社会開発調査部報告書



Japan International Cooperation Agency (JICA)

Ministry of Construction and Public Works
Male' Municipality

# THE STUDY ON SOLID WASTE MANAGEMENT FOR MALE' CITY IN THE REPUBLIC OF MALDIVES

## FINAL REPORT

## MAIN REPORT



May 1999

Pacific Consultants International
Environmental Technology Consultants Co., Ltd

Japan International Cooperation Agency (JICA)

Ministry of Construction and Public Works
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**FINAL REPORT**

**MAIN REPORT**

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Pacific Consultants International
Environmental Technology Consultants Co., Ltd


Foreign Currency Exchange Rates Applied in this Report

| Currency | Exchange Rate / US$ |
|---|---|
| Maldivian Rufiyaa (Rf) | 11.72 |
| Japanese Yen (JPY) | 130 |

(Average rate from October 1 to October 9, 1998)

# PREFACE

In response to a request from the Government of the Republic of Maldives, the Government of Japan decided to conduct the mater plan and feasibility Study on Solid Waste Management for Male' City in Maldives and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Mr. Kihachiro Urushibata, Pacific Consultants International (PCI) and composed of staff member of PCI and Environmental Technology Consultants Co., Ltd. to the Republic of Maldives, three times between May 1998 and June 1999. In addition, JICA set up an advisory committee headed by Mr. Kenichi Tanaka, Development Specialist of Japan International Cooperation Agency, between May 1998 and June 1999, which examined the Study from specialist and technical points of view.

The team held discussions with the officials concerned of the Government of the Republic of Maldives, and conducted field surveys at the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Maldives for their close cooperation extended to the study.

May, 1999

Kimio Fujita
President
Japan International Cooperation Agency

**THE STUDY ON SOLID WASTE MANAGEMENT FOR MALE' CITY IN THE REPUBLIC OF MALDIVES**

May, 1999

Mr. Kimio Fujita
President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

Dear Sir,

We are pleased to submit to you the final report entitled "The Study on Solid Waste Management for Male' City in the Republic of Maldives". This report has been prepared by the Study Team in accordance with the contracts signed on 12 May 1998 and 30 April 1999 between the Japan International Cooperation Agency and the Joint Study Team of Pacific Consultants International and Environmental Technology Consultants Co., Ltd.

The report examines the existing national basic policy for solid waste management, master plan for Male' city including Thilafushi final disposal site and feasibility study for priority projects concluded in the master plan.

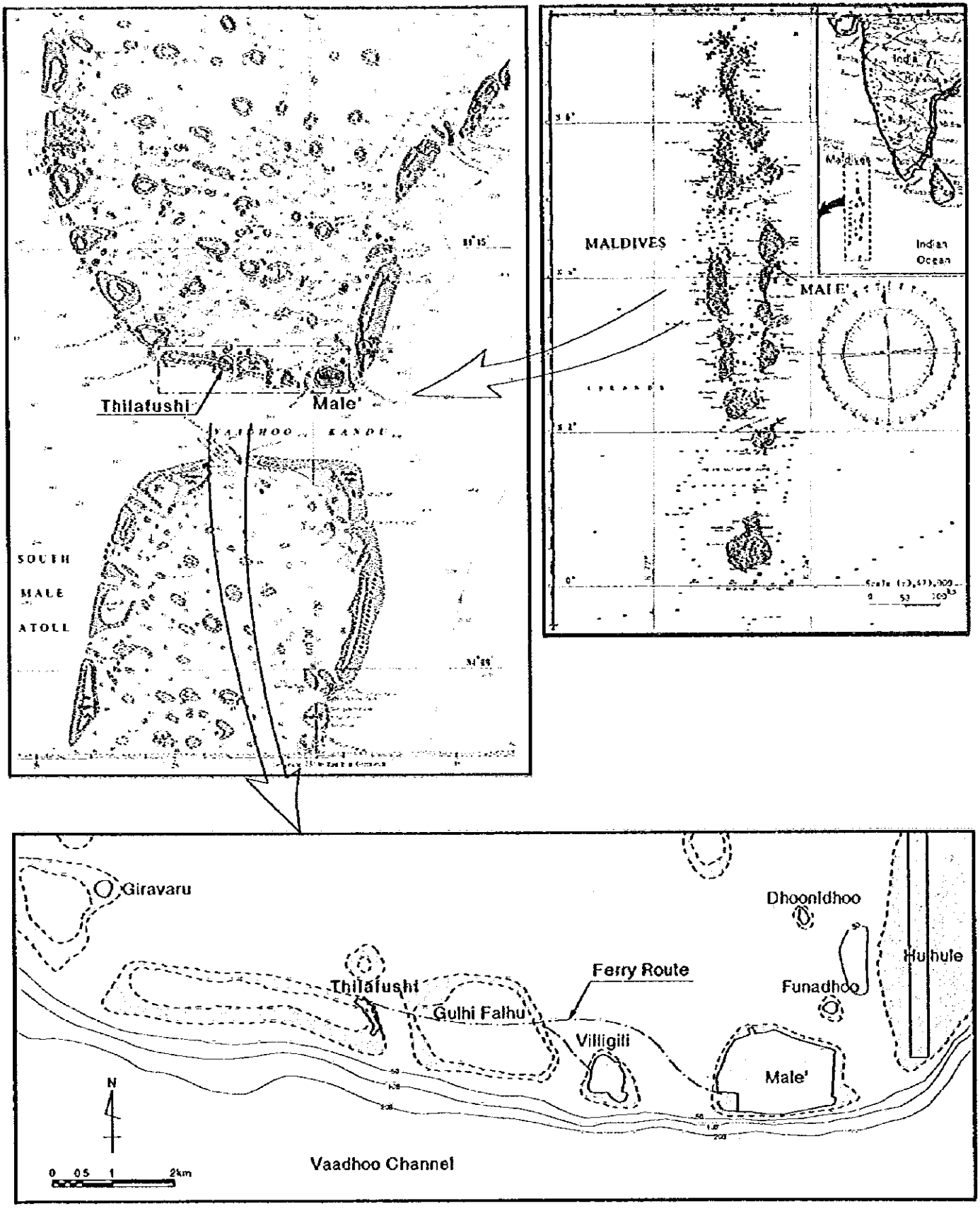
The report consists of the Summary, Main Report, Supporting Report and Data Book. The Summary summarizes the results of all studies. The Main Report contains the existing conditions, master plan, results of the feasibility study, and conclusions and recommendations. The Supporting Report includes technical details of contents of the Main Report. In addition, Data Book have been prepared and is submitted herewith.

All members of the Study Team wish to express grateful acknowledgement to the personnel of your Agency, Advisory Committee, Ministry of Foreign Affairs, Ministry of Health and Welfare, Ministry of Transport and Embassy of Japan in Sri Lanka, and also to officials and individuals of the Republic of Maldives for their assistance extended to the Study Team. The Study Team sincerely hopes that the results of the study will contribute to the improvement of the Republic of Maldives and that friendly relations of both countries be promoted further by this occasion.

Yours faithfully,

漆畑喜八郎

Kihachiro Urushibata
Team Leader



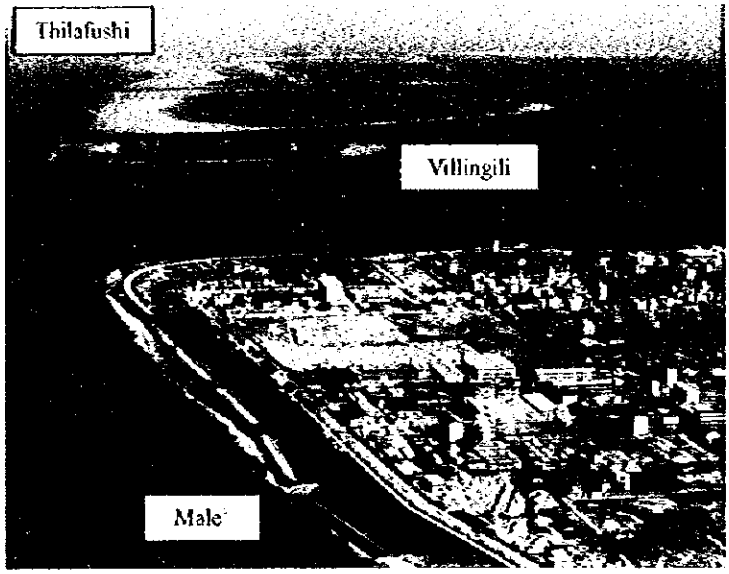

**Location Map**

# SOLID WASTE MANAGEMENT IN MALE'

## 1. Male'

① Male'　②,③ Thilafushi island

①

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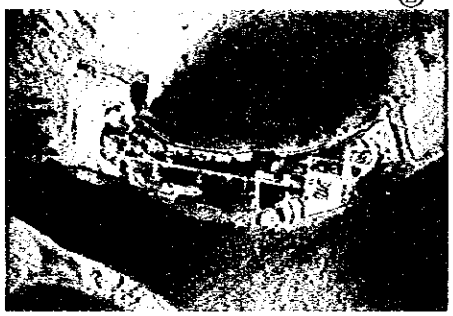

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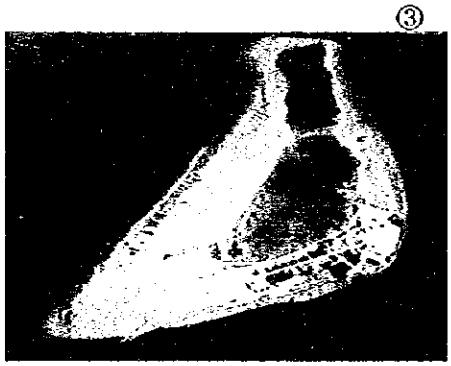
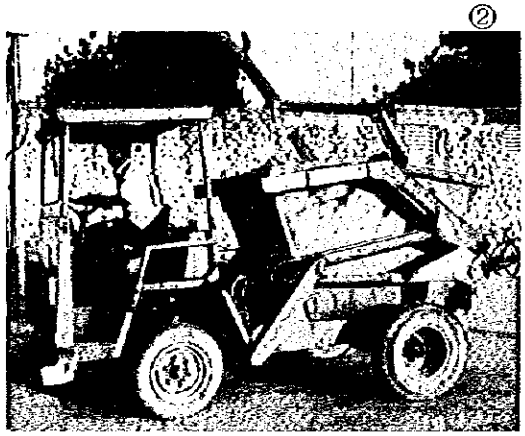


## 2. Collection

① Container
② Microbin
③ Handcart

①

②



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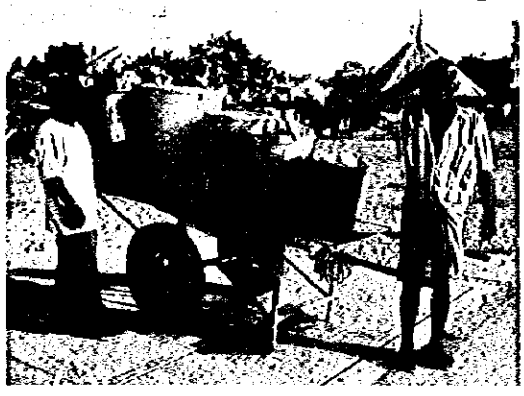
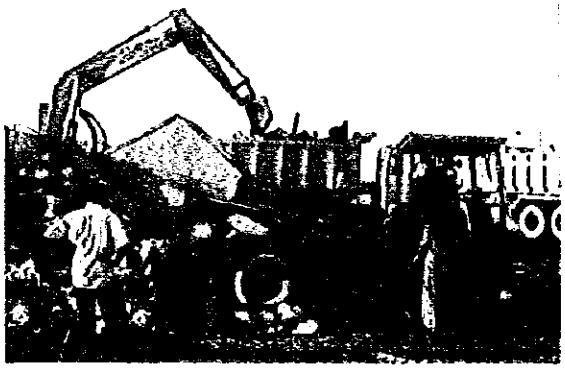
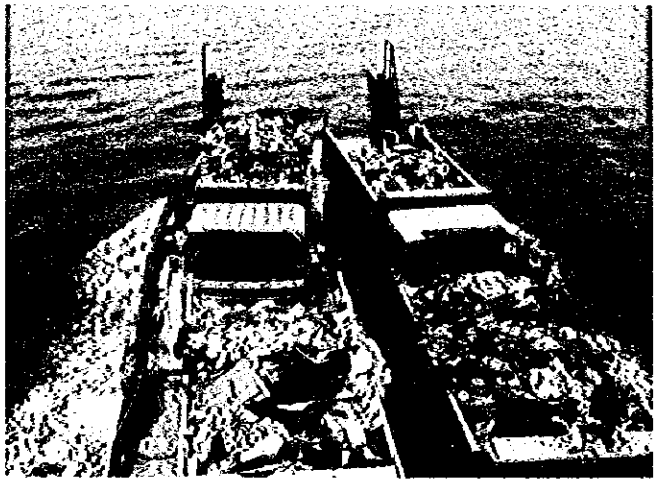


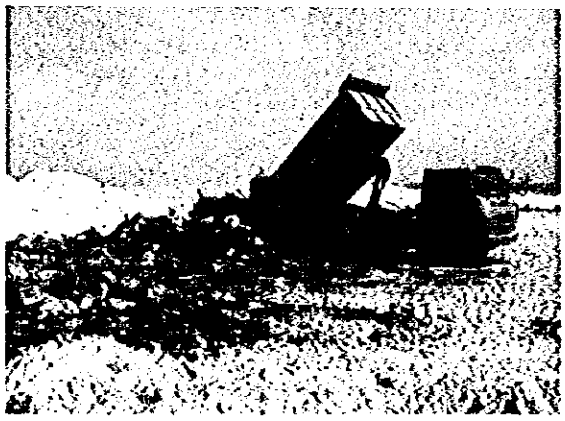
### 3. Transfer Station



### 4. Transportation

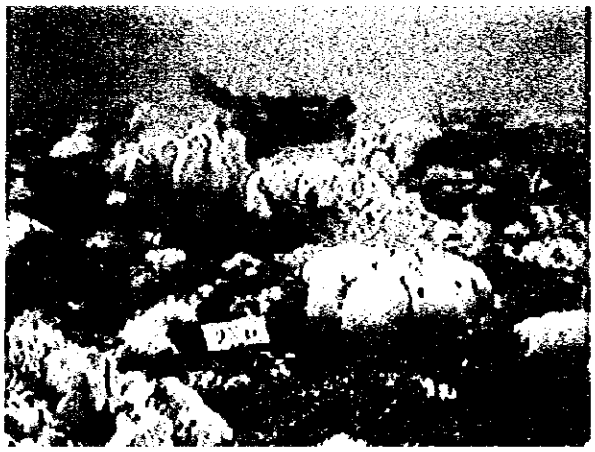


### 5. Final Disposal (Thilafushi)

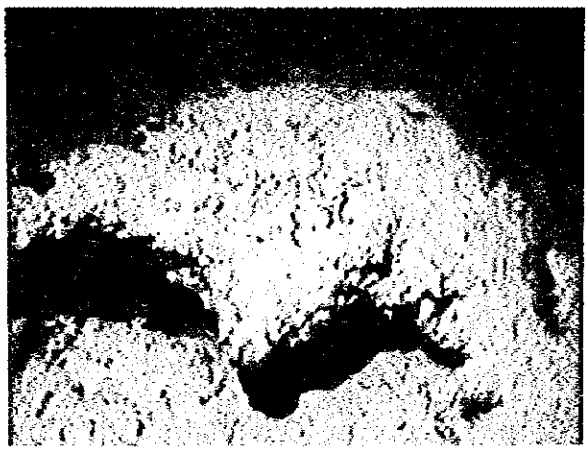


# Coral Reef in Thilafushi

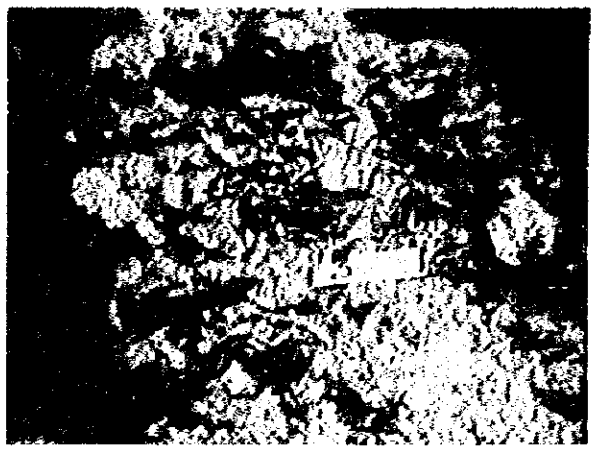
Southern Reef (-10m)



Southern Reef (0m)

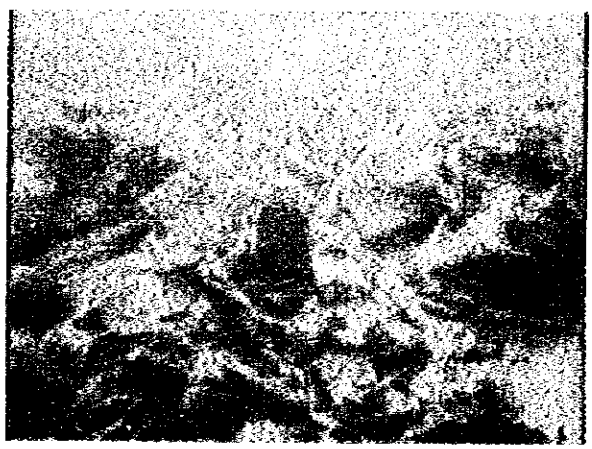


Sedimentation on Coral
(Southern corner)



Glass Bottles and Cans
(Channel on eastern reef-south)

Steel Can
(Channel on eastern reef-north)



Scattered Plastic Sheets,
Plastic Bottles and Others
(Inside lagoon)

# SUMMARY

## 1 Introduction

The target of this study is to establish a comprehensive solid waste management system for the Republic of Maldives, which is aiming at drastic solution of problems taking place in solid waste disposal.

Study Area Male' City including Villingili and Thilafushi island as landfill site of solid wastes from Male' City, airport island and surrounding resort islands

Target year Master Plan : 2010
Priority Projects : 2003

The study, which commenced on May 1998, was composed of two phases ; "Phase 1" to formulate the master plan of solid waste management in Male' City and "Phase 2" to study the feasibility of priority projects selected from the master plan.

The study was conducted in co-ordination with the Ministry of Construction and Public Works (MCPW) and Male Municipality (MM), the principal responsible government agencies of solid waste management in the capital region.

## 2 Master Plan of Solid Waste Management

An outline of the master plan is summarised below.

| Item | Present (1998) | | 2003 | | 2010 | |
|---|---|---|---|---|---|---|
| 1. Basic Data | Population | Waste Generation [ton/d] | Population | Waste Generation [ton/d] | Population | Waste Generation [ton/d] |
| Male' City | 69,080 | 174.5 | 80,684 | 216.9 | 97,928 | 286.9 |
| Male' island | 67,236 | 173.4 | 77,097 | 214.3 | 88,822 | 278.9 |
| Villingiri island | 1,844 | 1.1 | 3,587 | 2.6 | 9,106 | 8.0 |
| Inhabited island*1 | 201,427 | 136.9 | 235,261 | 185.6 | 285,543 | 270.7 |
| Resort island*2 | - | 70.7 | - | 99.6 | - | 150.6 |

*1 There are about 130 inhabited islands administrated by Ministry of Atolls Administration besides resort islands. Most of Maldivian citizens live in inhabited islands.

*2 There are about 70 islands registered as resort island, which is developed and operated mainly for foreign tourists and is controlled by MT. Inhabitants of these islands are merely employees of resort facility with no Maldivian citizens.

| Item | Present (1998) | 2003 | 2010 |
|---|---|---|---|
| 2. Collection System<br>Male' Municipality<br><br><br><br>Private Sector | Container Collection<br><br><br><br>Door to Door Collection | Vehicle Station Collection (collection area : 11) and Bell Collection by Compactor Truck<br>Door to Door Collection | Vehicle Station Collection (collection area : 15) and Bell Collection by Compactor Truck<br>Door to Door Collection |
| 3. Transportation | Dump Truck + Ferry | Dump Truck + Large Compactor Truck + Ferry | |
| 4. Transfer Station | Male' island : 1<br>Villingiri island : 1 | Male' island : 1 (new)<br>Villingiri island : 1 (remodeled) | |
| 5. Port Area Cleansing Equipment | Small Boat + Tractor | Motor Boat + Dump Truck | |
| 6. Final Disposal<br>Landfill Site<br><br><br>Landfill Type<br>Capacity | <br>Thilafushi island (Thilafushi-1)<br><br>Anaerobic landfill<br>- | <br>Thilafushi-2<br><br>Anaerobic sanitary landfill<br>434,000 $m^3$ | <br>Thilafushi-3<br><br>Anaerobic sanitary landfill<br>729,000 $m^3$ |
| 7. Jurisdiction<br>MCPW<br><br><br><br>Male' Municipality<br><br><br><br>Sate Own Enterprise | Transportation from transfer station to final disposal site, Final disposal<br><br>Collection of municipal waste, Cleansing public space | Development and construction of new landfill site, Construction of new transfer station<br><br>Collection of municipal waste and charge.<br>Enlightenment of citizens regarding waste reduction, reusing and recycle<br><br>Reception, storage, transport and final disposal of municipal waste,<br>Collection of waste charge,<br>Treatment and disposal of special waste, Composting | |

## 2.1 Solid Waste Collection System

### a. Waste Collection Concept

The waste collection plan will target only the residential waste. Other kind of wastes like commercial, business and industrial waste shall be conveyed to the transfer station by the waste generator themselves. Therefore, the existing private companies will continue to provide higher quality service upon full cost payment. Major modification to existing collection system is the introduction of new collection system to provide basic level of solid waste collection service for all the residents.

### b. Organization of Residential Collection Vehicles

The new "Vehicle Station Collection System", will organize the collection vehicle as a container and set up specific collection area for each vehicle.

Compactor truck is adopted as the collection vehicle. In 2003, each vehicle will cover about 20ha (a radius of 250m of service area) within 4 minutes walking distance. In 2010 each vehicle will cover about 15ha (a radius of 220m) resulting in shorter walking distance than that in 2003. Accordingly, the proposed vehicle organization would lead to gradual increase in service level and convenience of residents.

## 2.2 Solid Waste Transportation System

The current transport system consisting of two ferryboats and large dump trucks is adequate to remove solid waste from the two target islands of Male' and Villingili in a few days. The existing ferryboats could continue operation throughout the planning period until 2010, as they have sufficient transportation capacity. Therefore the current system will be basically continued though there are some need for capacity expansion to meet the increasing waste quantity and improvement in operational aspects.

The quantity of waste transportation, assuming a 6 day work a week, is estimated as about 215 ton/day in 1999, 255 ton/day in 2003 and 335 ton/day in 2010.

## 2.3 Construction of New Transfer Station

The present the Male transfer station is located in the area designated as residential area by the authorized land use plan. To avoid the conflict with the designated land use, it is decided to relocate it with the construction of a new improved transfer station by this master plan.

## 2.4 Final Disposal Site

The master plan aims at realizing the function at Thilafushi Island where the landfill operation is now ongoing and will be continued for a certain time period beyond the target year of 2010. The master plan for this aspect consists of the following two target projects.

- Construction of New Landfill Site
  With due consideration to of the condition of site, where it is difficult to obtain inorganic cover or filling material, anaerobic sanitary landfill similar to the existing Thilafushi is identified as the inevitable type of landfill system.
- Improvement of Existing Island
  The coastal improvement is proposed for preventing dispersal of solid waste due to coastal erosion.

## 2.5 Economic Analysis

The total cost for the solid waste management master plan was estimated at about 350 million Rf, consisting of construction cost about 290 million Rf and procurement cost 60 million Rf.

As a result of economic analysis, the project would have the EIRR of 17.0 %, which would substantially exceed 10%, the estimated opportunity cost of capital in the Maldives. Hence, the master plan project was judged to have a sufficient economical feasibility.

## 3 Priority Projects

The priority projects concluded by the master plan are summarized below.

| Project | Content | Cost | |
|---|---|---|---|
| | | 1,000 Rf | 1,000 US$ |
| Innovation of Waste Collection System | Procurement of compactor trucks | 9,055 | 773 |
| Enhancement of Waste Transport System | Procurement of dump trucks and large compactor trucks | 24,489 | 2,090 |
| Improvement of Waste Transfer Station | Construction of transfer station in Male' and remodeling in Villingiri | 39,300 | 3,353 |
| Enhancement of Port Area Cleaning | Procurement of motor boat and small dump truck | 757 | 65 |
| Construction of New Landfill Site | Construction of seawall, pond and supplementary facilities, Procurement of relevant equipment | 106,932 | 9,124 |
| Environmental Improvement of Existing Thilafushi Island | Construction of seawall | 11,856 | 1,012 |
| Subtotal | | 192,389 | 16,415 |
| Engineering Services and Physical Contingency | | 26,423 | 2,255 |
| Total | | 218,812 | 18,670 |

The total cost of the priority projects was estimated at about 220 million Rf, consisting construction cost about 160 million Rf and procurement cost 60 million Rf.

The financial analysis of the feasibility project is made based on the following basic assumptions.

(i) Opportunity cost of capital is 10%
(ii) Project life is 20 years from the start of project implementation
(iii) The collection ratio of solid waste service charge is 95%

As a result of financial analysis, the project would have the FIRR of 12.4 %, which would substantially exceed 10%, the estimated opportunity cost of capital in the Maldives. Hence, the priority projects were judged to have a financial feasibility.

# 4 Recommendation

## 4.1 Waste Reduction and Enhancement of Awareness in Solid Waste Management

As an important means of achieving sustainable means of solid waste management, waste reduction and recycling shall be promoted. In this respect, the basic step is the promotion of waste segregation at source by residents and other business entities.

Enhancement of public awareness of solid waste generators, residents and other entities, is very important is soliciting their due co-operation in achieving waste reduction and recycling. To this end pubic campaign and education by Male' Municipality is recommended to be initiated. It is further noted that the solid waste management awareness needs to be improved in the Ministry of Construction and Public Works (MCPW).

## 4.2 Implementation Schedule of Priority Projects

In consideration to the ongoing improper landfill operation activities in Thilafushi requiring urgent improvement, an early implementation of the project that incorporates the necessary technical and environmental improvement measures is strongly recommended. The earliest case of implementation schedule is shown below.

**Table. Implementation Schedule of Priority Project**

| Item | 2000 | 2001 | 2002 | 2003 |
|---|---|---|---|---|
| Innovation of Waste Collection System | | | | |
| Enhancement of Waste Transport System | | | | |
| Improvement of Waste Transfer System | | | | |
| Construction of Male' Transfer Station | | | | |
| Construction of Villingili Depot | | | | |
| Enhancement of Port Area Cleaning | | | | |
| Construction of New Landfill Site | | | | |
| Promotion of Material Recycling | | | | |
| Environmental Improvement of Existing Thilafushi Islan | | | | |

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## 5 PROJECT EVALUATION



## 6 CONCLUSION AND RECOMMENDATION

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# ABBREVIATIONS AND ACRONYMS

(in alphabetical order)

| | |
|---|---|
| BCMW | Building Construction & Mechanical Works (a subsidiary to MCPW) |
| CSS | Community Service Section (Male' Municipality) |
| EIA | Environmental Impact Assessment |
| EIS | Environmental Impact Statement |
| G.O.M. | Gvernment of Maldives |
| IEE | Initial Environmental Examination |
| IGMH | Indira Gandhi Memorial Hospital |
| IHF | Ibrahim Hassan Fulham Carpentry (a company serving for collection) |
| LIT | Line Intercept Transect (a survey method of coral bed) |
| MAA | Ministry of Atolls Administration |
| MCPW | Ministry of Construction & Public Works |
| MCV | Municipality Collection Vehicle |
| MEB | Maldives Electricity Board |
| MFAMR | Ministry of Fisheries, Agriculture & Marine Resources |
| MH | Ministry of Health |
| MHAHE | Ministry of Home Affairs, Housing & Environment |
| MM | Male' Municipality |
| MOE | Ministry of Education |
| MOFA | Ministry of Foreign Affairs |
| MPA | Marine Protected Area |
| MPHRE | Ministry of Human Resources & Environment |
| MRS | Marine Research Section |
| MT | Ministry of Tourism |
| MTCA | Ministry of Transport & Civil Aviation |
| MTCC | Maldives Transport & Contracting Company (a subsidiary to MCPW) |
| MTI | Ministry of Trade & Industries |
| MWSA | Maldives Water & Sanitation Authority |
| NCPE | National Commission for the Protection of the Environment |

| | |
|---|---|
| NFEC | Non-Formal Education Center |
| NLS | Non-Living Substrate |
| NSS | National Security Service |
| O & M | Operation & Maintenance |
| PET | Poly-Ethylene Terephthalate |
| PHL | Public Health Laboratory (subordinate to MH) |
| PSI | Private Sector Involvement |
| PTA | Parent-Teacher Association |
| Rf | rufiyaa: currency unit of Maldives |
| SOE | State Owned Enterprise |
| SSP | Steel Sheet Pile |
| STO | State Trading Organization |
| STT | Special Task Team |
| SWM | Solid Waste Management |
| T/S | Transfer Station |
| TMS | Time Motion Study |
| WMS | Waste Management Section (MCPW) |

# *Part I. Master Plan*

# 1. STUDY FRAMEWORK

## 1.1 Objectives of the Study

The Scope of Work signed on 17th December, 1997 between the Ministry of Foreign Affairs, The Republic of Maldives and Japan International Cooperation Agency (JICA), Japan (hereinafter called the Scope of Work or SW in abbreviation) defines the objectives of the Study as follows.

(1) to recommend a national policy for solid waste management in Maldives;
(2) to formulate a solid waste management plan for Male City;
(3) to formulate an improvement plan for Thilafushi landfill site; and
(4) to pursue technology transfer to counterpart personnel in the course of the Study.

## 1.2 Study Area

The Study Area prescribed in the Scope of Work included the following areas;

- Male City including Villingili
- Thilafushi landfill site
- Selected inhabited islands

## 1.3 Types of Waste

Types of solid waste studied include household waste, market waste, commercial waste, public space sweeping waste, office waste, industrial waste and medical waste.

## 1.4 Organisation for Implementation of the Study

The Study was carried out as a joint study by the Study Team in cooperation with Maldives counterpart personnel. The counterpart personnel were designated from the Ministry of Construction and Public Works and Male' Municipality.

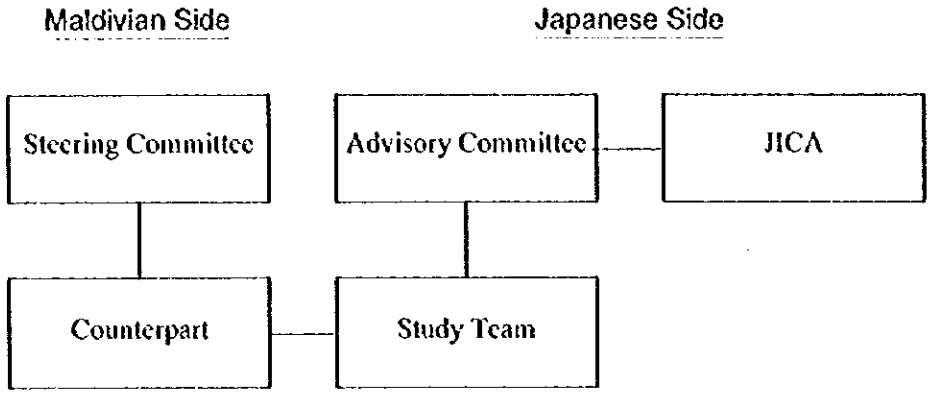



**Figure 1-1. Study Organizational Structure**

**Table 1-1. Study Team Members**

| | NAME | ASSIGNMENT |
|---|---|---|
| 1 | Kihachiro URUSHIBATA | Leader / Solid Waste Management Plan |
| 2 | Takashi GOTO | Collection / Transport Plan |
| 3 | Masaharu TAKASUGI | Solid Waste Characteristic / Quantity / Recycle |
| 4 | Akira HIDAKA | Solid Waste Management Facilities Design |
| 5 | Sadao ORISHIMO | Coastal Structure Design |
| 6 | Hiroyuki FUJIWARA | Institutional Building |
| 7 | Naomichi ISHIBASHI | Economic and Financial Evaluation |
| 8 | Hiromi NAMIKI | Construction Plan / Cost Estimation |
| 9 | Somasundaram JAYAMOHAN | Natural Environment Survey (1) |
| 10 | Akinori SATO | Natural Environment Survey (2) |
| 11 | Masashi HASEGAWA | Social Environment Survey |
| 12 | Takayuki ARAKI | Administration |

**Table 1-2. Advisory Committee Members**

| | NAME | ASSIGNMENT |
|---|---|---|
| 1 | Kenichi Tanaka | Chairman / Environmental Impact Assessment |
| 2 | Shuji Fujiwara | Solid Waste Management |
| 3 | Katsutoshi Kimura | Ocean Engineering |

## Table 1-3. Steering Committee Members

| | Name | Ministry | Position |
|---|---|---|---|
| 1 | Hon. Umar Zahir | Minister of Construction and Public Works (MCPW) | Chairman |
| 2 | Ahmed Latheef | Director General of External Resources, Department of External Resources, Ministry of Foreign Affairs | Committee member |
| 3 | Ismail Ibrahim | Deputy Director, Engineering, Ministry of Construction and Public Works (MCPW) | Committee member |
| 4 | Mohamed Latheef | Assistant Director, Operation, Ministry of Construction and Public Works (MCPW) | Committee member |
| 5 | Abdul Hameed Ali | Deputy Director, Male' Municipality Ministry of Home Affairs, Housing and Environment (MHAHE) | Committee member |
| 6 | Mohamed Hunaif | Deputy Director, Physical Planning, Ministry of Planning and National Development | Committee member |
| 7 | Azima Abdul Shukoor | Legal Officer, Environment Section, Ministry of Home Affairs, Housing and Environment | Committee member |
| 8 | Mohamed Farook | Director, Ministry of Atolls Administration | Committee member |
| 9 | Mohamed Rasheed Bari | Senior Engineer, Environment Health Section, Ministry of Health | Committee member |
| 10 | Moosa Zameer Hassan | Environment Analyst, Ministry of Tourism | Committee member |
| 11 | Abdulla Saleem | Deputy Director, Maldives Housing and Urban Development Board | Committee member |
| 12 | Ibrahim Mohamed | Director, Ministry of Finance and Treasury | Committee member |

**Table 1-4. Counterpart Team Members**

| Sector | Name | Organization | Position |
|---|---|---|---|
| Leader | Ismail Ibrahim | MCPW | Deputy Director, Engineering |
| Co-leader | Abdul Hameed Ali | Male' Municipality | Deputy Director |
| Waste Management | Abdul Hameed Ali | Male' Municipality | Deputy Director |
| | Mohamed Latheef | MCPW | Assistant Director |
| Facility Planning | Ismail Ibrahim | MCPW | Deputy Director, Engineering |
| | Mahjoob Shujau | | Civil Engineer |
| Natural Environment | Mohamed Aslam | MCPW | Oceanographer |
| | Ahamed Fazeel | MCPW | Construction Office Trainee |
| | Ajla Rasheed | MFAMR | Computer Operator Trainee |
| Social Environment | Nasrullah Haroon | Male' Municipality | Secretary |
| | Hussain Ibrahim | | Data Processing Trainee |
| Institution | Ahmed Ashraf | MCPW | Assistant Director |
| | Abdul Hameed Ali | Male' Municipality | Deputy Director |
| Finance | Ahmed Ashraf | MCPW | Assistant Director |

Note: MFAMR (Ministry of Fishery, Agriculture and Marine Resources)

## 1.5 Study Schedule and Reports

The Master Plan Study on solid waste management was conducted from May 1998 to September 1998, followed by Feasibility Study on solid waste management improvement in the capital region of Maldives, principally in Male, until February 1999.

The reports of the entire Study are as follows:

i) Main Report

ii) Summary Report

iii) Environmental Impact Statement (EIS)

iv) Supporting Report

v) Data Book

# 2 PRESENT SITUATION OF SOLID WASTE MANAGEMENT (SWM)

## 2.1 Legal Basis of SWM

### 2.1.1 Basic Law and Derivative Legislation

#### (1) Legal Basis of SWM at National Level

##### a. Overview

Laws and regulations concerning solid waste management are very few at the national level.

As of today, no comprehensive law on SWM is legislated today in Maldives.

The ENVIRONMEMT PROTECTION AND PRESERVATION ACT OF MALDIVES (Law No. 4/93) is a basic that prescribes the management and control of specific wastes as harmful waste and hazardous waste.
There are two tourism regulations that prescribe garbage control and SWM in the tourist resorts. Those regulations of the Ministry of Tourism, the SANITATION REGULATION and the REGULATION ON DISPOSAL OF GARBAGE are definite provision for the tourism sector.

##### b. The ENVIRONEMT PROTECION AND PRESERVATION ACT OF MALDIVES

The act is composed of the following ten clauses.

| | |
|---|---|
| Clause 1 | Introduction |
| Clause 2 | Environmental Guidance |
| Clause 3 | Environmental Protection and Conservation |
| Clause 4 | Protected Area and Natural Reserves |
| Clause 5 | Environment Impact Assessment (EIA) |
| Clause 6 | The Termination of Projects |
| Clause 7 | Waste Disposal, Oil, Poisonous Substances |
| Clause 8 | Hazardous/ Toxic or Nuclear Wastes |
| Clause 9 | The Penalty for Breaking the Law and Environment |
| Clause 10 | Compensation |

Clause 7, 8, 9, 10 of the act prescribe SWM of specific wastes as mentioned below.

*Waste Disposal, Oil, Poisonous Substances*

Clause 7

(a) Any type of waste, oil, poisonous gases or any substances that may have harmful effects on the environment shall not be disposed within the territory of the Maldives.

(b) In case where the disposal of the substance started in paragraph (a) of this clause become absolutely necessary, they shall be disposed only within the areas designated for the purpose by the government. If such waste is to be incinerated, appropriate precaution should be taken to avoid any harm to the public health.

*Hazardous / Toxic or Nuclear wastes*

Clause 8

Hazardous/ Toxic Nuclear Waste that is harmful to human health and the environment shall not be disposed anywhere within the territory of the country. Permission should be obtained from the Ministry of Transport and Shipping at least 3 months in advance for any transboundary movement of such wastes through the territory of the Maldives.

*The Penalty for Braking the Law and Damaging the Environment*

Clause 9

(a) The penalty for minor offences in breach of this law or any regulations made under this law, shall be a fine ranging between Rf. 5.00 (five Rufiyaa) and Rf. 500.00 (five hundred Rufiyaa), depending on the actual gravity of the offence. The fines shall be levied by the Ministry of Planning, Human Resources and Environment or by any other government authority designated by that ministry.

(b) Except for those offences that are stated in (a) of this clause, all major offences under this law shall carry a fine of not more than Rf. 100,000,000 (one hundred million Rufiyaa) depending on the seriousness of the offence. The Ministry of Planning, Human Resources and Environment shall levy the fine.

*Compensation*

Clause 10

The government of the Maldives reserves right to claim compensation for all damages caused by activities that are detrimental to the environment. This includes all the activities that are mentioned in clause No.7 of the law as well as those activities that taken place outside the projects that are identified here as environmentally damaging.

**e. Tourism Regulations**

Two tourism regulations concerning solid waste management have been enacted to keep sanitation of the tourist resort facilities and sustainable and sound environment of resort islands.

## TOURISM REGULATION ON SANITATION OF TOURIST RESORTS

Although the major portion of responsibility for the tourists health protection resides with the individual, the tourism establishment owner, however must accept a large measure of responsibility for creating an environment free from disease, special attention has to be paid to food and water, especially drinking water.

Water can be a medium for the transmission of many diseases including typhoid, paratyphoid, dysentery, infectious hepatitis, cholera and gastroenteritis.

Hence the need for protection of water and food against contamination is important.

Therefore, the criteria developed in the following regulation with regard to the protection of water, food, waste materials, and the surrounding in which the tourist establishment is located, should be closely observed.

### i) Administration

At least one competent person should be engaged in every tourist establishment to check on proper standard in all areas mentioned below.

1. Keeping the grounds, the building and the facilities clean and well maintained.
2. Ensure the proper functioning of the water system, and human waste disposal system.
3. Ensure cleanliness of the beach and other areas in general.
4. Ensure cleanliness of toilets, showers and laundries.
5. Ensure proper functioning and cleanliness of freezers, refrigerators, ice rooms, cooking utensils and dish washing facilities.
6. Ensure regular and sanitary disposal of refuse and garbage.
7. Inspect the work done to control insect and rodents.
8. Ensure that suitable arrangements made for medical attention for the guests and staff at the tourist resort/hotel.

### ii) Refuse Handling and Disposals

1. All public areas should be swept and cleaned at least once a day.
2. Refuse containers should be kept closed at all times.
3. Refuse should be disposed of daily.

iii) **Insect and Rodent Control**

1. Garbage and refuse, after accumulation or collection, should be kept closed containers.

TOURISM REGULATION ON DISPOSAL OF GARBAGE OF TOURIST RESORT

1. Garbage from tourist resorts should be disposed of in a manner that would not cause any damage to the environment.
2. All garbage disposed into the sea should be done as far away in to the sea as necessary in order to ensure that it doesn't get washed on to any island with current.
3. Empty cans should be compressed and bottles should be broken into small peace before disposing into the sea.
4. Plastic bags should not be thrown into the sea. These must be burnt.
5. Those who contravene this regulation will be fined. The amount shall vary between Rf. 100 and Rf. 2,000 depending on the facts and circumstances. If contravention of this regulation is repeated the fine shall be doubled.
6. Tourist resorts are required to have incinerators and compactors adequate in size to burn all flammable materials and crush all the cans respectively. Those who lack these facilities will not be allowed to operate.

**(2) Legal Basis of SWM at Local Level**

The Male' Municipality provides a regulation which prescribes cleansing and SWM of Male'. There is no local legal provision for SWM of the inhabited islands at all.

**a. Solid Waste Related By-law of the Male' Municipality**

- The Municipality is responsible for cleansing of the public spaces and for collection of wastes in the public areas.
- Nobody should be allowed to throw away solid waste into the place other than the refuse containers settled or to the transfer station (the depot).
- Anybody should clean the street in front of his/her house at least once a day.
- Those who contravene this by-law will be punished by this by-law.

Though the Municipality provides garbage collection service to all parties upon payment, any legal arrangement is not provided for this business oriented services.

### (3) Evaluation of Legislative Arrangement

There are some SWM related activities being not provided by the existing laws and regulations. Table 2-1 is summary of the situation of the legislative arrangement on such SWM activities in Maldives. Existing laws and regulations do not cover such field of activities as shown below:

1. Garbage collection services of the Municipality
2. Disposal of waste transferred from some resorts islands to Thilafushi
3. Disposal of waste transferred from Male' and Villingili to Thilafushi
4. Sea transportation of waste from some resort islands to Thilafushi
5. Garbage collection services of the private sector and individual collectors
6. Throwing and dumping of waste of inhabited islands community
7. Incineration of hospital waste in Male' and Atolls

**Table 2-1. Legal Arrangement on SWM**

| Activities | Gov. Authorities | Private Involvement | Waste Generators |
|---|---|---|---|
| Collection of Waste | | | |
| Harmful waste | | | Yes |
| Resort Islands | | No | Yes |
| The Municipality | No (Yes) | No | Yes |
| Inhabited Islands | | | No |
| Disposal of Waste | | | |
| Harmful waste | | | Yes |
| Resort Islands | No | | Yes |
| The Municipality | No | | No |
| Inhabited Islands | No | | No |

(Note) Yes; activities with legal base, No; activities without legal base

Technical regulations are quite few in the country. There is no act or regulation to prescribe technical aspects of SWM.

There are few laws and regulations provided to prescribe right and duties of the responsible government authorities.

## 2.1.2 Responsibility of Concerning Bodies

### (1) Overview of Concerning Bodies

Existing SWM concerning bodies can be classified into three categories of government agencies, private sector and waste generators.

Many central ministries and local government agencies concerned could be classified in regulatory organisms and execution organisms (Table 2-2).

Private sector which are involved in SWM are one private company which runs a collection business in Male', number of individual collectors in Male' and some individual dhoni owners employed by tourist resorts for waste transport services.

As any regulation or permission is not provided for private involvement, the numbers of private sectors involved seems to be adjusted according to the profitability. All parties such as government organs, social organs, private business entities and households are waste generators by themselves and most of them carry on SWM by themselves.

From the legal aspect, only waste generators are controlled by the existing SWM relating laws and regulations. On the other hand, other two categories, government agencies and private involves, may be free from legal duties at present, may be covered by new law for their SWM works.

**Table 2-2. Government Agencies Responsible for SWM**

| Name of agencies | Function | Main field of responsibility |
|---|---|---|
| Ministry of Planning, Human Resources and Environment (MPHRE) | Regulatory | Harmful waste |
| Ministry of Home Affairs | Regulatory | Waste of the Municipality |
| Ministry of Atolls Administration | Regulatory | Waste of inhabited islands |
| Ministry of Construction and Public Works (MCPW) | Execution | Disposal of waste |
| Ministry of Tourism | Regulatory | Waste of tourist resorts |
| Ministry of Health | Regulatory | Hospital waste |
| Ministry of Trade & Industries | Regulatory | Package material, export for recycle |
| Ministry of Fisheries & Agriculture | Regulatory | Fish viscera |
| Male' Municipality | Execution | Collection in Male' public areas |
| Maldives Housing & Urban Development Board | Execution | Collection in Villingili public area |
| Island Office | Execution | Coordination in inhabited islands |

### (2) Leadership and Cooperation of Government Agencies Concerned

#### a. Responsible Agencies for the Fifth National 3 Year Plan

Under the ongoing National Development Plan, strategic plans for solid waste disposal area are being carried on by various government agencies concerned.

It is quite common to introduce a formation of lead and support agencies to carry and implement those strategic plans. The MPHRE is the lead agency for national level strategies and Ministry of Atolls Administration and Home Affairs are the leaders at local level ones.

**Table 2-3. Responsible Agencies for SWM in the Fifth National 3-year Plan**

| Strategy | Lead Agency | Support Agency |
|---|---|---|
| 4.5.10. | MPHRE | Atolls, Fisheries |
| 4.5.11. | MPHRE | Trade & Industries |
| 4.5.12. | Atolls, Home Affairs | MCPW, Fisheries, Information |
| 4.5.13. | Atolls, Home Affairs | MCPW, Fisheries, Information |
| 4.5.14. | MPHRE, Trade, Attorney General's Office | Finance (custom) |

(Note) contents of strategies;

4.5.10. Development and implement a plan for solid waste management

4.5.11. Restrict importation of non degradable products

4.5.12. Encourage household waste sorting, use of waste collection depots and potential opportunities to export waste for recycling.

4.5.13. Encourage municipal and island level composting of appropriate organic waste to improve soil fertility.

4.5.14. Development and implement regulation, pricing incentive and other mechanism to minimizes the generation of waste materials.

#### b. Responsible Agencies of "Environmental Action Plan"

MPHRE and the Ministry of Atolls Administration will take a major role in the Environmental Action Plan. MPHRE is appointed to the lead agency in development and implementation of SWM in the Fifth National 3 Year Plan, hence the Ministry is regarded as the responsible body for environmental pollution cause by inadequate SWM. Meanwhile, the Ministry of Atolls Administration is responsible for maintaining the quality of environment and sanitation in the local communities. Supporting agencies, the Ministry of Health, Education, Foreign Affairs, Construction and Public Works, the Municipality and the Maldives Housing and Urban Development Board, are given the supporting role in SWM in technical aspects and mobilization of the resources.

## 2.2 Responsible Body for SWM and Organization

### 2.2.1 Male'

#### (1) Outline of SWM in Male'

The responsibility of the Male Municipality extends collection of the waste of the public spaces and operation on the refuse containers those are placed around Male'.

The responsible bodies are, from the legal point of view, all parties as household, business entities, government offices, hospitals and so on. They should dispose by themselves or entrust garbage collectors to dispose their waste. In other words everybody should dispose waste upon the self –responsibility base.

Government authority concerned designates and provides disposing places. Now 21 refuse containers of the Municipality which are placed in 9 spots along the outer ring road and the depot of the MCPW are available for dumping.

In Male' 3 types of collection services are available. Those are provided by the Community Service Section of the Municipality, a private company named I.H.F. Carpentry and numbers of individual collectors. Those services are costly so that those collectors have small numbers of clients to date.

The SWM Section of the MCPW takes charge of disposal of solid waste. This section is responsible for transferring waste from the depot to Thilafushi (final disposal site).

Though almost all waste of Male' are in the end disposed in Thilafushi, some amount of hospital waste are incinerated by incinerators of the hospitals.

#### (2) The Male Municipality (the Community Services Section)

##### i) Scope of services

The Municipality is in charge of following services:

- management of refuse containers
- door to door collection of garbage on charges
- cleansing of public facilities (markets, public toilets etc.), road, parks, beach, graveyard etc.;
- maintenance of streetlights
- maintenance of street trees

##### ii) Management of Refuse Containers

The Municipality is responsible for management of refuse containers.
The Municipality places 21 refuse containers at 9 selected spots along the outer

ring road of Male'.
The Municipality collects the waste of refuse containers by the special container pick-up vehicles from 6.00am 5.30/6.00 p.m. Each container turns about 3 times per day. Total daily collection amount of waste is estimate by the section as about 9 tons.

According to the Deputy Director in charge following two problems are serious; (1) Two of five vehicles have been out of order for long period because of procurement bottleneck of its unique spare-parts. Moreover, road-running performance of the vehicle is inferior from the design reason. (2) Odor from refuse containers makes the section negative to place containers in the streets or in the residential areas.

### iii) Door to Door Collection

The Municipality has carried a door to door collection services since 1995 by taking over the MTCC's such business. Present situation of the services is as shown below.

| Numbers of Contract | |
|---|---|
| Household | 294 |
| Government office | 72 |
| Business | 41 |
| Total | 417 |

*Service hour : 7.30 am – 5.30/6.00
*Collection volume : about 30 t/day
*Vehicles : 2 units

### iv) Tariff of Collection Service

(Unit: Rf / month)

| | Collection charge | Rental charge of additional dustbin (option) |
|---|---|---|
| Once a week | 120 | 96 |
| Twice a week | 160 | 124 |
| 3 times a week | 200 | 160 |
| Daily | 400 | 320 |

(Note)
*One 25 litters of dustbin is rented free of charge
*Charge should be paid monthly to the cashier of the Municipality.
*Client should submit the application to the Chairman of the Municipality.

Deputy Director in charge points out the following negative points;

1. The expansion of the service is difficult because of limited resources such as vehicle and manpower.

2. The large vehicle blocks the road during stopping on the collection spots results in terrible traffic congestion.

**v) Collection of Waste of the Public Spaces**

The Municipality places 36 dustbins around public places of Male'. Collection of the waste of these dustbins is carried every day from 6.00am to evening by the small tractors.

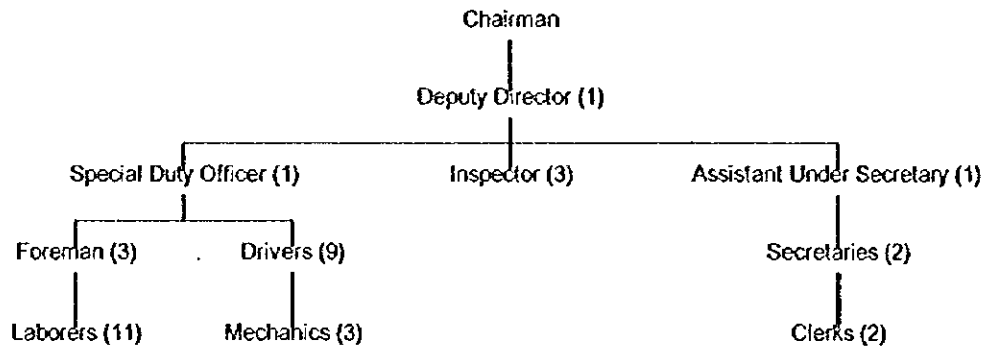
**vi) Enforcement of the Regulation**

Each ward of the Municipality employs 9 inspectors to enforce the Municipality Regulation on Cleansing and SWM. Offenders shall be punished in correlating with number of times of breach. A few breaches of regulation have been observed in these years.

First time offence : oral advice
Second time offence : written warning
Third time offence : fine by court
Fourth time offence : banishment by court

**vii) Organization and Personnel of the Community Service Section**

With large number of personnel among 5 sections of the Municipality, the Community Service Section is organized as shown below:




(Note) Figures in parentheses are number of personnel

### (3) The MCPW (the Solid Waste Management Section)

#### i) Scope of works

The SWM section is in charge of following works:

- management of the Male' depot
- operation and maintenance of trucks, landing crafts (barges), heavy machines
- sorting of waste for recycling
- sales of recycling material
- transfer of waste from the Male' and Vilingili depots to Thilafushi
- unloading and disposal of waste brought from adjacent resort islands and others
- burying of waste at Thilafushi
- land reclamation of Thilafushi
- leasing of plot of Thilafushi
- poultry farming in Thilafushi

#### ii) Acceptance and Storage of Waste

The Male' depot accepts actually all kinds of waste from all parties of Male'. The SWM section is fully responsible for transfer of those wastes from the depot to Thilafushi. A large mountainous pile of the waste caused by the imbalance between inflow and outflow of waste is being remained in the depot for long period until now.

#### iii) Transfer and Disposal of Waste

Transfer and disposal of the waste are the most important role of the section. The section carries out those works every day from early morning to evening by using of 10 trucks and 2 barges. However, the existing balance between those two kinds of measures brings inefficiency on the work, and could be improved to large extent if 22 trucks could be applied to this sequence of the work, according to the Assistant Director of the section.

### iv) Organization and Personnel of the SWM Section of MCPW

| Workshop | | Thilafushi | | Administration |
|---|---|---|---|---|
| Driver | 25 | Supervisor | 1 | Senior Administration 1 |
| Helper | 25 | Operator | 3 | Officer |
| | | Operator - helper | 3 | |
| | | Labor | 25 | |
| Male Depot | | Vessels | | |
| Supervisor | 1 | Captain | 3 | |
| Operator | 3 | Crew | 24 | |
| Operator - helper | 3 | | | |
| Labor | 4 | | | |

## 2.2.2 Airport Island

### (1) Outline of SWM in the Airport Island (the Male' International Airport)

This island was developed as the Male' International Airport, and is managed by the Maldives Airport Authority. This island is a self-contained unit with full set of own utility facilities.

For the SWM purpose one incinerator, can compactors, bottle crashers, and large trucks are equipped. There are open land spaces in the island and some areas are used for stockyard of iron scraps, construction debris and transfer station of general waste.
The Authority organizes the Maintenance Department with numbers of staff and labors. One section of the department is in charge of island's SWM for full range of activities starting from collection to disposal.

The Authority also carries out the collection service for its tenants on charges.
General waste, which is, generated about 8 tons daily in the island is transferred by the dhonies to Thilafushi everyday. Construction debris is stored in the yard to be reused in the island. Iron scraps are stored in the yard for a period to form an accumulation being enough to be exported through an international bidding.

## 2.2.3 Vilingili Island

### (1) Outline of SWM in Vilingili Island

Villingili Island is the new urban development area where Maldivian Government has been developing a new town since 1993. 286 houses, a shipbuilding, a carpentry workshop, an elementary school and two mosques are already constructed and more than 1,800 people inhabit in the island as of today.

Moreover, the island which had once been a famous tourist resort for foreign tourist becomes today the most popular tourist spot for local people and many Male' citizens visit here on every holiday.

Though the legal basis is not yet arranged, practice of the SWM is established as fundamentally same as that of Male'. In other words, cleansing and SWM of the public spaces are governmental responsibility and those of other places are inhabitant's self-responsibility.

At present the Maldives Housing and Urban Development Board, the execution body of the Villingili development project, is responsible for cleansing and SWM of the public spaces of the islands.

As refuse containers are not provided and collection service is not found in this island, inhabitants are in more inconvenient position than that the citizens of Male'.

There is one transfer station in the island. The MCPW takes charge of transfer of waste to Thilafushi.

**(2) The Maldives Housing and Urban Development Board (the Villingili Project section)**

**i) Objective of the Organization**

1. Development of Vilingili Island
2. Reclamation of reefs
3. Re-development of Male'
4. Housing plot development

**ii) Solid Waste Management**

Villingili Project Office of the Board takes charge of cleansing and SWM of the public spaces. The Board places 6 dustbins for tourists in the public area. Waste of the area is collected by means of one handcart at every beginning of the week.

Organization for cleaning, SWM and other maintenance works consists of 2 foremen, 10 crafts and 20 labors.

| Organization and Personnel of the Villingili Project Section |
|---|
| Director General (0) |
| Director (1) |
| Deputy Director (1) |
| Villingili Project Section |
| Senior Project Coordinator (0) |
| Site Manager (1) |
| Secretary (1) |
| Clerk (1) |
| Foreman (2) |
| Craft (10) |
| Labor (20) |

(Note) Figures in parentheses are the number of personnel

### (3) MCPW (the Solid Waste Management Section)

The MCPW carries empty trucks to Villingili by a landing craft, and loads waste on trucks and again carry those to Thilafushi. The SWM Section of the MCPW transfers waste of Villingili twice a week.

The MCPW has a future organization plan for Villingili depot as shown below.

| | |
|---|---|
| Supervisor | 1 |
| Operator | 2 |
| Operator helper | 2 |
| Labor | 4 |

### (4) Transfer of the Administration

After the completion of the Villingili Development Project, the administrative authority of the area would be transferred to Male' Municipality from the Maldives Housing and Urban Development Board.

This means that Viliingili would be administered as the fifth ward of the Municipality and same kind of public services on SWM would be applied to Villingili as those of other four wards of the Municipality in the very near future.

### 2.2.4 Resort Islands

#### (1) Outline of SWM of the Resort Islands

Maldives resort islands are sophisticated tourist resorts those established through the schematic development of the small-uninhabited islands.

Each resort island is developed as a kind of self contained unit which is managed and operated by tourist resort owner independently in economic, social and infrastructure provision aspects.

The resort enterprises are completely responsible for SWM of their managing island. They carry their SWM by themselves in accordance with the tourism law and regulations.

On one hand, the Ministry of Tourism plays so important role in the guidance to and support for the tourism industries, as they are able to develop and improve the quality of sanitation of their tourist resorts.

Both the policy measures such as the legislative arrangement and the financial subsidies for introduction of incinerators might brought considerable effects on the levels of sanitation and solid waste management of the tourism resources.

On the other hand, the resort enterprises have been making effort in SWM and environmental preservation as their key strategies to improve the image and alternative of their tourism resources.

Fortunately, because a high growth of the foreign tourist arrival results fair business performance of the tourism industries, those enterprises can afford to pay for substantial investment and operation and maintenance costs of their SWM to the extent to catch and international level of quality.

Final disposal of solid waste of the resort islands is carried out by the incineration or by the dumping into the sea in accordance with the regulations today. Some resort islands bring a part of their waste to Thilafushi with appreciation in comparison with conventional methods.

#### (2) The Ministry of Tourism

The Ministry of Tourism is not responsible for the SWM of resorts but the Ministry carries out the regulatory functions of the Government for tourism sector.

**i) Scope of Works**

- Plans for the development of the tourism industry
- Develops options for collecting revenue from tourism

- Formulates and enforces regulations for tourism industry

**ii) Legislation of Law and Regulations**

- The Law of the Tourism in Maldives (Law No. 15/79)
- The Regulation on Sanitation
- The Regulation of Solid Waste Management

Ministry of Tourism is currently updating the existing tourism regulations. The new guidelines will take into consideration any national SWM guidelines for tourist resorts, to be inline with the national policy.

**iii) Waste Management Project (a financial assistance scheme)**

Under this project, incinerators are supplied to Maldivian tourist resorts under a mixed-credit-financing scheme from the Norwegian government. Under this scheme, 15% of the cost of the unit has to be paid to the supplier in advance. Half of the remaining 85% are a grant, and the remainder is a loan to be in ten installments over a five-year period.

The necessary agreements for implementation of this project were signed in March 1994. The total cost of the projects is 17.7 million Norwegian Krone (approximately US $ 2.7 million at current exchange rate), for 70 units. The amount, however, depend on the actual number of incinerators supplied under the scheme.
The incinerators are supplied to the resorts under a hire-purchase scheme.

It is acquired Norwegian made sewage treatment plants to tourist resorts under a similar financing scheme, utilizing the remaining funds of the project once all incinerator orders are placed.

**(3) Plan for Resort Environmental improvement Measures (Tourism Master Plan 1996- 2005)**

**i) Resort Infrastructure Standards**

At the level of the resort, the recommended approach is to allow different type of infrastructure provision but to regularize and maintain standards of performance irrespective of the technology used. Choice of equipment should be left to the individual but all systems adopted for infrastructure must be acceptable within the confines of a performance specification.

Currently the Law on Tourism in Maldives (Law No. 15/79) sets out basic sanitary provisions emphasizing the importance of creating a health environment that is free from disease. It is proposed that these should be reviewed and re-drafted in the form of performance specifications which could be drawn up more

stringently than at present. Specifications should be made for the main items of infrastructure, namely: -

- Water cycle
- Solid waste management
- Energy

The prime objectives of this approach would be to improve the safety and efficiency as well as installing better environmental protection and prevention measures.

**ii) Organization**

The Ministry of Tourism does not establish any organization in charge of the SWM of resort islands concerned.

**(4) Tourism Industry**

**i) Facilities of the SWM**

- Own incinerator (65 Kvaerner Golar Incinerator units)
- Own can compactor
- Own bottle crasher

**ii) Tourism Resorts Depend on Thilafushi**

- GIRAAVARU Tourist Resort
- FULL MOON Beach Resort
- KURUMBA Village
- BANDOS Island Resort
- Banyan Tree Maldives VABBINFARU
- KANIFINOLHU Resort
- PARADISE Island

### 2.2.5 Inhabited Islands

**(1) Outline of SWM in the Inhabited Islands**

Informative data and materials on SWM of the whole inhabited islands are not available at present time.

Following information gotten through interview survey of the study team at THULUSDHOO island (North Male' Atoll) is reported as an example of SWM in the inhabited islands.

There is one dumping site, available for all parties such as households, shops, restaurants, manufacturing factories etc., The island office is responsible for the

management of the dumping site, and all parties dump their waste to this site freely due to the open door management policy of the office.

As people throw solid waste away in easy accesses spots, waste is often scattered around the dumping site.

When the dispersion of the waste became severe in the circumference, the island office used to ask the island community to clean around the place.

A manufacturing factory is treating its garbage by kind in three ways; burning of carbon board etc., in the open pit of the dumping site, dumping of general garbage to the site, and transfer of non-degradable garbage to Thilafushi by its own dhoni. Because there is no regulation, this waste management is carried out on the factory's own decision.

The projects in high priority of this island those are supported by the central government subsidy are construction of elementary school, road and jetty. There is a certain possibility for this island to ask and get government's support for SWM facilities after completion of the projects mentioned above according to the island office.

### (2) Ministry of Atolls Administration

The Constitution recognizes only one tier of Government in the country; the Government of the Republic of Maldives. However, the government recognizes the historical and on-going importance of the Atolls as the basic unit for administration with the appointment of Atoll and Island Chiefs to Atoll and Island Offices respectively. The Ministry of Atoll Administration and its Northern and Southern Regional Offices, Atoll Offices and Island Offices are collectively responsible to the President for Atoll Administration. (5th National 3 year plan)

#### i) Scope of Works

The Ministry of Atolls Administration;

- Supervises duties carried out by Atoll and Island Chiefs
- Looks after state land in the Atolls
- Carries out all function in Atolls not directory the responsibility of other offices
- Promotes the socio-economic development of the Atolls

#### ii) Solid Waste Management

In the 5th 3 year National Plan the Ministry is taking charge of the lead agency in two strategic plans and the support agency in one plan. However, because there are many priority projects such as construction of island office, island courts, mosques, road, jetties, schools, community centres, island electrification projects, apparently SWM project of rural area does not seem to be carried out.

### (3) Ministry of Health and Welfare

SWM of Local Hospitals

All four local hospitals incinerate their hospital waste. Ministry of Health is not confident on the performance capacity of these incinerators, which were introduced by the selection decided mainly on economic reason. The Ministry needs a technical support to carry on inspection and advice for the hospitals, right now.

## 2.3 Budget Allocation for SWM

### 2.3.1 Male'

#### (1) Collection of Solid Waste

At present, the collection of solid waste in the Male' Island is carried out by the Male' Municipality, two private companies and some 30 individuals.

However, they do not cover all households, establishments and institutions. As of 1997 there were 6,670 houses, 104 government offices and 248 private businesses, of which about one third are estimated to be their clients.

The remaining two thirds are considered to take their garbage by themselves to the 9 transfer stations and the depot located at the rims of the island.

Male' Municipality's clients are 294 houses, 72 government offices and 41 businesses.

Institutionally, the Community Services Section of the Male' Municipality is in charge of solid waste collection. This section is one of five sections composing the municipality, the other four being the Administration and Budget Section, Foreign Relations Section, Land Distribution and Mapping Section and House Registration and Birth Certificates Section.

The expenditure budget of the Male' Municipality and the expenditure of the Community Services Section for eight years from 1990 to 1997 are summarized hereunder.

Unit: Rf. thousand

| Item | 1990 | 1991 | 1992 | 1993 |
|---|---|---|---|---|
| Expenditure Budget of Male' Municipality (A) | 8,761 | 8,993 | 9,041 | 9,246 |
| Expenditure of Community Services Section (B) | 2,537 | 6,886 | 3,448 | 1,571 |
| B/A x 100 | 29.0 | 76.6 | 38.1 | 17.0 |

Unit: Rf. thousand

| Item | 1994 | 1995 | 1996 | 1997 |
|---|---|---|---|---|
| Expenditure Budget of Male' Municipality (A) | 9,684 | 9,907 | 10,685 | 13,665 |
| Expenditure of Community Services Section (B) | 1,645 | 943 | 2,253 | 4,263 |
| B/A x 100 | 17.0 | 9.5 | 21.1 | 31.2 |

As the above tables show, the expenditure budget of the Male' Municipality is on the whole increasing steadily every year, having exceeded Rf. ten million from 1996 onward.

The 8 year average of the municipality's expenditure budget works out to Rf. 9,998 thousand. Of it, recurrent and capital expenditures were Rf. 6,849 thousand and Rf. 3,149 thousand, accounting for 68.5% and 31.5% respectively. (Refer to Table 1 in Supporting Report G.)

"Personnel" and "Communications" occupy the major part of the recurrent expenditure, and "Vehicles", "Land & Property" and "Road Construction, Water, Toilets & Sanitation" account for the major percentage of the capital expenditure. (Refer to Table 1 in Supporting Report G.)

The expenditure of the Community Services Section appears to fluctuate irregularly, the 8 year average coming to Rf. 2,943 thousand. The 8 year average of the share of the expenditure of the above section in the total municipality budget works out to 29.9%.

The expenditure items of this section include "Road lights", "Construction of fish market", "Garbage collection and disposal", "Cemetery renovation", "Road lights for Villingili" and "Maintenance of vehicles". (Refer to Table 2 in Supporting Report G.)

The revenue of the Male' Municipality from 1990 to 1997 is presented below.

Unit: Rf. thousand

| 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 |
|---|---|---|---|---|---|---|---|
| 1,332 | 1,777 | 2,105 | 2,699 | 2,757 | 2,670 | 3,340 | 3,984 |

As the table shows, the revenue is on the whole increasing every year, exceeding Rf. 3 million from 1996 onward. The 8 year average of the revenue comes to Rf. 2,583 thousand, which constitutes 25.8% of that of the expenditure budget.

The revenue items include "Rent from flats", "Rent from buildings", "Rent from land, "Waste collection fee", "Rent from markets", "Public toilets" and "Fines". (Refer to Table 3 in Supporting Report G.)

### (2) Disposal of Solid Waste

The solid waste gathered at the depot is loaded on several numbers of trucks, the latter are transported in a barge to the Thilafushi Island, and the solid waste is unloaded there to be used for reclamation. This is repeated several times a day.

The Waste Management Section of the Ministry of Construction and Public Works (MCPW) has been in charge of solid waste disposal since 1994. Before that time the

Male' Municipality was responsible for the disposal as well as the collection of solid waste.

This section is also in charge of solid waste disposal in the Villingili Island similar to that of the Male' Island.

The expenditure budget of MCPW for 8 years from 1990 to 1997 is shown below.

Unit: Rf. thousand

| 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 |
|---|---|---|---|---|---|---|---|
| 27,289 | 38,834 | 48,014 | 36,208 | 42,020 | 64,185 | 73,002 | 107,971 |

As the above table shows, the budget is on the whole increasing, surpassing Rf. 100 million for the first time in 1997.

The expenditure budget of MCPW, that of the Waste Management Section and their comparison for the four years from 1994 to 1997 are tabulated below.

Unit: Rf. thousand

| Item | 1994 | 1995 | 1996 | 1997 |
|---|---|---|---|---|
| Ministry of Construction and Public Works (A) | 42,020 | 64,185 | 73,002 | 107,971 |
| Waste Management Section (B) | 3,445 | 3,143 | 5,765 | 7,933 |
| B/A x 100 | 8.2 | 4.9 | 7.9 | 7.3 |

As the above table shows, the four year average of the expenditure budget of MCPW is calculated at Rf. 71,795 thousand.

Of it, "Ministry" and "Projects" were Rf. 34,297 thousand and Rf. 37,498 thousand, accounting for 47.8% and 52.2% respectively. (Refer to Table 4 in Supporting Report G.)

The expenditure budget of the Waste Management Section is on the whole increasing every year, reaching Rf. 7,933 thousand in 1997. The four year average comes to Rf. 5,052 thousand.

Of it, recurrent and capital expenditures were Rf. 3,980 thousand and Rf. 1,072 thousand, accounting for 78.8% and 21.2% respectively. In 1997 the capital expenditure reached Rf. 2,989, occupying 37.7% of the total budget. (Refer to Table 5 in Supporting Report G.)

"Expenditure stock" and "Employee expenditure" are the two major items influencing the recurrent expenditure, while "Vehicles", "Buildings", "Road & harbor and "Machinery & heavy equipment" are the important items controlling the capital expenditure. (Refer to Table 5 in Supporting Report G.)

The Waste Management Section's share in the expenditure budget of MCPW is 7.1% on average.

### 2.3.2 Airport Island

Solid waste generated from the air passengers, employees of Maldives Airports Authority, etc. in the Hulhule Island reaches something like 4 to 7 tonnes per day. It is transported to the Thilafushi Island twice a day.

No public budget is allocated to the solid waste management in this island.

The Maldives Airports Authority is legally responsible for the collection and disposal of solid waste, and it appears that the authority is financially quite capable of it.

### 2.3.3 Villingili Island

At present 32 people composed of 16 Sri Lankans, 3 Bangladeshis and 13 Maldivians work for the cleaning of public areas such as road and parks under the Maldives Housing and Urban Development Board. Their work includes solid waste management.

Rf. 1,500 is said to be paid per such worker on average, the annual cost coming to Rf. 576,000. It derives from the public budget.

Institutionally, the Villingili Island is going to be put under the jurisdiction of the Male Administration in the near future.

### 2.3.4 Resort Island

No public budget is allocated for the solid waste management of resort islands. The management of a resort island are legally responsible for the collection and disposal of solid waste. They are obliged to install the incinerator under the law.

Aware of the implications of a good solid waste management on tourism, they are usually highly motivated in this connection having an efficient workforce and collection/disposal system. Behind it, lies financial success of resort business in general.

### 2.3.5 Inhabited Island

No public budget is allocated for the solid waste management in inhabited islands.

The budget for such purpose is appropriated from the account of the Island Development Committee (IDC) and the Atoll Development Committee (ADC). Those committees collect revenue from such sources as trading licences, vehicle registration fees, land rents, income from atoll and community shops, income from shares in Bank of Maldives, and interest from funds on deposit.

Committee people are usually aware that solid waste presents hazardous problems and they have to improve disposal measures to meet the current standards, and they are ready to spend money using committee resources.

## 2.4 Collection and Transport System of Solid Waste

### 2.4.1 General

The field studies of collection and transport system was carried out for the areas in (1) Male', (2) Adjacent Island to Male', (3) Resort Island and (4) Inhabited Island.

Collection system is not required in most of the inhabited islands except for Male' and some large islands of the Atoll centres, because most of islands are very small and the short distance to the disposal site. Solid waste is brought into the site easily by the residents by themselves. In Male', the collection services are provided by the Male' Municipality and private companies.

Transportation system is not required except for Male' metropolitan area and the resort islands, because all inhabited islands have disposal site in each island. In Male' metropolitan area, Ministry of Construction and Public Works (MCPW) is responsible for transportation (from the Transfer Station in Male' and Villingili island to the Thilafusi disposal site) of solid waste generated in the Metropolitan area and management of the final disposal site. Waste Management Section (WMS) of MCPW carry out the practical activities of the transportation and final disposal of the waste.

The current conditions and problems of the collection and transport system in these islands are mentioned as below.

### 2.4.2 Current Condition of Collection System

#### (1) Legal Basis of Collection System

- The national level laws and the Male Municipality By-law concerned with SWM is described in "Supporting Report, Section A Collection" and "Master Plan, Section 2.1 Legal Bases of SWM".

#### (2) Present Situation of Collection System

**a. Male'**

**i) Condition of Waste Discharged**

In the Male Municipality area, the municipal waste from house, office, shop, market, restaurant and etc. is not separated.

The major separation activities are observed with the industrial waste and public work waste because these activities will produce a large volume and homogeneous waste. The major separated waste is construction waste and iron-scraps. The construction waste will be used for cover material or the land

reclamation material at the disposal site. However, the iron-scraps are retained at the station for several years. International markets are not interested in the recovered materials in Male'. The waste discharge condition is shown in Table 2-4.

**Table 2-4 Condition of Waste Discharged**

| Waste Type | Discharged Condition | From Where | Note (Major Components) |
|---|---|---|---|
| Municipal Waste | Mixed | House, Hotel, Office, Market, Restaurant, etc. | Kitchen garbage, paper, plastic, can, glass, i.e. |
| Industrial Waste | Separated | Construction Site, Industry Companies | Construction waste, iron scrap material, glass |

### ii) Main Bodies of Collection and Their Equipment

In the Male' Municipality Area, Male' Municipality and private companies provide collection services.

1. Male' Municipality

Community Service Section (CSS) of Male' Municipality provides two types of collection services for residents, the first service is container collection service free of charge and the other service is door to door collection service to all the requesters upon payment. There is no legal arrangement as to the payment service, the door to door collection service is considered as a trial activity.

The detail organization of Community Service Section (CSS) is described in "Supporting Report, Section A Collection" and " Master Plan, Section 2.2 Responsible Body for SWM and Organization". The CSS consists of 11 positions and 96 persons.

The numbers of persons who work at the collection service in CSS are shown in Table 2-5.

**Table 2-5 The Persons Engaged in Collection Service**

| Position | officer | driver | mechanic | worker |
|---|---|---|---|---|
| Number | 1 | 9 | 3 | 70 |

The CSS's equipment of collection services is described in "Supporting Report, Section A Collection". CSS has two trucks for door to door collection services, five Micro-bin trucks for container collection services and has two tractors for cleansing of public space. In addition, CSS has a little more than a hundred numbers of $2m^3$ micro-bins and some number of plastic bins.

2. Private Company

The collection services by private companies are categorized four types of services. The contents of the services are shown in Table 2-6.

The detail information of the private companies is described in "Supporting Report, Section A Collection".

**Table 2-6 Collection Services by Private Company**

| Type of Collection Service | The Name of Company | Note |
|---|---|---|
| Door to door collection service | Ibraham Hassan Fulham (IHF) Carpentry | Solid waste collection service based on contract |
| Door to door collection service | Individual hand-cart collectors | Solid waste collection service based on contract |
| Office cleansing service | MULTILINKS Pvt., Ltd. | One of the services of building maintenance |
| Haulage service | Taxi companies | Temporary haulage service requested by residents and office |

### iii) The Outline of Collection Services

1. Container Collection System

Male' Municipality introduced the container collection system as a minimum level collection service for residents upon free of charge. Twenty two (22) number of containers are installed at 9 stations along the out side road in the southern part of the island. The collection stations are shown in Figure 2.4.1. The capacity of each container is 2 $m^3$. The Municipality rotates the containers in making their round three times in a day. The collection time is from 5 a.m. to 10 p.m. The residents can discharge waste into the containers at any time in a day. The system has started almost 10 years ago, therefore the system is familiar to the residents.

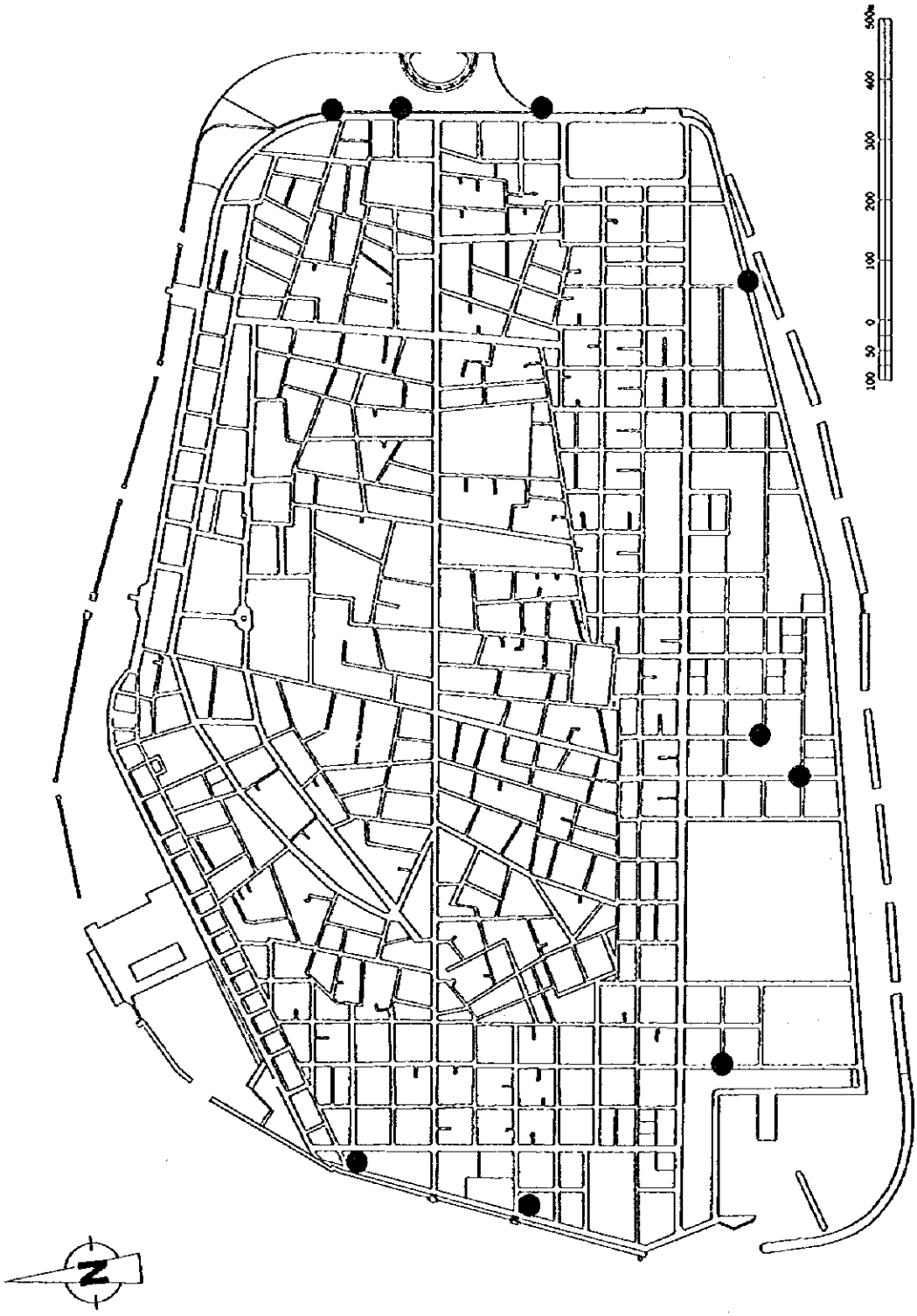



**Figure 2-1. The Location Map of the Containers**

2. Door to Door Collection System

Male' Municipality has 417 clients, and IHF has 120 clients upon payment.

The services is provided with collection charge. The collection charge is different by the frequency of collection times and the amount of the waste. The detail is described in "Supporting Report, Section A Collection". The level of collection charge varies from 120 Rf/month to 400 Rf/month.

3. Self-carry by Generators

Some residents, shops, offices and some industrial companies carry the generated waste to the transfer station directly by walking, using bicycles and own cars. The transfer station is opened for all day long, therefore the waste generators can carry and dispose the waste at any convenient time without waste charge.

**iv) The Collection Ratio and Volume of Collected Waste**

Whatever may be the collection modes, the existing collection system collects 100% of the generated waste of Male' Island. The present total generated waste amount is 173.7 ton per day and the classification and each amount of collected waste is shown in Table 2-7. The amount of industrial waste is 105-ton/day and accounts for 60.4 % of the total waste. The residential waste amount to 48.2 t/d, and accounts for 27.8 % of the total waste. The detail collection system of the municipal waste and residential waste are shown in Table 2-8. The Table shows that the minimum collection service system (micro-bin collection system) collect only 43.2 % of the total residential waste. The other waste is carried to the transfer station by generators or contractors.

The private companies collects only 7.6-ton/day and accounts for 11.1 % of the total municipal waste.

**Table 2-7 Collected Waste Amount of Each Collection System (1998)**

| Classification of the Waste (t/d) | | | Method of Collection and Haulage (t/d) | | Share (%) |
|---|---|---|---|---|---|
| Municipal Waste 68.7 | Residential | 48.2 | Generator | 23.08 | 13.3 |
| | | | IHF | 0.61 | 0.4 |
| | | | Hand Cart | 3.18 | 1.8 |
| | | | *M.C.V. | 0.53 | 0.3 |
| | | | Micro-bin | 20.80 | 12.0 |
| | Commercial | 20.5 | Generator | 16.18 | 9.3 |
| | | | IHF | 0.61 | 0.4 |
| | | | Hand Cart | 3.18 | 1.8 |
| | | | *M.C.V. | 0.53 | 0.3 |
| Industrial Waste 105.0 | Business | 36.2 | Generator | 32.41 | 18.6 |
| | | | M-Tractor | 3.79 | 2.2 |
| | Construction | 68.8 | Generator | 68.8 | 39.6 |
| 173.7t/d | | 173.7t/d | | 173.7t/d | 100.0 |

* Male' Municipality Collection Vehicle (4t Roof Truck)

**Table 2-8 The Collected Waste Amount of Each Collection System (1998)**

| Classification | Municipal waste | | Residential waste | |
|---|---|---|---|---|
| | Collected Waste Amount (t/d) | Share (%) for municipal waste | Collected Waste Amount (t/d) | Share (%) for residential waste |
| Generator | 39.2 | 57.2 | 23.08 | 47.9 |
| IHF | 1.22 | 1.8 | 0.61 | 1.3 |
| Hand-Cart | 6.36 | 9.3 | 3.18 | 6.6 |
| *M.C.V. | 1.06 | 1.5 | 0.53 | 1.0 |
| Micro-bin | 20.80 | 30.3 | 20.80 | 43.2 |
| Total | 68.74 | 100 | 48.2 | 100 |

*Male' Municipality Collection Vehicle (4t Roof Truck)

### v) The efficiency of the Existing Collection Systems

The efficiency of the existing collection systems is studied through the Time Motion Study (TMS) conducted in the first field survey period. The detail analysis of TMS is attached in Data Book 4, the results of the study is summarised in Table 2-9. The item 12) Working Time Efficiency makes clear the efficiency of each collection system. The coefficient indicates that the most efficient collection system is Micro-bin system. The system can collect waste at the rate of 80 min./ton/person. The door to door collection system by the Municipality require 1176 min./ton/person which shows the lowest efficiency. The system can work 7% effective of the Micro-bin system. The working efficiency of the system is almost same as that of handcart system. Male' Municipality has to improve the efficiency of the system at least up to the same level of IHF's efficiency.

**Table 2-9 The Comparison of Each Collection System**

| Item | M.C.V. | Micro-bin | HIF | Tractor | Hand-cart |
|---|---|---|---|---|---|
| 1) Total Operation Time | 5:15'27 | 5:04'54 | 4:21'52 | 5:09'22 | 5:58'05 |
| 2) Moving Time (to collection point) and Distance | 22'23<br>4.9km | 9'10<br>2.0km | 8'28<br>4.9km | 15'05<br>1.7km | 26'26<br>2.4km |
| 3) Collection Time | 3:19'16 | 33'00 | 2:05'15 | 2:31'35 | 2:24'50 |
| 4) No. of Collection Points | 39 | 20 | 40 | 31 | 47 |
| 5) Traveling Time and Distance | 1:00'21<br>12.3km | - | 1:11'10<br>13.1 | 1:35'24<br>10.4km | 1:15'03<br>4.8km |
| 6) Haulage time and Distance | 24'41<br>5.1km | 3:52'18<br>47.1km | 9'54<br>1.8km | 23'17<br>2.4km | 36'25<br>3.1km |
| 7) Dumping Time | 6'39 | 17'04 | 25'57 | 14'21 | 44'03 |
| 8) Moving Time (to garage) and Distance | 5'24<br>1.3km | 8'25<br>1.5km | 13'41<br>2.1km | 12'01<br>1.7km | 18'42<br>1.6km |
| 9) Collected Waste | 1.17 | 8.15ton | 2.80ton | 3.74ton | 0.4ton |
| 10) Total Distance | 23.4km | 50.7km | 18.3km | 16.4km | 10.9km |
| 11) Collection Time Efficiency 3)+5)+6)/ 8) min/ton (/person) | 251 (1004) | 34 (64) | 92 (368) | 73 (292) | 868 (868) |
| 12) Working Time Efficiency 1)/8) min/ton | 294 (1176) | 40 (80) | 118 (472) | 84 (336) | 1148 (1148) |
| 13) Collection Time min./point | 5'14 | 1'40 | 3'07 | 4'57 | 3'18 |
| 14) Haulage Time Velocity 6) Km/h | 2.8km | 12.3km/h | 4.0km/h | 2.5km/h | 1.4km/h |

**b. Neighbouring Islands of Male'**

Villingili island is very close to Male' island and the island belong to the Male' Municipality. The island is developing residential area for the metropolitan area, therefore the population will increase in near future.

There is not any waste collection system or own final disposal site. Residents bring waste to the transfer station by themselves. Waste Management Section (WMS) transfers and transports the waste to the Thilafushiu disposal site. The transfer station located at the northern part of the island and the residents who live in the southern area have to walk at most 500m to discharge waste. It is considered that Villingili would not require collection service by the Municipality because the current self-collection system seems working well. Therefore WMS will be able to continue the current collection system even in the future as a suitable system for Villingili.

**c. Resort Island**

Ministry of Tourism is responsible for the management of Resort Islands. The Ministry enacted a law concerned with SWM in resort islands. According to the law, each resort island is responsible for solid waste management and the

island have to construct a suitable capacity incinerator to treat combustible waste. Some resort islands carry non-combustible waste to Thilafushi disposal site.

**d. Inhabited Island**

Ministry of Atoll is responsible for the management of Inhabited Islands. Island office takes measures for SWM in each island. Most of the inhabited islands are very small islands therefore the waste collection and transportation system are not required. Usually, residents carry their waste to communal disposal site by themselves. Generally, solid waste is dumped at the disposal site without covering by soil. There is a possible secondary pollution to seawater although the amount of wastewater leaching is negligibly small comparing with the dispersion capacity of the current.

### 2.4.3 Current Condition of Transportation System

**(1) Legal Basis of Transportation System**

There is not any natural nor local level laws and regulations concerning transportation of solid waste.

**(2) Present Situation of Transportation System**

WMS is a sole organisation engaged in operation of waste transportation in Maldives.

**a. Organisation of WMS**

The detail of organisation is shown in "Supporting Report, Section B Transportation" and "Master Plan, Section 2.2 Responsible Body for SWM and Organisation". WMS consists of 13 positions and 120 persons.

**b. Equipment**

WSM has two ferryboats, four excavators, one wheel loader, one bulldozer and ten dump trucks for waste transportation.

**c. Transportation Record**

Transportation record of solid waste from Male' to Thilafushi is shown in Table 2-10 and Table 2-11.

The record indicates that the number of trucks increase from March in 1996. The reason is that the new ferry (UFULI 3) started to transport the waste trucks. Two ferries (UFULI 1 & 3) transport 15 - 35 numbers of the trucks per day for the last 2 years. In 1997, annual average trucks are 28 number, it means 6 trip per day. One trip needs approx. one hour and half and the total transportation time is approx. 9 hours/day.

**Table 2-10 Number of Tracks/Month**

| Year | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1992 | - | - | - | 161 | 324 | 310 | 210 | 293 | 230 | 301 | 319 | 357 | (2505) |
| 1993 | 453 | 396 | 226 | 431 | 265 | 291 | 323 | 319 | 371 | 259 | 299 | 389 | 4022 |
| 1994 | 243 | 281 | 353 | 188 | 56 | 211 | 413 | 394 | 348 | 413 | 363 | 305 | 3568 |
| 1995 | 467 | 390 | 433 | 399 | 231 | 331 | 352 | 364 | 289 | 169 | 381 | 391 | 4197 |
| 1996 | 360 | 392 | 608 | 640 | 688 | 617 | 611 | 968 | 845 | 773 | 707 | 893 | 8102 |
| 1997 | 769 | 649 | 1098 | 823 | 754 | 737 | 745 | 728 | 724 | 582 | 622 | 664 | 8895 |
| 1998 | 457 | 562 | 719 | 850 | 697 | | | | | | | | (3285) |

**Table 2-11 Number of Trucks /Year**

| Year | Number of trucks / Year | Number of trucks / Day (1year=313days) | Trips |
|---|---|---|---|
| 1992 | (2,505) | 10.9 (230) | 3 |
| 1993 | 4,022 | 12.8 | 3 |
| 1994 | 3,568 | 11.4 | 3 |
| 1995 | 4,197 | 13.4 | 3 |
| 1996 | 8,102 | 25.9 | 6 |
| 1997 | 8,895 | 28.4 | 6 |
| 1998 | (3,285) | 25.3 | 6 |

### d. Time Motion of Waste Transportation

One trip of transportation from transfer station to the disposal site requires about one hour and half. The required transportation time can not shorten because the time is controlled by the time of a round trip of the ferry and disposal activities at the disposal site. If MCPW wish to increase the waste transportation amount, MCPW has to make use of two ferries. Loading and the moving from the transfer station to the jetty require only half an hour therefore MCPW can increase the number of trips to double by the operation of two ferry system.

### 2.4.4 Problems Observed and Proposed Solution

#### (1) Collection

##### a. Male'

##### i) Problem

The problems of Male' collection system is summarised as follows;

- The collection system of the Municipality covers only 44.2% of residential waste;
- The vehicles and equipment of the container collection system have aged;
- Door to door collection services of the Municipality is not effective;
- Private Sector Involvement (PSI) for the collection service is not enough because the policy of the central and the local government is not decided yet. Private company can not invest to purchase the vehicles and employ the staffs for collection services and
- There is no future plan of collection system in Male' Municipality.
- In fact, there are many persons who are not satisfied with the container collection system, which shoulders major waste collection from residents, because of the following reasons,
  1. The container collection service is unfair to the northern area residents because the containers are located along with the south side road of the island;
  2. The maintenance cost of container collection system increased, because the container collection vehicle (Micro-bin truck) become old and need special ordering of spare parts;
  3. The Micro-bin drivers complain about hard seat because the vehicle has no shock absorber;
  4. The neighbouring residents of the stationary containers complain about smell of the waste in the container and
  5. The private company dumps a lot of waste to the container, especially at night-time.

### ii) Proposed Solution

The primary objective of the waste collection plan is to enhance the collection service for the purpose of maintaining public health and cleanliness and to protect the City's environment. The existing collection system has some week points therefore the Municipality has to introduce a new collection system.

1. Legal Arrangements

Male' Municipality shall have the authority and responsibility for setting by-law and regulations with respect to municipal SWM which must comply with central government laws and requirements. The Municipality shall have the right to contract out SWM to the private sector and must implement appropriate arrangements to regulate the private sector.

2. Effective Organisation and Management

Male' Municipality has the primary duty of care for SWM including planning, financing and management of services, formulation of regulations, etc. The Municipality needs to develop effective organisational and management capabilities.

3. Technical Arrangement

The Municipality should provide the minimum level services equally to all the residents throughout the Male' island until private sectors will grow up to collect all the waste generated in the island. Technical options for collection is considered in two systems, the station (include container system) and the door to door collection (include bell collection system) system. In consideration of the merits and demerits of the two options, the mixed type system of door to door collection and station system will be proposed. The new system proposed in Chapter 3 is socially and environmentally acceptable for Male' City.

### b. Other Islands

Other Islands are narrow and small therefore the residents carry waste to the disposal site by themselves. The collection system is not required except for some islands. The islands that require the collection system have to introduce a system similar to that of Male' island. The new collection system in Male' will be a model case for the other islands.

## (2) Transportation

### a. Male'

#### i) Problem

There are four major problems of the existing transportation system as described below;

- The environmental problems at the transfer station are that the waste heap at the transfer station turns out to be a source of secondary pollution. Smoke, odour and dust will affect health of the people reside near by the transfer station. And the transfer work of the dumped waste loading to trucks makes noise and dust;
- The transportation capacity is limited due to only one ferry in service therefore some amount of waste is always remained in the transfer station;
- The management of the transfer station is not suitable. The private companies and the individual waste generator carry waste to the transfer station for 24 hours and dump the wastes without control of WMS;
- According to the city plan, the existing transfer station area will be used for the residential area. The new transfer station should be constructed as soon as possible.

#### ii) Proposed Solution

Transfer station has to prepare the required minimum equipment to operate and manage the system properly to conserve the better environmental conditions. Firstly, WMS of MCPW shall ensure the permanent area for the transfer station and install required operation equipment, management office, truck scale, stockyard, transfer equipment etc.

And the section has to prepare the accession standard of waste at the transfer station to make easy the work of transfer and transportation.

It is important to transfer the daily waste within the regulated time to reduce the environmental problems at the transfer station. In this respect, adequate number of trucks should be procured to transport the waste generated in the whole city in a day.

**b. Other Islands**

WMS has transfer station in Villingili island to transport waste to the Thilafushi disposal site. WMS will continue with the existing SWM system in the future. The current system of Villingili needs some improvement.

Resort Islands in the Metropolitan Region have to prepare the waste transportation plan of the waste generated from the Resort Islands.

Local islands need construction of the disposal sites within own island area in accordance with guidelines. These islands do not require the transportation system.

## 2.5 Final Disposal of Solid Waste

### 2.5.1 Male'

There is no final disposal site in Male'. All the garbage discharged in the island are once collected at the transfer station in Male' and reloaded to lorries. The lorries are shipped to Thilafushi Island taking on RORO ferry to the final disposal site.

#### (1) Method of Landfill

The pond method is adopted. The pond is first excavated the reef flat up to about 2.5 m deep under the water. Coral rock and sand taken out of reef flat is used to form an encircling mound with a height of about 1.5 m. A pond with the size of 30 m × 30 m and the depth of 4m is then completed and used for waste dumping. Soil cover is made when the waste layer comes to the top level of the mound for the first time. The completed area is about 12 ha as of August 1998 including confined lagoon and deposit site of dredged sand out of channel excavation point.

#### (2) Assessment of Present Operation

**a. Situation of Completed Area**

(a) Land use for business activity is already started or being prepared. For example, STO, one of tenants, is building facilities for LNG and cement storage in the area. Also a fish processing firm is producing smoked fish and dried fish there.

(b) Among the completed buildings, a warehouse has a damage of crack in the wall and deformation of roof due to uneven ground subsidence.

(c) Exposure and blown out of ground are observed due to lack of cover soil.

**b. Landfill Structure**

(a) The pond method is classified as anaerobic landfill

(b) Beneath the foundation of LNG tank, discolored old waste was noted and the ground water (leachate) was brown in color. Gas generation was also observed. It is forecast that ground subsidence will occur in the site because the dumped garbage are still in the process of decomposition.

**c. Waste Retaining Structure**

(a) Seawall is provided only in front of STO leased lot on the east coast and the rest of coast is the mound of pond method itself.

(b) West coast is encroached by waves and wastes once dumped are exposed or drifting out.

(c) Fly breeding, offensive odor down the wind and blown out of waste are observed because daily soil cover is not adopted.

**d. Water Retaining Structure**

(a) No water retaining facility is installed.

(b) Outflow of leachate is observed outside the mound and seawall. Rocks scattered on the shore are gathering green moss. This may be the effect of aeration of $NH_4$-N by sea water.

(c) Water color in the harbor for small boats looks slightly dark which implies the pollution by leachate

(d) It is observed that the ground water level in the monitoring well follows the tidal fluctuation that implies the leachate is seeping out in accordance with the ebb and flow of the tide.

**e. Leachate Treatment**

No leachate treatment facility is provided.

**f. Operation and Maintenance**

(a) Operation and maintenance are conducted by one supervisor, three operators, three assistants and 30 workers in total 37 people. There seems no particular problem with filling operation.

(b) As the monitoring equipment, a vertical well of PVC tube is installed, however, it seems water quality examination has not been conducted for a long time.

**g. Awareness of Operators of Sanitary Landfill**

(a) Present landfill operation seems as if it were considered as land creation and the waste were regarded simply as filling material.

(b) Above consciousness leads to unawareness of unsanitary conditions that happen wherever in the dump site, which are erosion and collapse of surrounding mound, waste drift and blown out, and leachate outflow.

### (3) Items to be Improved

#### a. Instruction of Sanitary Landfill to Operators

(a) First of all, it is necessary to instruct people engaged in the operation on the importance of final disposal as the last process of consecutive treatment flow of solid waste.

(b) It is also necessary to educate people engaged in the operation on the required function of final disposal site.

#### b. Short Term Improvement Measures

(a) Seawall construction endurable against sea surge

(b) To conduct daily soil cover and thicker final cover

#### c. Medium and Long Term Improvement Measures

To establish land use plan first before execution of landfill and to conduct landfill according to the plan lot by lot. For example, the filling material is discriminated by type of planned land use after completion: only demolition debris is filled for planned building site and for the other purpose of land use such as sports ground, park the garbage is utilized.

(a) To secure the space for storage and treatment of hazardous waste

(b) Introduction of proper landfill structure which enables early stabilization and is friendly to living and global environment

(c) Introduction of leachate treatment facility to reduce the volume and to improve the quality of leachate

## 2.5.2 Adjacent Islands to Male'

Adjacent islands are Vilingili, airport, oil island and jail island. There is no final disposal site in these islands therefore they transport garbage to Thilafushi for disposal.

### 2.5.3 Resort Islands

#### (1) Disposal in Thilafushi

Approximately 40 resorts are relying on Thilafushi for their need of garbage disposal. They transport their garbage by their own boat or temporarily hired one to Thilafushi. The range of this type of resorts reaches as far as north and south Ari Atoll.

#### (2) Disposal in Each Island

The other resorts are disposing garbage within their islands. Combustible portion is incinerated. Incombustible glass bottles and cans are crushed or pressed to reduce volume and buried in the ground together with the other incombustible waste.

### 2.5.4 Inhabited Islands

Each island has one or more final disposal sites in each island.

#### (1) Assessment of Present Operation

(a) Residents bring garbage to the final disposal site by themselves.

(b) There is no other SWM facility than final disposal site.

(c) Final disposal site can be classified into two categories: non-controlled type and controlled type.

#### (2) Example of Non-controlled Disposal Site

(a) This type of disposal site was observed in Graidhoo Island and Hitadhoo Island.

(b) There is no waste retaining facility.

(c) There remained a trace of fishing net for enclosing the site, however, it does not work any more

(d) Some wastes were observed floating in the sea.

(e) Open air burning of solid waste was observed.

(f) There is no soil cover so that fly breeding was observed.

**(3) Example of Controlled Disposal Site**

(a) The site is provided with coral stone seawall, however, it is not closed completely and allows the drifting out of garbage to the sea in front.

(b) Sea water comes in and out freely because of wide gap of surrounding seawall.

(c) There is no daily soil cover so that fly breeding was observed.

**(4) Items to be Improved**

(a) Non-controlled type needs to be provided with seawall which can protect the site from encroachment of sea surge.

(b) Controlled type needs to close the seawall and prevent garbage from drifting out.

(c) Daily and final soil covering is necessary.

## 2.6 Waste Amount and Composition

### 2.6.1 Existing Data

#### (1) Waste Amount Carried Out from Transfer Station in Male'

By using the average load of 5.4 tons per trip per truck, the waste transportation amount can be deducted from the record of trip number undertaken by WMS/MCPW. The average load was obtained from the survey conducted by JICA Survey Team. Based on the record, transported waste amount is identified that it had increased from 58 ton per day in 1992 to 152 tons per day in 1997, however, decreased to 136 tons per day in 1998 as shown in Table 2-12 and Figure 2-2.

#### (2) Waste Amount Transported Directly to the Thilafushi Disposal Site

In addition to the waste from Male', the Thilafushi disposal site receive waste from Villingili, Hulhule and from more than 30 resort islands. Based on the records from January to May in 1998, the waste amount was estimated at 2,535 tons in total of the five months or 507 tons per month or 17 tons per day. The amount is estimated from the records of arrival of waste haulage boat at Thilafushi Island by using the number of trips and unit loading per trip. Meanwhile, Medical waste, waste oil and expired food wastes are carried to Thilafushi from time to time but the waste amount is not so much in comparison with that of ordinary waste.

### 2.6.2 Waste Amount and Composition

Waste amount and composition survey was conducted for two inhabited islands, two resort islands and for Male' from June to September, 1998 and summarised below.

#### (1) Inhabited Islands

Waste amount and composition survey of 10 houses for 10 days was conducted for Villingili and Thulusdhoo and tabulated in Table 2-13 and 2-14.

**a. Waste Amount in Inhabited Islands**

In Villingili, the waste generation amount of 10 houses having 115 population in total amount to 83 kg per day in average ranging from 59 kg to 126 kg. Waste generation amount in Thulusdhoo, taken from 10 houses having 119 residents, proved 96 kg per day on average ranging from 65 to 165 kg. The samples from 4 - 10th day records shows the waste generation rate at 621 grams per capita per day or 7.1 kg per house per day in Villingili is obtained and at 698 grams per capita per day or 8.3 kg per house per day in Thulusdhoo. The average waste generation rate of two islands is estimated at 662 grams per capita per day or 7.7 kg per house per day.

## Table 2-12. Operation Records of Solid Waste Transportation

| | Numbers of Trucks (trucks/month) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Year | | | | | | |
| Month | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 |
| January | | 453 | 243 | 467 | 360 | 769 | 457 |
| February | | 396 | 281 | 390 | 392 | 649 | 562 |
| March | | 226 | 353 | 433 | 608 | 1098 | 719 |
| April | 161 | 431 | 188 | 399 | 640 | 823 | 850 |
| May | 324 | 265 | 56 | 231 | 688 | 754 | 673 |
| June | 310 | 291 | 211 | 331 | 617 | 737 | |
| July | 210 | 323 | 413 | 352 | 611 | 745 | |
| August | 293 | 319 | 394 | 364 | 968 | 728 | |
| September | 230 | 371 | 348 | 289 | 845 | 724 | |
| October | 301 | 259 | 413 | 169 | 773 | 582 | |
| November | 319 | 299 | 363 | 381 | 707 | 622 | |
| December | 357 | 389 | 305 | 391 | 893 | 664 | |
| Total (year) | 2,505 | 4,022 | 3,568 | 4,197 | 8,102 | 8,895 | 3,261 |
| Monthly Average | 278 | 335 | 297 | 350 | 675 | 741 | 652 |
| Estimated Waste Amount Carried out from Transfer Station | | | | | | | |
| Annual (ton/year) | 13,427 | 21,558 | 19,124 | 22,496 | 43,427 | 47,677 | 17,479 |
| Monthly (ton/month) | 1,492 | 1,796 | 1,594 | 1,875 | 3,619 | 3,973 | 3,496 |
| Daily (ton/day) -work day | 58 | 69 | 61 | 72 | 139 | 152 | 136 |

(Data Source : Waste Management Section, MCPW)

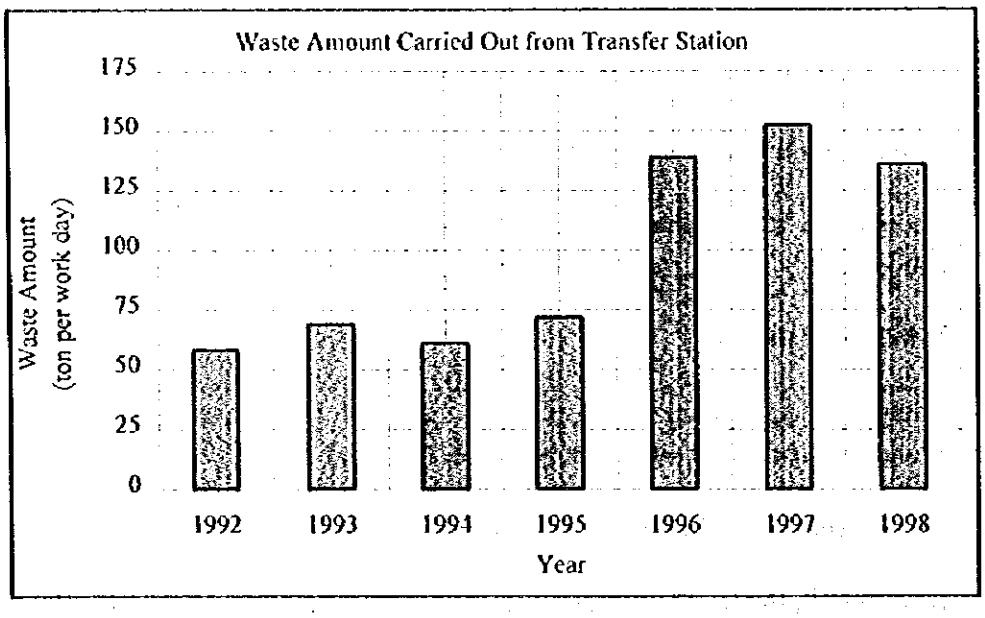



**Figure 2-2. Estimated Waste Amount Carried Out from Transfer Station**

## Table 2-13. Result of Waste Amount and Composition Survey in Inhabited Island (Villingili)

| Waste Composition | | Max. | Min. | Avg. | Ratio (%) |
|---|---|---|---|---|---|
| Organic Waste | | | | | |
| Food Waste | | 29,950 | 6,200 | 17,923 | 21.64 |
| Paper | Paper | 10,000 | 1,600 | 3,680 | 4.44 |
| | Cardboard | 4,300 | 590 | 2,117 | 2.56 |
| Paper (Total) | | 10,590 | 2,380 | 5,797 | 7.00 |
| Plastics | Film | 4,100 | 1,030 | 2,243 | 2.71 |
| | Bottle & Others | 4,700 | 20 | 2,018 | 2.44 |
| | PET | 930 | 100 | 588 | 0.71 |
| Plastic (Total) | | 7,770 | 1,920 | 4,849 | 5.86 |
| Rubber & Leather | | 2,780 | 10 | 1,581 | 1.91 |
| Textiles | | 13,550 | 100 | 3,061 | 3.70 |
| Yard Waste | | 26,200 | 5,100 | 11,510 | 13.90 |
| Wood | | 7,000 | 340 | 2,805 | 3.39 |
| Other Org. Waste | | 9,960 | 0 | 1,299 | 1.57 |
| Subtotal (Organic Wastes) | | 73,000 | 34,270 | 48,825 | 58.96 |
| In-organic Waste | | | | | |
| Glass | Broken Glass | 2,040 | 60 | 847 | 1.02 |
| | Bottle | 3,400 | 760 | 1,882 | 2.27 |
| Glass (Total) | | 5,440 | 840 | 2,729 | 3.30 |
| Tin Cans (Steel Cans) | | 4,300 | 840 | 2,777 | 3.35 |
| Aluminum cans | | 980 | 100 | 305 | 0.37 |
| Other Metals | | 2,780 | 200 | 1,256 | 1.52 |
| Dirt, Ash, Stone, Sand | | 47,400 | 6,800 | 26,695 | 32.24 |
| Subtotal (Inorganic Wastes) | | 53,160 | 11,140 | 33,761 | 40.77 |
| Hazardous Waste (Batteries) | | 440 | 20 | 223 | 0.27 |
| Other Hazardous Waste | | none | none | none | none |
| Subtotal (Hazardous Waste) | | 440 | 20 | 223 | 0.27 |
| Total Weight (g) | | 126,200 | 59,030 | 82,809 | 100.00 |
| Total Waste Volume (lit.) | | 342 | 234 | 296 | |
| Bulk Density (kg/lit.) | | 0.391 | 0.194 | 0.280 | |

## Table 2-14. Result of Waste Amount and Composition Survey in Inhabited Island ( Thulusdhoo)

| Waste Composition | | Max. | Min. | Avg. | Ratio (%) |
|---|---|---|---|---|---|
| Organic Waste | | | | | |
| Food Waste | | 31,090 | 12,660 | 18,449 | 22.22 |
| Paper | Paper | 2,780 | 580 | 1,550 | 1.87 |
| | Cardboard | 2,440 | 500 | 1,285 | 1.55 |
| Paper (Total) | | 4,720 | 1,700 | 2,835 | 3.41 |
| Plastics | Film | 2,900 | 1,200 | 1,528 | 1.84 |
| | Bottle & Others | 1,160 | 200 | 551 | 0.66 |
| | PET | 340 | 40 | 113 | 0.14 |
| Plastic (Total) | | 3,440 | 1,500 | 2,191 | 2.64 |
| Rubber & Leather | | 2,220 | 140 | 641 | 0.77 |
| Textiles | | 2,320 | 1,100 | 1,454 | 1.75 |
| Yard Waste | | 73,960 | 5,680 | 42,220 | 50.85 |
| Wood | | 9,800 | 100 | 1,443 | 1.74 |
| Other Org. Waste | | 11,100 | 0 | 3,851 | 4.64 |
| Subtotal (Organic Wastes) | | 110,950 | 50,680 | 73,084 | 88.03 |
| In-organic Waste | | | | | |
| Glass | Broken Glass | 1,320 | 480 | 603 | 0.73 |
| | Bottle | 980 | 360 | 533 | 0.64 |
| Glass (Total) | | 2,120 | 640 | 1,135 | 1.37 |
| Tin Cans (Steel Cans) | | 5,160 | 680 | 1,955 | 2.35 |
| Aluminum cans | | 280 | 40 | 123 | 0.15 |
| Other Metals | | 720 | 100 | 280 | 0.34 |
| Dirt, Ash, Stone, Sand | | 11,450 | 1,350 | 6,310 | 7.60 |
| Subtotal (Inorganic Wastes) | | 13,930 | 4,210 | 9,803 | 11.81 |
| Hazardous Waste (Batteries) | | 420 | 40 | 138 | 0.17 |
| Other Hazardous Waste | | none | none | 0 | 0.00 |
| Subtotal (Hazardous Waste) | | 420 | 0 | 138 | 0.17 |
| Total Weight (kg) : | | 164,970 | 64,750 | 83,024 | 100.00 |
| Total Waste Volume (lit.) | | 488 | 186 | 298 | |
| Bulk Density (kg/lit.) | | 0.360 | 0.208 | 0.279 | |

### b. Waste Composition in Inhabited Islands

Waste composition in Villingili is characterised by the high ratio of inorganic waste with 41 % while organic waste takes about 59 %. Meanwhile, food waste is about 21.6 % followed by paper and plastic with the ratio at 7.0 and 5.9 % respectively. The ratio of organic waste in Thulusdhoo shows 88.0 %. Yard waste has the highest ratio at about 50.9 % followed by food waste with the ration about 22.2 %. Yard waste is one of the major waste generated in two islands, the ratio shows about 13.9 % and 50.9 % for Villingili and Thulusdhoo respectively. The high ratio of yard waste in Thulusdhoo is mainly due to the coconuts shell drops which are not discharged normally but discharged during the waste survey.

## (2) Resort Islands

Waste amount and composition surveys were conducted for 10 day-samples in Kanifinol and Thulhagiri resort islands respectively and summarised in Table 2-15 and 2-16.

### a. Waste Amount in Resort Islands

During the survey period, the average numbers of hotel guests and hotel staff were 150 and 356 in Kanifinol Resort Island and 73 and 125 in Thulhagiri Resort Island respectively. Waste generation amount reached at 1,030 kg per day and 590 kg per day in Kanifinol and Thulhagiri respectively. Generation rate per hotel guest is estimated at 6.9 kg and 8.1 kg for Kanifinol and Thulhagiri respectively which include the wastes discharged by the hotels staff. Total waste amount and the numbers of hotel guest in bed-nights reached at 15,610 kg and 2,159 person respectively. From these survey data, waste generation rate per hotel guest is estimated at 7,230 kg per day.

### b. Waste Composition in Resort Islands

The high waste generation rate is caused by the amount of yard waste such as trimmings of trees and plants, fallen leaves and sand stick to the fallen leaves. The ratio of yard waste, dirt and sand amount to about half of the waste collected as 58.0 % by weight in Kanifinol and 43.9 % in Thulhagiri.

Other major wastes generated in the resort islands are food waste - 26.5 % / 43.3 %, glass bottles - 4.0 % / 1.3 % and carton box (cardboard) - 3.1 % / 2.8 % in Kanifinol and Thulhagiri respectively.

## Table 2-15. Result of Waste Amount and Composition Survey in Resort Island (Kanifinol Resort Island)

(unit : grams)

| Waste Composition | | Max. | Min. | Avg. | Ratio (%) |
|---|---|---|---|---|---|
| Organic Waste | | | | | |
| Food Waste | | 340,850 | 220,800 | 272,555 | 26.45 |
| Paper | Paper | 61,070 | 4,100 | 21,903 | 2.13 |
| | Cardboard | 56,640 | 19,620 | 31,429 | 3.05 |
| | Total | 117,710 | 23,720 | 53,332 | 5.18 |
| Plastics | Film | 7,930 | 1,500 | 3,413 | 0.33 |
| | Bottle & Others | 12,200 | 0 | 3,885 | 0.38 |
| | PET | 6,830 | 880 | 3,190 | 0.31 |
| | Total | 26,960 | 2,380 | 10,488 | 1.02 |
| Rubber & Leather | | 6,450 | 0 | 1,487 | 0.14 |
| Textiles | | 7,100 | 1,000 | 3,241 | 0.31 |
| Yard Waste | | 1,224,000 | 270,000 | 401,400 | 38.96 |
| Wood | | 13,700 | 240 | 6,636 | 0.64 |
| Other Org. Waste | | 65,360 | 0 | 27,018 | 2.62 |
| Total (Organic Wastes) | | 1,802,130 | 518,140 | 776,157 | 75.33 |
| In-organic Waste | | | | | |
| Glass | Broken Glass | 3,800 | 0 | 1,270 | 0.12 |
| | Bottle | 110,240 | 20,650 | 40,844 | 3.96 |
| | Total | 114,040 | 20,650 | 42,114 | 4.09 |
| Tin Cans (Steel Cans) | | 15,650 | 5,200 | 10,762 | 1.04 |
| Aluminum cans | | 7,750 | 450 | 1,609 | 0.16 |
| Other Metals | | 4,750 | 100 | 2,037 | 0.20 |
| Dirt, Ash, Sand | | 300,000 | 104,950 | 196,495 | 19.07 |
| Total (Inorganic Wastes) | | 442,190 | 131,350 | 253,017 | 24.56 |
| Hazardous Waste | | | | | |
| Batteries | | 340 | 0 | 60 | 0.01 |
| Other Hazardous Waste | | 6,350 | 260 | 1,139 | 0.11 |
| Total (Hazardous Waste) | | 6,690 | 260 | 1,199 | 0.12 |
| Total Weight (kg) : | | 2,251,010 | 649,750 | 1,030,373 | 100.00 |

## Table 2-16. Result of Waste Amount and Composition Survey in Resort Island (Thulhagiri Resort Island)

(unit : grams)

| Type of Waste | | Max. | Min. | Avg. | Ratio (%) |
|---|---|---|---|---|---|
| Organic Waste | | | | | |
| Food Waste | | 364,400 | 193,200 | 255,422 | 43.30 |
| Paper | Paper | 18,450 | 0 | 7,694 | 1.30 |
| | Cardboard | 40,700 | 0 | 16,264 | 2.76 |
| | Total | 59,150 | 0 | 23,959 | 4.06 |
| Plastics | Film | 7,450 | 0 | 2,733 | 0.46 |
| | Bottle & Others | 6,850 | 0 | 3,910 | 0.66 |
| | PET | 5,950 | 0 | 2,947 | 0.50 |
| | Total | 20,250 | 0 | 9,590 | 1.63 |
| Rubber & Leather | | 2,350 | 0 | 370 | 0.06 |
| Textiles | | 3,020 | 0 | 980 | 0.17 |
| Yard Waste | | 447,500 | 62,650 | 157,317 | 26.67 |
| Wood | | 14,500 | 0 | 3,562 | 0.60 |
| Other Org. Waste | | 78,850 | 0 | 22,037 | 3.74 |
| Total (Organic Wastes) | | 990,020 | 255,850 | 473,237 | 80.22 |
| In-organic Waste | | | | | |
| Glass | Broken Glass | 2,500 | 0 | 709 | 0.12 |
| | Bottle | 26,730 | 0 | 7,494 | 1.27 |
| | Total | 29,230 | 0 | 8,203 | 1.39 |
| Tin Cans (Steel Cans) | | 8,100 | 0 | 4,069 | 0.69 |
| Aluminum cans | | 4,100 | 0 | 1,233 | 0.21 |
| Other Metals | | 2,840 | 0 | 1,104 | 0.19 |
| Dirt, Ash, Sand | | 297,500 | 35,750 | 101,528 | 17.21 |
| Total (Inorganic Wastes) | | 341,770 | 35,750 | 116,138 | 19.69 |
| Hazardous Waste | | | | | |
| Batteries | | 340 | 340 | 38 | 0.01 |
| Other Hazardous Waste | | 1,800 | 150 | 519 | 0.09 |
| Total (Hazardous Waste) | | 2,140 | 490 | 557 | 0.09 |
| Total Weight (kg) | | 1,333,930 | 292,090 | 589,931 | 100.00 |

### (3) Waste Amount, Sources and Composition in Male'

#### a. Waste Amount Carried-in to Transfer Station

The survey was conducted for 19 days in the period from 17 August to 12 September, 1998. All the solid wastes was weighed including municipality collection vehicles, private vehicles, hand carts and individuals from the neighbouring area entering to the Transfer Station from 5 a.m. to 10 p.m.

According to the survey results summarised in Table 2-17, total carried-in waste amount in 19 days amount to 3,844 tons or 202 tons per day. Solid wastes in residential and commercial area generate about 80 tons per day or 39 %. Wastes from business and industrial activities including institutional wastes are 42 tons per day or 21 % and construction wastes is about 80 tons per day or 40 %. Among four collection & transportation modes, vehicles collect about 75 %; hand carts collect a little fewer than 4 % and collection by micro bins amount to 12 %; wastes carried by the individual person nearby Transfer Station and wastes brought in from midnight to early morning amount to about 10 %.

#### b. Volume of Waste Carried-out from Transfer Station

Carried-out waste amount by the trucks of MCPW was surveyed for 10 days in the period from 22 August to 20 September in 1998 and summarised in Table 2-18.

Two hundred ninety (290) trips were made and carried out 1,555 tons of wastes in total. The net loading per trucks is estimated at 5.36 tons. In average, 29 trips by the trucks transported about 155 tons of waste to the Thilafushi every day.

**Table 2-17. Summary of Waste Amount Survey in Male'**

| Generation Source Category | Code | Total - 19 days (ton) | Average-per day (ton) | Ratio (%) |
|---|---|---|---|---|
| Residential Area by Vehicles | A1 | 463.38 | 24.39 | 12.06 |
| Hand Cart | | 70.48 | 3.71 | 1.83 |
| Individual, Midnight to Morning Waste | | 69.72 | 3.67 | 1.81 |
| Micro Bin | A2 | 461.10 | 24.27 | 12.00 |
| Sub Total | (A1&2) | 1064.67 | 56.04 | 27.70 |
| Commercial Area (General) by Vehicles | B-1 | 271.30 | 14.28 | 7.06 |
| Hand Cart | | 70.48 | 3.71 | 1.83 |
| Individual, Midnight to Morning Waste | | 69.72 | 3.67 | 1.81 |
| Commercial Waste (STO) | B-2 | 40.26 | 2.12 | 1.05 |
| Sub Total | (B1&2) | 451.76 | 23.78 | 11.75 |
| Total (A+B) | | 1516.44 | 79.81 | 39.45 |
| Buildings (Government Office) | C-1 | 133.99 | 7.05 | 3.49 |
| Building (Private Office & Shops) | C-2 | 231.55 | 11.79 | 5.83 |
| Sub Total | (C1&2) | 365.54 | 19.24 | 9.51 |
| Fruits Market & Parks | D | 107.57 | 5.66 | 2.80 |
| Restaurant & Hotels | E | 77.37 | 4.07 | 2.01 |
| Home Industry (Carpentry - Saw Dust) | F-1 | 100.88 | 5.31 | 2.62 |
| Home Industry (Metals) | F-2 | 30.29 | 1.59 | 0.79 |
| Home Industry (Others) | F-3 | 100.16 | 5.27 | 2.61 |
| Sub Total | (F1 to 3) | 231.33 | 12.18 | 6.02 |
| School*1 | G | 1.84 | 0.10 | 0.05 |
| Hospital & Clinics | H | 18.26 | 0.96 | 0.48 |
| Total (C-H) | | 801.92 | 42.21 | 20.86 |
| Construction Waste (Sand & Concrete Debris) | I-1 | 679.44 | 35.76 | 17.68 |
| Midnight to Morning Concrete Debris & Sand | I-1 | 229.05 | 12.06 | 5.96 |
| Construction Demolition Waste | I-2 | 268.36 | 14.12 | 6.98 |
| Construction Waste (Mixed) | I-3 | 348.31 | 18.33 | 9.06 |
| Total (I) | (I1 to 3) | 1525.16 | 80.27 | 39.68 |
| Ground Total | (A to I) | 3843.51 | 202.29 | 100.00 |

*1 : Most of the wastes of schools are collected together with the item "Residential Area by Vehicle" and the survey record do not show actual amount of wastes collected from schools.

**Table 2-18. Summary of Carried-out Waste Amount from Transfer Station**

| Summary : Transportation Loading by Truck Number | | | |
|---|---|---|---|
| Plate No. of Vehicle | Total Weight (ton) | Total Times of Transportation (time) | Truck Loading per Trip (ton) |
| T03-2598 | 141.80 | 24 | 5.91 |
| T03-2590 | 158.56 | 28 | 5.66 |
| T03-2589 | 137.62 | 26 | 5.29 |
| T03-2588 | 136.91 | 26 | 5.27 |
| T03-1491 | 163.37 | 29 | 5.63 |
| T03-1490 | 151.42 | 29 | 5.22 |
| T03-1446 | 4.60 | 4 | 1.15 |
| T03-1353 | 6.59 | 4 | 1.65 |
| T03-1320 | 55.45 | 9 | 6.16 |
| T03-1271 | 204.91 | 34 | 6.03 |
| T03-1270 | 8.83 | 1 | 8.83 |
| T03-1217 | 119.75 | 29 | 4.13 |
| T03-1149 | 6.46 | 1 | 6.46 |
| T03-1148 | 152.99 | 27 | 5.67 |
| Total | 1554.87 | 290 | 5.36 |

## c. Generation Sources and Composition of Wastes in Male'

### i) Generation Sources of Solid Wastes

Solid waste amount by generation sources in Male' is obtained from Table 2-17. Wastes collected from residential houses amount to 28 % or 56 tons per day and the amount added the wastes from the shop & residence houses and shops reach at 39.4 % or 79.8 tons per day approximately.

Industrial waste collected from office buildings, restaurants & hotels, home industries, hospitals & clinics amount to 20.9 % or 42.2 tons per day.

Waste from construction works is the largest waste generator, which discharged about 39.7 % or 80.3 tons per day. Among the construction wastes, concrete debris and sand amount to 23.7 % or 47.8 tons per day.

### ii) Waste Composition

As an average solid waste composition, Table 2-19 shows the ratio of 54.9 %, 41.7 %, 0.2 % and 3.2 % of the total waste amount of 202.3 tons per day for organic wastes, in-organic waste, hazardous wastes and other mixed wastes respectively. Meanwhile, for the individual elements, the wastes including dirt, ash & sand and concrete debris show the largest ratio of 37.4 % followed by waste wood, food waste, cardboard, and paper reach at 11.8 %, 11.8 %, 7.5 % and 7.2 % by weight respectively.

## Table 2-19. Summary of Waste Composition by Waste Generation Source in Male'

Survey Period : August - September, 1998

Daily Average Waste Amount Collected during Survey Period: 202.29 ton/day

| Type of Waste | | | Domestic & Commercial Wastes | Business & Industrial Wastes | | Construction Waste | | Total | |
|---|---|---|---|---|---|---|---|---|---|
| Total Weight | | | 79.81 | 42.20 | | 80.27 | | 202.29 | |
| Sampling Weight & Composition Ratio | | | Weight (ton) | Weight (ton) | Ratio (%) | Weight (ton) | Ratio (%) | Weight (ton) | Ratio (%) |
| Organic Waste | | | | | | | | | |
| | Food Waste | | 15.33 | 8.49 | 20.11 | 0.00 | 0.00 | 23.82 | 11.78 |
| | Paper | Paper | 7.84 | 6.42 | 15.22 | 0.19 | 0.24 | 14.46 | 7.15 |
| | | Cardboard | 10.06 | 4.36 | 10.33 | 0.66 | 0.82 | 15.08 | 7.45 |
| | | Subtotal | 17.90 | 10.78 | 25.55 | 0.85 | 1.06 | 29.53 | 14.60 |
| | Plastics | Film | 3.38 | 0.97 | 2.30 | 0.47 | 0.58 | 4.81 | 2.38 |
| | | Bottle & Others | 2.73 | 0.79 | 1.88 | 0.08 | 0.10 | 3.60 | 1.78 |
| | | PET | 0.72 | 0.34 | 0.82 | 0.01 | 0.01 | 1.08 | 0.53 |
| | | Subtotal | 6.83 | 2.11 | 5.00 | 0.55 | 0.69 | 9.49 | 4.69 |
| | Rubber & Leather | | 0.84 | 0.30 | 0.72 | 0.02 | 0.03 | 1.17 | 0.58 |
| | Textiles | | 2.36 | 0.28 | 0.66 | 0.01 | 0.01 | 2.65 | 1.31 |
| | Yard Waste | | 8.60 | 2.71 | 6.42 | 0.17 | 0.21 | 11.48 | 5.68 |
| | Wood | | 2.54 | 5.77 | 13.68 | 15.55 | 19.37 | 23.86 | 11.80 |
| | Other Org. Waste | | 8.08 | 0.83 | 1.97 | 0.11 | 0.14 | 9.03 | 4.46 |
| Organic Waste Total | | | 62.50 | 31.28 | 74.11 | 17.26 | 21.51 | 111.04 | 54.89 |
| In-organic Waste | | | | | | | | | |
| | Glass | Broken Glass | 0.33 | 0.10 | 0.23 | 0.00 | 0.00 | 0.42 | 0.21 |
| | | Bottle | 1.36 | 0.47 | 1.11 | 0.01 | 0.01 | 1.84 | 0.91 |
| | | Subtotal | 1.69 | 0.57 | 1.34 | 0.01 | 0.01 | 2.26 | 1.12 |
| | Tin Cans (Steel Cans) | | 2.25 | 0.61 | 1.46 | 0.19 | 0.24 | 3.06 | 1.51 |
| | Aluminum cans | | 0.44 | 0.18 | 0.42 | 0.01 | 0.01 | 0.63 | 0.31 |
| | Other Metals | | 1.04 | 1.65 | 3.92 | 0.26 | 0.32 | 2.95 | 1.46 |
| | Dirt, Ash, Sand | | 11.68 | 1.47 | 3.48 | 62.39 | 77.72 | 75.54 | 37.35 |
| In-orrganic Waste Total | | | 17.10 | 4.48 | 10.62 | 62.86 | 78.30 | 84.44 | 41.74 |
| Hazardous Waste | | | | | | | | | |
| | Hazardous Waste (Batteries) | | 0.15 | 0.07 | 0.16 | 0.00 | 0.00 | 0.22 | 0.11 |
| | Other Hazardous Waste | | 0.07 | 0.05 | 0.11 | 0.15 | 0.18 | 0.26 | 0.13 |
| Hazardous Waste Total | | | 0.21 | 0.11 | 0.27 | 0.15 | 0.18 | 0.47 | 0.23 |
| Home Industry (Others) | | | | 5.27 | 12.49 | | | 5.27 | 2.61 |
| School | | | | 0.10 | 0.24 | | | 0.10 | 0.05 |
| Hospital & Clinics | | | | 0.96 | 2.27 | | | 0.96 | 0.47 |
| Total Weight (kg) | | | 79.81 | 42.20 | 100.00 | 80.27 | 100.00 | 202.28 | 100.00 |
| Total Waste Volume (m3) | | | 378 | 265 | | 72.71 | | 716.03 | |
| Bulk Density (ton/m3) | | | 0.211 | 0.159 | | 1.104 | | 0.283 | |

### d. Waste Amount Survey in Thilafushi Disposal Site

Thirty two (32) days' survey was conducted from 8 July to 9 August in Thilafushi and summarised results are shown in Table 2-20. During the survey period, there were 31 resort islands, 2 nearby inhabited islands and Hulhule transported wastes about 454 tons by 302 dhoni and barges in total. The waste amount transported by the dhoni ranges from about 3.6 tons to 32 tons per day by the numbers of 3 to 15 boats. In average, nine (9) boats arrive daily to bring-in about 14.2 tons of wastes. The boat anchor about 35 minutes for unloading 1.5 tons of waste in average.

**Table 2-20 Summary of Waste Amount Survey in Thilafushi**

| | Nos. of Boat Arrival (boat) | Unloading Time (min.) | Estimated Weight (ton/day) |
|---|---|---|---|
| Total | 302 | 1,135 | 453.57 |
| Maximum | 15 | 53 | 32.00 |
| Average | 9 | 35 | 14.17 |
| Minimu | 3 | 20 | 3.56 |
| Average Loading Weight (ton/boat) | | | 1.50 |

The questionnaire survey for 74 resort islands was summarised for 45 respondents in Table 2-21. Thirty one (31) resort islands out of 45 respondents are using the Thilafushi for the final disposal site. Each resort island spend Rf 1,238 per trip or Rf 77,500 in a year in average for the cost of transportation and unloading.

**Table 2-21 Summary of Waste Disposal Survey for Resort Islands**

| Items | Transport & Unload Cost per Trip (Rfs) | Annual Transport Cost (Rfs) | Annual Hotel Guest in 1997 (bed-night) | Nos. of Staff on Season (person) | Nos. of Staff off-season (person) | Nos. of Hotel Rooms (room) |
|---|---|---|---|---|---|---|
| Effective Count | 33 | 32 | 41 | 44 | 44 | 45 |
| Total | 40,839 | 2,480,400 | 2,247,967 | 7,503 | 7,320 | 3,962 |
| Average | 1,238 | 77,512 | 54,828 | 171 | 166 | 88 |

All the details under this section are presented in the Supporting Report E and Section 3 in Data Book.