorological Department.

10. Wind Map

These will indicate the predominant wind direction and velocities of the region.

Summary of Data Collection

Data to be Collected	Importance of the Information to Site Selection
1. Topographic Maps	Will help in deciding a more suitable area or a section of land avoiding natural water drains or flood plains. This will also help in designing the landfills.
2. Soil Maps	Types of soil near the surface layer is important in designing landfill liner systems. Clay soil is preferred to sandy soils so as to reduce the infiltration of leachate into the ground water.
3. Land Use Plans	Land use plans are important in selecting a landfill site since landfills are long-term and therefore future developments planned for the area should be taken into account before deciding on the site.
4. Transport Maps	Easy access and routes with less development in the area is a very important factor to be considered when deciding on a landfill site. Therefore, the transport maps (preferably GIS) with residential houses, should be referred to before deciding on the site.
5. Water Use Plans	Water use plans are important as landfill sites normally tend to pollute the ground even with the liner systems in place. Therefore, public health should be protected from ground waste contaminations. The new site must be located to avoid these contaminations.
6. Flood Plain Maps	It is important to avoid flood plains in selecting a site. If the landfill site were flooded regularly, the environmental pollution would be unacceptable.
7. Geological Maps	It is important to know the ground conditions such as soil type, bedrock levels, ground water levels and streams in a site before deciding on the design of the site.

8. Ground Water Maps	Again, it is important designing the landfill, especially the liner system, to prevent leachate contaminating the ground water systems.
9. Rainfall Data	Collection of rainfall data for the last few years would be useful in landfill designing with respect to control of contamination of surface run off water at the site. Also, very high rainfall areas should be avoided when selecting a site.
10. Wind Maps	Wind directions and velocities are important in planning the landfill site to avoid scattering of the litter during the unloading and handling operations.

Assessment of Public Reaction

As soon as a list of potential sites are developed, the public should be informed of the possibility of siting a landfill near their area. A preliminary assessment of public opinion regarding all sites on the list is essential. A site may be technically and economically feasible yet may be opposed heavily by the public.

Environment Impact Assessment

Wherever possible, an IEE or an EIA study has to be conducted for two alternative sites. A comparison of both alternatives as well as a null alternative (what would happen if the project is not carried out) should be made and suitability of the sites summarized. Further details on environmental approvals regarding landfill sites are given in Annexure 14.

Final Site Selection, Site Investigations, Landfill Planning and Designing, and Design Life

Final Site Selection

The final selection of the site should be carried out by comparing:

a. The environmental impacts

b. Social acceptance

c. Transportation and land filling costs

A landfill site with low environmental impact, high social acceptance and low costs is the most desirable. However, the environmental impact minimization should normally be given top priority. It should be noted that ideal sites like this are VERY HARD to find and in Sri Lanka may not be available anywhere due to the density of the population throughout the island. Therefore, tradeoffs are balanced with public need and must be made by the Council and discussed through an open public process.

Site Investigation and Site Characterization

The data collected during site selection may not be sufficient for landfill design. To be able to undertake detailed design of a landfill at the selected site, it is essential to characterize the landfill site and evaluate the parameters required for design. It is necessary to collect all data listed in Annexure 13A for a site characterization.

Exercise on Landfill Site Selection

Data to be Collected	Expected Result	Site Selection		
		Ideal	Suitable	Not Suitable
1. Topographic Map				
2. Soil Maps				
3. Land Use Plan				
4. Transport Maps				
5. Water Use Maps				
6. Flood Plains				
7. Geological Maps				
8. Ground Water Maps				
9. Rainfall Data				
10. Wind Maps				
11. Environmental Impact				
12. Social Acceptance				
13. Transportation and Landfill Costs				
Total Score				

If the total score is 7 or more for 'not suitable' category, that site should be rejected.

Landfill Planning and Designing

Design Life

A landfill design life will comprise of an active period, closure period and post-closure period. The active period may typically range from 10-25 years depending on the availability of the land area. The closure and post-closure periods will be 25 years after the active period is completed. However, under Sri Lankan conditions the land extents available will never be of this range as the LA will only be able to find land in the region of 2-5 acres for disposal.

The volume of waste to be placed in a landfill will be computed for an active period of the landfill, taking into account:

a. The amount of current generation of waste.

b. The anticipated increase in rate of waste generation on the basis of past records or population growth rate.

The required landfill capacity is significantly greater than the waste volume it accommodates. The actual capacity of the landfill depends on the:

1. Volume occupied by the liner system.
2. Type of cover (daily, intermediate and final).
3. Compacted density of the waste.
4. Amount of settlement that will happen due to the weight and bio degradation.

Landfill Layout

A landfill site will comprise of the area in which the waste will be filled as well as additional area for support facilities. Work may proceed in phases with only a part of the area under active operation. A typical site layout is shown in Fig.1. The following facilities must be located in the layout: (a.) Access roads (b.) A building for equipment (c.) Weigh bridge (d.) Office building (e.) Waste receiving bay (f.) Temporary waste storage area (g.) Area for stockpile cover material (h.) Drainage facilities (i.) Landfill gas management facility (j.) Location for leachate treatment facility (k.) Location for environmental monitoring facility.

Type of Landfills and Selection

Depending on the topography of the area the type of landfill can be designed:

a. Above ground landfills.
b. Below ground landfills (trench landfills).
c. Slope landfills.
d. Valley landfills (canyon landfills).
e. A combination of the above.

Phased Operation

Before the main design of a landfill can be undertaken it is important to develop the operating methodology. A landfill is operated in phases because it allows the progressive use of the landfill area, such that at any given time:

- a part of the site may have a final cover
- a part being actively filled
- a part being prepared to receive waste
- a part undisturbed

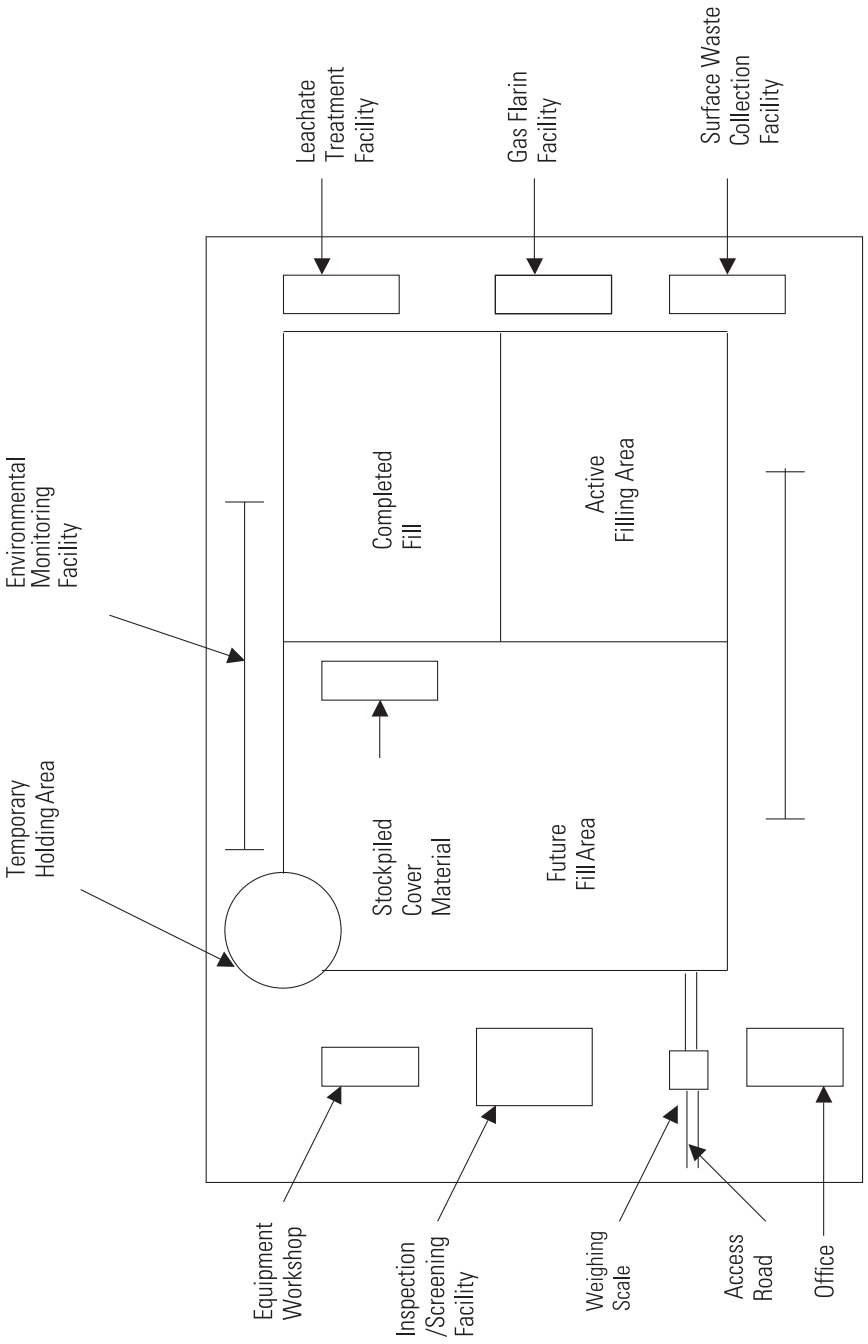


Figure 1. Typical Site Layout Plan of a Landfill

Liner Systems, Leachate Drainage and Collection Systems

Liner System

Leachate control within a landfill involves the following steps:

1. Prevention of migration of leachate from landfill sides and base to the sub soil by a suitable liner.
2. Drainage of leachate collected at the base of a landfill to the sides of the landfill, and removal of leachate from within the landfill.

Liner systems are comprised of a combination of leachate drainage, collection layer and barrier layer. A proper liner system:

a. Should have low permeability.
b. Be robust and durable.
c. Be resistant to chemical attack, puncture and rupture.

A liner system may be comprised of a combination of barrier materials such as natural clays, amended soils and flexible geomembranes.

Leachate Drainage, Collection and Removal

A leachate collection system is comprised of a drainage layer, perforated pipe collector system, sump collection area and a removal system. Leachate is removed from the landfill by:

a. Pumping-in side slope risers.
b. By gravity, drains through the base of the landfill.
c. Pumping in vertical wells.

Landfill Gas Management, Waste Compaction and Application of Daily Cover

Leachate Management

1. Discharge to lined drains.
2. Discharge to waste water treatment system.
3. Recalculation.
4. Evaporation of leachate.
5. Treatment of leachate.

Landfill Gas Management

The gas management strategies should follow one of three plans:

a. Controlled passive venting.
b. Uncontrolled release.
c. Controlled collection and treatment/reuse.

Waste Discharge and Placement at the Disposal Site

Solid waste must be discharged by tipping at the working area of the landfill, within the area demarcated for the cell. A designated operator should visually inspect every discharged load. Working area personnel should be trained and competent at solid waste identification in order that they can recognize waste which may be non-conforming.

Once the waste has been discharged, it must be spread in layers and compacted in a well-defined manner to ensure that the completed slopes of a daily cell are at the designed gradients.

Waste placement can be done by the following methods:

a. Face tipping method - solid waste is deposited on top of the existing surface and spread horizontally by tipping over an advance face.

b. Inclined layering method - similar to (a) but inclined layering (gentle slope) used instead of advancing face.

c. Working upwards - waste is deposited on the lower surface and pushed upwards.

Operation of Landfill Pollution Prevention, Final Closure and Monitoring

Pollution Prevention

Measures are required to ensure that the landfill operation does not adversely affect the environment within or outside the landfill.

Final Closure of the Site

After the last sets of cells of a phase are placed, the final cover is constructed. A final cover is usually composed of several layers, each with a specific function. The final cover system must enhance surface drainage, minimize infiltration, establish vegetation and control the release of landfill gas.

Operation After Closure

The following facilities should be operated routinely after closure:

1) Leachate management system.

2) Surface water management system.

3) Environmental monitoring system - covers rehabilitation and repair system. The operating methodology will depend on the type of system adopted at the landfill.

Landfill Monitoring System

A landfill monitoring programme should be designed and developed to monitor the following quantitative and qualitative parameters:

Quantitative Parameters

1. Leachate quantity.
2. Landfill gas quantity.
3. Surface water runoff quantity.
4. Cover system settlement quantities.

Qualitative Parameters

1. Leachate quality within the landfill.
2. Leachate quality after treatment.
3. Ground water quality.
4. Gas quality within the landfill.
5. Surface water quality at the exit of the landfill.
6. Air quality.

ANNEXURE 13A: SUGGESTED INVESTIGATIONS FOR SITE CHARACTERIZATION

Type of Investigation	Suggested Scope of Work
Subsoil/Geotechnical Investigations	(a) For Landfill design (i) Borehole study up to 10M below the base of landfill. (ii) In situ permeability tests. (iii) Laboratory tests on undisturbed samples; permeability, strength, compressibility. (b) For burrow area of liner material and cover material (i) Two test pits or shallow boreholes. (ii) Laboratory tests classification, Proctor compaction, permeability and strength tests. (c) For approach road landfills.
Ground Water/ Hydro-geological Investigations	(a) Ground water well observations, level fluctuations and ground water flow. (b) Collection of ground water samples for quality testing.
Topographical Investigations	(a) Surveying of land area and preparation of a topographical map with 0.3 m contour intervals.
Hydrological Investigations	(a) Collection of detailed topographical data of the surrounding area. (b) Collection of hydro meteorological data from meteorological dept. (c) Performance of flood routing analysis for the one in a 100-year flood. (d) Collection of surface water samples for water quality testing.
Geological and Seismic Investigations	(a) Geophysical survey. (b) Collection of seismic data.
Environmental Investigation Basis	(a) Collection of surface water samples, ground water samples and air samples for analysis. (b) Vegetation/ecology mapping survey.
Traffic Investigations	(a) Collection of data on existing traffic for six months. (b) Road condition survey for existing roads.
Waste and Leachate Investigations	(a) Waste characterization of fresh waste. (b) Waste characterization of old waste from different depths in existing waste dumps. (c) Collection and laboratory analysis of samples of leachate from existing waste dumps. (d) Estimate the leachate quantity from lab tests.

ANNEXURE 14: CENTRAL ENVIRONMENTAL AUTHORITY BASIC INFORMATION QUESTIONNAIRE

APPLICATION NO

CENTRAL ENVIRONMENTAL AUTHORITY
BASIC INFORMATION QUESTIONNAIRE

(Essential information to determine the environmental approval requirement of projects)

1 Name of the Project:

2 Name of the Developer:
(Company/firm/individual).

Postal Address:.....

Phone No: ..... Fax No:.....

Person

Contact

Name:.....

Designation: .....

Phone No: ..... Fax No:.....

3. Brief description of the project (Use a separate sheet)
Attach copy (ies) of pre-feasibility/feasibility study report (s) if available

4. Scale/magnitude of the project:
(e.g. For a road project: Length of the trace; Tourist hotel: No. of rooms; Agriculture Project: Extent of land etc.)

5. Is the project an extension to an existing project? If so, scale/magnitude of the existing project:

6. Main objective(s) of the project:

7. Investment and Funding sources:

8. Location of the Project: Pradeshiya Sabha; Divisional Secretariat; District Provincial Council

Provide a location map indicating the project site, access to the site, surrounding development and infrastructure within 500 m of the site (1:50000 scale).

9. Extent of the project area (in ha):
(Copy of the survey plan should be attached)

10. Does the project wholly or partly fall within any of the following areas?

Area	Yes	No	Unaware
100m from the boundaries of or within any area declared under the National Heritage Wilderness Act No 4 of 1988.			
100m from the boundaries of or within any area declared under the Forest Ordinance (Chapter 451).			
Coastal zone as defined in the Coast Conservation Act No 57 of 1981.			
Any erodable area declared under the Soil Conservation Act (Chapter 450).			
Any Flood Area declared under the Flood Protection Ordinance (Chapter 449).			
Any flood protection area declared under the Sri Lanka Land Reclamation and Development Corporation Act 15 of 1968 as amended by Act No 52 of 1982.			
60 meters from the bank of a public stream as defined in the Crown Lands Ordinance (Chapter 454) and having width of more than 25 meters at any point of its course.			
Any reservations beyond the full supply level of a reservoir.			
Any archaeological reserve, ancient or protected monument as defined or declared under the Antiquities Ordinance (Chapter 1881.			
Any area declared under the Botanic Gardens Ordinance (Chapter 446).			
Within 100 meters from the boundaries of, or within, any area declared as a Sanctuary under the Fauna and Flora Protection Ordinance (Chapter 469)			
100 meters from the high flood level contour of or within, a public lake as defined in the Crown Lands Ordinance (Chapter 454) including those declared under section 71 of the said Ordinance.			
Within a distance of one mile of the boundary of a National Reserve declared under the Fauna and Flora Protection Ordinance.			

11. Present ownership of the project site:

State	Private	Other-specify

12. Present land use: (Please tick the relevant cage/s)

Land use Type		Land use Type	
Paddy		Marsh/Mangrove	
Tea		Scrub/Forest	
Rubber		Grassland/Chena	
Coconut		Built-up area	
Other Plantations/Garden		Other (pl. specify)	

13. Does the site/project require any

	Yes	No	If yes give the extent (in ha)
Reclamation of land, wetlands Clearing of land Clearing of forest Felling of trees			

14. Does the project envisage any resettlement?

Yes	No	If yes, give the number of families to be resettled >

15. Does the project envisage laying pipelines?

Yes	No	If yes, give the length of the pipeline (km)

16. Does the project involve any tunnelling activities?

Yes	No

17. Proposed timing and schedule including phased development:

18. Applicable laws, regulations, standards and requirements covering the proposed project:

19. Clearances/permits obtained or should be obtained from relevant state agencies and/or LAs. (Attach required copies of the same)

The above information is accurate and true to the best of my knowledge. I am aware that this information will be utilized in decision-making by the relevant state authorities.

Date Signature of Applicant

FOR OFFICE USE ONLY

1. Date of receipt of the application:

2. A site inspection done? Yes/No

   If yes,

   Date of the inspection: .....

   Name(s) of the officer(s):

   Inspection fee

   Amount: Rs..... Date of payment:.....

   Receipt No: .....

   Special comments regarding significant environmental concerns
   (Based on site inspection):

3. Require approval under part IVC of NBA?
   (i.e. Need to go through the EIA/IEE process)

4. If need to go through the EIA, process appropriate PAA:

5. Other Remarks:

REFERENCES

1. Technical guidelines for SWM in Sri Lanka, Central Environmental Authority, Ministry of Environment and Natural Resources, Battaramulla, June 2005
2. Integrated Solid Waste Management Engineering Principles and Management issues McGraw - Hill International Edition, 1993, Eds. George Tchobanoglous, Hilary Theisen, Samuel Vigil.