

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

SUMMARY

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May 1999

Pacific Consultants International
Environmental Technology Consultants Co., Ltd

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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 master 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,

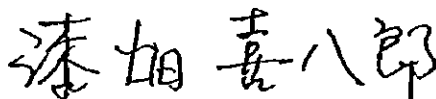
We are pleased to submit to you the final report entitled "The Study on Solid Waste Management for Male' City in the Republic of Maldives". This report has been prepared by the Study Team in accordance with the contracts signed on 12 May 1998 and 30 April 1999 between the Japan International Cooperation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

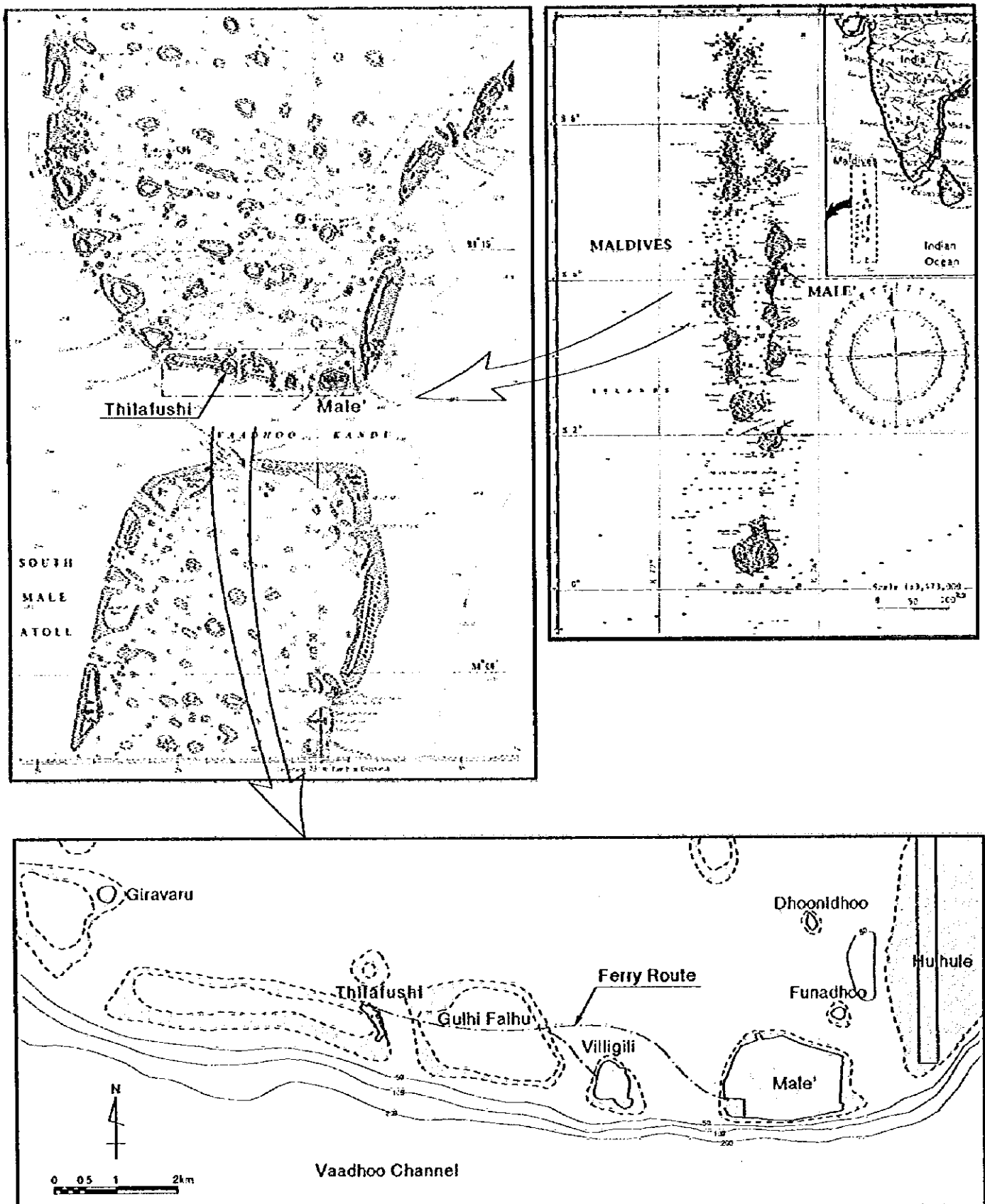
The report consists of the Summary, Main Report, Supporting Report and Data Book. The Summary summarizes the results of all studies. The Main Report contains the existing conditions, master plan, results of the feasibility study, and conclusions and recommendations. The Supporting Report includes technical 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,



Kihachiro Urushibata
Team Leader

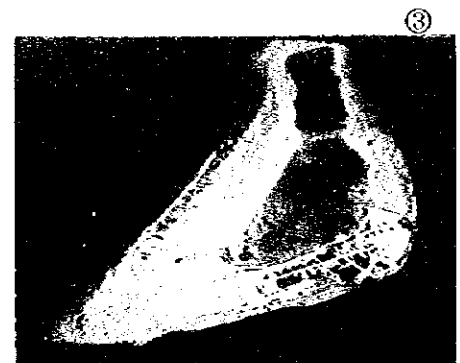
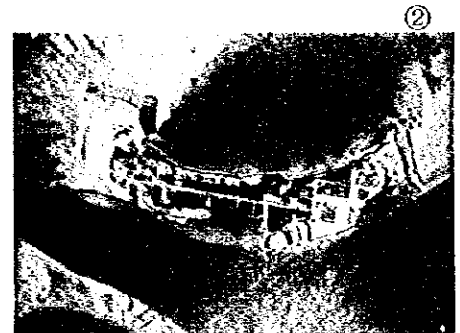
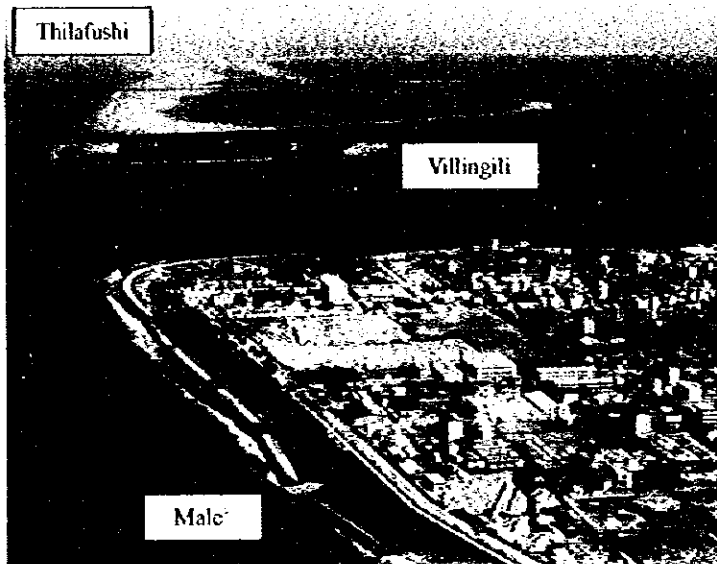


Location Map

SOLID WASTE MANAGEMENT IN MALE'

1. Male'

① Male' ②,③ Thilafushi island



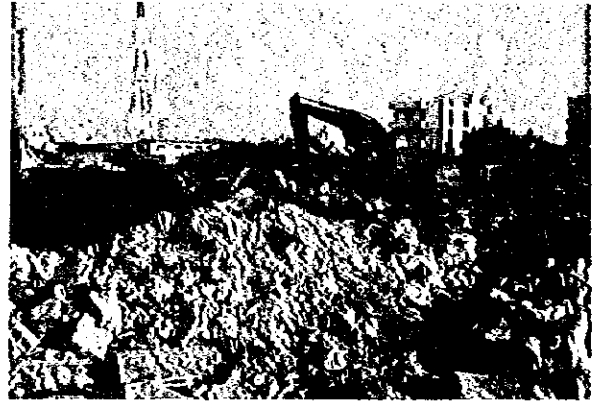
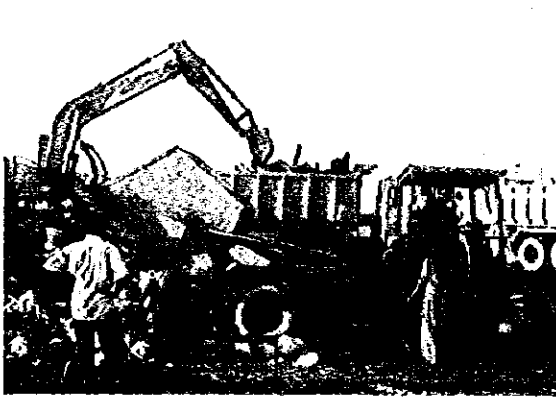
2. Collection

① Container
② Microbin
③ Handcart

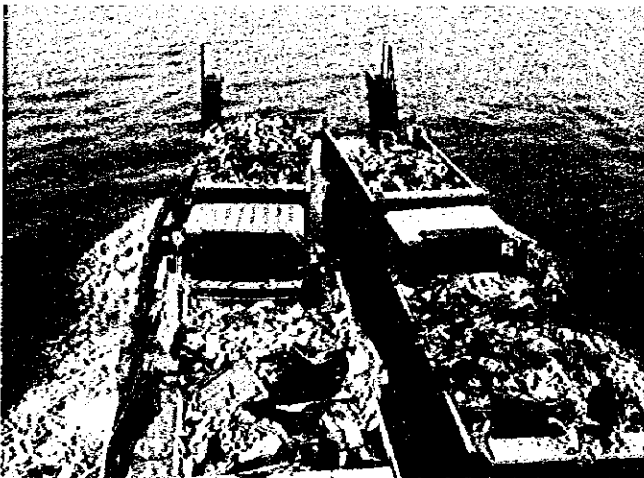




3. Transfer Station



4. Transportation



5. Final Disposal (Thilafushi)





ABSTRACT

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	
	Population	Waste Generation [ton/d]	Population	Waste Generation [ton/d]	Population	Waste Generation [ton/d]
I. Basic Data						
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 Male' Municipality	Container Collection	Vehicle Station Collection ^{*3} (collection area : 11) and Bell Collection by Compactor Truck	Vehicle Station Collection (collection area : 15) and Bell Collection by Compactor Truck
Private Sector	Door to Door Collection	Door to Door Collection	Door to Door Collection
3. Transportation	Dump Truck + Ferry	Dump Truck + Large Compactor Truck + Ferry	
4. Transfer Station	Male' island : 1 Villingiri island : 1	Male' island : 1 (new) Villingiri island : 1 (remodeled)	
5. Port Area Cleansing Equipment	Small Boat + Tractor	Motor Boat + Dump Truck	
6. Final Disposal Landfill Site	Thilafushi island (Thilafushi-1)	Thilafushi-2	Thilafushi-3
Landfill Type	Anaerobic landfill	Anaerobic sanitary landfill	Anaerobic sanitary landfill
Capacity	-	434,000 m ³	729,000 m ³
7. Jurisdiction MCPW	Transportation from transfer station to final disposal site, Final disposal	Development and construction of new landfill site, Construction of new transfer station	
Male' Municipality	Collection of municipal waste, Cleansing public space	Collection of municipal waste and charge, Enlightenment of citizens regarding waste reduction, reusing and recycle	
Sate Own Enterprise		Reception, storage, transport and final disposal of municipal waste, Collection of waste charge, Treatment and disposal of special waste, Composting	

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} The new "Vehicle Station Collection System" will deploy collection vehicles as container stations in the collection areas assigned to each vehicle.

3 Priority Projects

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.

The first part of the document discusses the importance of maintaining accurate records of all transactions. It emphasizes that proper record-keeping is essential for the integrity of the financial system and for the ability to detect and prevent fraud. The document also outlines the specific requirements for record-keeping, including the need to maintain records for a minimum of five years and to ensure that all records are properly indexed and stored.

The second part of the document discusses the importance of maintaining accurate records of all transactions. It emphasizes that proper record-keeping is essential for the integrity of the financial system and for the ability to detect and prevent fraud. The document also outlines the specific requirements for record-keeping, including the need to maintain records for a minimum of five years and to ensure that all records are properly indexed and stored.

The third part of the document discusses the importance of maintaining accurate records of all transactions. It emphasizes that proper record-keeping is essential for the integrity of the financial system and for the ability to detect and prevent fraud. The document also outlines the specific requirements for record-keeping, including the need to maintain records for a minimum of five years and to ensure that all records are properly indexed and stored.

The fourth part of the document discusses the importance of maintaining accurate records of all transactions. It emphasizes that proper record-keeping is essential for the integrity of the financial system and for the ability to detect and prevent fraud. The document also outlines the specific requirements for record-keeping, including the need to maintain records for a minimum of five years and to ensure that all records are properly indexed and stored.

The fifth part of the document discusses the importance of maintaining accurate records of all transactions. It emphasizes that proper record-keeping is essential for the integrity of the financial system and for the ability to detect and prevent fraud. The document also outlines the specific requirements for record-keeping, including the need to maintain records for a minimum of five years and to ensure that all records are properly indexed and stored.

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1 Introduction

This is a summary of the master plan and feasibility study conducted by the JICA Study Team principally targeting the solid waste management improvement in the capital region of the Republic of Maldives.

The target year of the master plan of solid waste management is 2010 and that of feasibility study is 2003. The feasibility study, also referred to as the short term development plan, is essentially aimed at instituting the required improved facilities for the solid waste management in Male' Island, the principal solid waste generation area, and the final solid waste disposal area the Thilafushi reef. It is noted that a portion of the Thilafushi reef is being reclaimed with ongoing solid waste land filling activity.

The master plan and feasibility 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.

The master plan study was conducted from May 1998 to September 1998, followed by the feasibility study until February 1999.

The entire study reports 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 Organization

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

Many central ministries and local government agencies concerned could be classified into regulatory organism and execution organism.

Table 1. Government Agencies Responsible for SWM

Name of agencies	Function	Main field of responsibility
Ministry of Planning & National Development (MPND)	Regulatory	Hazardous waste
Ministry of Home Affairs, Housing & Environment (MHAHE)	Regulatory	Waste of the Municipality
Ministry of Atolls Administration (MAA)	Regulatory	Waste of inhabited islands
Ministry of Construction and Public Works (MCPW)	Execution	Disposal of waste
Ministry of Tourism (MT)	Regulatory	Waste of tourist resorts
Ministry of Health (MH)	Regulatory	Hospital waste
Ministry of Trade & Industries (MTI)	Regulatory	Package material, export for recycle
Ministry of Fisheries, Agriculture & Marine Resources (MFAMR)	Regulatory	Fish viscera
Male' Municipality (MM)	Execution	Collection in Male' public space
Maldives Housing & Urban Development Board	Execution	Collection in Villingili public space
Island Office	Execution	Coordination in inhabited islands

2.2 Solid Waste Flow

Solid waste flow of Male' and vicinity islands is shown below.

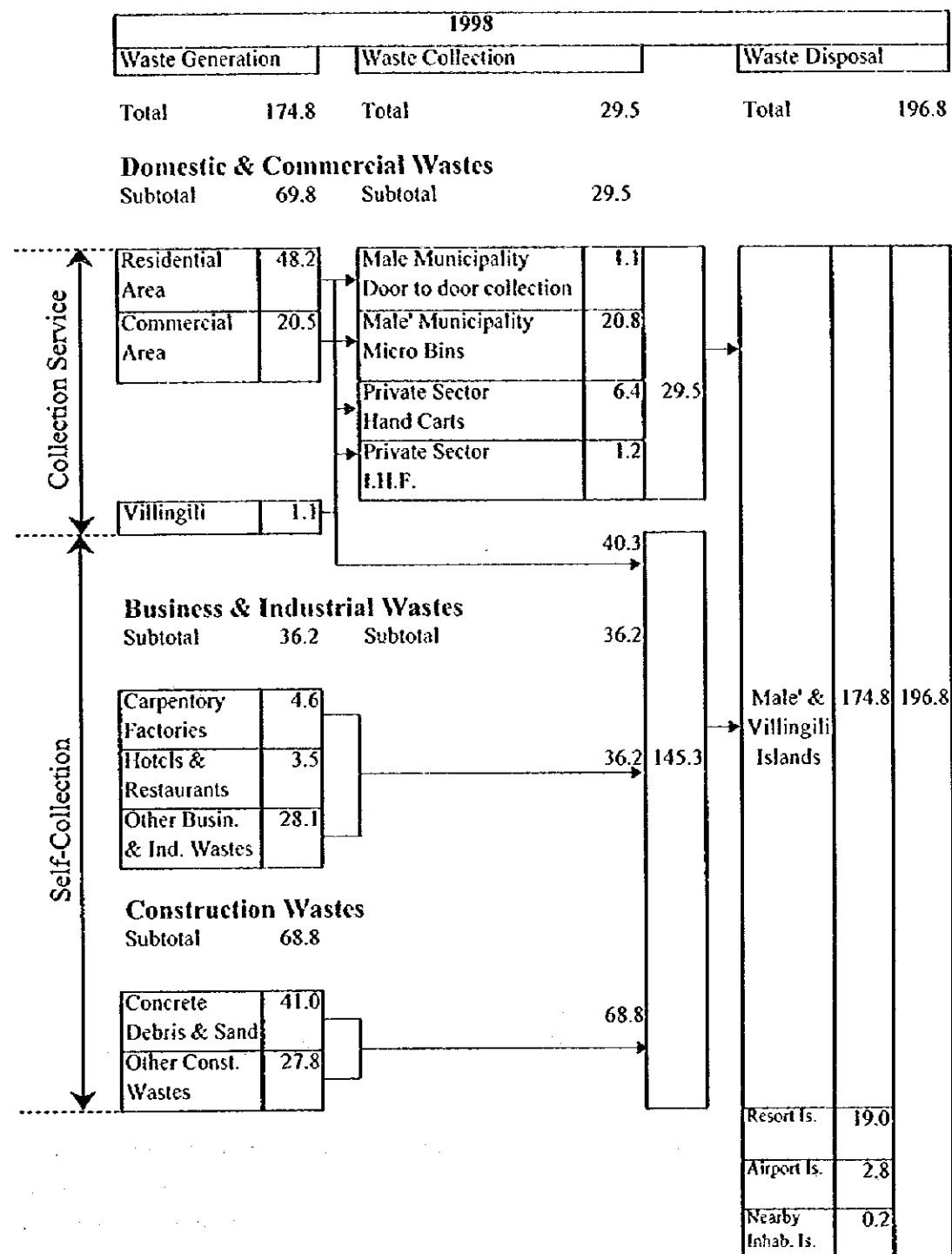


Figure 1. Solid Waste Flow in 1998 (ton / day)

2.3 Current Condition of Collection System

(1) Male'

In the Male Municipality area, the municipal waste from house, office, shop, market, restaurant and others, is not separated. The major separated waste is construction waste and iron-scraps. The construction waste is used as cover material or the land reclamation material at the disposal site. However, the iron-scraps are retained at the transfer station for several years.

In the Male Municipality Area, Male' Municipality and private companies provide solid waste collection service.

Community Service Section (CSS) of Male' Municipality provides two types of collection service for residents, the first service is container collection service free of charge and the other is door to door collection service at request upon payment. Twenty two (22) container units are installed at nine (9) stations along the coastal road in the southern part of the island. Some private companies also provide door to door collection service and haulage service.

Whatever may be the collection mode, the existing collection system collects 100% of the generated waste of Male' Island. The present total solid waste generation is estimated as 173.7 ton per day. All collected solid waste is transported to the transfer station.

Based on Time Motion Study (TMS) conducted by the Study Team, the most efficient collection system is determined as the micro-bin system. The door to door collection system by the Municipality is the least efficient system.

(2) Villingili

Villingili island is very close to Male' island and the island belong to the Male' Municipality. The island has been developed as a residential area and therefore the population will increase in near future.

There is no organised waste collection system or final disposal site in Villingili. Residents bring solid waste to the transfer stations by themselves. It is considered that the maximum distance of 500m a resident has to walk up to the transfer station is acceptable and organised collection service by the Municipality is not required.

(3) Resort Islands

There are about 70 islands registered as resort islands, which is developed and operated mainly for foreign tourists. Ministry of Tourism is responsible for the management of resort islands. By law, each resort island is responsible for its solid waste management and the island should have a suitable incinerator to process combustible waste. However, some islands are not equipped with incinerator and carry raw waste to Thilafushi final disposal site.

(4) Inhabited Islands

There are about 130 inhabited islands administrated besides resort islands. Ministry of Atoll Administration (MAA) is responsible for the management of inhabited islands. Island office take measures for solid waste management (SWM) in each island. Most of the inhabited islands are very small. Therefore the waste collection and transportation system is not required. Usually, residents carry their waste to disposal site by themselves. Generally, solid waste is dumped at the disposal site without any cover. Localised secondary coastal pollution may exist even though overall pollution level is generally insignificant.

2.4 Current Condition of Solid Waste Transportation System

Solid waste transportation system is not required except for Male' metropolitan area and the resort islands, because all inhabited islands have local disposal sites. In Male' Metropolitan area, Ministry of Construction and Public Works (MCPW) is responsible for transportation of solid waste generated in the Metropolitan area (Male' and Villingili) from the transfer stations to the final disposal site in Thilafushi. Moreover, MCPW manages the final disposal site, Thilafushi.

One trip of transportation from transfer station to the final disposal site in Thilafushi require about 90 minutes. Waste transportation efficiency could be increased by adopting two ferry conveyance system instead of the single ferry system adopted at present.

2.5 Present Waste Management Issues of Male'

(1) Collection

The major problems of Male' collection system are as follows:

- The collection system of the Municipality covers only 44.2% of residential waste since northern residents are not served.
- 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 adequately promoted.

(2) Transportation

The major problems of the existing transportation system are as follows:

- The waste heap at the transfer station causes secondary pollution, in particular, odor nuisance.
- The waste transportation capacity is limited due to the single ferry system in use resulting in some amount of waste remained in the transfer station.
- The management of the transfer station is inadequate. Waste deposition in the transfer station is permitted for 24 hours without adequate control on waste segregation and waste disposal zone.
- Open truck transportation of solid waste results in scattering of garbage along the route

2.6 Present Status of Thilafushi Island

The solid waste landfill operation in the existing Thilafushi island (Thilafushi-1) was commenced in December 1992 and has been in operation for about six years. Thilafushi, the island being reclaimed from Thilafushi reef (Thilafushi-1 of Fig. 3) with solid waste land filling, receives its waste from Male', Villingili and resort islands.

The ongoing landfill operation in Thilafushi could be classified as solid waste dumping in ponds created by dredging in reef-flat and raising the land level just above sea level with a final cover of dredged material from reef flat. Infrequent open burning of garbage prior to land-filling, as a crude means of processing of solid waste, was also noted. This

inadequate solid waste management results in strong unpleasant odor and severe fly nuisance. Apart from these basic landfill management issues, other significant operational and environmental issues concerned to the present Thilafushi landfill management are summarized below.

(1) Dispersal of dredged material due to unconfined dredging

Unconfined and uncontrolled dredging of reef flat for the creation of pond space for filling garbage and for generating cover material for landfill results in dispersal of sediment to the surrounding marine water environment. This sediment load is perceived to adversely affect the marine biota, in particular coral life. It is noted that mitigation of dispersal of dredged sediment will not only eliminate any adverse effect on marine biota but also save valuable cover material for landfill.

(2) Dispersal of garbage due to ineffective confinement

Floating garbage (solid waste) in water of a new solid waste dumping area is prevalent due to inadequate confinement of solid waste dumping area. Moreover temporary storage of solid waste too close to the shoreline may also be a cause of dispersal of garbage to surrounding marine water environment. Moreover ineffective coastal erosion mitigation measures and the progressing coastal erosion also results in dispersal of even compacted solid waste to the surrounding marine water environment.

(3) Degradation of inner lagoon of Thilafushi

The inner lagoon located along the western face of the existing Thilafushi island is essentially a semi-enclosed water body. Insufficient dilution and dispersion of leachate from the landfill is perceived as the cause of progressing eutrophication of this inner lagoon that also resulted in coral disease and mortality.

(4) Improper land-use of completed landfill area

Land reclaimed with solid waste has already been earmarked for various industrial and warehouse use and some tenants have already commenced construction of relevant facilities. In this case of present Thilafushi island, solid waste is simply considered as a land reclamation material and reclaimed land is used with scant attention to the hazardous nature of leachate and other flammable gases generated consequent to the progressing degradation (stabilization) of dumped solid waste underground.

3 Environmental Condition

The Study Team conducted an assessment on the ecological status of coral life in the Thilafushi reef, the area adjacent to the present solid waste land filling island of Thilafushi. Based on the coral ecological survey results, the present status of coral life in and around the Thilafushi reef was assessed as summarized below.

- The Thilafushi reef-flat coral life of channel reef and inner reef is more degraded in comparison to the outer channel reef-flat facing the Vaadhoo channel.
- No significant specific areas of degraded coral life on the reef-slope of Thilafushi were noted.
- Dispersed dredged material from the Thilafushi reef consequent to the ongoing landfill operation leads to silt deposition on adjacent Gulhifalhu reef affecting its coral life.

The Study Team also conducted sampling and analysis of a variety of water and seabed material quality.

Based on the analytical results of sea water and sea-bed material (sediment) sampling conducted in and around Thilafushi and Male', both are assessed as unpolluted and representative to background levels of natural condition. However the groundwater in Male' is assessed as significantly polluted, since the COD level was mostly in the range of about 15-20 mg/l. It is noted that COD level of unpolluted groundwater does not normally exceed 5 mg/l. The leachate quality in the existing solid waste landfill island of Thilafushi indicated active stabilization of leachate aided by exchange with surrounding sea water. Also the metallic contamination level in leachate was found to be insignificant.

4 Master Plan of Solid Waste Management

4.1 Solid Waste Collection System

a. Objective

The objective of the solid waste collection plan is to establish an economically viable collection system in Male' island, which ensures equal or better sanitary and aesthetic condition, compared to present condition.

b. Waste Collection Concept

The waste collection plan targeted only the residential waste. Other kind of wastes like commercial, business and industrial waste should 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.

c. Legal Implications

The Municipality has to establish the legal framework clearly. The By-law of Male' Municipality shall include the following new clauses;

- Residents have to carry their solid waste to the collection station/vehicle at the designated time and place set by the Municipality or to the transfer station. The entrepreneurs have to carry their waste to the transfer station by themselves. Daily cleaning of frontal street area of a house be the responsibility of the house occupant.
- Residents have to carry their bulky waste to the transfer station by themselves.
- Male' Municipality is responsible for cleansing of public spaces and collection of waste from the public area. Male' Municipality shall provide minimum collection services to all the residents upon minimum waste charge.
- Male' Municipality can provide high quality solid waste collection service to anyone upon request and full cost recovery.
- Male' Municipality will permit registered private companies to provide high quality solid waste collection service to anyone upon payment.

d. Alternative Residential Collection System

The affordable waste charge and the financial capacity of the Municipality decide the level of collection service. The new collection system will ensure the better sanitary and aesthetic condition compared with the present condition.

Three (3) alternative solid waste collection systems for residents are comparatively evaluated as shown below.

Table 2. New Solid Waste Collection System Alternatives

Item	Name	Major Merit	Major Demerit	Unit Collection Cost (Rf/ton)
Option 1	Road Side Station Collection System	High collection efficiency	Environmental problems, Inconvenient for residents	282
Option 2	Door to Door Collection System	Convenient for residents	Low collection efficiency	450
Option 3	Vehicle Station Collection System	High collection efficiency	Inconvenient for residents	226

Option 3 was selected as the most economical and efficient collection system. Also it is suitable for the congested traffic condition in Male' Island. Moreover the duration time of waste exposure to the air is minimum and hence acceptable in terms of environmental, sanitary and aesthetic aspects as well.

Accordingly, the "Vehicle Station Collection System" is adopted as the new solid waste collection system for Male' to provide minimum service for all residents.

e. Organisation 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 organisation would lead to gradual increase in service level and convenience of residents.

f. Collection System for the Commercial and Business Waste

The commercial and business waste shall be conveyed to the transfer station by the waste generators themselves. To this end a waste generator can hire a private company (including handcart) or the Municipality. Such a system of the private collection service is in operation at present and would continue in future as well.

The Municipality is responsible for supervision and monitoring the activities of waste generators and private collectors.

g. Collection System for Construction Waste

Ministry of Construction and Public Works (MCPW) shall be responsible for supervision and monitoring of the construction waste. MCPW shall monitor large-scale development, demolition and construction activities. A construction initiator shall submit the waste hauling plan before commencement of the construction work to the MCPW for its approval.

4.2 Solid Waste Transportation System

a. Objective

The objective of the transportation plan is to establish an effective and efficient transportation system to remove the collected waste to the final disposal site efficiently in order to maintain public health and cleanness.

b. Transport 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 week, is estimated as about 215 ton/day in 1999, 255 ton/day in 2003 and 335 ton/day in 2010.

c. Transport System Improvement Alternatives

Three (3) alternative solid waste transportation improvement systems are considered for evaluation considering the current situation of SWM in Male'. The results of evaluation are tabulated below.

Table 3. Improved Solid Waste Transport System Alternatives

Item	System	Major Merits	Major Demerits	Unit Transportation Cost (Rf/ton)
Option 1	Improvement of transfer station	Improve transfer work efficiency, Improve the environmental conditions of transfer station.	Environmental problems at the access road and waiting area.	255
Option 2	Improvement of transfer station + introduction of compactor truck	Improve transfer work efficiency, Improve the environmental condition of transfer station, access road waiting area.	Transfer work is complicated.	245
Option 3	Introduction of compactor-container system	Improve transfer work efficiency, Improve the environmental condition of transfer station, access road waiting area	Total cost is high.	394

Option 2 was selected as the most suitable solid waste transportation system with due consideration to economics and environmental improvement.

From the year 2003, when the proposed transportation system would begin operation, total number of required trucks are determined as 18 (5 trucks x 3 teams with each team having 3 compactor trucks and 2 normal trucks).

4.3 Construction of New Transfer Station in Male

a. General

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

The quantity of solid waste disposed at the Male' transfer station is estimated to increase from about 18 ton/day in 1999 to about 280 ton/day in 2010.

b. Significant features of Transfer Station

Planned site for new solid waste transfer station is facing the south coast of Male' island and entirely surrounded by public roads. The planning concept for the facility is summarized below:

- Capacity of stock volume is secured for an equivalent to 3 day generation except for the miscellaneous perishable waste.
- Miscellaneous perishable waste is removed within a day or two.
- Facility is enclosed with fence to mitigate waste and smell dispersion, and noise control.
- Entrance for transport vehicles is placed on the side facing the sea to mitigate adverse effects by traffic noise.
- Entrance for collection vehicles is located at the opposite end to the transport vehicle entrance to facilitate convenient separate access.
- Internal vehicle passages are separately assigned to vehicles by their role of collection, transport and administration.
- Waste storage area is separated according to the type of waste.

The layout of the new solid waste Transfer Station is shown in Figure 2.

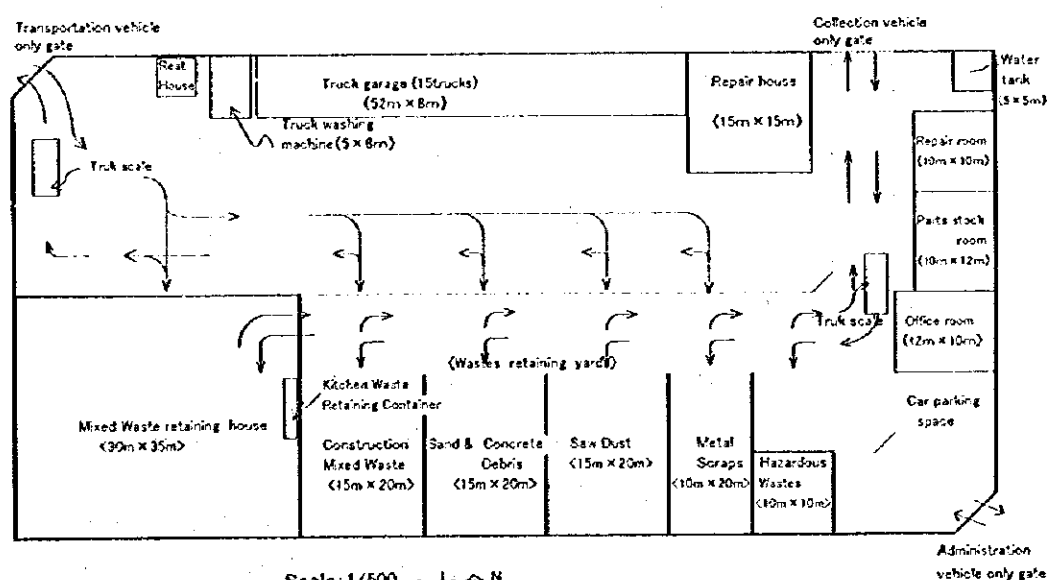


Figure 2. Transfer Station (200 ft x 400 ft)

4.4 Improvement of Transfer Site in Villingili

a. Deposit Site

Enclosing fence be installed to prevent the dumped waste from scattering outside. Segregated storage by type shall be instituted to facilitate proper placement of waste according to the waste type by residents.

b. Loading Facility

Existing solid waste loading pier is deteriorated due to erosion by waves. It needs to be repaired to facilitate proper and safe loading of solid waste to ferry boat.

4.5 Final Disposal Site in Thilafushi

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.

1. Construction of New Landfill Site
2. Improvement of Existing Island

(1) Construction of New Landfill Site

a. Landfill Type

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.

b. Landfill Structure

The concept of the landfill structure is summarized below.

Table 4. Summary of the Concept for Landfill Structure

Depth of Bottom layer	Layer of Waste Filling	Height of Filling	Seawall Structure of Inner Lagoon Reef	Seawall Structure of Outer Reef
E.L. -2.5 m	2 Layers	E.L. +4.0 m	Sheet Pile	Rock
3.2m below mean sea level	First layer up to +2.0m Second layer up to +4.0m	3.4m above mean sea level	Impermeable wall	Retention ditch between rock walls

Above concept is recommended for the development of new landfill site in Thilafushi considering environmental aspect, operational aspect, economical aspect and land stability.

The typical section and functions of the structure are shown in Figure 3.

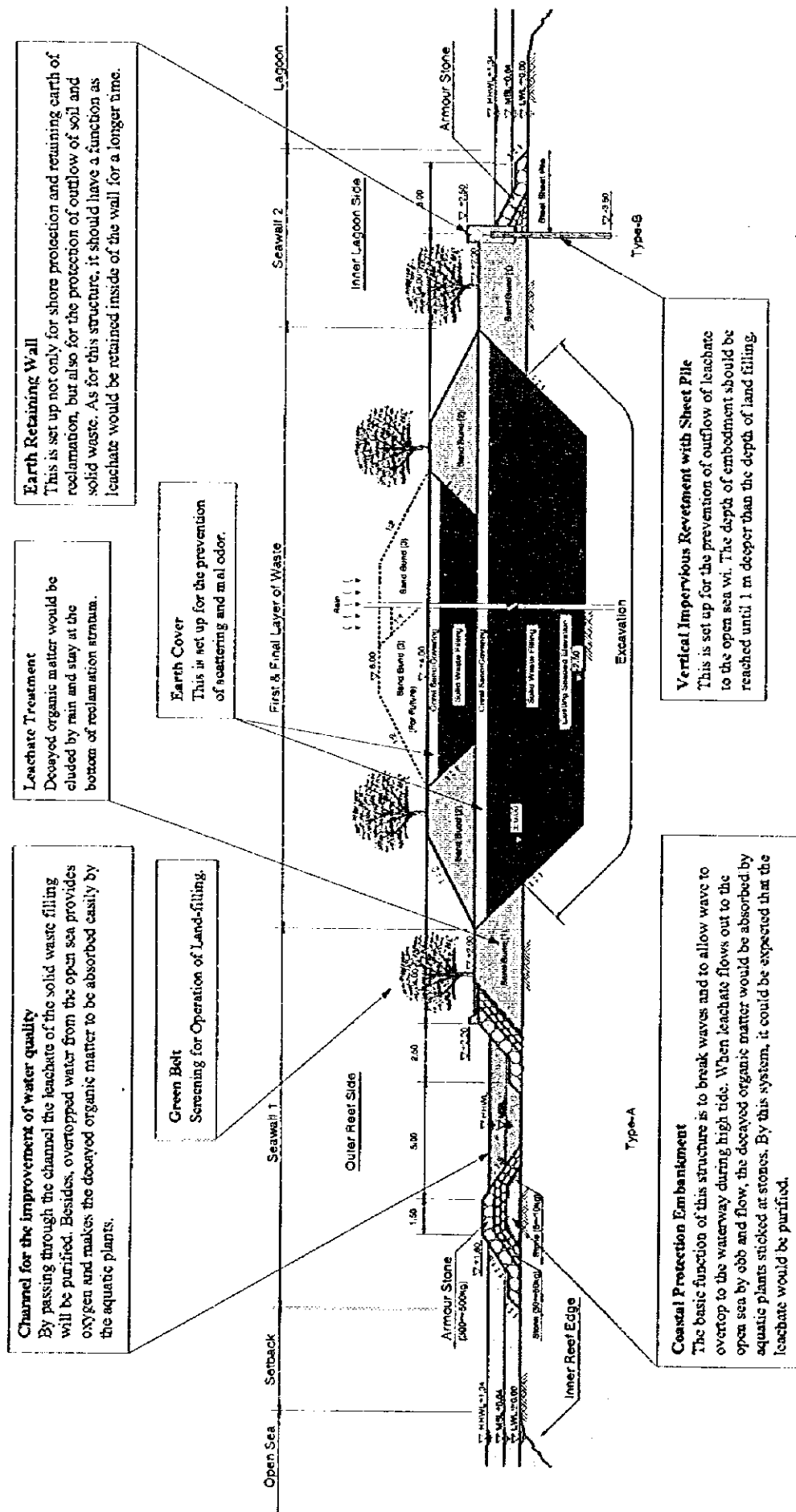


Figure 3. Function of Each Structure at Final Disposal in Thilafushi

c. Direction of Future Landfill Extension

For future landfill extension it is recommended to use the north reef flat for the following reasons.

- i) High swells are always approaching south reef facing Vaadu channel. Construction cost will be high.
- ii) Corals along the south flat are very active while those of north reef are degraded. Also there are many sightseeing spots for scuba diving on the south reef
- iii) Water depth in the inner lagoon is about 6m. Cost for the seawall construction in the deep water will be twice compared to the shallow one.

d. Capacity of Landfill

Estimated solid waste volume and required area for the solid waste land filling in Thilafushi from 1999 to 2010 is summarized below. It is assumed that only 40% of construction waste will be used for land-filling and the rest 60% will be reused.

Table 5. Waste to be Disposed

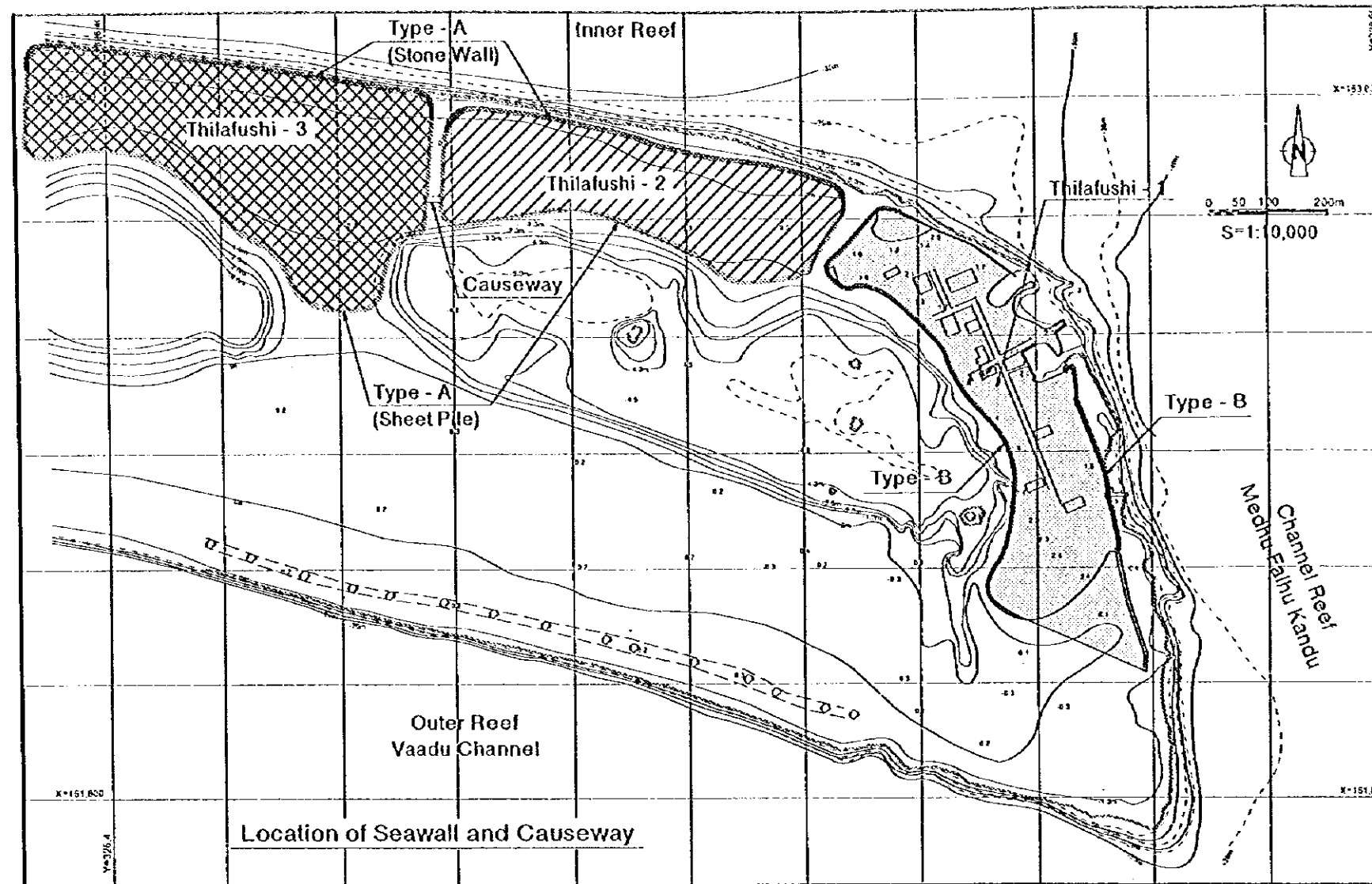
Period (years)	Total amount (tons)	Amount excluding 60% of construction waste (tons)	Volume excluding 60% of construction waste (m ³)	Required Landfill Area (m ²)
1999-2003	410,990	328,000	402,000	105,000
2004-2010	767,595	629,000	786,000	180,000
Total	1,178,585	957,000	1,188,000	285,000

(2) Improvement of Existing Island

Two third of coast line of the existing Thilafushi Island is facing or occupied by the leasing lots such as STO site, industrial area, harbour area and slipway for barge repairing, which are all concluded contracts. It is difficult to determine the possible improvement measures for these areas. Therefore, the coastal improvement measure will be limited to the portion of the coast unrelated to any significant business activity.

(3) Overall Plan in Thilafushi

The overall plan of Thilafushi Island landfill development, including the existing Thilafushi up to the year 2003 and also beyond up to 2010 is summarized in Figure 4.



Length of the Proposed Structure (m)

Target Year	Location	Type-A		Type-B	Causeway
		Stone wall	Sheet Pile		
2003	Thilafushi-1	—	—	1,320	—
	Thilafushi-2	740	970	—	50
2010	Thilafushi-3	800	1,300	—	50
	Total	1,540	2,270	1,320	100

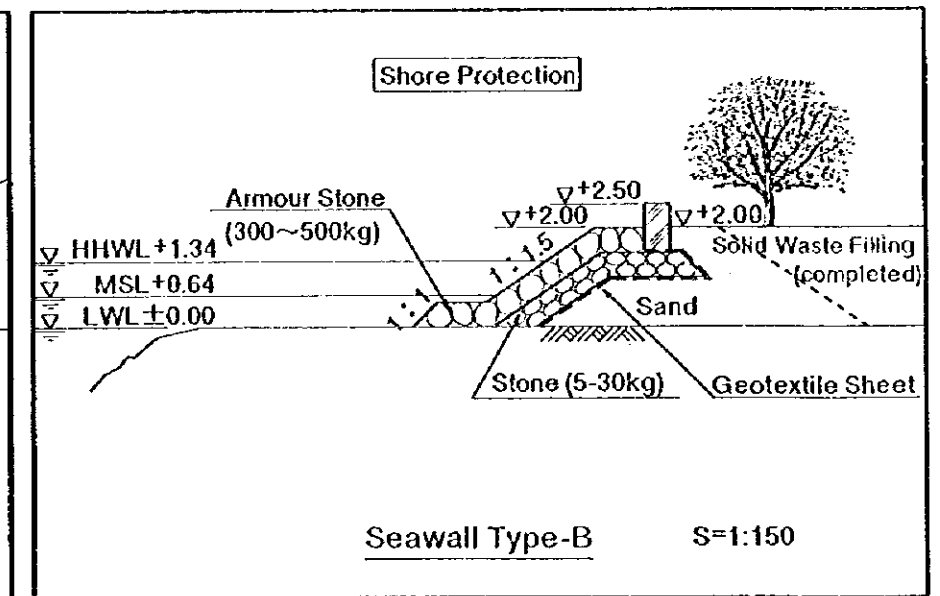
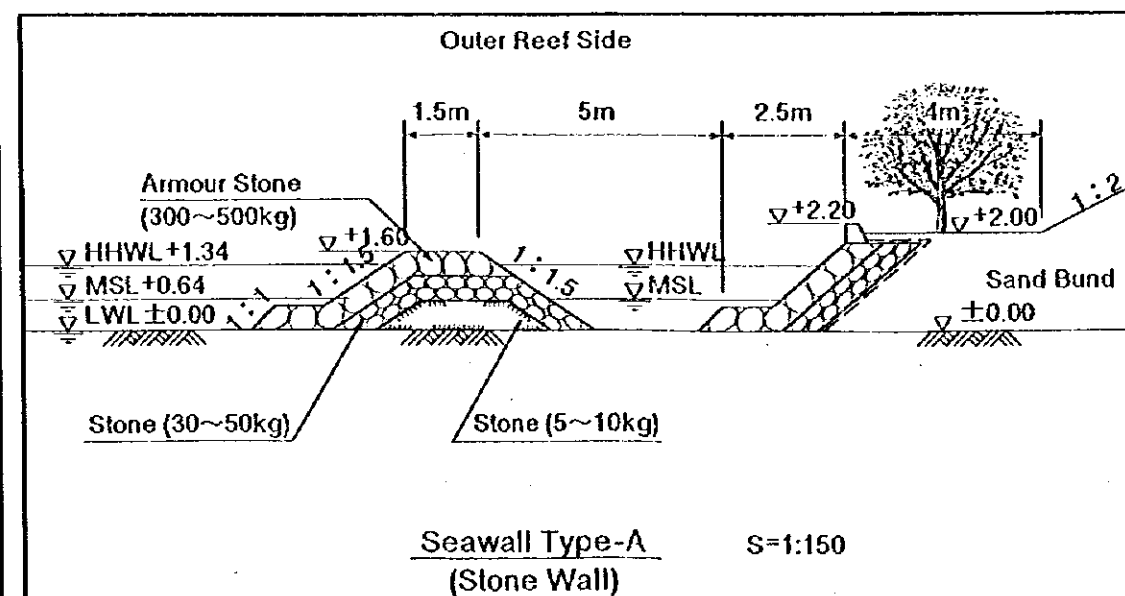
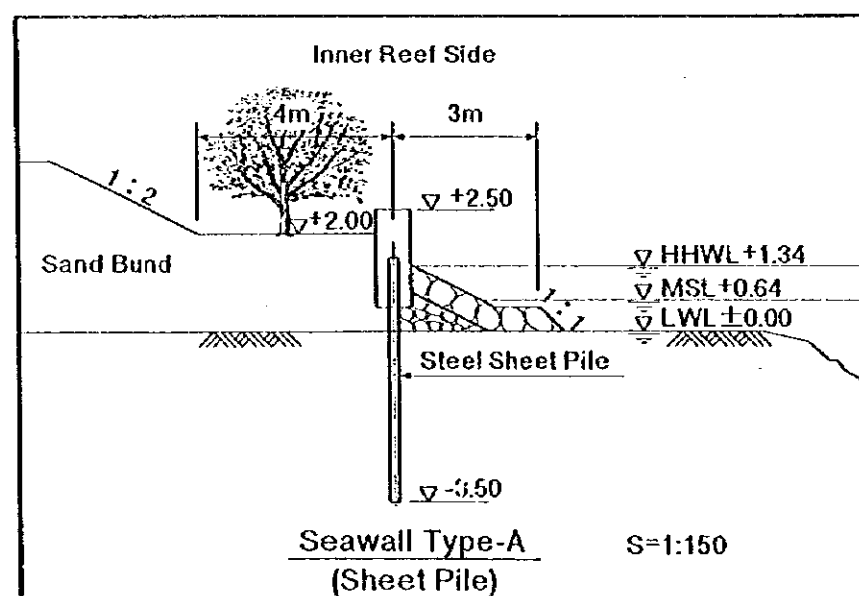
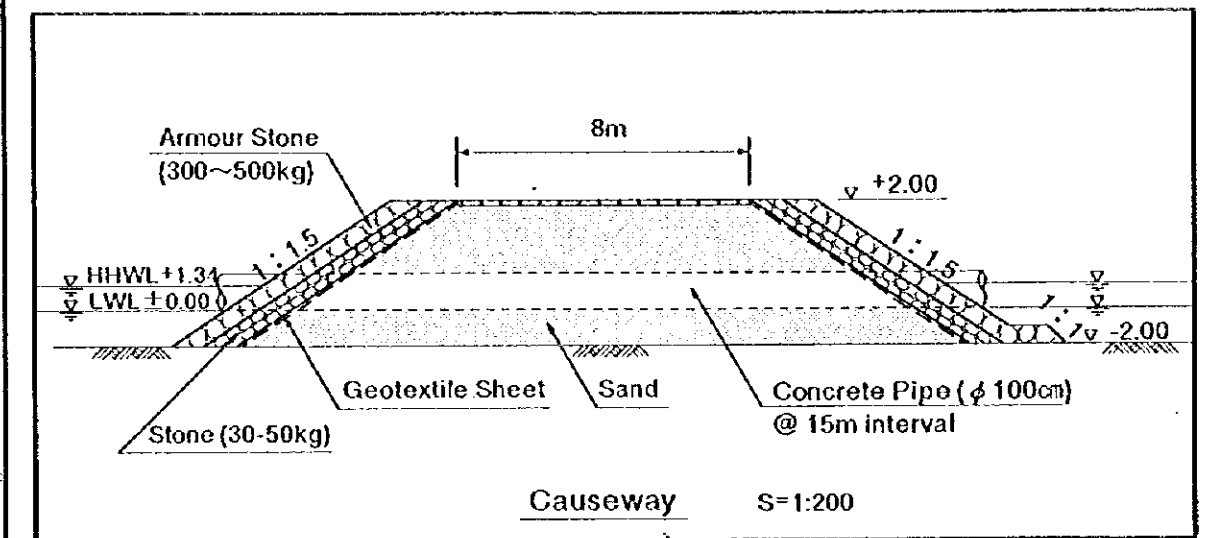


Figure 4. Master Plan of Final Disposal Site

4.6 Waste Reduction and Recycling

(1) Planning Strategy

- ① Male Municipality shall have the primary responsibilities for Waste Reduction Plan
- ② MCPW shall have the primary responsibilities for Waste Recycling Plan
- ③ Waste reduction shall be targeted to domestic, commercial and business, industrial and institutional wastes
- ④ Initial solid waste recycling shall be implemented for the recyclable materials carried-in to the Transfer Station
- ⑤ Establishment of Special Task Team as a implementing organisation in Male' Municipality by recruiting members from MCPW
- ⑥ Composting of food waste and saw dust shall be carried out by appropriate technology and scale of the facilities

(2) Waste Reduction and Recovery/Recycling Plans

Waste Reduction and Recovery/Recycling Plans was composed of followings

- Generation Source Control
- Waste Discharge Control
- Recovery/Recycling of Materials

(3) Action Plan for Waste Reduction Plan

a. Short Term Plan

- ① Establishment of Special Task Team,
- ② Implementation of "Generation Source Control" and "Waste Discharge Control",
- ③ Implementation of "Distribution & Sale Control" and "Consumer Control",
- ④ Waste amount reduction shall be realised by means of self-disposal, repair and reuse of broken appliances/instruments, and exchange/sale of second hand goods
- ⑤ Male Municipality shall commence the public campaign and education.

ii) Middle/Long Term Plan

- ① Public campaign and education shall be made continuously,
- ② "Production Control", "Waste Charge Control" and "Commercial Waste Control" shall be implemented.

(4) Action Plan for Waste Recovery/Recycling

a. Short Term Plan

- ① Collect information, analysis and study
- ② Recovery/Recycling of materials shall have started with the programs of "Recovery by Junk Dealers",
- ③ Promotion, encouragement and support to set up the Buy-back Centre in the compound of Transfer Station
- ④ Recovery of materials at the Transfer Station
- ⑤ Reuse of recovered concrete debris and sand properly
- ⑥ Recyclable material from the resort islands shall be separated and stored
- ⑦ Commencement of pilot scale food waste - saw dust composting and test application of the compost
- ⑧ Regular collection and storage system of waste dry batteries
- ⑨ Research and study of recycling industries & technology
- ⑩ Promotion, encouragement and assistance to the interesting investors for waste recycling activities,

a. Middle/Long Term Plan

- ① Continuation of the resource recovery and waste recycling plans
- ② Provision of periodic base market for recovered materials
- ③ Assist the investor(s) to develop the Recycling Centre to secure the sale routes,
- ④ Review of the on-going resource recovery and recycling plans and systems for future improvement and development of the activities

4.7 Promotion of Raising Public Awareness and Participation

(1) Planning Strategy

Raising public awareness shall be made by means of conducting the regular public education to adult and school education to children and students including visiting the operation sites of SWM services.

(2) Raising Public Awareness and Education Plan

Raising Public Awareness and Education Plan was composed of followings

- Raising Awareness within MCPW and Male Municipality
- Public Announcement of the SWM Master Plan
- Public Education
- School Education
- Participation to Cleansing of Public Areas and Reduction of Waste
- Participation to Waste Recycling Activities

(3) Implementation of Public Awareness and Education Plan

a. Short Term Plan

- ① “Raising Awareness within MCPW and Male Municipality” shall be promoted through the procedure to study, discuss, adjust or modify and finalise the most appropriate plans and programs for the SWM Master Plan for Male’,
- ② “Public Announcement of the SWM Master Plan” shall be made immediately after approval of the SWM Master Plan by the Government. The announcement shall be made through the mass media and by the pamphlets distributed through the community groups,
- ③ “Public Education” shall be started following to the public announcement of the SWM Master Plan. Contents of the education shall include the specific requirements asking co-operation to the public for implementation of the SWM Master Plan,
- ④ “School Education” shall be carried out continuously every year in accordance with the schooling subjects and schedule prepared by the Ministry of Education in co-operation of the STT. It is recommended to prepare the video programs for an effective tool for school education.
- ⑤ “Participation to Cleansing of Public Areas” shall be implemented in co-ordination with the “Clean Maldives, Independent Maldives” project “.

b. Middle/Long Term Plan

- ① “Participation to Waste Recycling Activities” shall be implemented following to the announcement of MCPW to notify commencement of the Waste Recycling Plan and continuous operation of the Waste Reduction Plan.

4.8 Cost Estimate for Project Components of Master Plan

(1) Basic Assumption for Cost Estimation

The Project cost are estimated based on the unit price as of 1998 and foreign currency exchange rate of 1US\$ = 11.72 Rf = 130.0 ¥. The composition of the project cost is tabulated below. The contingency for price escalation is not considered.

Table 6. Contents of Project Cost

Construction	Procurement
Construction Cost (C.C)	Procurement Cost (P.C)
Direct Construction Cost(D.C)	Equipment Cost (CIF Price) (E.C)
Facilities Construction Cost	Installation Cost (= 10% of E.C)
Direct Temporary Cost	Overhead (= 3.5% of E.C)
Indirect Construction Cost	
Common Temporary Cost	
(= 10% of D.C)	
Site Expense (=13% of D.C)	
Overhead (=8% of D.C)	
Engineering Services (= 8% of C.C)	Engineering Services (= 3% of P.C)
Physical Contingency (= 10% of C.C)	Physical Contingency = 0

(2) Cost of Master Plan

The total cost of solid waste management master plan for Male' until the year 2010 is estimated as about 349 million Rf. Summary of cost breakdown is shown in Table 7.

(3) Implementation schedule

The proposed tentative implementation schedule of the Master Plan from 1998 to 2010 is shown in Figure 5.

Table 7. Summary of Total Cost of Master Plan

	Items	Cost (1,000MR)	Cost (1,000US\$)	Remarks
1.	Construction			
1)	Construction of Thilafushi (2)	97,457	8,315	(for 2003)
2)	Construction of Thilafushi (3)	109,505	9,343	(for 2004~2010)
3)	Construction of Existing Thilafushi (Local Rock Type)	11,856	1,012	
4)	Construction in Male'	25,742	2,196	Transfer Station
5)	Construction in Villingili	2,525	215	Rehabilitation
	Sub-Total	247,085	21,081	
6)	Engineering Services	19,767	1,686	{1)~5)} × 8%
7)	Physical Contingency	24,709	2,108	{1)~5)} × 10%
	Total (1)	291,561	24,875	
2.	Procurement			
1)	Innovation of Collection System	12,539	1,070	
2)	Enhancement of Transport System	24,489	2,090	
3)	Male' Transfer Station	11,033	941	
4)	Enhancement of Public Space Cleaning			
(1)	Dust Bin in Public park	141	12	
(2)	Port Area Cleaning	616	53	
5)	New Landfill Site in Thilafushi	7267	620	
	Sub Total	56,085	4,786	
6)	Engineering Services	1,680	144	(1)~5)) × 3.0%
	Total (2)	57,765	4,930	
	TOTAL MASTER PLAN COST	349,326	29,805	Total (1) + Total (2)

Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Project Component													
Feasibility Study	—												
Basic and Detail Design		—	—	—	—	—							
Tender			—	—	—	—							
Construction of Thilafushi (for 2003)			—	—	—	—	—	—					
Construction of Thilafushi (for 2010)				—	—	—	—	—	—	—	—	—	—
Construction of Male'				—	—	—	—	—					
Construction of Villingili					—	—							
Procurement for Male'				—	—	—			—				
Procurement for Thilafushi				—	—	—							
Solid Waste Filling													
(for 2003)		—	—	—	—	—	—	—					
(for 2010)							—	—	—	—	—	—	—

Figure 5 Implementation Schedule

4.9 Economic and Financial Analysis of Master Plan

(1) Overview of Financial Aspects of Implementing Agencies

The national expenditure budget is not overburdened with debt servicing. The Republic of the Maldives deems to have a sufficient capacity to shoulder the repayment of the initial cost of the Projects, supposing it is financed by loans.

Already the households of Male' are overburdened with the payment for water and electricity charges, which occupies more than 15% of their income. Therefore, it is essential that the additional financial load through the introduction of solid waste charge should not be severe. Thus, it is finally proposed that solid waste charges do not exceed beneficiaries' willingness to pay. In the case of households, the charge is proposed to be around 1% of their income.

MCPW and MM should share the O & M cost by allocating 7 to 8 percent of their budget for solid waste management. It means the continuation of their current practice.

(2) Estimated Cost of Master Plan Projects

(Unit: Rf. thousand)

Initial Cost	O & M Cost		
	Direct O & M Cost	Depreciation	Total
349,326	16,543	17,397	33,940

The total initial cost of the Male' and Vicinities Master Plan Project is estimated as Rf. 349,326,000 or US\$ 29,806,000. Besides, the direct cost of operation and maintenance composed of collection, transportation and disposal of solid waste amounting to Rf 16,543,000 and depreciation reaching Rf. 17,397,000, adding up to Rf. 33,940,000 will be annually required from the year 2010 onward.

(3) Budget Allocation

a. Concept

Expenditure Budget	Revenue Budget
Initial Cost	Grants, Loans, Conventional Revenue Sources
Direct O & M Cost	Solid Waste Charge from Beneficiaries
Depreciation	Conventional Revenue Sources/Solid Waste Charge

The expenditure budget of MCPW for the initial cost will be appropriated from the governmental revenue budget whose sources will be foreign grants, new foreign/domestic loans and/or conventional governmental revenue sources such as tourism tax, lease and rent of governmental estate and import duty.

Likewise, the expenditure budget of MM and MCPW for the direct O & M cost to collect, transport and dispose solid waste will be appropriated from the governmental/public revenue budget whose source will be solid waste charge imposed to beneficiaries.

Regarding the expenditure budget of MM and MCPW for depreciation of SWM equipment and facilities, it will be allocated from the governmental/public revenue budget deriving from conventional sources such as tourism tax, lease and rent of governmental/public estate and import duty.

b. Quantitative Analysis

The initial cost is estimated to take up 1.0% of the cumulative government revenue budget during the implementation period of 2000 to 2010. It is expected to account for 16.9% of the cumulative MCPW expenditure budget in the same period.

To meet the direct O & M cost, solid waste charge is proposed to be collected from the beneficiaries. According to the results of analysis, the monthly charge of Rf. 166 and Rf. 86 will be imposed per house from 2003 to 2010 on average in the Male' and Villingili islands, respectively. The tariffs correspond to 88.5% and 177.0% of beneficiaries' willingness to pay in Male' and Villingili respectively. Also, on average Rf. 97 per tonne will be taken in the same period from establishments / institutions in Male'. The Maldives Airports Authority and a resort island will pay a monthly charge of Rf. 2,281 and Rf. 398 for disposal of their solid waste in the Thilafushi islands,

respectively (these figures are only for disposal. The Maldives Airports Authority and a resort island will have to pay transport fee themselves).

To cater for depreciation of collection vehicles, 7.7% of the revenue budget of MM deriving from conventional sources such as transfer from the central government and rents will be appropriated. Currently, 8.3% of MM budget is estimated to be allocated for SWM. Also, for depreciation of transportation, disposal and cleaning vehicles/equipment and facilities, 6.7% of the MCPW revenue budget deriving from conventional sources will be appropriated. At present 7.0% of MCPW budget is transferred to the Waste Management Section (WMS).

(4) Economic Analysis

The economic analysis was performed for the Male' and Vicinities Master Plan Projects.

The economic benefits of the project such as the freedom from unpleasant sight and odour of solid waste in and out of the houses and reduction of sanitation-related diseases such as diarrhoea, dysentery and skin diseases can be interpreted to be quantitatively reflected in the beneficiaries' willingness to pay for solid waste management service.

As a result of economic analysis, it was revealed that the project will have the EIRR of 16.9%, which is substantially above 10%, the estimated opportunity cost of capital in the Maldives. Therefore, the master plan project is judged to be economically highly feasible. According to the results of sensitivity analysis, the master plan project will stay viable even under the most unfavourable conditions conceived.

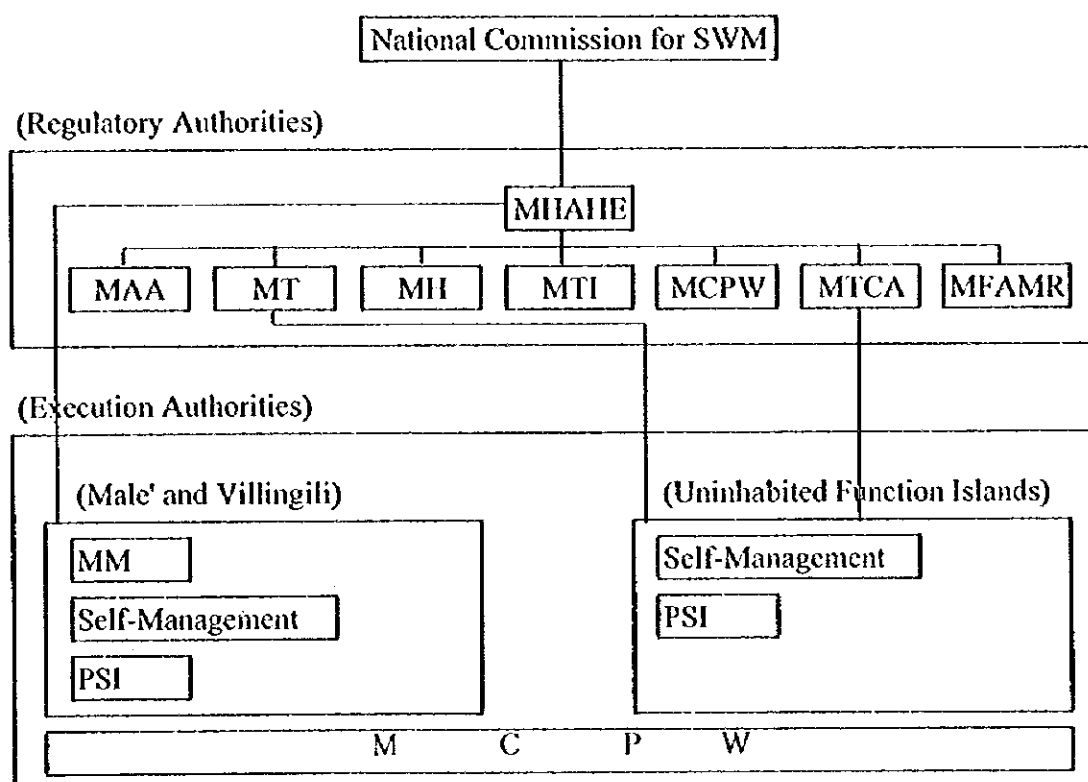
(5) Financial Analysis

On conditions that the initial cost of the project is borne by the government whether it is financed by grants, loans or budgetary revenues, that the households set aside more or less about 1% of their income and establishments/institutions pay around Rf. 100 per tonne for solid waste management, and that MCPW and MM allocate several percent of their budget for solid waste management, then the master plan projects will roll ahead in the years to come in a financially sustainable manner.

4.10 Institutional Arrangement

(1) Institutional Arrangement at National Level

The proposed structure of the institutional system is as shown in Figure 6. Being set up through coordination and mobilisation of the functions and resources of authorities concerned, this framework aims to create a proper institution for comprehensive SWM.



Note: MTCA (Ministry of Transport & Civil Aviation)

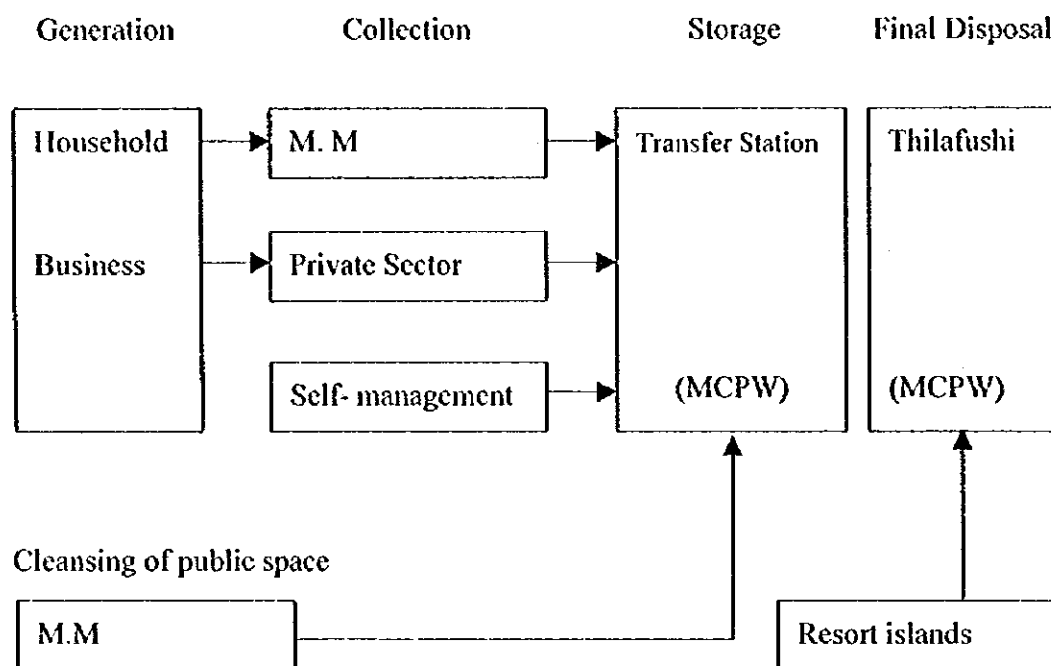
Figure 6 . Proposed Basic Structure of Institutional System

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

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

(2) Organisation Plan for SWM of Male' City and Vicinity

A current demarcation of SWM (solid waste management) function between the organisations concerned, namely, MCPW (Ministry of Construction and Public Works) and MM (Male' Municipality) is shown below (solid waste amount is shown in Figure 1). In Male' and Villingili, the demarcation is between the collection and disposal of wastes. There are three (3) way collection methods; collection by the Male' Municipality, by private sector involvement and by self-disposal.



The proposed functional reinforcement of MCPW is as follows;

- Client management function
- Operation of new SWM undertakings, material recycling, incineration of waste oil and composting
- Operation of information processing system for SWM
- Environmental management

The proposed functional reinforcement of Male' Municipality is as follows;

- Planning and publicity function
- Function for legal provision
- Client management function

- Operation of solid waste collection work
- Maintenance function
- Operation of information management system for SWM
- Setting up of a SWM branch function in Villingifi

4.11 Implementation Schedule of Master Plan



The project components concluded by the master plan are summarised below.

- i. Improvement of Final Disposal Site in Thilafushi
- ii. Enhancement of Collection and Transport Capacity
- iii. Reinforcement of Sea Cleaning Equipment
- iv. Installation of Composting Plant in Thilafushi
- v. Installation of Waste Oil Incinerator in Thilafushi
- vi. Installation of Stock Yard and Processing Yard for Special wastes in Thilafushi

The implementation schedule of master plan is proposed as shown in Table 8.

Table 8. Implementation Schedule of Master Plan

Proposed Action	Implementing Schedule											
	99	00	01	02	03	04	05	06	07	08	09	10
Priority Projects												
Improvement of Final Disposal Site in Thilafushi for the year until 2003												
Enhancement of Collection and Transport Capacity												
Reinforcement of Sea Cleaning Equipment												
Consecutive Expansion of Thilafushi for the period until 2010												
Other Component Projects in Thilafushi												
Installation of Composting Plant												
Installation of Waste Oil Incinerator												
Installation of Stock Yard and Processing Yard for Special Wastes												
Non-project Type Actions												
Legal, Institutional and Financial Arrangement												
Waste Charge System												
Private Sector Involvement												

 : to be implemented under cooperation scheme
 : to be implemented by Maldivian Government

The component projects are to be implemented in two successive terms connected at the beginning of 2003. The priority projects are proposed to be completed by 2003, and the other component projects be implemented by 2010.

5 Feasibility Study on Priority Projects

5.1 Components of Priority Projects

- (1) Innovation of Waste Collection System
- (2) Enhancement of Waste Transport System
- (3) Improvement of Waste Transfer System (Male' and Villingili)
- (4) Enhancement of Public Space Cleaning (Replacement of Equipment for Port Area Cleaning)
- (5) Environmental Improvement of Existing Thilafushi Island
- (6) Construction of New Landfill Site in Thilafushi Island
- (7) Promotion of Material Recycling

5.2 Improvement of Waste Collection System

The solid waste generated in Male' is broadly categorized by four kinds of wastes, namely, residential, commercial, business and construction waste. The Municipality has responsibility for collection service of the residential waste and supervision and monitoring of waste collection and transportation of all the other types of wastes except construction waste. The collection plan is formulated only for the residential waste under the initiative of the Municipality. All other kind of wastes have to be transported to the transfer station by the waste generators themselves.

(1) Design of Collection System

"Vehicle Station Collection System" is proposed for Male' as the economical residential solid waste collection system.

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

The residential waste amount to be collected in 2003 is 75 ton per day and the required number of vehicles is 13 (including 2 standby vehicles), when the new collection system will start. In 2003, each vehicle will cover about 20ha (a radius of 250m). Residents can

discharge their solid waste at a vehicle collection station within 4 minutes walking distance (60m/min. walking speed).

(2) Collection Cost

Collection cost consists of procurement cost of solid waste collection vehicle, personnel expenditure and operation and maintenance cost. The procurement cost is estimated at about Rf 9.1 million and the annual collection cost including personnel expenditure but excluding procurement in the year 2003 is estimated at about Rf 3.0 million.

5.3 Improvement of Waste Transportation System

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

The current transportation 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. These ferryboats could continue operation throughout the planning period until 2010. Therefore, the current system will be basically continued as per the master plan though there are some need for capacity expansion to meet the increasing waste volume and improvement in operational aspects.

(1) Design of Transportation System

The proposed system will be formulated to have suitable combination of manpower and machines. The proposed transportation system is improvement of the transfer station and introduction of compactor truck for transportation. The basic transportation system from transfer station to final disposal site is the same as the present system. The compactor trucks will carry the waste to the final disposal site directly by using the ferry. Introduction of the compactor trucks for the transportation of all wastes except the construction waste is effective to improve the transportation efficiency and to mitigate odour nuisance.

From the year 2003, when the proposed transportation system would begin operation, total number of trucks required is determined as 18 (5 trucks x 3 teams with each team having 3 compactor trucks and 2 normal trucks).

The layout of the proposed new transfer station in Male is shown in Fig. 1 and its significant features are illustrated in Section 4.3 under solid waste management master plan. The proposed improvement of Villingili transfer site is described in Section 4.4.

(2) Transportation Cost

The total transportation cost consists of construction cost of transfer station, procurement of trucks and heavy machinery, personnel expenditure and operation and maintenance cost. The construction cost of the both transfer stations (Male' and Villingili) is about Rf 33.6 million. The procurement cost of trucks and machinery is about Rf 35.5 million. The annual operation and maintenance cost including personnel expenditure in the year 2003 is about Rf 9.1 million.

5.4 Environmental Improvement of Existing Thilafushi Island

(1) Target Coast to Be Improved

Some shore lines have seawalls already provided by the government agencies and private companies. Therefore, the target coast to be improved by this project is limited to only the coastal area as shown in Figure 7.

(2) Design Condition

Waves approaching to Thilafushi are summarized as below.

North and East coast : $H_{1/3} = 1.2 \text{ m}$, $T = 6.4 \text{ sec}$

West coast (inner lagoon) : $H_{1/3} = 0.7 \text{ m}$, $T = 6.0 \text{ sec}$.

South coast : $H_{1/3} = 3.0 \text{ m}$, $T = 16.0 \text{ sec}$.

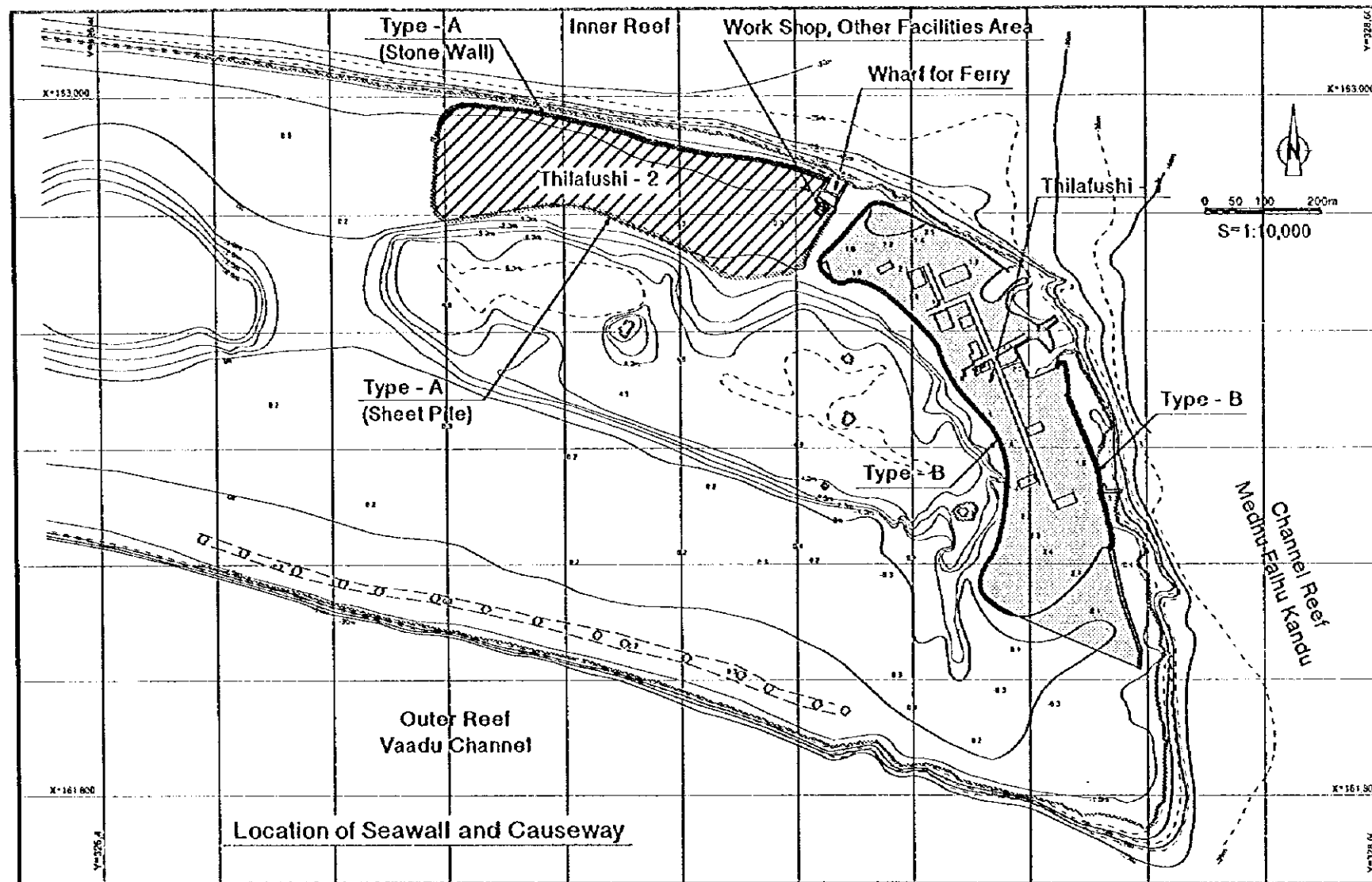
(3) Method of Improvement

The traditional type seawall with coral rocks and cement mortar, same as the already constructed seawall, will be provided. Appropriate yearly maintenance of seawall is required. The typical section is shown in Figure 7.

The length of seawall is 970 m for west coast and 350 m for east coast.

(4) Project Cost

Project cost for existing Thilafushi seawall provision is about Rf 11.9 million.



Length of the Proposed Structure (m)

Target Year	Location	Type-A		Type-B
		Stone wall	Sheet Pile	
2003	Thilafushi-1	—	—	1,320
	Thilafushi-2	740	970	—

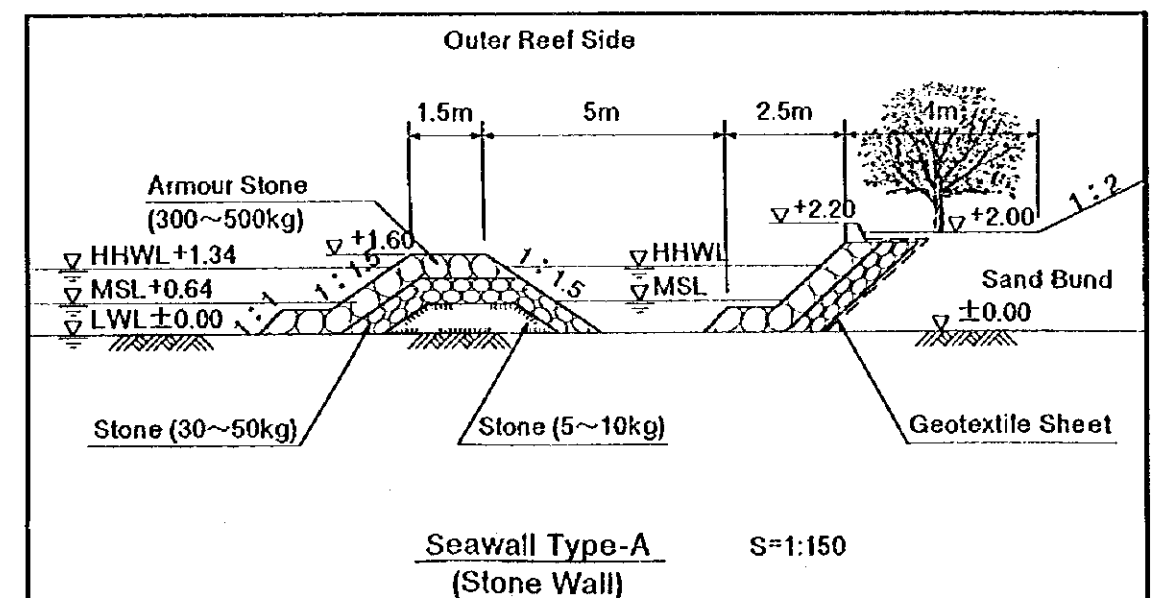
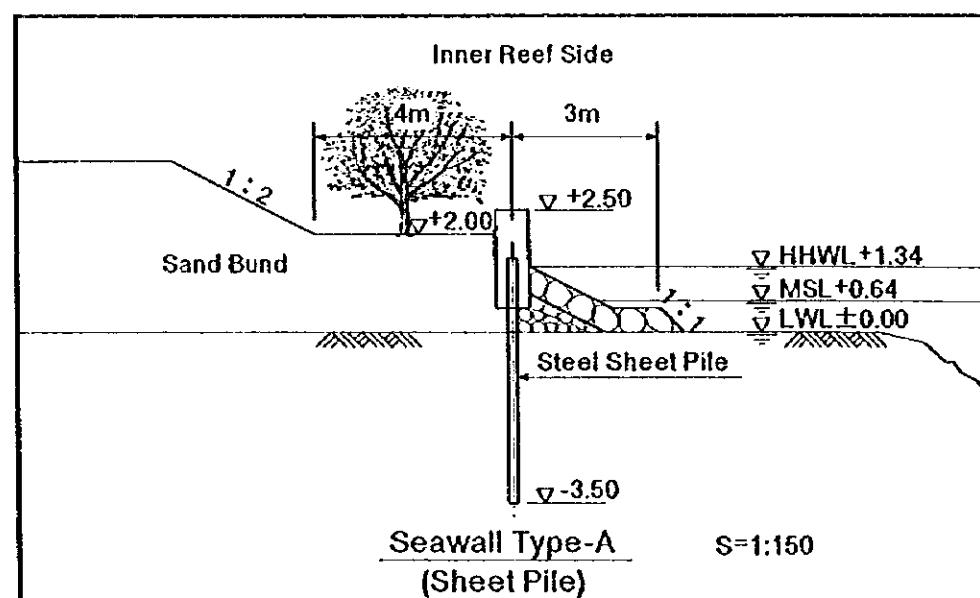
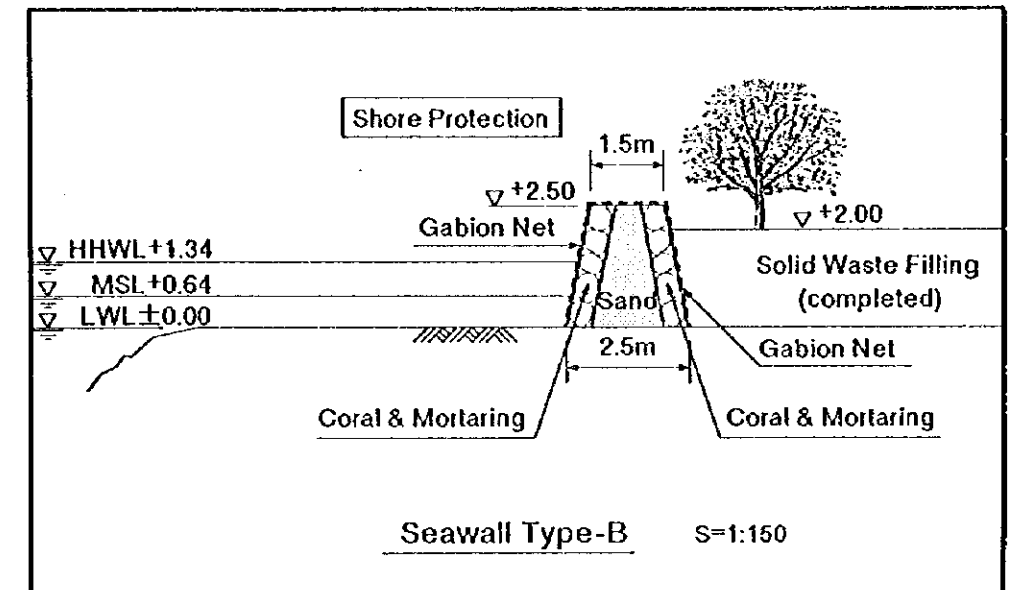


Figure 7. Short Term Development Plan in Thilafushi

5.5 Construction of New Landfill Site in Thilafushi Reef

(1) Target Waste to Be Disposed

Estimated total solid waste volume to be transported to Thilafushi from 1999 to 2003 is 411,647 tons (402,565 m³). However, it is assumed that 30% of the waste produced in 1999 will be filled in existing Thilafushi (Thilafushi-1 of Fig. 3). The construction of project facilities is expected by the end of 2000. Accordingly, 70% of the waste produced in 1999 and 90% of the waste produced in 2000 will be filled in the new site before the Start of the Project. Therefore, the target volume to be filled in the new site of Thilafushi-2 is estimated as 381,000 m³.

(2) Design Condition

Design wave condition is summarized as follows.

North coast : $H_{1/3} = 1.2$ m, $T = 6.4$ sec

South coast (inner lagoon) : $H_{1/3} = 0.7$ m, $T = 6.0$ sec

(3) Method of Landfill for New Site

The landfill of new site in Thilafushi-2 is divided into two layers of waste filling into water (First stage) and waste filling above water (Second Stage).

The landfill for First stage(E.L. -2.5m ~E.L. +2.0m) will be divided into three areas and the filling procedure is as follows.

- Before the landfill of new site, the approach of the ferry should be constructed.
- The filling by MCPW before the Project shall be proceeded at center space having 60 m in width and 700 m in length of the reef flat in the site. Ponds having 1,500 m³ in the area for the waste filling should be made by the excavated sand as in the past.
- Seawall construction by the Project will be started from the north edge to south edge of the reef along the planned site, and the north area of the land filled by MCPW before the Project is made as ponds having 3,000 m³ in the area for the waste filling. Then the filled waste shall be covered by the excavated sand of 50 cm thickness and compacted. The filling operation in the south area of land filled by MCPW is also proceeded same as above.

The landfill for Second stage (E.L +2.0m~E.L +4.0m) will be divided into two areas and the filling procedure is as follows.

- The bunds made of excavated sand for the waste filling area is allocated at center and edge of the First stage.
- The waste filling is proceeded from north area to south area. Daily waste covering will be done followed with compaction of landfilled waste.

(4) Cost of New Landfill

The total cost of the new landfill site Thilafushi-2, including procurement of required equipment and machinery, is estimated as about Rf 107 million.

5.6 Promotion of Material Recycling

(1) Target Waste to be Recycled

a. Target Wastes Recovered at Generation Sources

- clothes, books, coconut shells, glass bins, toys, 5 gallons steel cans, electric appliances, electric wire, etc.

b. Target Wastes Recovered at Transfer Station and Thilafushi

- food wastes from hotels and restaurants, saw dust from carpentry factories, metal & non-metals, electric wire, etc.
- concrete debris, dirt & sand, metal & non-metals, electric wire, sacks
- wastes from resort islands including live bottle bins, tins & cans, aluminium cans, PET bottles, Plastic bottles, etc.

c. Target Amount of Waste Reduction and Recovery/Recycling

The target ratio was proposed at 5 % and 2.5 % by 2005 for waste reduction and recovery/recycling plans respectively. With this target, the estimated waste reduction amount reach at 7.4 tons per day in 2005 and the waste recovery/recycling amount is estimated at 62.4 tons in total.

(2) Method of Recycling**a. Action Plans for Waste Reduction and Recovery/Recycling**

The waste reduction and recovery/recycling shall be carried out in combination of the plan and programs summarised in the followings.

Generation Source Control

- Production Control *, Distribution and Sale Control, Consumer Control, Waste Charge Control *, & Commercial Waste Control *

Waste Discharge Control

- Promotion of Self-disposal & Reuse of second Hand Goods

Recovery/Recycling of Materials

- Recovery by Junk Dealers & Community Groups & Recycling of Recovered Materials

(Note: The programs marked by * shall be implemented after 2003 responding the progress of the activities in the initial stage.)

b. Implementation of Waste Reduction and Materials Recovery Plans

Among the Action Plans, the followings are the major programs which shall be implemented during the initial stage of the plan.

- Raising Awareness of the Society for Waste Reduction Programs
- Division of Waste Recovery/Recycling Districts
- Reusable Goods Bazaars and Buy-back Centres
- Encouragement of Scavengers and Junk Dealers
- Co-operation by Residents and Enterprises for Waste Separation

c. Implementation of Waste Recycling Plan

Regarding the waste reduction and recovery programs, the followings are the major activities required to perform for implementation of the recycling plan in the initial stage.

- Storage of Recyclable Materials at Transfer Station and Thilafushi
- Link with Buyers and Recycling Industries

- Food Waste and Saw Dust Composting

(3) Required Input

a. Construction Work

Stock Yard in the Transfer Station is included in the Transfer Station design.
Stock Yard in the Thilafushi is included in the design of Thilafushi new disposal site.

b. Procurement of Equipment and Marketing Study

Public Campaign Materials

- Education Video Programs for Adults
- Education Video Programs for Children
- Campaign Posters

Public Education Materials for Adults

- Text for Non-formal Education

School Education Materials for Children

- Text for School Education

Promotion of Recycling Industries

- Linking with Recycle Markets in India, Indonesia and Singapore
- Accumulation of technical data and study on appropriate technologies for the Maldives

c. Personnel

Waste reduction and recover/recycling programs must be implemented with the involvement of various types of people and agencies in the society, the programs must be implemented by the social movement in other words. In the centre of the activities, Special Task Team (STT) having 8 staff established in Male Municipality shall have the responsibilities to play a leading role.

(4) Cost Estimates

a. Construction and Procurement Cost

Construction cost is included in the construction cost of the transfer station and disposal site. Procurement cost is estimated as Rf 1,324,000.

b. O & M Cost

Personnel cost is estimated as Rf 294,000 per year.

5.7 Cost of Priority Projects

Total project cost of the priority projects (short-term solid waste management improvement plan for the capital region until 2003) including the procurement of machinery and equipment is determined as about Rf 218.8 million. The breakdown of construction cost is summarized in Table 9 and that of procurement of equipment and machinery in Table 10.

Table 9. Construction Cost of Priority Project

	Items	Cost (1,000 Rf)	Cost (1,000US\$)	Remarks
1	Construction			
1)	Construction of Thilafushi-2	97,547	8,323	
2)	Construction in Existing Thilafushi	11,856	1,012	Local materials used
3)	Construction in Male'	25,742	2,196	New transfer station
4)	Construction in Villingili	2,525	215	Transfer site improvement
	Sub- total	137,670	11,746	
2	Engineering Service	11,014	940	Sub-total (1) × 8%
3	Physical Contingency	13,767	1,175	Sub-total(1) × 10%
	Total Construction Cost	162,451	13,861	1+2+3

Table 10. Procurement Cost of Equipment and Machinery for Priority Projects

	Items	Cost (1,000 Rf)	Cost (1,000US\$)	Remarks
1	Procurement			
1)	Innovation of Waste Collection System	9,055	773	Pucker Truck(2t)
2)	Enhancement of Waste Transport System	24,489	2,090	Pucker Truck(10t), Dump Truck
3)	Male' Transfer Station	11,033	941	Truck Scale, Wheel Loader, etc.
4)	Enhancement of Public Space Cleaning			
(1)	Dustbin in Public Park	141	12	Dust Box
(2)	Port Area Cleaning	616	53	Small Boat, Small Truck
5)	New Landfill Site in Thilafushi	9,386	801	Excavator, Truck, Bulldozer, etc.
	Sub-Total	54,720	4,670	
2	Engineering Services	1,642	140	Sub-total × 3.0%
	Total Procurement Cost	56,362	4,809	

5.8 Financial Analysis

(1) Estimated Cost of Priority Projects

(Unit: Rf. thousand)

Initial Cost	O & M Cost		
	Direct O & M Cost	Depreciation	Total
218,813	14,088	14,369	28,457

The total initial cost of the priority projects is estimated as Rf. 218,813,000 or US\$ 18,670,000. Besides, the direct cost of operation and maintenance composed of collection, transportation and disposal of solid waste amounting to Rf 14,088,000 and depreciation reaching Rf. 14,369,000, adding up to Rf. 28,457,000 will be required annually.

(2) Budget Allocation

a. Concept

Expenditure Budget	Revenue Budget
Initial Cost	Grants, Loans, Conventional Revenue Sources
Direct O & M Cost	Solid Waste Charge from Beneficiaries
Depreciation	Conventional Revenue Sources

The expenditure budget of MCPW for the initial cost will be appropriated from the governmental revenue budget whose sources will be foreign grants, new foreign/domestic loans and/or conventional governmental revenue sources such as tourism tax, lease and rent of governmental estate and import duty.

Likewise, the expenditure budget of MM and MCPW for the direct O & M cost to collect, transport and dispose solid waste will be appropriated from the governmental/public revenue budget whose source will be solid waste charge imposed to beneficiaries.

Regarding the expenditure budget of MM and MCPW for depreciation of SWM equipment and facilities, it will be allocated from the governmental/public revenue budget deriving from conventional sources such as tourism tax, lease and rent of governmental/public estate and import duty.

b. Quantitative Analysis

The initial cost is estimated to take up 3.0% of the cumulative government revenue budget during the implementation period of 2000 to 2002. It is expected to account for 51.8% of the cumulative MCPW expenditure budget in the same period.

To meet the direct O & M cost, solid waste charge is proposed to be collected from the beneficiaries. According to the results of analysis, the average monthly charge of Rf. 153 and Rf. 67 will be imposed per house from 2003 to 2010 in the Male' and Villingili islands, respectively. The tariffs correspond to 81.8% and 163.6% of beneficiaries' willingness to pay in Male' and Villingili respectively. Also, Rf. 85 per tonne in the same period on average will be taken from establishments/institutions in Male'. The Maldives Airports Authority and a

resort island will pay a monthly charge of Rf. 2,281 and Rf. 398 for disposal of their solid waste in the Thilafushi island, respectively (these figures are only for disposal. The Maldives Airports Authority and a resort island will have to pay transport fee themselves).

To cater for depreciation of collection vehicles, 7.3% of the revenue budget of MM deriving from conventional sources such as transfer from the central government and rents will be appropriated. Currently, 8.3% of MM budget is estimated to be allocated for SWM. Also, for depreciation of transportation, disposal and cleaning vehicles/equipment and facilities, 6.5% of the MCPW revenue budget deriving from conventional sources will be appropriated. At present 7.0% of MCPW budget is transferred to the Waste Management Section (WMS).

(4) Financial Analysis

The economic benefits of the project such as the freedom from unpleasant sight and odour of solid waste in and out of the houses and reduction of sanitation-related diseases such as diarrhoea, dysentery and skin diseases can be interpreted to be quantitatively reflected in the beneficiaries' willingness to pay for solid waste management service.

As a result of financial analysis, it was revealed that the project will have the FIRR of 12.4 %, which is substantially above 10%, the estimated opportunity cost of capital in the Maldives. Therefore, the master plan project is judged to be financially highly feasible. However, according to the results of sensitivity analysis, proposed priority projects could not be implemented under the most unfavourable conditions conceived.

On conditions that the initial cost of the project is borne by the government whether it is financed by grants, loans or budgetary revenues, that the households set aside more or less about 1% of their income and establishments/institutions pay around Rf. 85 per tonne for solid waste management, and that MCPW and MM allocate several percent of their budget for solid waste management, then the proposed priority projects will roll ahead in the years to come in a financially sustainable manner.

5.9 Enhancement of Implementing Organisation

The Implementing Organisations execute the scope of undertakings as shown in the Table II.

Table 11. The Types of Waste and the Responsibility

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

The study team studied framework of the implementing organization of the project by taking account of various circumstances.

The basic requirements of the implementing organization are, generally speaking, capability to provide adequate service and financial sustainability. The organizations should pass these three criteria; (1) adequate service, (2) financial sustainability and (3) collection of charges on SWM.

Following three alternatives of the organization structures are studied.

- (A) Enhancement of existing organizations
- (B) Establishment of State Owned Enterprise(SOE)
- (C) Combination of Administrations and SOE

The Government of Maldives (the Ministry of Finance) suggests that its policy related to the project is; (1) subsidy system would not be desirable, (2) MCPW would not be allowed to collect charges on the SWM.

The Study Team recommends Alternative C as the most adequate organization plan among three Alternatives, considering above policy and the following issues; (1) less profitability of the SWM project in comparison with those of existing SOEs (electricity, water supply and sewerage) and (2) the ongoing improper landfill operation activities in Thilafushi.

In the framework of the organization, the Male' Municipality, the MCPW and SOE, shall carry out SWM of Male' and vicinity, the duty of each organization shall be as described hereunder.

Male' Municipality

- (1) Collection of municipal waste (residential waste, commercial waste)
- (2) Collection of charge on SWM.
- (3) Enlightenment of citizens regarding reduction of waste discharge, reusing of waste materials and recycling of waste materials.

State Own Enterprise of SWM (SOE)

- (1) SWM from reception, storage, transport, to final disposal of all waste, except hazardous and hospital waste.
- (2) Collection of charges on SWM services.
- (3) Composting
- (4) Treatment and disposal of special waste such as waste batteries and waste oil.

Ministry of Construction and Public Works (MCPW)

- (1) Consensus formation of Beneficiary Pay Principle with potential clients.
- (2) Development and construction of new final landfill site
- (3) Construction of new Male' Transfer Station

Therefore, the Implementing Organisations shall execute the scope of undertakings as shown in the Table 12.

Table 12. The Types of Waste and the Responsibility

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

6 Evaluation of Priority Projects

6.1 Technical Evaluation

The proposed components of the priority projects have two (2) basic technical elements.

1. Solid waste collection and conveyance to Thilafushi from Male' using newly introduced compactor trucks, among others.
2. The improved facilities for the proposed new sanitary land fill system (Thilafushi-2 of Fig. 3) that incorporates coastal seawall protection structure including primary treatment system for landfill leachate.

These improvements are evaluated as technically adaptable and effective in consideration to the following:

- The present solid waste collection truck drivers can easily adapt to the operation of compactor trucks that would mitigate spillage of garbage and odour nuisance
- The construction of seawall system in Thilafushi-2 could be accomplished with intentional tendering of construction works
- Steel sheet pile seawall (sheet pile seawall-Type A of Fig. 3) would mitigate dispersion of leachate to semi-enclosed Thilafushi lagoon. Moreover the stonewall system (Type A stonewall seawall of Fig. 3) would impart primary leachate treatment in its retention pond. This primary leachate treatment prior to the dispersion of leachate to surrounding marine waters is evaluated as adequate to mitigate marine pollution

6.2 Social Evaluation

(1) Implementation of Waste Reduction and Recovery/Recycling Programs

The programs are not easy to attain the targeted results without participation of all the bodies composing the society. The public awareness survey shows that more than 80 % of the respondents are interested in recycling of wastes and almost all the respondents answered to participate in waste separation at the generation sources. From these aspects, waste reduction plan will also be accepted by the residents as well as separation of wastes.

(2) New Solid Waste Collection System

The new system, considering particular conditions of Male' and defined as the minimum level of services in Male', will be more convenient since the vehicle station is located in the centre of the service area of 250 m circle. It may cause decrease in the numbers of collection services for the collection service provider with the residents having existing collection services. However, it is prospected that the residents who enjoyed convenience in exchange of money would tend to dislike losing the more convenient system although it cost more and the present service providers will be able to continue the service contract with the customers.

(3) Collection of Waste Charge

As prescribed, the public awareness shows that about 38 % of the respondents discharge wastes through collection service providers. The average fee paid by them reach at Rf 164 per month or 1.5 % of average monthly income of one house. The proposed service charge of solid waste management would be Rf 154 and account for about 82% of the amount that the residents and other entities willing to pay.

Accordingly the proposed service charge system is evaluated as socially acceptable.

6.3 Financial Evaluation

The financial evaluation 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%

The cost-benefit analysis of the Male and vicinity project resulted in the following:

NPV (net present value) :	Rf 18.8 million
B/C (cost benefit ratio) :	1.08
FIRR (financial internal rate of return) :	12.4%

Accordingly the project is evaluated as financially feasible with FIRR exceeding the assumed opportunity cost of capital. Still, sensitive analysis indicated that the project would lose its economic viability under unfavourable conditions.

However, it is emphasised that the provision of solid waste management service is a basic human need to ensure habitable urban environment. Hence economic viability alone can not dictate the viability of project implementation.

(2) Financial Evaluation

The proposed service charge of solid waste collection would fully cover the operation and maintenance cost of the solid waste management facilities including personnel. Moreover, the proposed solid waste collection service charge is considered affordable by the beneficiary since it falls within their willingness to pay.

Accordingly, the project is evaluated as financially viable.

6.4 Environmental Evaluation

The most significant irreversible long term environmental effect as the direct consequence to the implementation of the project is identified as the very alteration of the ecosystem of the project area (Thilafushi-2 of Fig. 3) from saline aquatic ecosystem to a land based terrestrial ecosystem and the resultant elimination of immobile marine biota, in particular coral life, and their habitat in the reef-flat area subjected to this ecological alteration (Thilafushi-2). Still the effect is minimised, if not entirely eliminated, with the selection of ecologically most degraded reef-flat area as the landfill project area.

Silt screen is adopted as the most significant direct mitigation system of the project. This is both intended at mitigating the dispersal of dredged material to the surrounding reefs thereby potentially affecting the coral life and as well the marine water quality and also at conserving valuable landfill cover material. Its proper and continued use throughout the project is essential and be ensured by the implementing agency (Project Initiator), the MCPW (Ministry of Construction and Public Works). All other impacts by the project are evaluated as insignificant.

Based on the above aspects the project, in fact the entire master plan, is evaluated as environmentally beneficial in an overall sense with negligible adverse environmental effects.

7 Recommendations

7.1 Waste Reduction and Recycling

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.

In particular, recycling of nonperishable and essentially nonbiodegradable materials like metal cans, glass bottles and plastic products shall be promoted both as means of resources conservation and optimal utilization of the capacity of final solid waste landfill disposal system.

Moreover, composting as the means of both producing fertilizer and reducing perishable waste requiring land-filling is recommended to be introduced in Thilafushi.

7.2 Enhanced Awareness in Solid Waste Management (SWM)

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 public campaign and education by Male' Municipality is recommended to be initiated.

It is further noted that the solid waste management awareness need to be improved in the Ministry of Construction and Public Works (MCPW). In particular, the notion of treating solid waste simply as land reclamation material shall be abandoned. This is very important in realizing sanitarily and environmentally acceptable means of final solid waste disposal, with due consideration to the hazardous nature of leachate and flammable gas generated underground of a landfill system.

7.3 Project Implementation

Seven component projects are classified and packaged for the convenience of implementation in accordance with the nature of the projects. Most of the components are recognized as environmental projects through the improvement of SWM except the project, Improvement of Existing Thilafushi Island. Improvement of existing Thilafushi is really an environmental project to prevent the drifting of waste from the eroded coast, however, it has at the same time a different aspect due to the current situation of land use in the island. Therefore the whole components are packaged into the following two groups.

- (1) Package 1:
1. Innovation of waste collection system
 2. Enhancement of waste transport system
 3. Improvement of waste transfer system
 4. Enhancement of port area cleaning
 5. Construction of new landfill site
 6. Promotion of material recycling
- (2) Package 2: Environmental improvement of existing Thilafushi Island

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.

Implementation of the package 1 needs a certain lead time for the preparation of investment fund because of large amount requirement. The earliest case of implementation schedule is shown below.

Table 13. 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 Island				

Appendix Improvement Plan of Final Disposal in Local Islands

1. Scenario for Stepwise Improvement

There are 130 inhabited islands other than resort islands in Maldives. Each island has at least one final disposal site in each island, however all the islands need improvement of sanitary condition of final disposal site. Because the level of environmental protection measure is generally very poor and the number of islands is very large, it is recommended to improve the sanitary condition in a stepwise manner.

Technically, it would cost too much to apply high sanitary level of Thilafushi-2 to local islands. So a medium technical level between existing final disposal and ideal sanitary landfill is recommended. One island in each of the 20 atolls is selected as the priority island for the provision of medium technical level final disposal site.

2. Conceptual Design of Final Disposal Site

a. Structure

The proposed structure of final disposal site as medium sanitary level has the following features.

- The landfill site is enclosed entirely with permanent seawall of sufficient stability against sea surge and erosion.
- Sand cover will be applied at least once a week to prevent blown waste dispersal and proliferation of vectors.
- The capacity of the final disposal site is determined to meet the landfill demand for 10 years (corresponds to the area of about 3,000 m²).
- Simple composter and incinerator are installed for residents to reduce waste volume disposed.

b. Operation

Operation of disposal site is in principle undertaken by residents themselves. Local government unit such as atoll office or island office are to support local community. Hereby equipment is provided to local government unit who is responsible for the maintenance of disposal site.

3. Project Cost

a. Initial Investment Cost

The initial investment cost for one final disposal site is estimated at about Rf 16.5 million ; that brings the total cost for 20 islands to about Rf 330 million.

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

b. Running Cost

Overall running cost until 2010 when 20 islands are provided with new final disposal sites is estimated at Rf 65 million including O&M cost and depreciation. After 2010, Rf 12 million will be needed for operation annually.

c. Cost Allocation

It is reasonable the initial investment of Rf 330 million is borne by the government and the amount comes to about 16% of the budget of the Ministry of Atolls Administration. Running cost should be imposed on beneficiaries as waste charge and the average amount of charge is estimated at Rf 38 per house per month. The estimated waste charge corresponds to 36% of the value of willingness to pay expressed by local people.

4. Implementation Schedule

Improvement of final disposal in local islands may be conducted at the pace of 4 islands in two years, 20 islands in 10 years under the repetitive process.

Table. Implementation Schedule

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Group 1 (4 islands)														
Group 2 (4 islands)														
Group 3 (4 islands)														
Group 4 (4 islands)														
Group 5 (4 islands)														
(Master Plan for Male' City)														



