

5.3 Formation of Comprehensive SWM System

5.3.1 Reinforcement of Institutional System

(1) Basic Law System for SWM

a. Basic Structure of Institutional System

i) Introduction

The objective of the SWM should be placed on the protection of living environment, improvement of public health and preservation of the natural environment. These aspects comprise a fundamental condition for the future development through the proper SWM in respect of discharge reduction, storage, collection, transport, recycling and disposal of the waste.

All parties such as households, industries, local and national government authorities concerned should play role for this intended achievement.

An appropriate institutional and legislative arrangement should be indispensable condition for the effective SWM.

The study team shall hereafter present the proposed framework for basic institutional and legislative arrangement being required for SWM at national level of the Republic.

ii) Setting Up of the Principle

In the light of the national goal mentioned in this study, the framework should be established based on each following principle.

The First principle is the "principle of environment esteem". As the environment, the fundamental base of the future development of Maldives, is one of the most important resources of the nation, SWM should be carried by the method that is paid attention particularly to the preservation of the environment. This is the most important principle among others.

The Second is "the principle of self responsibility disposal". The essential responsibility for SWM should be charged on any entity that generates waste, irrespective of household, businessman and public sector. The government authorities concerned are only responsible for provision of the circumstances in that those generators are smoothly able to carry out their duties.

The Third is "the principles of classification of general waste and industrial waste". One of the most realistic and effective classification of wastes, to

correspond the institutional and legislative system with waste, is to classify into the domestic and industrial wastes.

The Fourth is "the principle of the management responsibility by administrative authorities". The SWM is the part of main duty of the administrative authorities for the safety and improvement of the life of the citizen directly.

The Fifth is "the principle of the guidance by government". A nation can implement the SWM of industry appropriately through the leadership of an authority concerned. The SWM of the tourism industry should be a good example in Maldives.

The Sixth is "the principle of private sector involvement". A more efficient SWM service would be offered through appropriate competition by both public and private entities concerned. And the public financial burden on the matter would be reduced more than otherwise.

The Seventh is "beneficiary-payment principle". By this principle, people can theoretically receive the service on SWM more fairly.

The Eighth is "the Polluter Pay Principle". This is the common sense in the world today.

The Ninth is "the constitutional government principle". The improvement of the legislative system is the consistent policy goal of the government. However, several activities of the SWM are lacking the legal provision, because "a comprehensive SWM act" is not enacted yet. Therefore, the Maldives government should prepare this aspect urgently.

The Tenth is "the principle of local circumstances correspondence". The SWM in the metropolitan area could not work, if the big population area does not correspond with a high level system of a large-scale technology standard. However, they can contrastively solve the problem efficiently with the conventional method of small-scale in a local community in where there lives extremely little population. Accordingly, development of appropriate SWM system to various situations is very important.

The Last is "the principle of comprehensive SWM system". It is extremely important to set up the structure of the SWM institutional and legislative arrangements with consistency to across the whole country.

iii) The Proposed Institutional Framework of the SWM System at National Level

When the SWM continues to be carried out without a planning as used to be, there is the fear that might bring about the environmental deterioration in the future in Maldives.

The islands in where waste is generated could be classified into two types; the inhabited island such as Male' and so-called inhabited island, and the function island that is used for a business purpose such as resort islands, airport islands and Thilafushi etc.,

No administration is provided for any function island. Also, the population scale and the population density are diverse to large extent across the inhabited islands. The geographic spread of this demographic diversity of islands shapes the characteristics of the Maldives.

Like this, the local conditions are various across the areas. Nevertheless, these SWM would be able to be managed by an integrated single management. And this type of management system should be introduced for the national SWM of the Maldives.

Because, first of all, this management system consistently enables the comprehensive planning and implementation of the national SWM policy.

Furthermore, this management system would bring about advantages that would be able to transplant success experiences performed in some areas into other areas, or that would be able to afford more effective multiple utilisation of the valuable SWM facilities than otherwise.

And, the most important advantage of this institutional system is the formation of firm base for the long-term policy execution.

The proposed structure of the institutional system is as shown in Figure 5-1. With being set up through coordination and mobilisation of the functions and resources of authorities concerned, this framework aims to create a proper institution for comprehensive SWM.

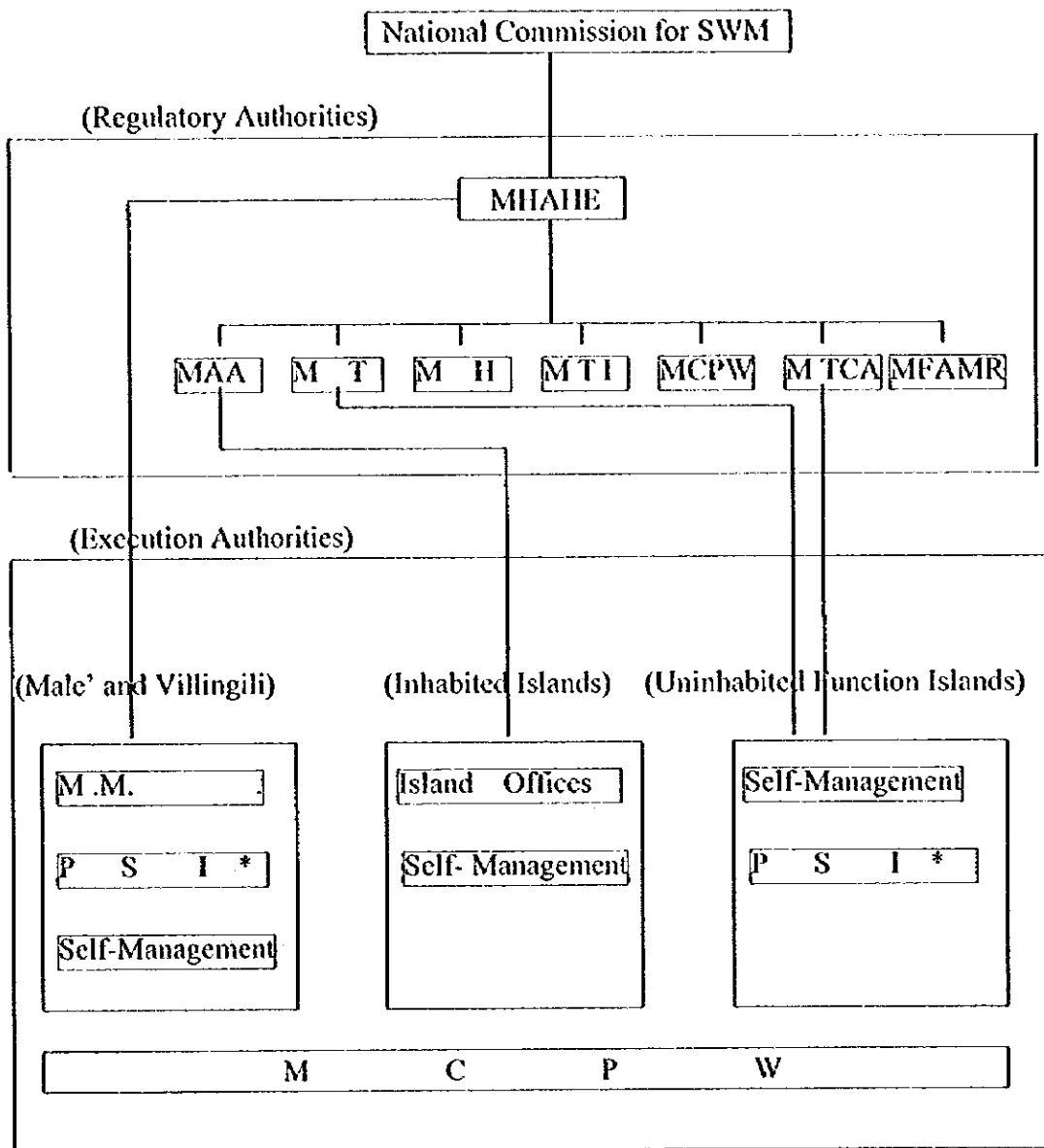
In the Maldives, SWM will be the subject that the highest organ of the nation should take direction. The importance of the environment of Maldives is understood well in this country. The relation of environment and SWM is just same as that of the two wheels of a cart. In other words, environment protection can not exist without proper SWM. Therefore, a national highest organization should shake a flag to direct and stimulate people even for SWM.

New establishment of a National Commission for SWM should be proposed. Constitution and management of this organization shall be conform to those of the National Commission for the Protection of the Environment

Lead agencies for the area would be the Ministry of Home Affairs, Housing & Environment as well as the Ministry of Atolls Administration.

The MHAHE because of prime environment concerns associated with solid waste pollution and the plurality of sectors that are responsible for generating it. This ministry and MAA because of stewardship role those have to play in the administrative areas to which the issues of sanitation and protection of their environment related.

As no administration is provided any function island such as resort islands and airport islands etc., each responsible authority concerned should regulate and control those enterprisers in the islands to carry out the SWM properly on their own responsibility.



* Private Sector Involvement

Note;

MHAHE (Ministry of Home Affairs, Housing & Environment)

MAA (Ministry of Atolls Administration)

MT (Ministry of Tourism)

MH (Ministry of Health)

MTI (Ministry of Trade & Industries)

MCPW (Ministry of Construction & Public Works)

MTCA (Ministry of Transport & Civil Aviation)

MFAMR (Ministry of Fisheries, Agriculture & Marine Resources)

MM (Male' Municipality)

Figure 5-1. Proposed Basic Structure of Institutional System

b. Basic Law System for SWM

i) Introduction

The government should legislate SWM related laws and regulations as necessary. Recommendations on legislation regarding the national SWM are expressed hereafter in this section.

A Cleansing and SWM Act of Maldives (draft name) as the basic law for comprehensive SWM, and the National Solid Waste Disposal Technical Standard of Maldives (draft name) and the National Solid Waste Treatment Facilities Standard of Maldives (draft name) should be legislated simultaneously. Those three basic laws and standards shall be the guidelines for all SWM interests of the country.

Each authority also shall be required, in accordance with the basic laws, to legislate proper laws and regulations that shall prescribe more detail and more concrete SWM activities for its concerns.

Thus, the institutional system shall provide a proper SWM in full range of activities from collection, transport, storage, intermediate disposal, sea transport, to final disposal across the areas in the Maldives.

ii) A "Cleansing and SWM Act of Maldives" (draft name)

The main contents suggested of the basic law are as being presented below.

The fundamental purpose of this basic law is to provide the legal basis for the proper disposal of waste.

This law should prescribe duties on solid waste disposal of all parties concerned such as citizens, enterprisers, the national government, municipality and Atolls respectively.

This law also should prescribe the technical and facility standards on solid waste disposal to be applied in accordance with the national technical and facility standards laws.

Thus, the SWM of the Maldives must be managed in accordance with laws and regulations completely.

iii) A model of "Cleansing and SWM Act of Maldives" (draft name)

CHAPTER I GENERAL REGULATIONS

1. Purpose

This law would be enacted for the purpose of preserving the living environment and improving public health through the restriction of waste discharge, appropriate sorting, storage, collection, transport, recycling, disposal, etc. of a clean living environment.

2. Definition

In this law, "wastes" refers to refuse, bulky refuse, ashes, sludge, waste oil, waste acid and alkali, carcasses and filthy and unnecessary matter, which are in solid or liquid state (excluding radioactive wastes and wastes polluted by radioactivity).

In this law, "domestic waste" refers to waste to those other than industrial wastes.

In this law, "industrial waste" comprises the waste categories defined below:

- 1) Ashes, sludge, waste oil, waste acid and alkali, waste plastics and others specified by a proper order or regulation among all the waste left as a result of enterpriser's activity.
- 2) Imported wastes (if any)

3. Principle of Management within Maldives and Restriction of Imports

Wastes generated within Maldives shall be appropriately managed within Maldives whenever it is possible.

Imports shall be restricted so as to prevent from hindering appropriate management of waste within Maldives.

4. Duties of Citizens

The citizens shall manage wastes by themselves as far as possible. The citizens shall cooperate with the national government, municipality and Atolls (island offices) in their activities for waste reduction by restricting their waste discharge, using recycled articles or otherwise contributing towards the recycling and re-use of wastes, sorting wastes prior to discharge.

5. Duties of Enterprisers

The enterprisers shall appropriately manage the waste left as a result of their activities by themselves as far as possible.

The enterprisers must endeavour to reduce the amount of waste by recycling or re-use of wastes.

The enterprisers shall co-operate with the national government, municipality and Atolls (island offices) in their activities to reduce waste, ensure appropriate management and so on.

6. Duties of National Government, Municipality and Atolls (Island Offices)

The municipality and Atolls (island offices) shall endeavour to promote resident's voluntary activities to reduce wastes in their respective administrative areas and take the necessary action for proper management of those domestic wastes. They shall also endeavour to perform the management personnel, consolidating treatment facilities and developing operation techniques.

The national government shall collect information about wastes, keep in orderly arrangement and use it, take measures for promotion of waste treatment technology development and also take suitable action for proper and smooth management throughout Maldives.

The national government shall endeavour to give the necessary technical advice to the municipality and Atolls (island offices) to ensure their adequate performance of their duties prescribed in the foregoing paragraph.

7. Maintaining Cleanliness

Land and building owners (or caretakers) shall endeavour or to maintain cleanliness of the land and buildings under their care.

CHAPTER II GENERAL WASTE

1. Domestic Waste Management Plan

The local governments shall set forth a definite plan for management of domestic wastes in respective administrative areas (which will hereinafter be referred as a "domestic waste management plan")

The domestic management plan shall include following matters:

- 1) Estimate of the volume of domestic wastes to be generated and the volume to be treated of.
- 2) Matters related to measures for suppressing of domestic waste discharge.
- 3) Kind of domestic wastes to be pre-sorted for collectors and descriptions of those kinds.
- 4) Fundamentals of proper domestic waste management and also the fundamentals relating to the authorities/persons engaged in such management.
- 5) Matters pertaining to the improvement or expansion of waste treatment plants
- 6) Other matters necessary for the management of domestic wastes.

2. Management by the Municipality

The municipality shall collect, transport of domestic wastes in the municipal area before they interfere with the conservation of the living environment, according to the domestic waste management plan.

Standards on collection and transport of wastes which are to be conducted by the municipality and standards for the case in which the municipality commissions someone else to collect and transport of domestic wastes shall be prescribed in a regulation of MHAHE.

Land and building owners (or caretakers) must exert themselves to dispose of wastes in their land or buildings which are easily disposable without hindrance to the conservation of living environment. As to the wastes which the owners (or caretakers) cannot dispose of by themselves, they must endeavour to cooperate with the municipality in the collection and transport of the domestic wastes conducted by the municipality by properly sorting and storing the said wastes according to the domestic waste management plan or take other necessary action.

The chairman of the municipality is entitled to give owners (or caretakers) of land and buildings where a large amount of domestic wastes is generated due to their business activities, instructions regarding planning for reduction of the said wastes, the place to which they are to be transported, the method of transporting them and other necessary matters.

The municipality may collect handling charges for the collection, transport and disposal of the domestic wastes conducted by the municipality and MCPW in accordance with a municipal order. The amount of the said handling charges shall be fixed by taking into account the cost of its collection, transport and disposal and other matters.

3. Management by the Atolls (Island Offices)

The Atolls (island offices) shall dispose (in necessary case collect, transport and disposal) of domestic wastes in the areas which land and buildings owners (or caretakers) collect and transport by themselves before they interfere with the conservation of the living environment, according to the domestic waste management plan.

Standards on collection, transport and disposal of said wastes which are to be conducted by land and buildings owners (caretakers) and the Atolls (island offices) shall be prescribed in a regulation of MHAHE.

Land and buildings owners (or caretakers) must exert themselves to collection and transport wastes in their land or buildings which are easily collect and transport without hindrance to the conservation of living environment.

The island chief of an island is entitled to ask to owners (or caretakers) of land and buildings in the community to cleanse the final disposal sites and around places in the island.

The Local Centers may collect handling charges for the disposal of the domestic wastes conducted by them and by joint ventures with the MCPW in accordance with an article of association of the organisation. The amount of the said handling charges shall be fixed by taking into account the cost of its collection, transport and disposal and other matters.

4. Domestic Wastes Handling Agent

Any person is allowed to undertake as a handling agent the collection and transport of domestic wastes with registration to the government concerned. The domestic waste handling agents shall conduct their undertakings in accordance with laws and standards to which are applied to the municipality and Atolls.

CHAPTER III INDUSTRIAL WASTES

1. Management by enterprisers and the municipality and Atolls

The municipality and Atolls (island offices) may manage those industrial wastes which can be managed of together with domestic wastes and which are judged to be in need of their management, either solely or jointly with someone else as part of their work.

2. Management Plan

The chairman and Atoll chiefs shall set forth a plan for management of industrial waste in the entire areas (which will hereinafter be referred to as the " industrial waste management plan")

The industrial waste management plan shall include the matters associated with industrial waste management in the administrative areas in accordance with a regulation of MHAHE.

- 1) Estimate of the volume of industrial wastes to be generated and the volume to be treated of.
- 2) Fundamentals related to reduction of industrial wastes and their proper treatment.

3) Other matters necessary for treatment of industrial wastes.

3. Treatment by Enterprisers

In the case where enterprisers transport and dispose their industrial waste by themselves, it shall be in accordance with the standards the collection, transport and disposal of industrial wastes stipulated in a regulation of MPHRE.

The enterpriser shall store the industrial waste till the time of management without hindering the conservation of the living environment in accordance with technical standards stipulated in a regulation of the MHAHE.

If an enterpriser is to commission anyone else to transport or dispose of their industrial wastes, that enterpriser shall act in accordance with the standards stipulated in a regulation of MHAHE and commission an industrial waste collection and transport agent.

CHAPTER IV FINAL DISPOSAL OF WASTES

① The chairman, Atoll chiefs and minister of the Ministry of Tourism can instruct plentiful industrial waste to make the plans regarding the loss in weight or other disposal of the industrial waste regarding a proper business, to the businessman who happens inside the area.

As for the vicarious execution of final disposal of the domestic waste and also industrial waste is exclusive duty of MCPW and Local Centers.

② The standard regarding the storage, transport, final disposal of the general waste and industrial waste that MCPW and Local Centers carry out are determined with a government regulation of MHAHE.

③ MCPW and Local Centers can impose the charges for the storage, transport, final disposal of the general waste and industrial waste to the beneficiaries. MCPW and Local Centers must determine the amount of the charges, in consideration of costs for the disposal of the wastes.

CHAPTER V MISCELLANEOUS REGULATIONS

1. No person shall unnecessarily dump wastes.
2. Collection of Report (if necessary)
3. Improvement Order (if necessary)
4. Order for Actions (if necessary)
5. Government Subsidy (if necessary)
6. Technology Guidance (if necessary)

CHAPTER VI PENAL REGULATIONS

(To be established in accordance with the conditions of the country)

c. Required By-laws

Beside the basic laws proposed, each authority concerned shall be required, in accordance with the basic laws, to legislate proper laws and regulations which shall prescribe more detail and more concrete SWM activities for its concerns.

The government authorities concerned shall be suggested to legislate following regulations to complete the legal base for waste management neatly.

The MHAHE regulations;

The MHAHE shall be proposed to legislate a regulation regarding the formation of the national plan of SWM, a regulation regarding the co-ordination among ministries about SWM, and a hazardous waste management. The Ministry shall be also proposed to legislate regulations for cleansing and SWM in Thilafusi.

The MT regulations;

The MT shall be proposed to amend the existing tourism waste management regulations to be in accordance with the waste management requirement to reduce discharge of waste, to demand disposal of waste in Thilafushi and so on.

The MTI regulations;

The MTI shall be proposed to co-operate with MPHIRE to legislate a regulation for waste management of industrial product wastes such as waste batteries, waste oil, waste electric appliances and waste automobile and so on.

The MFAMR regulations;

The MFAMR shall be proposed to legislate regulations for waste management of fishery related matters such as waste engine oil of fishing boat, waste fishing boat and fishing tools and so on.

The MTCA regulations;

The Ministry of Transportation & Civil Aviation shall be proposed to legislate regulations for waste management of the airport island, and cleaning and SWM of sea and harbours.

The MH regulations;

The MH shall be proposed to legislate regulation for waste management of medical waste to prescribe the treatment of them neatly.

The Male' Municipal ordinance;

The Male' Municipality shall be proposed to amend the by-laws for waste management in accordance with the change of the state of waste collection practice as well as the change of the administrative areas.

(2) Task Re-allocation among Authorities Concerned

a. Basic Management in Capital Region

i) Basic Management in Male' and Villingili Islands

• Final Disposal

At present, the final disposal site of the capital region is only one place of Thilafushi which is managed by the MCPW. This will not be changed in the future. Also, the MCPW, the sole execution body of the final disposal of wastes from the region will continue to carry out its duties directly or indirectly.

• Intermediate Storage of Wastes from Male' and Villingili

At present, two transfer stations are set, one in Male' island and the other in Villingili Island. Although the manager of the Male' transfer station is the MCPW clearly, it is not so obvious who is responsible for the management of the Villingili transfer station. From the viewpoint of this function, it may be most adequate to put this under the management of the MCPW. The Government should be advised by the study team to decide the authority in responsibility at the occasion that the administrative duty on the island will be transferred from the Maldives Housing & Urban Development Board to the Male' Municipality in the near future. Thus, the management of the Villingili transfer station would become the sole responsibility of the MCPW clearly.

• Haulage to Thilafushi

As for the haulage of the wastes from the transfer stations to the Thilafushi carried out by the MCPW now, the present states should be continued even in the future.

• Collection of Wastes in the Municipality

At present, practices of the collection of wastes in the capital region are rather complicated.

The types of the collection are various as follows, even if it limits the cases to be revealed.

Table 5-3. Type of Collection of Wastes in Male'

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- A. Self disposal (carrying to discard) of domestic wastes
 - A-1. Carrying wastes to discard them to the transfer station by oneself
 - A-2. Carrying wastes to discard them to the containers set by the Municipality

 - B. Self disposal (carrying to discard) of the enterpriser's wastes

 - C. Collection by the Municipality
 - C-1. Collection of the waste containers
 - C-2. Collection of the garbage boxes set in public space
 - C-3. Door to door collection (an experiment stage, on charge)

 - D. Collection by the private sector involvement
 - D-1. Door to door collection (on charge)
 - D-2. Door to door collection (free of charge)
 - D-3. Spot transport (on charge)
 - D-4. Collection by individual collectors (on charge)
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As soon as possible, a decision should be made to change this state in order to form a simpler and more effective system for the collection of waste.

ii) Basic Management in Capital Region other than Male'

At present, waste management in capital region other than Male' and Villingili is carried out by self-management.

Tasks in this area shall not be re-allocated basically.

iii) Proposed Additional Tasks of Authorities in the Capital Region

The tasks based on the proposed policy will be managed by the Male' Municipality and the MCPW. Following tasks will be proposed to the authorities, by addition to the conventional ones.

Male' Municipality

1. Introduction of Station Type Collection and Bell Collection
2. Abolishment of the waste container management in Male'
3. Privatisation of the Collection Service

MCPW

1. Composting in Thilafushi
2. Material recycling
3. Waste oil incineration in Thilafushi
4. Introduction of waste disposal charge

b. Basic Management in Local Islands

i) Basic Management

In local inhabited islands, mainly the Ministry of Atolls Administration manages public services. The Ministry of Tourism is independently responsible for the SWM in local resort islands as well as in the capital region. Basic management in those local islands shall be continued almost as same as at present. However commitment of the Administration will increase in some populated islands to improve final disposal sites.

ii) Introduction of A Collective SWM System to Local Centers

In accordance with the proposed policy, SWM of the local inhabited islands will be developed through three development stages. Those would be:

Existing stage;

SWM of this stage is as same waste management practice as used to be, with self disposal sites. The coverage of the waste management is limited within an inhabited island.

Second stage;

SWM of this stage shall be developed with improved type disposal sites built with support of the MCPW. The coverage of the waste management shall also be limited within an inhabited island.

Third stage;

SWM of this stage shall be developed with an amalgamated disposal site, which shall be built with support of the MCPW. The coverage of the waste management shall be extended to carry out the SWM activities across plural islands at the same time. This SWM system should be introduced only in the areas where huge numbers of people will populate and discharge huge volumes of wastes. And this SWM system shall offer services on charge such as collection, transport and final disposal to both of households and industries in the areas.

Local Centers, the execution organ of SWM in the third stage, shall be established in accordance with the proposed policy.

The resources and functions of Local Centers will be:

- (1) Vehicles, ships, loading and unloading facilities and transfer stations and final disposal sites;
- (2) Operation and maintenance of the machines and equipment;
- (3) Collection of charges;
- (4) Manpower resources including fair numbers of skilled and technical staffs.

These Local Centers will become a fairly big organization in number of staffs, in operation and maintenance costs and financing etc., and will require a high level of management. These requirements shall be beyond the sole capacity of the local communities or local private sector involvement even in the future.

The study team proposed an alternative of the organization concerned as follows.

In accordance with the basic goal to reduce waste discharge and to correspond with local conditions, Local Centers shall be established based on a new organization concept that is called Collective SWM System.

Fund source for establishment of the organization would be shared by beneficiaries, Atolls and the national government. The operation costs should be covered as much as possible by revenue from charges. However, in case of deficit, the national government shall subsidise to it for a certain period in the early stage.

The MCPW shall assist it about necessary matters such as an advice on the amount of charge, sustainable support for procurement and operation and maintenance of its machines and equipment. The MCPW shall also give sustainable assistance to it through the technology transfer and technical assistance.

c. Special Management by Type of Waste

Based on the proposed policy, four kinds of wastes shall be required special management in addition to the conventional waste management; medical waste, waste oil, waste battery and sea waste.

i) Medical Waste

At present, the medical wastes are discharged from two hospitals and about 27 clinics in Male'. In many cases those wastes are managed improperly by depending on the self-judgement and conditions of each hospital and clinic.

One hospital in Male' incinerates its medical wastes properly with the incinerator equipped by its self. Others convey those wastes into the transfer station to incinerate waste there by using of the metal barrel. This is quite inadequate practice.

The local hospitals incinerated medical wastes with the incinerator of each hospital. However, as for the clinics, there exists the possibility that they dispose the medical wastes generated inadequately.

The study team proposes to the government that the management of medical wastes should be improved with the application of following methods.

- (1) All medical wastes should be stored safely and should be incinerated with the incinerators strictly.
- (2) The medical wastes generated from clinics in Male' should be incinerated by using the incinerators of two hospitals of the municipality. To incinerate medical wastes from the local clinics, by using the incinerators appropriately, the government may provide subsidies to them for acquisition of said equipment.
- (3) The MCPW should prohibit any body from incinerating medical wastes at the its sites in accordance with the said improvement.
- (4) The Ministry of Health should play important role in the matters mentioned above.

Table 5-4. Proposed Task Allocation for Medical Waste Management

authority	Present	proposed
Hospital	1. Store medical waste safely 2. Incinerate medical waste	1. Store medical waste safely 2. Incinerate medical waste
Clinics in Male'	1. Store medical waste safely 2. Transport to transfer station and incinerate it	1. Store medical waste safely 2. Transport to hospital and incinerate it
Clinics in local		1. Store medical waste safely 2. Incinerate medical waste
Ministry of Health	1. Supervision on Hospital and Clinics	1. Supervision on Hospital and Clinics
MCPW	1. Allow Incineration at the Transfer Station	

ii) Waste Oil

At present, some entities bring waste oil to the transfer station in Male' to incinerated it there. Also some others may discard waste oil into some places in spite of the entire inadequacy. There is the possibility that this deed may break the prescription of article 7-(a)/Law No. 4/93 of the

ENVIRONMENTAL PROTECTION AND PRESERVATION ACT OF MALDIVES.

Under the circumstances, every party concerned including users and suppliers should make the effort, to improve the situation at once.

The government authorities concerned should make special efforts to sweep out those cases for the promotion of environmental conservation.

The MHAHE should take initiative among authorities concerned with co-operation of those concerned. The MCPW shall facilitate matters to establish facilities to solve the matters concerned of the waste oils.

Table 5-5. Proposed Task Allocation for Waste Oil Management

authority	present	proposed
User	1. Bring to Transfer Station or throw it somewhere	1. Store waste oil safely 2. Bring it to Supplier
Supplier		1. Store waste oil safely 2. Bring it to Transfer Station or Thilafushi
MPHRE/MTI		1. Establishment rule of waste oil collection 2. Supervise waste oil collection
MCPW	1. Incinerate at transfer station	1. Install storage at transfer station & Thilafushi 2. Design and Construction of waste oil incinerator 3. Incinerate at Thilafushi

iii) Waste Battery

In most case, the waste batteries are mingled into domestic and industrial wastes and disposed together with those wastes. The method of collection and final disposal of the waste batteries is quite improper at present.

The special efforts of government authorities concerned should be made with cooperation of all parties concerned, as it as in the case of the waste oil, to improve the situation at once.

Table 5-6. Proposed Task Allocation for Waste Battery Management

authority	proposed
User	1. Store waste batteries 2. Bring them to suppliers
Supplier or Thilafusi	1. Store waste batteries 2. Bring them to transfer stations
MHAHE/MTI	1. Establish rule and regulations of batteries collection 2. Supervise waste battery collection
MCPW	1. Install storage at transfer station or Thilafusi 2. Design and construction of storage and processing yard 3. Prepare confining boxes 4. Treat wet batteries

iv) Sea Waste

Whether in the navigation or in the anchoring, it is prohibited to discard wastes from the ships and boats into the sea. The more complete observance shall be requested.

Also, the management reach on the SWM should be extended to be able to cover the areas to the outside of the Male' harbour.

Table 5-7. Proposed Task Allocation for Sea Waste Management

authority	present	proposed
Ship Owner		1. Instruction of Due Equipment 2. Instruction of crew
Crew	1. Prohibited to throw waste in the sea	1. Prohibited to throw waste in the sea 2. Obey the Instruction
Passenger and People on the on shore	1. Prohibited to throw waste	1. Prohibited by rule and regulations
NSS*	1. Cleaning Male' Port (sea bed)	1. Cleaning Male' Port (sea bed) 2. Inspection on littering (out side)
MCPW	1. Cleaning Male' Port (surface)	1. Cleaning Male' Port (surface) 2. Inspection on littering (inside) 3. Cleaning Male' Port (outside)

Note * : NSS serves on voluntary base on holidays

(3) Capacity Building of Concerning Bodies

Restructuring of organisations are proposed in the previous section based on the roles and tasks allocated to each bodies concerning SWM for improvement and further development towards establishment of the integrated SWM system.

On the basis of the proposed organisation and task allocation to each relevant agency, the capacity building programs shall be implemented for the better functioning of daily operation of SWM through acquisition of sufficient numbers of staff assigned for each task.

a. Capacity Building for Daily Operation

In order to provide effective and efficient SWM services, the concerned bodies have to develop the organisational and management capabilities proposed as in the followings.

- ① Establishment of efficient organisational structure for overall SWM services and for daily operation with clear reporting lines, rational distribution of tasks, reasonable span for control and number of levels of managers/supervisors/inspectors/labours
- ② A clear assignment and delegation of responsibilities and adequate authority to managers and supervisors with accountability for individual performance
- ③ Establishment of procedures to clearly set and monitor objectives from the strategic level down to management and supervision of the services
- ④ Effective policy formulation and planning of SWM including daily operation, annual operation, middle term and long term plans in reflection of effective financial management
- ⑤ Effective decision making by managers with the right decision in the shortest time
- ⑥ Establishment of effective and appropriate information system including work flows and communication patterns for managers to make effective decision to carry out their responsibility
- ⑦ Periodic assessment of tasks with the target levels and criteria and improvement of performance of tasks
- ⑧ Training of staff to have common understanding and procedures for performing the tasks and services with standardised criteria

Daily operation requires the staffing and responsibilities for the functional activities set for the key staff as proposed in the followings for Male' Municipality but some of the staffing and responsibilities are also applicable for local municipalities.

Waste Collection

Waste Collection Manager

Undergoes entire responsibility for waste collection method, labour management and monitoring of the work performance. Preparation of the daily record for reporting to the municipality office.

Chief Waste Collection Operator

Assists the waste collection manager. Responsible for instructing the operation procedures, scheduling of drivers and workers for waste collection operation.

Waste Collection Inspector

Assist the chief waste collection operator for performing appropriate waste collection operation. Inspects periodically to maintain cleanliness, sanitation and aesthetic beauty of the service area.

Waste Collection Vehicle Driver

Drives collection vehicle, checks the vehicle before and after operation, wash vehicle after operation and reports the result of operation and inspection to the supervisor.

Waste Collection Worker

Loads solid waste from communal collection points or from person carry waste to the collection vehicle and sweeps waste droppings on the street.

Transfer Station and Waste Transportation

Waste Transfer/Transportation Manager

All the responsibility of handling waste transfer operation, labor management and monitoring of the work performance. Preparation of the daily record for reporting to the head office.

Chief Waste Transfer/Transportation Operator

Assist the waste transfer/transportation manager. Responsible for instructing the staff for scheduling, procedures of receiving, separating, storing, reloading and transporting wastes.

Clerk/Accountant

Supports the manager to regulate waste transfer operation and charging waste disposal fee.

Truck Scale Operator

Operates truck scale to measure and records quantity and types of wastes, number plate of direct transportation vehicles and directs the driver to the designated unloading area or pit.

Waste Loading Machine Operator

Operates and controls unloading/loading machines to receive/carry out waste at the transfer station and direct the waste transportation driver for departure.

Mechanics

Is responsible for repair and periodical maintenance of all the vehicles, machines and equipment.

Common Labour

Supports the waste transfer/transportation operation including control of vehicles entering/leaving from the transfer station.

Waste Transportation Driver

Drives waste transportation vehicle and checks the vehicle before and after operation, wash vehicle after operation and reports the result of operation and inspection to the site manager.

Barge Captain

All responsibility for navigation of barge to the disposal site, prepare daily records of operation and report to the site manager.

Waste Disposal

Waste Disposal Manager

Undergoes entire responsibility for receiving, separating, storing and disposing waste, labor management and monitoring of the work performance. Preparation of the daily record for reporting.

Chief Waste Disposal Operator

Assist the waste disposal manager. Responsible for instructing the staff for scheduling, procedures for receiving, separating, storing, and disposal of wastes, control of daily work of the operators to dispose at the designated area.

Site Inspector

Assist the chief waste disposal operator for performing appropriate waste disposal operation. Inspects safety against disaster, accident and environmental pollution at the site.

Machine Operator

Operates heavy machine for disposal of wastes, check condition of the machine before and after the operation.

b. Acquisition and Training of Personnel

In order to perform SWM services to the satisfactory manners, provision of sufficient numbers of capable and skilled staff will be indispensable. An acquisition of staff will be made through the expatriates from Sri Lanka and Bangladesh in addition to the Maldivian citizens or through privatisation of SWM services. However, it may be better to raise the social awareness and acceptance to the SWM services so that the Maldivian staff can proud of working for the public services to maintain cleanliness of the municipality. In practical, an acquisition of the staff can be made in accordance with the proposal in the followings.

Managerial Staff

- Administrator or engineer, a Maldivian national

Control and Monitoring

- Technician, a Maldivian national

Mechanics

- Technician from, a Maldivian national
- Engineer or technician from Sri Lanka

Truck and Machine Operator

- Truck and machine operator from Sri Lanka
- Truck and machine operator from Bangladesh

Common Labour

- Public service labor from Bangladesh

These staff need specific and periodic training for the purpose to perform a better quality services for contribution to the society and conservation of the environment. The followings are the training courses necessary to develop human resources to acquire the capable staff for SWM services.

- ① Managerial standards for SWM services
- ② Technical standards and criteria for planning and operation
- ③ Individual performance for accomplishing tasks

5.3.2 Reinforcement of Budgetary Sources for SWM

(1) Recommended Level of Budgetary Allocation

a. Initial Cost

i) Comparison with Government Budget

(Unit: Rf. million)

Year	Government Revenue Budget	Initial Cost of Male' Project	Ratio (%)	Initial Cost of Atolls Project	Ratio (%)	Total Ratio (%)
	A	B	C=B/A	D	E=D/A	F=C+E
Total*	35,268	349	1.0	330	0.9	1.9

Note: *=Total 2000 to 2010

The total amount of the initial cost of the SWM project for Male' and Vicinities is estimated at Rf. 349 million. It corresponds to 1% of the estimated cumulative total of the revenue budget of the government of Maldives from the year 2000 to 2010 as the above table shows.

Regarding the SWM project for the Atolls, it is assumed that starting in 2001 SWM facilities will be constructed for 2 Atolls per year, ending in 2010. The estimated total amount of the initial cost of the project comes to Rf. 330 million. It corresponds to 0.9% of the estimated cumulative total of the revenue budget of the government of Maldives from the year 2000 to 2010 as the above table shows.

Therefore, the total ratio of the initial cost of the two projects to the cumulative government revenue budget from 2000 to 2010 works out to 1.9%.

For more details, refer to Table 6 in Supporting Report G.

ii) Comparison with MCPW Budget

(Unit: Rf. thousand)

Year	MCPW Budget	Initial Cost of Male' Project	Ratio (%)	Initial Cost of Atolls Project	Ratio (%)	Total Ratio (%)
	A	B	C=B/A	D	E=D/A	F=C+E
Total*	2,069,680	349,326	16.9	329,360	15.9	32.8

Note: *=Total 2000 to 2010

As the above table shows, the estimated total amount of the initial cost of the SWM project for Male' and vicinities corresponds to 16.9% of the estimated cumulative total of the expenditure budget of MCPW from the year 2000 to 2010.

Regarding the SWM project for the Atolls, the estimated total amount of the initial cost of the project corresponds to 15.9% of the estimated cumulative total of the expenditure budget of MCPW from the year 2000 to 2010.

Therefore, the total ratio of the initial cost of the two projects to the cumulative MCPW budget from 2000 to 2010 works out to 32.8%.

For more details, refer to Table 6 in Supporting Report G.

iii) Evaluation of the Initial Cost of the Projects

The above analysis tells that the initial cost of the projects is going to be a substantial amount in comparison with the budget of MCPW. However, it will occupy a small portion in terms of the percentage to the government budget.

In connection with the former comparison, it is to be reminded that it is written in a World Bank report that it is usually the case that the proportion of SWM-related expenditure in the local government budget reaches 20 to 50%.

Besides, supposing the initial cost were financed by extra-budgetary means, that is, loans, the government might not suffer from repayment difficulties, judging from the current structure of the government expenditure as shown below.

(Unit: Rf. million)

Item	1992	1993	1994	1995	1996
Expenditure	1,206.3	1,388.7	1,360.8	1,720.1	1,652.6
Interest on Public Debt	21.5	31.0	56.1	76.5	93.1
Ratio (%)	1.8	2.2	4.1	4.4	5.6

Sources: Annual Report 1996

The above table shows that the debt service ratio, or the share of the interest on public debt in the total government expenditure is small, although it is increasing every year. It bespeaks of the healthy structure of the expenditure of the Maldives government.

With regard to the government debt as the percentage of GDP, it stands at 65.8%, of which external debt is 44.6% as of 1997. The latter value is less than one half of 90.0%, which is the average external debt ratio in the 135 low- and middle-income countries of the world.

b. O & M Cost

(Unit: Rf. thousand)

Item	Male' and Vicinities Project			Atolls Project		
	O & M	Depreciation	Total	O & M	Depreciation	Total
2010	16,807	17,397	34,204	1,900	9,892	11,792

The operation and maintenance cost of the SWM projects for Male' and Vicinities and Atolls is estimated to total Rf. 34,204 thousand and Rf. 11,792 thousand respectively in the target year of 2010 as the above table shows.

It is proposed that the O & M cost and depreciation in the former project be borne by the beneficiaries and MCPW/MM respectively, while both the O & M cost and depreciation in the latter project be borne by the beneficiaries.

In the first project each house in Male' will monthly pay Rf. 166 or 1.15% of its income on average during 2003 to 2010, and establishments/institutions will pay Rf. 97 per tonne on average during the same period. Also, MCPW and MM will allocate 6.67% and 7.65% of their budget respectively to cater for depreciation.

In the second project each house in an Atoll will monthly pay Rf. 38 or 0.58% of its income on average during 2001 to 2010.

It is to be reminded that the proposed monthly payment by both domestic and non-domestic beneficiaries is 88.5% and 36% of their willingness to pay in the Male' and Vicinities and Atolls projects respectively. Also, MCPW and MM now allocate about 7% and 8.3% of their budget for SWM respectively.

For more details, refer to Tables 8, 10 and 11 in Supporting Report G.

(2) Possible Sources to be Allocated

a. Initial Cost

There are several possible sources to finance the initial cost as shown below.

- i. Grants
- ii. Bond raising
- iii. Domestic loans
- iv. External loans
- v. Appropriation from revenue budget

In case ii to iv, principal and interest have to be paid. They are proposed to be paid basically by the government. However, depending on the size of initial cost, they can be borne by the beneficiaries.

In the latter case, O & M cost to be borne by the beneficiaries will go up.

Case v. means an allocation of the government revenues deriving from "import duty", "tourism tax" and "lease and rents of government property", etc.

One thing to be reminded in connection with case v. is that MCPW can make use of financial resources that can be made available if it decides to rent the newly created land plot in Thilafushi 2 and Thilafushi 3 for industrial and other uses.

A practical way will be a mixture or combination of the above-mentioned sources.

b. O & M Cost

As already mentioned in the preceding section, the sources to recover O & M cost are proposed to be as follows:

- i. Male' and Vicinities Project
 - (a) O & M cost : beneficiaries (houses and establishments/institutions)
 - (b) Depreciation : MCPW/MM
- ii. Atolls Project
 - (a) O & M cost : beneficiaries (houses and establishments/institutions)
 - (b) Depreciation : beneficiaries (houses and establishments/institutions)

(3) Simulation on Solid Waste Charge

Using the financial statements projection model, a wide range of simulation was performed to see how the solid waste charge to be borne by the beneficiaries will

change under different conditions involving initial cost, repayment, depreciation and O & M cost.

Broadly, 4 alternatives were conceived. In alternative A, initial cost will be loaned and all the cost to be required, namely O & M cost, depreciation cost and repayment cost will be recovered from beneficiaries in the form of solid waste charge. In alternative B, initial cost will be loaned and O & M cost and repayment cost will be recovered from beneficiaries, while depreciation cost will be met by conventional budgetary sources. In alternative C, initial cost (including repayment cost if it is loaned) will be borne by the government, while both O & M cost and depreciation cost will be borne by beneficiaries. In alternative D, initial cost (including repayment cost if it is loaned) and depreciation will be borne by the government, while only O & M cost will be borne by beneficiaries.

Each alternative has four different cases. Case 1 has no attendant limitation. In case 2, the construction of seawall in the existing Thilafushi will be left undone. In case 3, in addition to case 2 construction of Thilafushi 3 will be given up. In case 4, on top of cases 1 and 2 works for revetment of waste and protection of waste in Thilafushi 2 as well as construction of the office building at the transfer station in Male' will not be implemented.

In performing simulation, lending terms of fund for initial cost were assumed as interest rate: 6%, grace period: 3 years, and repayment period: 15 years. Also, project evaluation period was assumed to be 30 years from the start of project implementation.

After performing simulation on each alternative and case, the results were summarized in the table below.

**Table 5-8 Solid Waste Charge/Month/House and Its Ratio to Income
(1998 Level in Male')**

Item	Alternative A	Alternative B	Alternative C	Alternative D
Conditions				
Initial Cost	Loaned	Loaned	Not Specified	Not Specified
O & M cost	Beneficiaries	Beneficiaries	Beneficiaries	Beneficiaries
Depreciation	Beneficiaries	Government	Beneficiaries	Government
Repayment	Beneficiaries	Beneficiaries	(Government)	(Government)
Case 1: No other conditions	Rf. 335 (3.0%)	Rf. 223 (2.0%)	Rf. 245 (2.2%)	Rf. 128 (1.15%)
Case 2: No reinforcement of Thilafushi 1	Rf. 323 (2.9%)	Rf. 212 (1.9%)	Rf. 234 (2.1%)	-
Case 3: Case 1 + No construction of Thilafushi 3	Rf. 268 (2.4%)	Rf. 167 (1.5%)	Rf. 223 (2.0%)	-
Case 4: Case 2 + No revetment & protection of waste in Thilafushi 2, and no office bldg. in transfer station	Rf. 234 (2.1%)	Rf. 123 (1.1%)	Rf. 212 (1.9%)	-

Note: Figures in parentheses are the ratios of solid waste charge to income.

The above table shows if a project is to be financially sustainable, how much beneficiaries will have to bear as solid waste charge, in each case.

In view of the fact that a house in Male' now shoulders Rf. 452 or 4.1 % of its income for water plus Rf. 1,264 or 11.3 % of its income for electricity on average according to the questionnaire survey conducted by the JICA study team. The expenses altogether come to Rf. 1,716 or 15.4 %. The surveyed residents also showed a willingness to pay for solid waste management at 1.3 % of their income. It deems important for policy makers to pay a due respect to that willingness to pay, and be careful not to exceed it.

Then, as the table shows, there are only two possible choices, namely one case where initial cost is loaned and both O & M cost and depreciation cost are borne by beneficiaries, and another case where the initial cost (including repayment cost if it is financed by loan) and depreciation are borne by the government, while only O & M cost is shouldered by beneficiaries. In the former case, it is noted that major portion of construction plans undergoes stagnation due to excessive burden imposed on beneficiaries.

Thus, it is very clear that the latter case is the one and only practical selection. For more details refer to Table 23 in Supporting Report G.

5.3.3 Technical Guidelines

(1) Standard Disposal Method

a. Local Islands

① Discharge Method

- Individual discharge to disposal site
- Separation of food waste, paper and waste oil
- Size reduction of garden waste to maximum 1 m in length

② Treatment Method

- Incinerate waste oil, paper and medical waste
- Ash be dumped in the disposal site
- Composting of food waste and small pieces of garden waste
- Compost be placed in the communal space

③ Conventional Disposal Method

- Sand cover over the dumped waste once a week
- Removal of drifting waste

④ Improved Disposal Method

- Preferably be filled with inorganic waste beneath water
- Dumping within enclosed part of the sea
- Sand cover over the dumped waste once a week
- Removal of drifting waste
- User fee for disposal site be charged
- Conventional disposal site be no longer allowed to use

b. Capital Region

① Discharge Method

- Individual discharge to disposal site or hand over to collection service
- Separation of food waste, paper and metal at home and premises
- Food waste be wrapped not to emit smell during collection and transport
- Size reduction of wood waste and demolition debris to maximum 1 m in length
- Individual discharge of waste oil and waste batteries to suppliers

② Collection and Transport Method

- Collection service by multiple sectors
- Combined collection system of station-to-station method and bell collection
- Station be kept clean soon after collection vehicle passed by

- Transfer station be closed once a day and one day a week for maintenance
- Waste loaded on vehicle requires preventive measure from littering
- Stagnation of waste at the transfer station be controlled within 3 days
- Wastes stored in the transfer station be sprinkled with water to prevent dust diffusion from time to time
- Waste oil and battery be brought to transfer station or Thilafushi Island by supplier who collected them from users

③ Treatment Method

- Incinerate waste oil and bulky wood
- Medical waste be incinerated separately
- Ash be dumped in the disposal site
- Composting of food waste and sawdust
- Compost be placed in the gardening area
- Wet battery be neutralized and electrode metal be recovered
- Dry battery be confined in concrete box and dumped in the disposal site
- Separately collected materials be selected and packed for recycling sales

④ Disposal Method

- Bottom layer of dumping be done within a pond enclosed with permanent seawall
- Silt catching net be applied to earth work below water where lies a fear of silt plume outflow
- Second layer of dumping and thereafter be done within the area enclosed by sand mound
- Working face be designated according to the base plan prepared in advance
- Topographical survey of the site be done on completion of new pond, enclosing mound and filling operation
- Preferably be filled with inorganic waste beneath water
- Compression of waste layer with heavy equipment
- Each layer of waste be controlled in thickness
- Sand cover of 1m thickness be placed at least once a week
- Dumping in multiple layer up to at least 6m above sea level
- Artificial vegetation be considered on the surface sand cover of final configuration
- Surround the working face with movable fence
- Removal of drifting waste
- Heavy equipment be checked up once a month

c. Resort Islands

① Discharge Method

- Separation of food waste and combustible waste
- Size reduction of garden waste to maximum 1 m in length

② Treatment Method

- Incinerate combustible waste
- Ash be dumped in the disposal site
- Composting of food waste and small pieces of garden waste
- Compost be placed in the garden

③ Disposal Method

- Preferably be filled with inorganic waste beneath water
- Sand cover at least once a week
- Dumping within enclosed part of the sea
- Removal of drifting waste

(2) Standard Facility

a. Local Islands

① Treatment Facility

- Simple composting equipment adaptable to intermittent input
- Simple incinerator made of oil drum or block masonry

② Conventional Disposal Site

- Selection of designated disposal site by the community at least one in an island
- Preferably be located on the land
- Enclose the site with wood or metal paling on either land or shore side in order to prevent waste from scattering

③ Improved Disposal Site

- Selection of designated disposal site only one in an island
- Enclose the site with mortar bag or stone if available
- Top level of enclosing mound be at least 2m above sea level
- Site be selected along the coast where undergoes least influence of erosion by sea surge
- Site be also convenient to acquire sand for cover
- Planned lifetime be at least 10 years

b. Capital Region

① Collection Facility

- Total capacity of collection vehicle and cart be able to deliver the service 2 to 3 times a week
- How to select the location of stations for collection point be guided in the Master Plan

② Transfer Station

- Should have a capacity enough to accumulate waste for a week
- Be equipped with the followings:
 - (a) receptacle of segregated waste such as food waste, sawdust, demolition debris, waste oil, batteries and metal
 - (b) stockyard of ordinary waste
 - (c) loading equipment
 - (d) vehicle washing and maintenance facility
 - (e) sprinkler
 - (f) fence and protection net against waste blown out
 - (g) garage
 - (h) administrative building

③ Treatment Facility

- Compost plant, waste oil incinerator and waste battery processing yard be installed in Thilafushi final disposal site
- Compost plant should have enough capacity to confirm the effectiveness and adaptability
- Waste oil incinerator should have enough capacity to meet the demand and have simple operational characteristics
- Waste battery processing yard should have:
 - (a) enough space to store batteries and chemicals for one month before processing and to process them
 - (b) cemented floor which does not allow waste water to be discharged directly into the sea
 - (c) roof to avoid exposure to the rain

④ Transport Facility

- Transport vehicle and ferry have the capacity of 200 to 300 ton/d until 2010
- Unloading jetty for dhoni has a permanent structure
- Vehicles be checked up once a month

⑤ Final Disposal Site

- Appropriate size of landfill block be adopted to keep natural current across the reef flat as much as possible
- Current sea water passage be secured by means of channel or culvert
- Separate landfill block be connected with causeway or bridge
- Pond with enclosing mound be constructed within permanent seawall for the first step of landfill in the sea
- Top level of seawall be set at the level that allows sea wave to come in over at a certain frequency
- Seawall be enough permeable to filtrate leachate when it seeps out into the sea
- Retention ditch be installed with enough space to hold rainwater for a certain time duration
- Vertical perforated pipe work be installed above sea level to supply air into the waste layer and to disperse bio-decomposition gas into the atmosphere
- Maintenance facility be installed for heavy equipment working in the island
- Basic utility (fresh water, electricity, telecommunication) be provided
- Administrative office and accommodations for workers be provided

c. Resort Islands

① Treatment Facility

- Simple composting equipment adaptable to intermittent input
- Incinerator (already installed)

② Disposal Site

- Selection of designated disposal site within the island
- Preferably be located on the land
- Enclose the site with wood or metal paling on either land or shore side in order to prevent waste from scattering

(3) Concept of Final Disposal in Priority Local Island

a. Scenario for Stepwise Improvement

There are 130 inhabited islands other than resorts and function islands in Maldives. All the islands need improvement of sanitary condition of final disposal site, which is placed at least one in each island. Because the level of environmental protection measure is generally very poor and the number

is very huge, it is recommended to improve the sanitary condition stepwise in both view of technical level and priority in the order to be improved.

Regarding the technical level, it costs too much to apply the same sanitary level to numbers of local islands so that a medium level between existing final disposal and ideal sanitary landfill is recommended to the priority islands. Priority islands are selected among all according to the following criteria.

1. has a larger population in the vicinity
2. has well organized community cooperation
3. has capable branch of local administrative organization

Every atoll capital or the largest island may satisfy above criteria best in the same atoll and is considered a most likely island to be given the first priority in the atoll. On the other hand, a disposal site of medium sanitary level can be constructed by only MCPW for the moment. MCPW has an experience in this type of work and holds applicable types of heavy equipment for its regular operation. If MCPW does not have additional capacity to answer the request of local islands for final disposal, it is needed to reinforce the capacity in personnel and equipment. The extent of reserve capacity of MCPW is another restrictive factor to determine the priority islands particularly in number. Assuming the following conditions are satisfied by MCPW, the upper limit of the number of priority islands is determined at 20, which ensures the cyclic use of medium level disposal site in an interval of 10 years.

1. MCPW can provide one crew of construction with adequate equipment all through the year
2. The crew can construct two final disposal sites in a year
3. Practical capacity of disposal site is an equivalent of what can serve for 10 years.

Thus the number of priority islands corresponds to that of administrative atoll of 20 therefore one island of each administrative atoll is reasonably designated as the priority island. If the priority islands are grouped by four in one, it takes two years to construct a final disposal site for each of the group. In case the number of priority islands is extended or a collective disposal system is introduced to the growth centers or regional centers, there needs a further reinforcement of MCPW crew of construction.

b. Conceptual Design of Final Disposal Site

i) Structure

The structure of final disposal site recognized as medium sanitary level is defined as "Modified Gulhi Island Type" which is upgraded from the original situation in the following points.

- Enclose the landfill site entirely with permanent seawall of sufficient stability against sea surge and erosion
- Conduct sand cover at least once a week to prevent blown out of waste and proliferation of vectors

In addition to above fundamental modification, floating fence is planned to deploy nearby the working face to limit the sea surface where the waste drifting out. The average size of disposal site is determined by assuming the average population of largest 20 islands at 2,500.

$$\begin{aligned} \text{Total waste disposal volume in 10 years of lifetime:} \\ (2,500 \text{ person} \times 0.001 \text{ ton/day} \times 365 \text{ day}) \times 10 \text{ years} \times 1 \text{ m}^3/\text{ton}^* \\ = 9,000 \text{ m}^3 \end{aligned}$$

* where 1 m³/ton is specific weight after settling

By assuming the thickness of final waste layer at 3 m, the required square area is calculated at 55 m as shown below.

$$\sqrt{\frac{9,000 \text{ m}^3}{3 \text{ m}}} = 55 \text{ m}$$

As a conclusion, the required area is about 3,000 m², equivalent to the square area with a side of 55m.

ii) Fixed Equipment and Operation

After completion of the site, the following equipment are left there, which are utilized during the construction period.

- Excavator 1 unit 0.7 m³
- Composting vessel 1 unit
- Floating net 30 m

These equipment are transferred to the administration of local community represented by atoll office or island office. Local community is considered to be responsible for the operation and maintenance of the disposal site by using those equipment. The operation cost is duly borne by the local community.

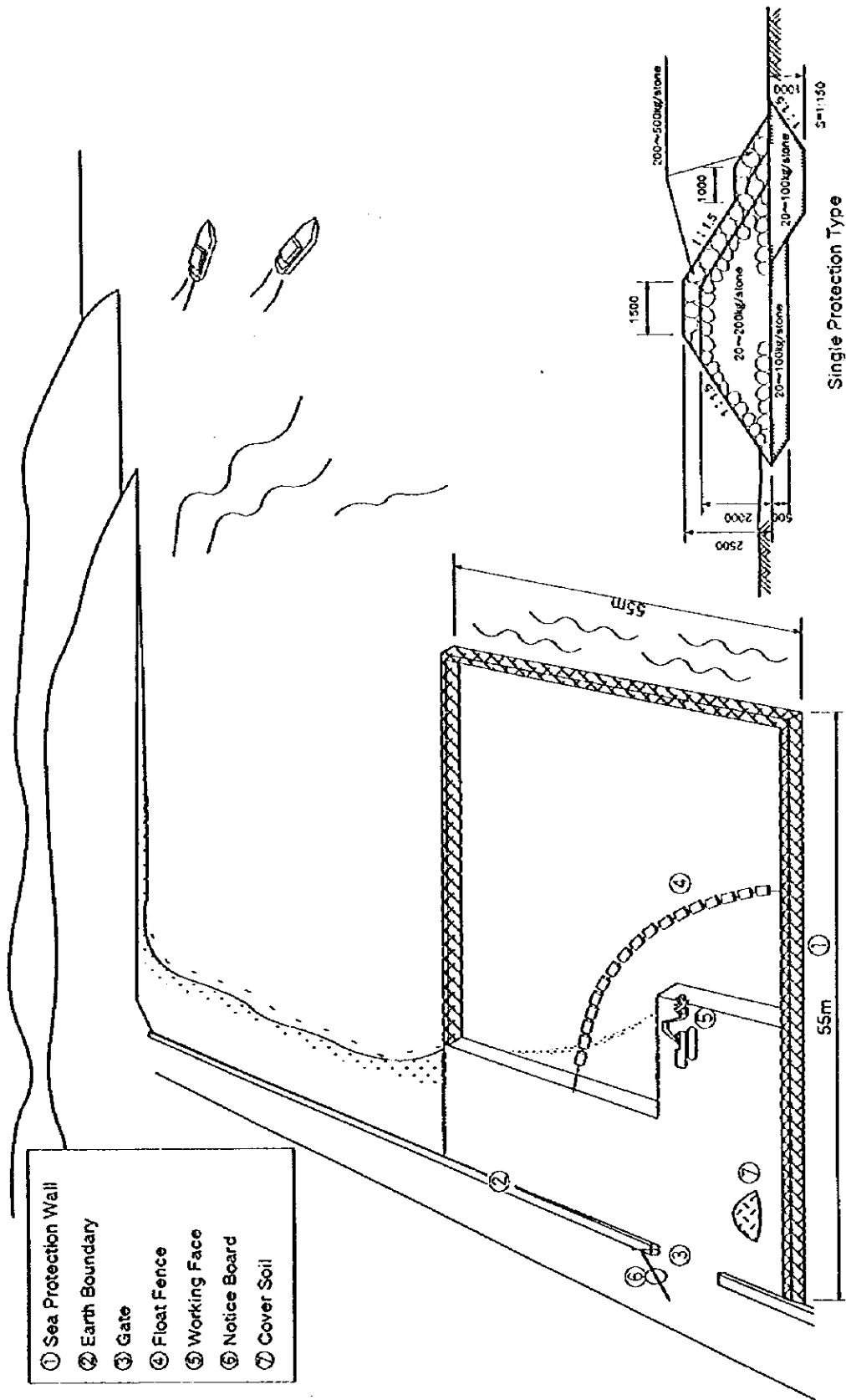


Figure 5-2 Conceptual Design of Final Disposal Site for Priority Inhabited Island

iii) Project Cost

The unit project cost for one final disposal site is estimated at about Rf 22 million for 10 years of lifetime.

• Construction cost	12.2 million Rf
• Procurement cost	2.0 million Rf
• Operation cost	7.7 million Rf
• Overall cost	21.9 million Rf

The cost estimates above is based on an assumption that major material of stone are imported. In case the local material like coral stone is adopted, the construction cost can be reduced to one third of above calculation approximately. However the seawall of local material has inferior durability and needs periodical repair in the long run.

Table 5-9. Project Cost of Inhabited Island

Unit : Rf

Description	Unit	Quantity	Unit Price	Amount (x 1,000)	Remarks
Construction					
1 Direct Construction Cost					
(1) Construction Seawall					
1) Rubble Stone	m ³	1,420	3,712.8	5,272	5~10.5 m ³ /m
2) Armour Stone	m ³	600	3,895.2	2,337	3~4 m ³ /m
3) Filter Sheet	m ²	735	351.6	258	3.5~5 m ² /m
(2) Enclosing Earth Wall	m	55	914.4	50	
(3) Access Road					1.0 m ³ /m
1) Grading	m	100	36.0	4	7.3 m ³ /m
2) Gate	L.S	1	22,800.0	23	0.78 m ³ /m
(4) Temporary Road	m	165	1,440.0	238	
Total Direct Cost				8,182	
2 Indirect Construction Cost					
(1) Mobilization (Male¹ ~ Site)	L.S	1		1,700	
(2) Common Temporary Work	%	10	D.C	750	
(3) Site Expenses	%	13	D.C	974	
(4) Overhead	%	8	D.C	600	
Total Indirect Cost					
Total Construction Cost				12,206	
Procurement					
1 Excavator (0.7 m3)	Unit	1		1,550	CIF SITE
2 Float Fence	m	30	12,000.0	360	CIF SITE
3 Container for Compost	Unit	10	2,710.0	27	CIF SITE
Overhead	%	3.5		68	
Total Procurement Cost				2,005	
Operation					
Annual O & M Cost	L.S	-	-	78	Excavator
Annual Operation Cost				690	
Total Annual Cost				768	

Note: The above table shows the project cost of each inhabited island. Therefore, total project cost of inhabited islands should be given by multiplying the above cost by 20.

5.4 Long Term Action plan

5.4.1 Implementation Schedule

National policy for SWM is expected to be completed in two years, accompanied by the necessary legal, institutional and financial arrangement. Institutional arrangement would duly cover central government organization, local government organization and the cooperation altogether. These non-project type action are need to be completed prior to the successive program of technical measures such as construction of final disposal site in local inhabited islands.

Improvement of final disposal in local islands should be initiated soon after completion of policy, institutional arrangement related to local organization. This action may take a repetitive process to penetrate the whole target islands, in total 20. Assuming the MCPW has the construction efficiency at two disposal sites a year, one group consisting of four islands are provided a medium level disposal site in two years.

For the capital region, a master plan is provided and implemented in accordance with the national policy and institutional arrangement. Component projects are planned to be completed by the year 2010.

Table 5-10. Long Term Action Plan for Advanced SWM

Proposed Action	Implementing Schedule													
	99	00	01	02	03	04	05	06	07	08	09	10		
Complete National Policy for SWM	■	■												
Institutional Arrangement														
Central Organization	■	■												
Local Organization	■	■												
Improvement of Final Disposal in Local Islands														
Group 1 (4islands)			■	■									■	■
Group 2 (4islands)				■	■									
Group 3 (4islands)						■	■							
Group 4 (4islands)								■	■					
Group 5 (4islands)										■	■			
Master Plan for Male' City	■	■	■	■	■	■	■	■	■	■	■	■	■	■

5.4.2 Recommendation

Generally speaking, improvement of final disposal of solid waste is the most urgent matter in local islands, however, there is severe spatial constraint in those islands which have small peripheral reef flat in spite of fully occupied ground space as residence. It becomes gradually more costly to construct a final disposal site recurrently and furthermore to construct the site in an adjacent uninhabited island is much more costly. In consideration of this sort of difficulty, incineration of bulky waste is inevitably focused on in order to extend the lifetime of final disposal site.

The largest component of solid waste in local islands is yard waste, which accounts for about one third of total waste even in tonnage. The composition of yard waste must be much bigger if it is measured in volume, which practically affects the rapid consumption of disposal site's life. To incinerate such bulky waste as yard waste contributes to the extension of disposal site's life significantly. If the other easily combustible organic waste like paper, cardboard and textile are entirely incinerated together with yard waste, the volume reduction can be expected to be half of the untreated situation.

This implies that the introduction of ready-made incinerator to a local inhabited island becomes feasible in addition to install an improved final disposal site. The feasibility may differ from each other by the size of island, population, required cost for construction and operation of final disposal site and incinerator that suite to the target islands. Therefore it is recommended that the competent authority identify specific islands which need special consideration on waste volume reduction by incineration and conduct a feasibility study. The output of the feasibility study should be duly considered by the government in line with the long term action plan based on the national policy on SWM.

6. SWM MASTER PLAN FOR MALE' AND VICINITY

6.1 Goal of Master Plan

The goal of the Master Plan is to establish a self-consistent and sustainable SWM system at the target year 2010 that enables the realization of the objectives of national policy in Male' City and adjacent area. Toward this goal, the master plan is formulated considering existing situation and fact findings stated in preceding Chapter 2 to 4 and proposed national policy in Chapter 5.

6.1.1 Self-consistent SWM System

The Master Plan proposes close cooperation between the government as service supplier of cleansing and citizens as recipient of the service to establish a self-consistent SWM system. The proposed system will have a firm legislative basis as an independent field of public services and built up on an expanded fund source by involving contribution of the recipient. The expanded fund source enables the adoption of upgraded technical measures in addition to those adopted so far. In accordance with the institutional reform and technical innovation, both capacity building of relevant authorities and promotion of public awareness are pursued as part of the Master Plan. Thus it is expected that all the efforts of relevant authorities and people regarding SWM are integrated to achieve the objectives at an advanced level (refer to Figure 6-1).

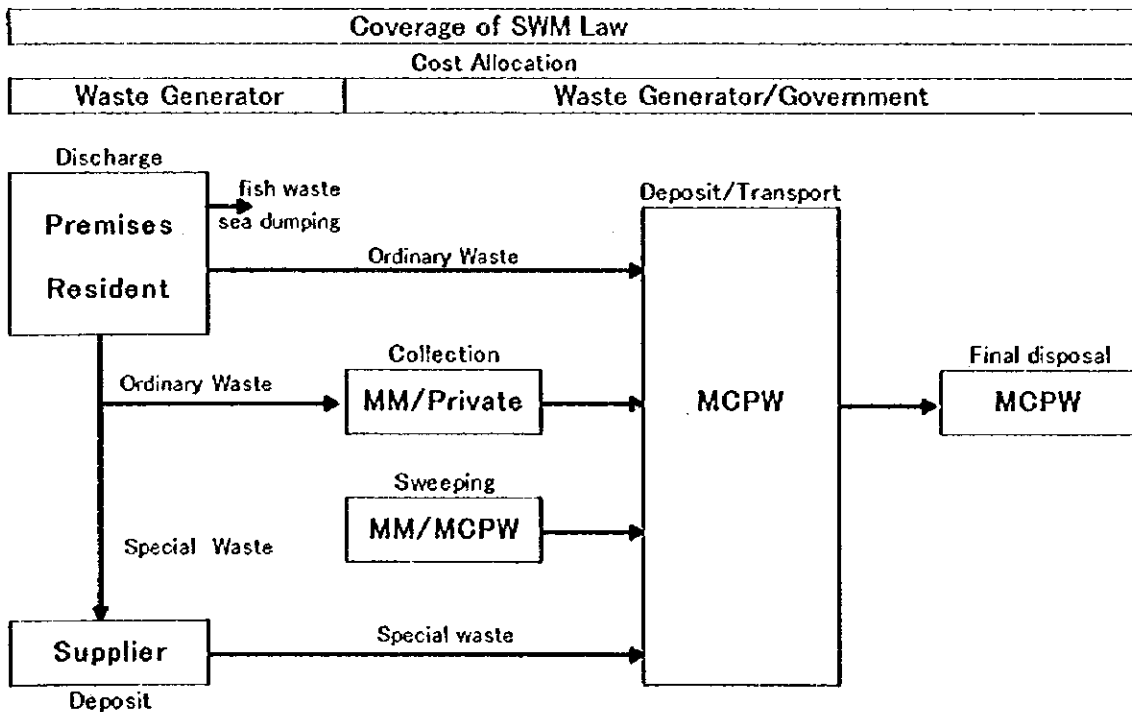


Figure 6-1. Structure of Proposed SWM System

6.1.2 Objectives of Master Plan

The Master Plan follows the three objectives of proposed national policy hereunder referred to.

- a. Healthy and Comfortable Life
- b. Sound Natural Environment
- c. Aesthetic Value of Domain

These are not only the common motives of improvement of SWM throughout the country but also have a particular sense in Male' City as stated below.

(1) Healthy and Comfortable Life

In Male' City, every kind of solid wastes are removed in a few days and disposed at an isolated island Thilafushi. The Present SWM system has almost achieved the timely removal of waste from immediate circumstances of daily life and consequently achieved a healthy and visually comfortable life in the area. Thus the remaining tasks to be pursued are to reduce the time of waste stagnation after collection in the residential islands and prevention of waste littering along the transport routes. This will mitigate the existing nuisance with the residents by offensive odor and waste dispersion.

(2) Sound Natural Environment

Natural environment worth preserved is mere a reef edge and immediate down slope covered with coral in each island in capital region. Above sea level, there is no natural environment because of extreme urbanized land use. Therefore the efforts to pursue these objectives should be directed to preserve the sound condition of submerged area covered with coral. The practical target of the Master Plan is to prevent waste from scattering which results in unfavorable deposit over coral, and to execute ecologically sound landfill operation in Thilafushi. Sound landfill operation shall cover the following checking points:

- a. coexistence of landfill site with surrounding coral
- b. minimization of waste volume
- c. treatment of hazardous waste
- d. reduction and purification of leachate

(3) Aesthetic Value of Domain

Male' City, as the capital of the country, is involved in ordinary tourists routes and accepts many of foreigners everyday coming from adjacent resorts. Thilafushi Island is also located on the same atoll with some famous diving spots where numbers of tourist divers visit. Most of visitors at present may find a conspicuous gap of cleanliness in the sea, both surface and bottom, between resort islands and Male'. The Master Plan is proposing that people are guided to perceive the aesthetic value of domain and to participate in keeping it clean. At the same time proposed is to improve the capacity of competent authority in cleaning up the sea along the coast.

6.2 Planning Frame

6.2.1 Target Year

(1) Master Plan

The target year of the Master Plan will be set at the year in 2010. The plan shall be phased with stepwise development plans.

(2) Priority Project

Priority Project to be formulated in the Feasibility Study will be selected from the plans and programs proposed in the Master Plan and formulated for the year 2003.

6.2.2 Population

Future population of the SWM Master Plan will adopt the second assumption data predicted by the Ministry of Planning, Human Resource Environment (MPHRE). Population in 2003 was estimated from the exponential model equation structured on the growth rate between 2000 and 2005. The population in 1995, 2000, 2003, 2005 and 2010 are presented in Table 6-1 for Male' and for inhabited islands by atolls. The estimated population in the target years in Male' including Villingili reach at 80,684 in 2003 and 97,928 in 2010. In addition, the yearly population for Male' and Villingili were estimated from 1998 to 2010 and indicated in Table 6-2.

6.2.3 Planning Area

The planning area of SWM Master Plan will be determined within the area in Male'. However, the waste disposal plan will be dealt with the solid waste amount generated in Villingili, Hulhule(Airport), resort islands, and some neighbouring inhabited islands transporting waste directly to the Thilafushi.

6.2.4 Hulumale Project

Waste collection and transportation plan will not be dealt within the frame of the SWM plan for Male' since the future development schedule of the Hulumale Project is not clear at present. However, in future, it is preferable to consider waste disposal at the Thilafushi in respect of removing wastes far from the municipal area to the remote area.

Table 6-1. Estimated Future Population by Atoll for 2000, 2003, 2005 and 2010

Year	1995	2000	2003*	2005	2010
Locality	Population	Population	Population	Population	Population
Republic	244,814	289,117	315,945	335,199	383,471
Male'	62,519	73,833	80,684	85,601	97,928
Atolls	182,295	215,284	235,261	249,598	285,543
North Thiladhunmathi	13,676	16,151	17,650	18,725	21,422
South Thiladhunmathi	15,365	18,146	19,830	21,038	24,067
North Miladhunmadhulu	10,462	12,355	13,502	14,325	16,387
South Miladhunmadhulu	10,103	11,931	13,038	13,833	15,825
North Maalhosmadhulu	12,953	15,297	16,716	17,735	20,289
South Maalhosmadhulu	8,712	10,289	11,243	11,928	13,646
Faadhippolhu	8,038	9,493	10,374	11,006	12,591
Male' Atoll	11,675	13,788	15,067	15,985	18,287
South Ari Atoll	6,695	7,907	8,641	9,167	10,487
North Ari Atoll	5,260	6,212	6,788	7,202	8,239
Felidhu Atoll	1,678	1,982	2,166	2,298	2,628
Mulakatholu	4,859	5,738	6,271	6,653	7,611
North Nilandhe Atoll	3,165	3,738	4,085	4,334	4,958
South Nilandhe Atoll	4,793	5,660	6,186	6,563	7,508
Kolhumadulu	9,545	11,272	12,318	13,069	14,951
Hadhunmathi	10,156	11,994	13,107	13,906	15,908
North Huvadhu Atoll	8,121	9,591	10,481	11,119	12,721
South Huvadhu Atoll	12,031	14,208	15,527	16,473	18,845
Fovahmulah	7,004	8,271	9,039	9,590	10,971
Addu Atoll	18,004	21,262	23,235	24,651	28,201

The year, 2003* indicates that the figure was estimated by JICA Study Team based on the following equation.

$$P = p * \text{EXP}(\text{LOG}(P/p) / (\text{period} (P - p) * \text{LOG}(\text{EXP}(1)))) * n$$

Note:

Assumption 2

1. Proportion of Census 1995 - Place of enumeration (de facto) is taken as constant up to 2010

2. Migration effect is not accounted for in the future years

3. 2003 is calculated by JICA study team

Source: Ministry of Planning, Human Resources and environment, Population Housing Census of Maldives 1995.

Table 6-2 Future Population in Male', Villingili & Atolls (1998 - 2010)

Year	Male' Island		Villingili Island		Atolls (Whole Country except Male' & Villingili)	
	Population	Growth Ratio	Population	Growth Ratio	Population	Growth Ratio
1998	67,236	-	1,844	-	201,427	-
1999	69,311	3.085%	2,106	14.234%	208,241	3.383%
2000	71,427	3.053%	2,406	14.234%	215,284	3.382%
2001	73,301	2.624%	2,749	14.234%	221,747	3.002%
2002	75,192	2.581%	3,140	14.234%	228,404	3.002%
2003	77,097	2.533%	3,587	14.234%	235,261	3.002%
2004	79,008	2.479%	4,098	14.234%	242,324	3.002%
2005	80,920	2.419%	4,681	14.234%	249,598	3.002%
2006	82,588	2.062%	5,347	14.234%	256,406	2.727%
2007	84,225	1.982%	6,109	14.234%	263,399	2.727%
2008	85,819	1.893%	6,978	14.234%	270,582	2.727%
2009	87,357	1.792%	7,971	14.234%	277,962	2.727%
2010	88,822	1.677%	9,106	14.234%	285,543	2.727%

6.2.5 Solid Waste Amount and Composition in Future

(1) Solid Waste Generation Amount in Future

Solid waste generation amount will be estimated for Male', Villingili, inhabited islands and resort islands based on the key elements shown in the followings.

- Trends of the past waste generation amount GDP growth,
- Current waste generation rate obtained from analysis of the data of the Waste Amount Survey,
- Correlations between waste generation rate and GDP per capita,
- Estimation of future waste generation rate per capita or per unit,
- Estimation of future population and the number of tourist arrivals,
- Estimation of growth rate of GDP per capita,
- Future trend of development in the project area.

The unit generation rate of the major wastes shown in the followings are adopted. for the prediction of the solid waste amount in future.

Type and Sources of Wastes	Waste Generation Rate per capita per day (g/c/d)	
	1998	2010
Domestic Waste in Male'	714	1,020
Commercial Waste in Male'	303	433
Industrial Wastes	105 ton/day	150ton/day
Domestic Waste in Villingili	621	876
Resort Islands	7,320	7,320

The detail method and procedures for prediction of waste generation amount was compiled in Supporting Report E and the result was summarised in Table 6-3. According to the prediction, the total waste amount generated in Male' including Villingili reach at 287 tons per day in 2010. The waste amount generated in inhabited islands other than Male and Villingili and resort islands reach at 271 tons per day and 151 tons per day respectively. Accordingly, the total waste amount generated in whole country will reach at 708 tons per day or 258,000 tons per year in 2010.

Table 6-3 Summary of Waste Generation Amount in Future

Year	Domestic Waste	Commercial Waste	Business & Industrial Waste	Construction Waste	Subtotal Waste Generation Amount in Male'	Domestic Waste in Villingili	Total Waste Generation Amount in Male & Villingili	Waste Generation Amount in Inhabited Island	Waste Generation Amount in Resort Islands	Total Waste Generation Amount in the Maldives	Total Waste Generation Amount in the Maldives
	(ton/d)	(ton/d)	(ton/d)	(ton/d)	(ton/d)	(ton/d)	(ton/d)	(ton/d)	(ton/d)	(ton/d)	(ton/d)
1998	48.0	20.4	36.2	68.8	173.4	1.1	174.5	136.9	70.7	382.1	139,463
1999	51	21.6	37.3	70.9	180.8	1.3	182.1	135.6	76.0	403.7	147,337
2000	54	23.0	38.4	73.1	188.7	1.6	190.2	135.0	81.5	426.7	155,760
2001	57	24.4	39.7	75.4	196.9	1.8	198.7	161.6	87.3	450.6	164,486
2002	61	25.8	41.0	77.9	205.5	2.2	207.6	174.8	93.3	475.8	173,660
2003	64	27.3	42.3	80.4	214.3	2.6	216.9	185.6	99.6	502.0	183,330
2004	68	28.9	43.6	82.9	223.3	3.0	226.3	196.7	106.1	529.1	193,129
2005	72	30.4	44.9	85.4	232.4	3.6	236.0	208.3	112.8	557.1	203,355
2006	75	32.0	46.2	87.9	241.4	4.2	245.6	219.9	119.9	585.3	213,651
2007	79	33.6	47.6	90.4	250.6	4.9	255.5	231.8	127.2	614.6	224,313
2008	83	35.2	48.9	93.0	260.0	5.8	265.7	244.3	134.7	644.8	235,340
2009	87	36.8	50.3	95.6	269.4	6.8	276.2	257.3	142.5	676.0	246,727
2010	91	38.4	51.7	98.2	278.9	8.0	286.9	270.7	150.6	708.1	258,168

(2) Solid Waste Disposal Amount in Thilafushi

Currently, the Thilafushi disposal site receives municipal solid wastes from Male' and Villingili, wastes from resort islands, wastes from Hulhule and wastes from several inhabited islands located nearby. Prediction of the waste disposal amount in future was conducted based on the islands transporting wastes currently to the Thilafushi by estimating the future increase amount from each island. In prediction of waste disposal amount in future, the following condition and factors were given.

- All wastes from Male' and Villingili are disposed at Thilafushi
- Waste amount of the resort islands currently transporting wastes to the Thilafushi will increase in proportion to the increase of the waste generation amount in the resort islands,
- Wastes from Hulhule (Airport) increase in proportion to increase of the numbers of tourist arrival, which is the same ratio adopted for that of the resort islands,
- Wastes from the neighboring inhabited islands will increase in proportion to the increase ratio in other atoll islands

The detail procedures for prediction of waste disposal amount was compiled in Appendix-1 and the results were summarised in Table 6-4. According to the prediction, the total waste amount required for disposal at the Thilafushi reach at 332 tons per day or approximately 121,000 tons per year in 2010.

Table 6-4 Estimated Waste Disposal Amount in Thilafushi

Year	Resort Islands	Airport	Nearby Inhabited Islands	Waste Disposal Amount except for Male'	Waste Disposal Amount of Male' + Villingili	Daily Total Waste Disposal Amount	Annual Waste Disposal Amount	Accumulated Waste Disposal Amount
	(ton/day)	(ton/day)	(ton/day)	(ton/day)	(ton/day)	(ton/day)	(ton/year)	(ton)
1998	19.2	2.8	0.2	22.3	174.5	196.8	71,843	71,843
1999	19.8	3.0	0.3	23.1	182.1	205.2	74,887	146,731
2000	21.0	3.3	0.3	24.6	190.2	214.8	78,410	225,141
2001	22.5	3.5	0.3	26.3	198.7	225.1	82,148	307,288
2002	24.1	3.7	0.3	28.1	207.6	235.8	86,061	393,349
2003	25.7	4.0	0.3	30.0	216.9	246.9	90,118	483,467
2004	27.4	4.3	0.4	32.0	226.3	258.3	94,281	577,748
2005	29.1	4.5	0.4	34.0	236.0	270.0	98,547	676,294
2006	30.9	4.8	0.4	36.1	245.6	281.8	102,842	779,137
2007	32.8	5.1	0.4	38.3	255.5	293.9	107,266	886,403
2008	34.8	5.4	0.4	40.6	265.7	306.3	111,818	998,220
2009	36.8	5.7	0.5	43.0	276.2	319.2	116,494	1,114,714
2010	38.9	6.0	0.5	45.4	286.9	332.3	121,291	1,236,005

(3) Waste Composition in Future

Prior to estimation of waste composition in future, analysis was made for the data obtained from the Waste Composition Survey and set up the following conditions.

- Future waste composition is basically the same with the present composition
- Changes of waste composition is estimated for increase of the ration of the portion of organic wastes rather than the ratio of in-organic wastes,
- Inorganic wastes especially sand commingled with yard wastes and demolition wastes shall be separated well and removed at the sites
- Dry batteries shall be separated and collected separately in future
- The role of waste management for environmental conservation will be realized by the waste generators in reduction and recycling of wastes at generation sources.

Considering the requirements for overall SWM planning, estimation of future waste composition was conducted for 18 components and bulk density of the waste categorised by the following 5 types.

- Domestic and Commercial Wastes in Male'
- Business and Industrial Wastes in Male'
- Construction and Demolition Wastes in Male'
- Domestic Wastes in Inhabited Islands
- Wastes Generated in Resort Islands

In estimation of the waste composition, the prerequisite condition was set for the ratio of organic, inorganic and hazardous wastes for 5 types of wastes as indicated in the followings.

Categories of Waste	Organic Wastes	Inorganic Wastes	Hazardous Wastes
Domestic and Commercial Wastes in Male'	80%	19.8%	0.2%
Business and Industrial Wastes in Male'	90%	9.8%	0.2%
Construction and Demolition Wastes in Male'	19.8%	80%	0.2%
Domestic Wastes in Inhabited Islands	75%	24.8%	0.2%
Wastes Generated in Resort Islands	80%	19.8%	0.2%

The results of estimation was indicated in Table 6-5 and 6-6 and also the references are available in Supporting Report E.

Table 6-5 Waste Amount and Composition in Male & Villingili (2010)

Type of Waste	Domestic & Commercial Wastes		Business & Industrial Wastes		Construction Waste		Total		
Total Weight	137.0		51.7		98.2		286.9		
Sampling Weight & Composition Ratio	Weight (ton)	Ratio (%)	Weight (ton)	Ratio (%)	Weight (ton)	Ratio (%)	Weight (ton)	Ratio (%)	
Organic Waste									
Food Waste	26.85	19.60	12.62	24.43	0.00	0.00	39.47	13.76	
Paper	Paper	13.77	10.05	9.55	18.48	0.21	0.22	23.53	8.20
	Cardboard	17.67	12.90	6.48	12.54	0.74	0.76	24.90	8.68
	Subtotal	31.44	22.95	16.03	31.03	0.96	0.97	48.43	16.88
Plastics	Film	5.92	4.32	1.45	2.80	0.52	0.53	7.89	2.75
	Bottle & Others	4.79	3.50	1.18	2.28	0.09	0.09	6.06	2.11
	PET	1.27	0.93	0.51	0.99	0.01	0.01	1.79	0.62
	Subtotal	11.99	8.75	3.14	6.07	0.62	0.63	15.75	5.49
Rubber & Leather	1.47	1.08	0.45	0.87	0.03	0.03	1.95	0.68	
Textiles	4.15	3.03	0.42	0.80	0.01	0.01	4.57	1.59	
Yard Waste	15.09	11.01	4.03	7.80	0.19	0.20	19.31	6.73	
Wood	4.46	3.26	8.58	16.61	17.52	17.83	30.56	10.65	
Other Org. Waste	14.16	10.33	1.23	2.39	0.13	0.13	15.52	5.41	
Organic Waste Total	109.62	80.00	46.49	90.00	19.45	19.80	175.57	61.19	
In-organic Waste									
Glass	Broken Glass	0.52	0.38	0.11	0.22	0.00	0.00	0.63	0.22
	Bottle	2.16	1.58	0.53	1.03	0.01	0.01	2.70	0.94
	Subtotal	2.68	1.95	0.64	1.24	0.01	0.01	3.33	1.16
Tin Cans (Steel Cans)	3.57	2.61	0.69	1.34	0.24	0.25	4.51	1.57	
Aluminum cans	0.70	0.51	0.20	0.39	0.01	0.01	0.91	0.32	
Other Metals	1.65	1.20	1.87	3.62	0.32	0.32	3.83	1.34	
Dirt, Ash, Sand	18.54	13.53	1.66	3.21	78.01	79.41	98.20	34.23	
Total (In-organic Waste)	27.13	19.80	5.06	9.80	78.59	80.00	110.78	38.61	
Hazardous Waste									
Hazardous Waste(Batteries)	0.14	0.10	0.05	0.10	0.00	0.00	0.19	0.07	
Other Hazardous Waste	0.14	0.10	0.05	0.10	0.20	0.20	0.39	0.13	
Total (Hazardous Waste)	0.27	0.20	0.10	0.20	0.20	0.20	0.57	0.20	
Total Weight (ton)	137	100.00	52	100.00	98	100.00	287	100.00	
Total Waste Volume (m³)	646		325		89		1,060		
Bulk Density (ton/m³)	0.212		0.159		1.104		0.271		

Table 6-6 Waste Amount and Composition in Inhabited and Resort Islands (2010)

Type of Waste	Waste Amount and Composition in 2010 in Inhabited Islands except for Male'			Waste Amount and Composition in 2010 in whole Resort Islands			
	Estimated Waste Composition (%)	Daily Waste Amount (t/d)	Annual Waste Amount (t/yr)	Estimated Waste Composition (%)	Daily Waste Amount (t/d)	Annual Waste Amount (t/yr)	
Organic Waste							
Food Waste	31.35	84.8	30,968	33.44	50.3	8,629	
Paper	Paper	1.80	4.9	1,777	1.92	2.9	495
	Cardboard	2.87	7.8	2,839	3.07	4.6	791
	Total	4.67	12.6	4,616	4.98	7.5	1,286
Plastics	Film	0.37	1.0	362	0.39	0.6	101
	Bottle & Others	0.46	1.3	456	0.49	0.7	127
	PET	0.36	1.0	360	0.39	0.6	100
	Total	1.19	3.2	1,178	1.27	1.9	328
Rubber & Leather	0.11	0.3	112	0.12	0.2	31	
Textiles	0.26	0.7	254	0.27	0.4	71	
Yard Waste	33.88	91.7	33,468	36.14	54.4	9,326	
Wood	0.61	1.7	607	0.66	1.0	169	
Other Org. Waste	2.92	7.9	2,888	3.12	4.7	805	
Total (Organic Wastes)	75.00	203.0	74,091	80.00	120.4	20,645	
In-organic Waste							
Glass	Broken Glass	0.13	0.4	131	0.11	0.2	27
	Bottle	3.30	8.9	3,261	2.65	4.0	684
	Total	3.43	9.3	3,392	2.75	4.1	711
Tin Cans (Steel Cans)	1.00	2.7	988	0.80	1.2	207	
Aluminum cans	0.19	0.5	186	0.15	0.2	39	
Other Metals	0.21	0.6	208	0.17	0.3	44	
Dirt, Ash, Sand	19.97	54.0	19,725	16.02	24.1	4,135	
Total (Inorganic Wastes)	24.80	67.1	24,499	19.90	30.0	5,135	
Hazardous Waste							
Batteries	0.15	0.4	148	0.05	0.1	13	
Other Hazardous Waste	0.05	0.1	49	0.05	0.1	13	
Total (Hazardous Waste)	0.2	0.5	198	0.10	0.2	26	
Total Weight (ton)	100.00	270.7	98,788	100.00	150.6	25,806	
Total Waste Volume (m³)	-	972	354,790	-	-	-	
Bulk Density (ton/m³)	-	0.278	0.278	-	-	-	

6.3 Proposed Components of Master Plan

6.3.1 Waste Removable System

(1) New Collection System

a. Objective

The objective of the collection plan is to establish an economically suitable collection system in Male' island, which ensures equal or better sanitary and aesthetic condition, compared with present operation. Among the various modes of collection now adopted there, the following modes are found reasonable and effective so that they are to be kept from now on.

- Self-carry in to the transfer station in Male' Island by private industries and others
- Self-carry in to the deposit site in Villingili Island

The other modes which are now undertaken by Male' Municipality and the private contractors for individual collection were reviewed and succeeded to the plan. The target waste corresponding to the planned collection mode is categorized as residential waste in municipal waste. The plan is proposed to cover all the residential waste under the initiative of Male' Municipality, who are responsible for solid waste collection in the planning area of the Master Plan.

b. Planning Concept

It is recommended for Male' Municipality to introduce more efficient collection system and provide at least the same level of service as present, which is considered the minimum level to be achieved in the plan. The residents who require higher quality of collection service have to adopt the special measures possibly delivered by private sector upon payment, which is not built-in the master plan though. The technical system for more efficient collection is selected among the alternatives within the affordability of Male' Municipality.

c. The Responsibility of the Male' Municipality

The solid waste generated in Male' is broadly categorized by four kinds of wastes, i.e. residential, commercial, business and construction waste. The responsibility for each type of waste is defined in Table 6-7. The Municipality has responsibility for collection services of the residential waste and supervising & monitoring of waste collection & transportation of all the other types of wastes except construction waste. Therefore, the waste construction plan dealt under this section shall be formulated with the residential waste.

Table 6-7 Types of Waste and the Responsibility

The Types of Waste			Implementation Body		Supervision & Monitoring	
			Collection & Haulage	Transportation & Disposal	Collection & Haulage	Transportation & Disposal
Municipal Waste	Residential		The Municipality	MCPW	The Municipality	MCPW
	Commercial		Generator	MCPW	The Municipality	MCPW
Industrial Waste	Business	Industry	Generator	MCPW	The Municipality	MCPW
		Market	Generator	MCPW	The Municipality	MCPW
	Construction		Generator	MCPW	MCPW	MCPW

The types of solid wastes and the present generation waste are tabulated in Table 6-8. The table shows that the Municipality deliver the collection services by the ratio at 46.0 % of the total waste amount. The other types of wastes account for 54% of the total waste amount. Supervising and monitoring of haulage activities by the waste generators will be very important job for the Municipality accordingly.

Table 6-8 Types of Waste and Generated Amount

The Types of Waste			Description	Generated Waste Amount (ton/d, 1998)	Ratio (%)
Municipal Waste	Residential		House and small shops (<30kg/day)	48.2	46.0
	Commercial		Big shops and restaurants, offices, schools (>30kg/day)	20.5	19.5
Industrial Waste	Business	Industry	Industry	36.2	34.5
		Market	Fish market, fruits market		
Total			-	104.9	100.0

The collection plan is formulated only for the residential waste under the initiative of the Municipality. The other kind of wastes i.e. commercial, business and industrial waste have to be carried into the transfer station by the waste generator themselves or by the contractors. Therefore, the existing private companies will be able to continue the service contract with the waste generators who require the higher quality services upon full cost recovery charge. Major modification of existing collection system is introduction of new collection system to provide minimum level collection service for all the residents.

The Municipality has to establish the legal ground clearly, the By-law of Male' Municipality should include the following new clauses;

- Residents have to carry waste to the collection station/vehicle at the designated time and place by the Municipality or transfer station. The entrepreneurs have to carry waste to the transfer station by their responsibility. Anybody must cleansing street in front of the house at least once a day.

- Residents have to carry bulky waste to the transfer station by their responsibility;
- Male' Municipality is responsible for cleansing of public spaces and collection of waste from the public area. Male' Municipality provides minimum collection services to all the residents upon minimum waste charge;
- Male' Municipality can provide high quality collection services on request of all the parties upon full cost recovery charge and
- Male' Municipality will permits the registered private companies to provide high quality collection services to the all the parties upon payment.

d. New Collection System for the Residential Waste

The Municipality has primary duty to collect the residential waste. The Municipality has to collect more than two times of the waste amount collected by the system in operation. The Male' Municipality have to improve efficiency of the collection system to provide collection service to all the citizens upon minimum waste charge.

i) Technical Alternatives

The affordable waste charge and the financial capacity of the Municipality decide the level of collection services. The technical system for more efficient collection is selected from the alternatives in consideration of the affordability of the Municipality. The options discussed and considered in the field studies are shown in Table 6-9. The detail considerations of each option are below.

The new collection system will ensure the better sanitary and aesthetic condition compared with the present operation. However, on the other hand, the new system will require cooperation of the citizens for the method of waste discharge and cleansing of public space. Prior to introduction of the new collection system, public campaign have to be made about the waste discharge method.

Table 6-9 Options of New Collection System

Item	Name	Major Merit	Major Demerit
Option 1	Road Side Station Collection System	High collection efficiency	Environmental problems, Inconvenient for residents
Option 2	Door to Door Collection System	Convenient for residents	Low collection efficiency
Option 3	Vehicle Station Collection System	High collection efficiency	Inconvenient for residents

1. Option1: Road -side Station Collection System

1.1 Collection System

The system does not use the containers to avoid the problems of the container system in operation. The system uses the open space of the roadside or house side as a temporary waste stations at the collection time. The Municipality decides the stations through discussion with the residents in consideration of the road space and traffic condition. The required number of stations are approx. 200 points (30 household per one station). The station is located along the main roads where is allowed to store waste outside the private land. The residents bring the packed waste bag to the nearest station during the designated time for waste discharge. The collection vehicle collects the waste bags discharged at the stations on the scheduled time. The system uses either compactor truck or normal truck for the collection vehicle and the collection cost estimation will be carried out for both types of the collection vehicles.

1.2 Required Number of Collection Vehicle

The required number of collection vehicles is shown in Table 6-10.

The detail calculation of the required number of collection vehicle is described in "Supporting Report, Section A Collection"

Table 6-10 Required Number of the Collection Vehicles

Year	Waste Amount t (t/d)		The Required Number of collection Vehicles (Compactor Truck)	
	Generated Waste Amount (t/day)	Waste Amount to be collected (t/d)	Full working	Net working 85%
(1999)	51	60	(11)	(13)
(2000)	54	63	(11)	(13)
(2001)	57	67	(11)	(13)
(2002)	61	71	(12)	(14)
2003	64	75	13	15
2004	68	79	13	15
2005	72	84	14	17
2006	75	88	15	18
2007	79	92	16	19
2008	83	97	17	20
2009	87	102	18	22
2010	91	106	18	22

Note: 1999-2002: Existing Collection System (preparation term for new system)

1.3 Collection Cost

Collection cost consists of procurement cost of collection vehicle, personnel expenditure, operation and maintenance cost. The detail cost estimation and the cost comparison with normal truck are described in "Supporting Report, Section A Collection". Total collection cost of the Option 1 is summarised in Table 6-11 (compactor truck). The Table suggests that the introduction of compactor track for collection activities is more economical than that of the normal truck.

Table 6-11 Collection Cost of the Option 1 (Compactor Truck)

Year	(1) Procurement Cost	(2) Personnel Expenditure	(3) Maintenance Cost	(4) Operation Cost	Total Cost
1999	-			(1,249)	(1,249)
2000	-			(1,249)	(1,249)
2001				(1,249)	(1,249)
2002	10,448			(1,249)	10,448
2003	-	1,320	606	1,714	3,640
2004	1,393	1,320	606	1,733	5,052
2005	697	1,466	686	1,907	4,756
2006	697	1,540	726	2,000	4,963
2007	11,145	1,613	766	2,101	15,625
2008	1,393	1,686	806	2,193	6,078
2009	1,393	1,832	886	2,367	6,488
2010	697	1,832	886	2,386	5,801
Total	27,862	12,609	5,968	16,401	62,841 (67,837)

2. Option2: Door to Door Collection System

2.1 Collection System

The collection vehicle of this system collects waste from door to door. The residents will evaluate that the system is most favorable collection service. However the system is most likely to cause of traffic congestion and very low collection efficiency. Considering the road condition in Male', the activity of many collection vehicles will obstruct the other traffic. And also, the municipality has to consider about the financial condition of the system. The collection cost of this system is estimated as follows. The system can use either the compactor truck or normal truck therefore the collection cost estimation will be carried out with both types of collection vehicles.

2.2 Required Number of Collection Vehicle

The required number of collection vehicle is shown in Table 6-12. The detail calculation of the required number of collection vehicle is described in "Supporting Report, Section A Collection"

Table 6-12 Required Number of Collection Vehicles

Year	Waste Amount t (t/d)		Required Number of the Collection Vehicle (Compactor Truck)	
	Generated Waste Amount (t/day)	Waste Amount to be collected (t/d)	Full working	Net working 85%
(1999)	51	60	(17)	(20)
(2000)	54	63	(18)	(22)
(2001)	57	67	(20)	(24)
(2002)	61	71	(21)	(25)
2003	64	75	22	26
2004	68	79	23	28
2005	72	84	25	30
2006	75	88	26	31
2007	79	92	27	32
2008	83	97	28	33
2009	87	102	29	35
2010	91	106	30	36

2.3 Collection Cost

Collection cost consists of procurement cost of collection vehicle, personnel expenditure, operation and maintenance cost. The detail cost estimation and the cost comparison with normal truck are described in "Supporting Report, Section A Collection". Total collection cost of the Option 2 is summarised in Table 6-13 (compactor truck). The Table suggests that the introduction of compactor truck for collection activities is more economical than that of the normal truck.

Table 6-13 Collection Cost of the Option 2

Year	(1) Procurement Cost	(2) Personnel Expenditure	(3) Maintenance Cost	(4) Operation Cost	Total Cost
1999	-			(1,249)	(1,249)
2000	-			(1,249)	(1,249)
2001				(1,249)	(1,249)
2002	18,110			(1,249)	(1,249) 18,110
2003	1,393	2,125	1,050	2,519	7,087
2004	1,393	2,272	1,131	2,685	7,481
2005	697	2,418	1,212	2,859	7,186
2006	697	2,491	1,252	2,951	7,391
2007	18,807	2,564	1,292	3,052	25,715
2008	2,786	2,638	1,332	3,145	9,901
2009	2,090	2,784	1,413	3,319	9,606
2010	697	2,857	1,453	3,411	8,418
Total	46,670	20,149	10,135	23,941	100,895 (105,891)

3. Option3: Vehicle Station Collection System

3.1 Collection System (Original System for Male')

The collection vehicle in this option is operated for parking at the vehicle collection station and for going around the designated service area for normal bell collection according to the time assigned to each collection mode. Residents bring waste to the nearest vehicle collection station while the vehicle parked at the station. Collection vehicle then shifts the mode of collection to go round the designated service area slowly with music sound. Residents bring out their waste to the vehicle as they hear the sound.

3.2 Required Number of Collection Vehicles

The required number of collection vehicles is shown in Table 6-14. The detail calculation of the required number of collection vehicle is described in "Supporting Report, Section A Collection"

Table 6-14 Required Number of the Compactor Trucks

Year	Waste Amount t (t/d)		Compactor Truck	
	Generated Waste Amount (t/day)	Waste Amount to be collected (t/d)	Full working	Net working 85%
(1999)	51	60	(9)	(11)
(2000)	54	63	(9)	(11)
(2001)	57	67	(10)	(12)
(2002)	61	71	(10)	(12)
2003	64	75	11	13
2004	68	79	11	13
2005	72	84	12	15
2006	75	88	13	16
2007	79	92	13	16
2008	83	97	14	17
2009	87	102	15	18
2010	91	106	15	18

3.3 Collection Cost

Collection cost consists of procurement cost of collection vehicle, personnel expenditure, operation and maintenance cost. The detail cost estimation is described in "Supporting Report, Section A Collection". Total collection cost of the Option 3 is summarised in Table 6-15 (compactor truck).

Table 6-15 Collection Cost of the Option 3

Year	(1) Procurement Cost	(2) Personal Expenditure	(3) Maintenance Cost	(4) Operation Cost	Total Cost
1999		-		(1,249)	(1,249)
2000		-		(1,249)	(1,249)
2001		-		(1,249)	(1,249)
2002		9,055		(1,249)	(1,249) 9,055
2003	0	986	525	1,399	2,910
2004	0	986	525	1,399	2,910
2005	1,393	1,104	525	1,554	4,576
2006	697	1,163	606	1,651	4,117
2007	9,055	1,163	646	1,651	12,515
2008	697	1,222	646	1,748	4,313
2009	697	1,280	686	1,843	4,506
2010	1,393	1,280	766	1,843	5,282
Total	22,987	9,184	4,925	13,088	50,184

ii) Selection of Alternatives of Collection System for Residential Waste

The Option 1 can keep pretty well collection efficiency, however, it still implicates some problems: there are waste bags put on the road until the time of collection and the station has a chance of contamination by waste water leaked out of the waste bags. The heap of waste bags looks untidy and tends to emit bad smells around the station. The system is commonly adopted in Japan under the condition that the residents have to keep the time scheduled for discharge and to clean up the station area. Even if the residents get accustomed to keep the station clean and the scene of the waste bags is tolerable for residential area, the system is not match for Male' where there are many tourist walking around the capital island.

The Option 2 requires the collection cost more than two times of the cost of option 3. Therefore, The Option 2 is not proposed as a suitable collection system for Male'.

The Option 3 requires the least numbers of collection vehicles and suitable for the congested traffic condition in Male' Island. Option 3 is the most efficient system among the three options. The Option 3 can also make the duration time of waste exposed in the air to the minimum, which is acceptable in term of environmental, sanitary and aesthetic conditions as well as the Option 2.

In consideration of the merits and demerits of three options, there seems no room of adopting The Option 1 and 2. Therefore, the Option 3 "Vehicle Station Collection System" is proposed for Male' for collection system of the residential waste.

The residents who are not satisfied with this collection services can make a contract with any private companies (include hand-cart) or the Municipality upon payment of the full cost recovery charge.

The collection cost of each option is summarized in Table 6-16. The Table suggests that The Option 3 is the most economical system among the three options.

Table 6-16 Collection Cost of Each Option (2003~2010)

Year	Option 1	Option 2	Option 3
Total	62,841,000	100,895,000	50,184,000

iii) Arrangement Plan of New Collection Vehicle

The proposed new collection system is called "Vehicle Station Collection System", the system will arrange the collection vehicle as a container and set up the collection area of each vehicle. Waste amount to be collected and the required number of truck in the period of Master Plan is shown in Table 6-14. The arrangement plan of the vehicle is shown in Figure 6-2 (2010). In 2003, each vehicle covers approx. 20ha (a radius of 250m circle), the residents can discharge waste at the vehicle collection station within 4 minutes walking (60m/min. speed). In 2010, each vehicle covers approx. 15ha (a radius of 220m circle), the required time is shorter than that of the 2003. The service area covered by one vehicle become smaller gradually year by year and the residents will be able to enjoy more convenience for carrying waste to the vehicle.

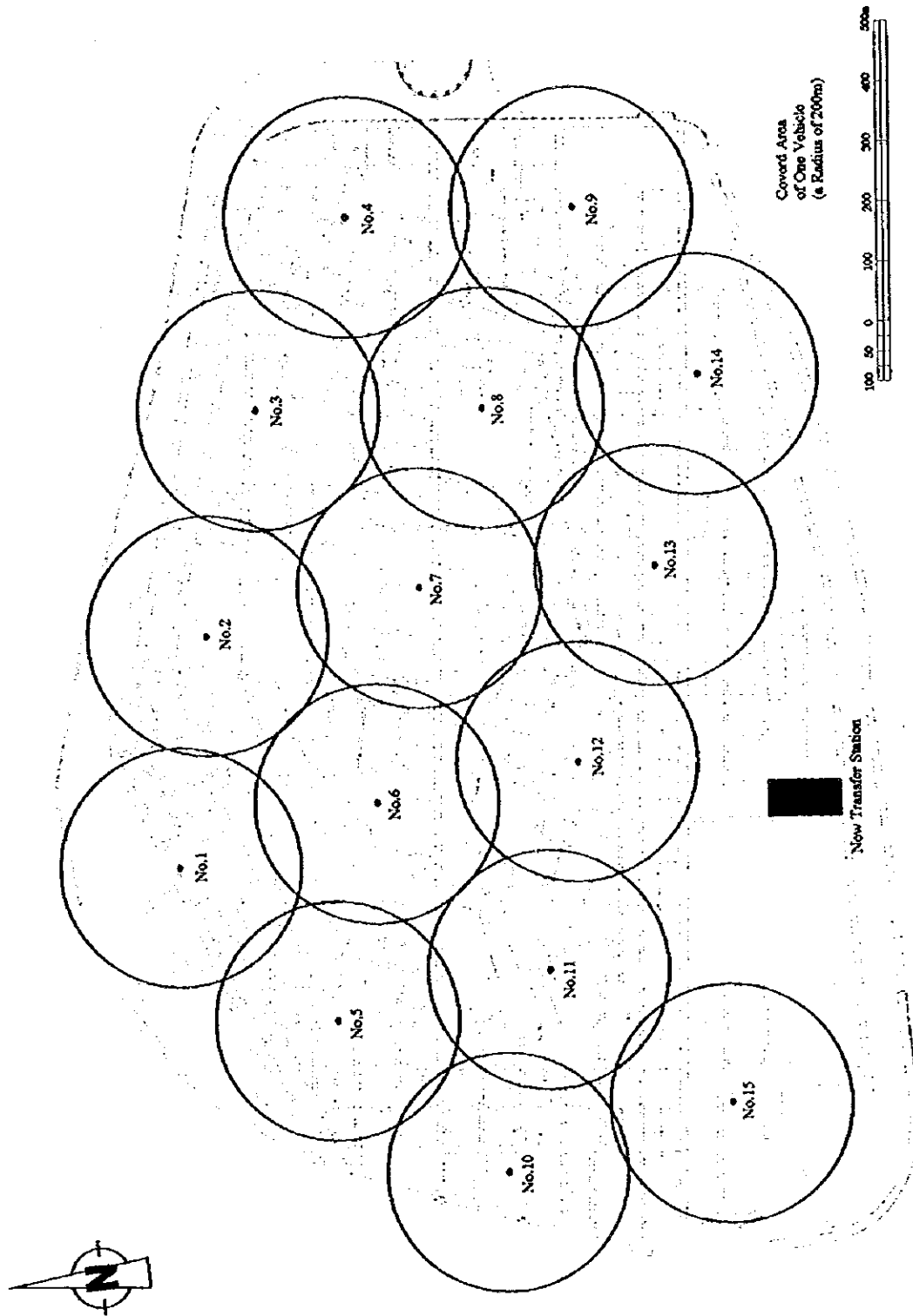


Figure 6-2. Station Plan of the Collection Vehicle (2010)

e. Collection System for the Commercial and Business Waste

The other types of waste, i.e. commercial and business waste shall be carried into the transfer station by the waste generators. The waste generators should have a responsibility of collection and hauling of their own waste, hence they can make a contract as to the delivery of collection service with private companies (include handcart) or with the Municipality. The system of the private collection services is in operation now. The collection services will provide the door to door collection.

At the present time, the capacity of the collection service upon payment is 8.64-ton/day in average (IHF 1.22-ton/day, Handcart 6.36-ton/day, the Municipality 1.06-ton/day). The amount account for 15% of the total commercial and business waste. If the contractors will make an effort to provide the high quality services upon reasonable charge (the Municipality also can provide the full cost recovery to the customer), the ratio will increase in the future. The market will decide own future direction, hence the Municipality has to make an effort to promote the private sector involvement (PSI). The merits of PSI are described in Master Plan Section 6.4.3.

The Municipality has responsibility of supervising and monitoring as to the activities of the waste generators and the private collectors. The Municipality has to consider about the provisions to prohibit illegal dumping or another illegal activities in the By-law.

f. Collection System for Construction Waste

Ministry of Construction and Public Works (MCPW) is responsible for supervising and monitoring as to the construction waste. MCPW should monitor the large-scale development and construction plan. MCPW has to guide the suitable collection & hauling system to the contractors. The contractors have to submit the waste hauling plan before commencement of the construction work.

(2) Transportation Plan**a. Objective**

The objective of the transportation plan to establish an effective and efficient transportation system to remove the collected waste to the disposal site immediately in order to maintain public health and cleanliness of the islands in the planning area.

b. Planning Concept

The current transport system consists of two ferryboats and large dump trucks works well enough to remove solid waste from the two target islands in a few days. The ferryboats still have a life remaining enough to continue operation during the planning periods until 2010. Therefore, it is reasonable to succeed the current system basically in the master plan though there are some needs of capacity expansion to meet with increasing waste volume and improvement in operational aspects. The most suitable way of capacity expansion and operation improvement is selected in view of cost effectiveness and environmental soundness.

c. Waste Amount to be Transported

The waste amount to be transported is shown in Table 6-17. The amount is estimated by 6-days working per a week.

Table 6-17 Projection of Waste Amount to be Transported (Unit: ton/day)

Year	Residential, Commercial, Business waste	Saw dust (to be separated)	Kitchen waste (to be separated)	Construction Waste	Total (Male')	Residential waste (villingili)
1999	128.2	-	-	82.7	210.9	1.5
2000	134.9	-	-	85.3	220.2	1.9
2001	141.7	-	-	88.0	229.7	2.1
2002	148.9	-	-	90.9	239.8	2.6
2003	151.7	4.0	1.0	93.8	250.5	3.0
2004	158.8	4.0	1.0	96.7	260.5	3.5
2005	166.5	4.0	1.0	99.6	271.1	4.2
2006	174.0	4.0	1.0	102.6	281.6	4.9
2007	182.4	4.0	1.0	105.0	292.4	5.7
2008	189.8	4.0	1.0	108.5	303.3	6.8
2009	197.8	4.0	1.0	111.5	314.3	7.9
2010	205.8	4.0	1.0	114.6	325.4	9.3

d. Technical Alternatives

The proposed system will be formulated to have suitable combination of manpower and machines. Considering the current situation of SWM in Male', there are three options i.e. improved existing system, introduction of compactor truck and introduction of compactor-container system for transportation system. The three options have different level of environmental protection capability. These systems are evaluated to identify the most appropriate system from both economic and environmental viewpoints.

Option 1: Improvement of transfer station

Option 2: Improvement of transfer station + introduction of compactor truck

Option 3: Improvement of transfer station + introduction of compactor-container system

i) Option 1: Improvement of Transfer Station (Dump Truck System)**1. Transportation System**

The Option 1 is improvement plan of the transfer station. The transportation system from the transfer station to the final disposal site is same as the system in operation. The loaded trucks carry waste to the final disposal site directly by using the ferryboat.

2. The Required Number of Trips

In the case the two ferries are used to transport the trucks, it is possible to make 10 times (50 times) of trips in 8 hours (net work time) by assuming the working time schedule as shown in Figure 6-3. In addition, it is possible to increase four trips more (20 trucks) by the working time by two hours. This modified transportation schedule is shown in Figure 6-4. In average, required number of trip is estimated for the trucks as shown in Table 6-18. The Table suggests that two ferryboats have enough transportation capacity during the planning period until 2010. Therefore, MCPW has to prepare the required number of trucks only. From the year 2003, when the proposed transportation system begin operation, total required number of trucks are 18 (5trucks x 3 teams and 85% of the net working ratio). The detail calculation condition is described in "Supporting Report, Section B Transportation"

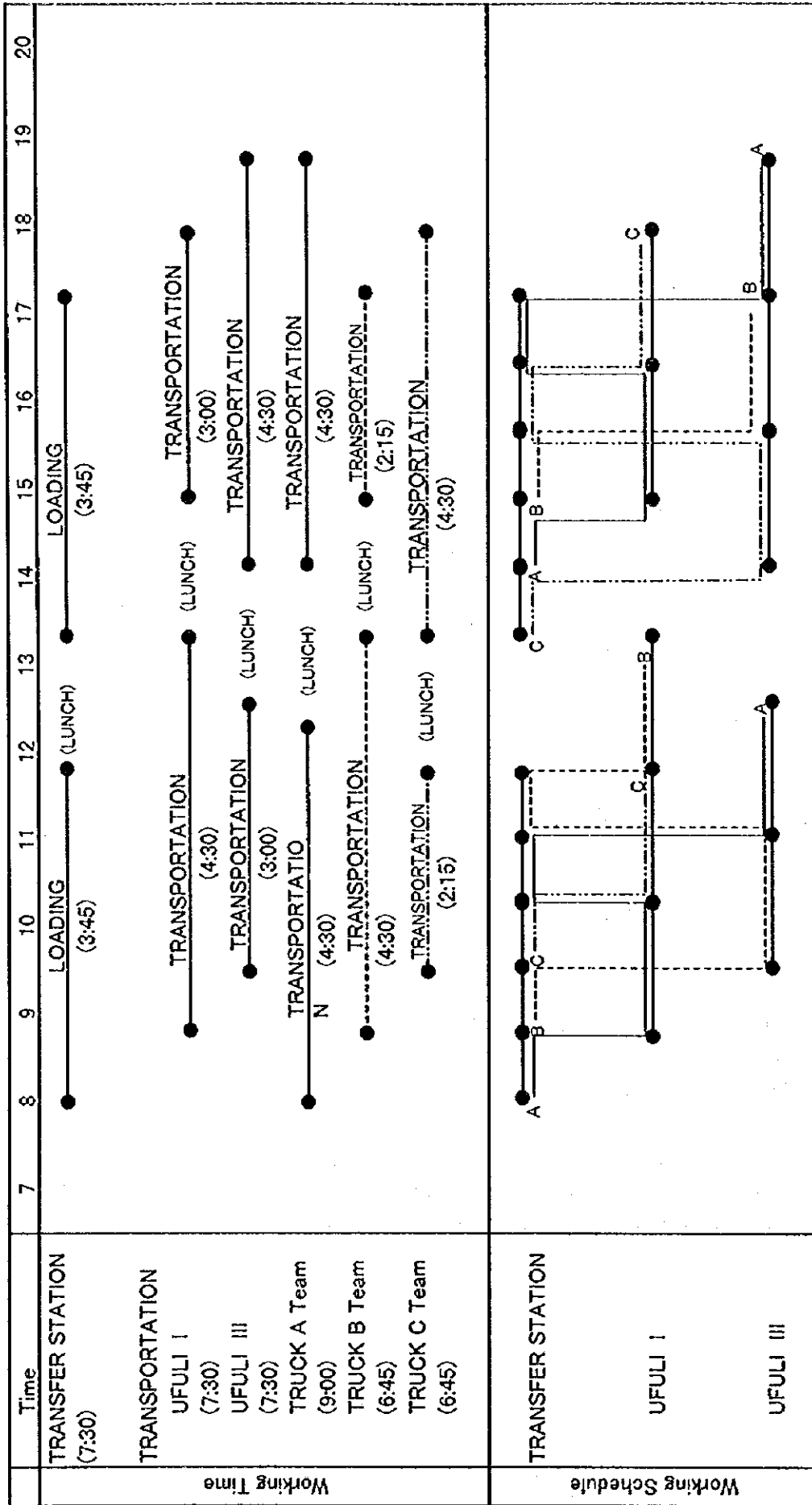


Figure 6-3 Proposed Working Schedule of Ferry and Trucks (10.5 hours)

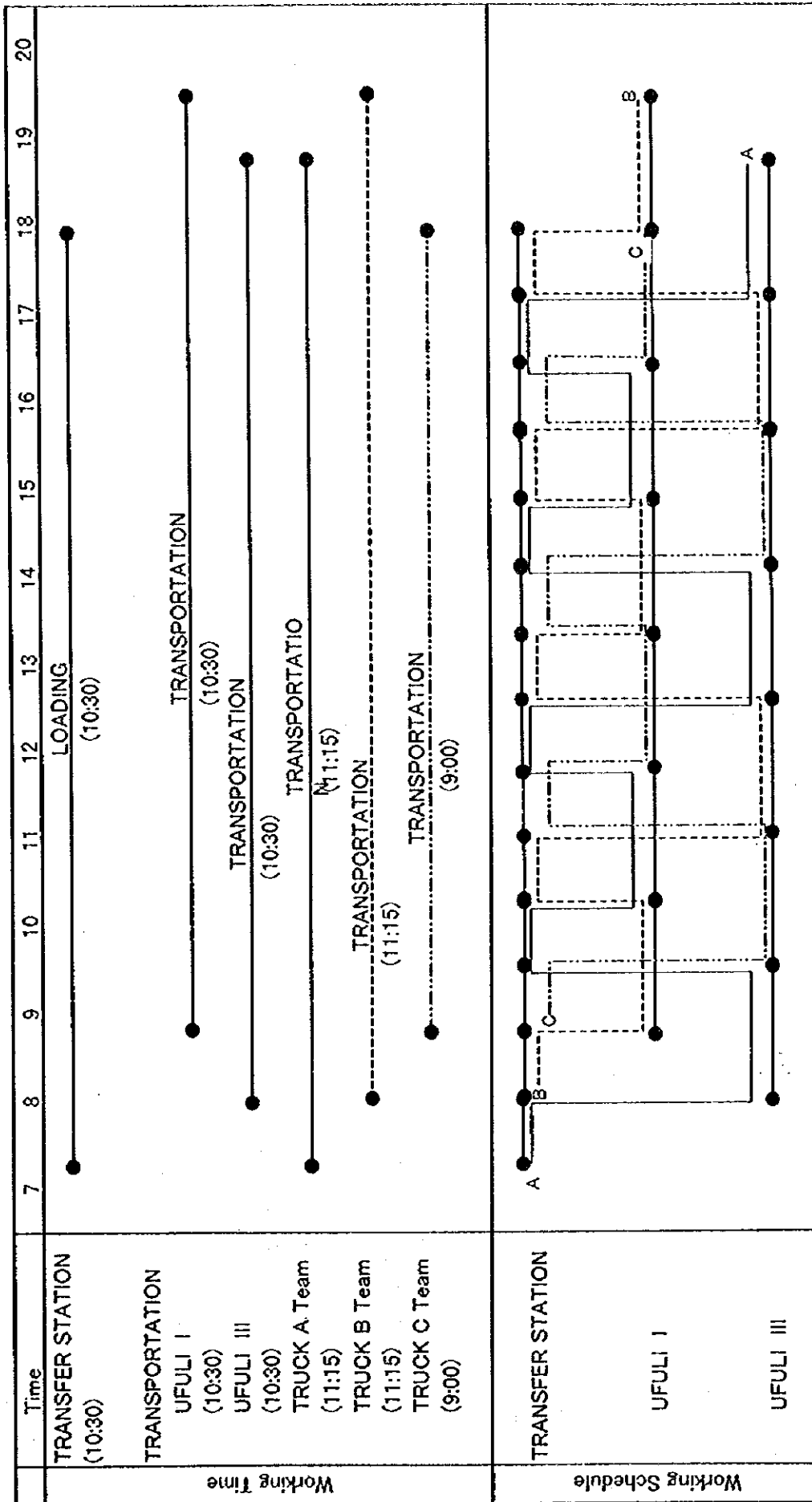


Figure 6-4 Proposed Working Schedule of Ferry and Trucks (12.0 hours)

Table 6-18 Required Number of Trucks and Trips (Option 1)

Year	Residential, Commercial, Business waste (ton-/day)	Saw dust (to be separated) (ton-/day)	Kitchen waste (to be separated) (ton-/day)	Construction Waste (ton-/day)	Residential waste (Villingili) (ton-/day)	Number of trucks (Number of ferry trip)
1999				36 (210.9)	1 (1.5)	37 (8)
2000				37 (220.2)	1 (1.9)	38 (8)
2001				39 (229.7)	1 (2.1)	40 (8)
2002				40 (239.8)	1 (2.6)	41 (9)
2003	38 (151.7)	1 (4.0)	1 (1.0)	10 (93.8)	1 (3.0)	51 (11)
2004	40 (158.8)	1 (4.0)	1 (1.0)	10 (96.7)	1 (3.5)	53 (11)
2005	42 (166.5)	1 (4.0)	1 (1.0)	10 (99.6)	2 (4.2)	56 (12)
2006	44 (174.0)	1 (4.0)	1 (1.0)	11 (102.6)	2 (4.9)	59 (12)
2007	46 (182.4)	1 (4.0)	1 (1.0)	11 (105.0)	2 (5.7)	61 (13)
2008	48 (189.8)	1 (4.0)	1 (1.0)	11 (108.5)	2 (6.8)	63 (13)
2009	50 (197.8)	1 (4.0)	1 (1.0)	12 (111.5)	2 (7.9)	66 (14)
2010	51 (205.8)	1 (4.0)	1 (1.0)	12 (114.6)	3 (9.3)	(14)

3. Transportation Cost

The transportation cost of the Option 1 consists of four items i.e., construction cost of transfer station, procurement cost of trucks and heavy machines, operation and maintenance cost, personnel expenditure. The detail cost estimation described in "Supporting Report, Section B Transportation". Total transportation cost is summarised in Table 6-19.

Table 6-19 Transportation Cost (Option 1)

Year	Construction cost	Procurement cost	Personal expenditure	Maintenance Cost	Operation Cost	Total
1999	-	-	(1,645)		(3,213)	(4,858)
2000	-	-	(1,645)		(3,213)	(4,858)
2001	10,074	-	(1,645)		(3,213)	10,074 (4,858)
2002	23,507	30,092	(1,645)		(3,213)	53,599 (4,858)
2003	-	-	1,938	1,744	7,241	10,923
2004	-	-	1,938	1,744	7,241	10,923
2005	-	-	2,072	1,744	7,856	11,672
2006	-	-	2,072	1,744	7,856	11,672
2007	-	25,893	2,206	1,744	8,472	38,315
2008	-	-	2,206	1,744	8,472	12,422
2009	-	-	2,341	1,744	9,089	13,174
2010	-	-	2,341	1,744	9,089	13,174
Total	33,581	55,985	17,114	13,952	65,316	185,948 (205,380)

ii) Option 2: Introduction of Compactor-truck (Compactor-Truck System)

1. Transportation System

The Option 2 is improvement plan of the transfer station and introduction of compactor truck for transportation. The transportation system from transfer station to the final disposal site is same as the system in operation. The compactor trucks carry waste to the final disposal site directly by using the ferry. Introduction of the compactor trucks for transportation of the waste except the construction waste is effective to improve the transportation efficiency and to protect diffusion of odour from the loaded waste.

2. The Required Number of Trip

The compactor truck can load almost two times of the waste amount comparing with that of the normal truck. Therefore, the required number of trips of ferry is lesser than the Option 1. The detail calculation condition is described in "Supporting Report, Section B Transportation"

Table 6-20 Required Number of Trucks and Trips (Option 2)

Year	Residential, Commercial, Business waste (ton-/day)	Saw dust (to be separated) (ton-/day)	Kitchen waste (to be separated) (ton-/day)	Construction Waste (ton-/day)	Residential waste (Villingili) (ton-/day)	Number of trucks (Number of ferry trip)
1999				36 (210.9)	1 (1.5)	37 (8)
2000				37 (220.2)	1 (1.9)	38 (8)
2001				39 (229.7)	1 (2.1)	40 (8)
2002				40 (239.8)	1 (2.6)	41 (9)
2003	22 (151.7)	1 (4.0)	1 (1.0)	10 (93.8)	1 (3.0)	35 (7)
2004	23 (158.8)	1 (4.0)	1 (1.0)	10 (96.7)	1 (3.5)	36 (8)
2005	24 (166.5)	1 (4.0)	1 (1.0)	10 (99.6)	2 (4.2)	38 (8)
2006	25 (174.0)	1 (4.0)	1 (1.0)	11 (102.6)	2 (4.9)	40 (8)
2007	26 (182.4)	1 (4.0)	1 (1.0)	11 (105.0)	2 (5.7)	41 (9)
2008	27 (189.8)	1 (4.0)	1 (1.0)	11 (108.5)	2 (6.8)	42 (9)
2009	28 (197.8)	1 (4.0)	1 (1.0)	12 (111.5)	2 (7.9)	44 (9)
2010	29 (205.8)	1 (4.0)	1 (1.0)	12 (114.6)	3 (9.3)	46 (10)

From the year 2003, when the proposed transportation system begin operation, total required number of trucks are 18 (5 trucks x 3 teams and 85% of net working ratio, each team consists of 3 compactor trucks and 2 normal trucks).

3. Transportation Cost

The transportation cost of the Option 2 consists of four items i.e., construction cost of transfer station, procurement cost of trucks and heavy machines, operation and maintenance cost, personnel expenditure. The detail cost estimation described in "Supporting Report, Section B Transportation". Total transportation cost is summarised in Table 6-21.

Table 6-21 Transportation Cost (Option 2)

Year	Construction cost	Procurement cost	Personal expenditure	Maintenance Cost	Operation Cost	Total
1999	-	-	(1,645)		(3,213)	(4,858)
2000	-	-	(1,645)		(3,213)	(4,858)
2001	10,074	-	(1,645)		(3,213)	10,074 (4,858)
2002	23,507	35,522	(1,645)		(3,213)	59,029 (4,858)
2003	-	-	1,831	2,059	5,175	9,065
2004	-	-	1,831	2,059	5,687	9,577
2005	-	-	1,831	2,059	5,687	9,577
2006	-	-	1,831	2,059	5,687	9,577
2007	-	31,324	1,831	2,059	6,169	41,383
2008	-	-	1,831	2,059	6,169	10,059
2009	-	-	1,831	2,059	6,169	10,059
2010	-	-	1,831	2,059	6,651	10,541
Total	33,581	66,846	14,648	16,472	47,394	178,941 (198,373)

iii) Option 3: Introduction of Compactor-container System

1. Transportation System

The Option 3 is the introduction of compactor-container system for transportation.

2. The Required Number of Trip

The compactor-container can load more than 10 % of the waste amount comparing with that of the compactor truck. Therefore, the required number of trips of ferry is lesser than the Option 2. The detail calculation condition is described in "Supporting Report, Section B Transportation"

Table 6-22 Required Number of Truck and Trip (Option 3)

Year	Residential, Commercial, Business waste (ton-/day)	Saw dust (to be separated) (ton-/day)	Kitchen waste (to be separated) (ton-/day)	Construction Waste (ton-/day)	Residential waste (Villingili) (ton-/day)	Number of trucks (Number of ferry trip)
1999				36 (210.9)	1 (1.5)	37 (8)
2000				37 (220.2)	1 (1.9)	38 (8)
2001				39 (229.7)	1 (2.1)	40 (8)
2002				40 (239.8)	1 (2.6)	41 (9)
2003	19 (151.7)	1 (4.0)	1 (1.0)	10 (93.8)	1 (3.0)	32 (7)
2004	20 (158.8)	1 (4.0)	1 (1.0)	10 (96.7)	1 (3.5)	33 (7)
2005	21 (166.5)	1 (4.0)	1 (1.0)	10 (99.6)	2 (4.2)	35 (7)
2006	22 (174.0)	1 (4.0)	1 (1.0)	11 (102.6)	2 (4.9)	37 (8)
2007	23 (182.4)	1 (4.0)	1 (1.0)	11 (105.0)	2 (5.7)	38 (8)
2008	24 (189.8)	1 (4.0)	1 (1.0)	11 (108.5)	2 (6.8)	39 (8)
2009	25 (197.8)	1 (4.0)	1 (1.0)	12 (111.5)	2 (7.9)	41 (9)
2010	26 (205.8)	1 (4.0)	1 (1.0)	12 (114.6)	3 (9.3)	43 (9)

From the year 2003, when the proposed transportation system begins operation, total required number of trucks are 18 (5 trucks x 3 teams and 85% of net working rate, each team consists of 3 compactor trucks and 2 normal trucks).

3. Transportation Cost

The transportation cost of the Option 3 consists of four items i.e., construction cost of transfer station, procurement cost of trucks and heavy machines, operation and maintenance cost, personnel expenditure. The detail cost estimation described in "Supporting Report, Section B Transportation". Total transportation cost is summarised in Table 6-23.

Table 6-23 Transportation Cost (Option 3)

Year	Construction cost	Procurement cost	Personal expenditure	Maintenance Cost	Operation Cost	Total
1999	-	-	(1,645)		(3,213)	(4,858)
2000	-	-	(1,645)		(3,213)	(4,858)
2001	10,074		(1,645)		(3,213)	10,074 (4,858)
2002	23,507	103,510	(1,645)		(3,213)	127,017 (4,858)
2003			1,921	6,001	5,775	13,697
2004			1,921	6,001	5,775	13,697
2005			1,921	6,001	5,775	13,697
2006			1,921	6,001	6,257	14,179
2007		37,670	1,921	6,001	6,257	51,849
2008			1,921	6,001	6,257	14,179
2009			1,921	6,001	6,739	14,661
2010			1,921	6,001	6,739	14,661
Total	33,581	141,180	15,368	48,008	49,574	287,711 (307,143)

iv) Cost Comparison of each Transportation Option

The calculation result of each option is shown in Table 6-24.

The Option 1 is implicated in environmental problems: the odor and flakes of waste from the loaded waste of dump truck will be scatter around of the access road and the standby parking are in the jetty.

The Option 2, the compactor truck is effective to protect the environmental problems mentioned above and the Option 2 is more economical than Option 1. Therefore, the Option 2 can be evaluated as the most suitable transportation system in Male'.

The option 3, the compactor-container is the best transportation system as to protection of the environmental problems, though the total transportation cost become most expensive.

Selection of the transportation system shall be made in economic and environmental viewpoints.

Table 6-24 Transportation Cost of Each Option

Year	Option 1	Option 2	Option 3
Total	185,948 (205,380)	178,941 (198,373)	287,711 (307,143)

e. Proposed Transportation System

The Option 2 is proposed to be the most appropriate transportation system from the economic viewpoint. In addition the system can improve the current environmental problems at the transfer station, access road and standby parking.

6.3.2 Treatment of Special Wastes

Some sort of wastes are proposed to have treatment or recycling prior to disposal in consideration of the benefit to avoid probable secondary pollution, recovery of materials for recycling, conservation of the environment, and reduction of the final disposal amount to prolong the life of the landfill site. The method of treatment and recycling of these wastes are proposed as in the following paragraphs.

(1) Food Wastes from Hotels & Restaurants : Composting

Wastes from hotels and restaurants generate about 4 tons per day and the food waste ratio commingled in the hotel & restaurants wastes amount to 83 % by weight. Soil in the Maldives mostly consists of coral sand, which lacks in organic matters for growing plant. The food waste is a good raw materials for producing compost for the use in the "Planting Two Million Trees Project", small scale farming in local islands, gardening in resort islands.

Firstly, the system for waste separation, collection and transportation must be established. Special containers must be provided at the transfer station to receive the food wastes carried by the hotels and restaurants. Secondly, the pilot scale composting facilities shall be constructed in the Thilafushi. Thirdly, distribution system of the final products shall be established. Operation shall be carried out by the direction of the Special Task Team organised under WMS of MCPW.

The pilot compost facility, the windrow type composting, shall be composed of 3 lots, namely reception-separation area, fermentation-turning area and maturation, storage and shipping area. The pilot facilities will be developed initially at the capacity to receive about 2 to 3 tons of raw material twice in a week. Food waste - saw dust composting will require 6 to 8 weeks by the windrow type processes. The composting capacity and/or the processes may be developed further in future as required.

(2) Saw Dust from Carpentry : Moisture Adjustment for Composting

Twenty two (22) carpentry factories operated in Male produce about 5 tons of saw dust and cuttings of lumbers. Saw dust will be useful to adjust the quality of compost in terms of moisture and C/N ratio. In order to enrich the nutrient elements in the final product of compost, the C/N ratio of raw material has to be kept between 25 to 30.

That enables to control the temperature of windrow higher than 45 degree Celsius but not higher than 75 degree Celsius at least for 3 days by watering and turning properly. The ratio of food waste and saw dust has to be studied initially through test operation of the pilot plant and test application of the compost at the trial farm.

(3) Waste Oil : Incineration at Thilafushi disposal site

Increase of vehicles brings about increase of waste oil naturally. At present, waste oil, most of them are lubricants from automobiles and vessels are transported to Thilafushi and burnt at site without proper procedures. Generation amount of waste oil is not clear yet but the small incinerator of the capacity from 20 to 30 kg/hr will be useful for incineration treatment.

(4) Fish Waste : Treatment by the FAO supported Project

About 3 tons of fish waste generated at the Fish Market in Male' is expected to be recycled by the project supported by FAO. Accordingly, the SWM plan for Male' do not deal the fish waste in SWM plan.

(5) Medical Waste : Incineration at IGMH and/or ADK Hospitals

There are two options for treatment of medical wastes. The first option is to have incineration treatment at the two hospitals, IGMH and ADK. The other option is to install the medical waste incinerator at the Thilafushi. For the practical point of view, it will be better to ask co-operation of the two hospitals to treat medical wastes of the clinics at the hospital incineration facilities. The total capacity of the incineration plants must be larger than 1 ton per day or about 200 kg per hour.

(6) Batteries : Collection and Cementing at Thilafushi

Waste Composition Survey conducted in Male' shows that the hazardous waste such as batteries, insecticides, pesticides, waste chemicals commingled with general municipal waste by the ratio of 0.2 % in weight. For recovery of waste batteries, it is important to establish the collection system. Considering the social conditions in Male', schools and mosques are the most convenient places for the resident to bring waste batteries and for periodical collection by the Municipality. The battery recovery boxes shall be placed at the entrance of 6 primary schools, 9 secondary schools and mosques to enable easy access to the students and the residents for discharging the waste batteries at anytime in daytime. Collection work is to be conducted by the Municipality once in a month alternately for the battery recovery boxes in 4 Wards. The waste battery shall be treated with cementing at the Thilafushi before landfill.