6.6 Initial Environmental Examination (IEE)

6.6.1 Introduction

This Initial Environmental Examination (IEE) is principally aimed at the proposed improved final solid waste disposal system as future expansion of the solid waste based land reclamation in the same reef of Thilafushi as well as the improvement of the completed landfill that exists at present, as envisaged by this Master Plan until the year 2010 (refer to section 6.3).

The proposed facilities of the Master Plan incorporates the required in-built mitigation measures for the protection of surrounding marine environment since it is intended to be a sanitary landfill system. The proposed facilities of the master plan are shown in Figure 6-14 .

It is noted that the proposed landfill system until the year 2010 will continue to serve as the location for final disposal of solid waste generated, as in the case of the present condition, in the capital region of Male and Villingili and other near-by tourist resort islands. Since the collection, intermediate treatment and transportation of solid waste generated in these service areas will always lead to improved environmental condition, in particular living environment, in relation to the hypothetical environmental condition under the no project condition, the effect of the master plan on these service areas is assessed as an inherent environmental beneficial effect and hence not dealt with any further in this IEE.

However, in contrast, the final solid waste disposal site of land reclamation from sea with solid waste in Thilafushi reef, as the consequence of the implementation of this master plan, even with planned in-built mitigation measures, has the potential of adverse environmental effect. Accordingly, this IEE targets only the proposed landfill site in Thilafushi and its surrounding marine environment by this master plan, with due consideration to the baseline (present) environmental condition and the relevant environmental issues consequent to the ongoing landfill operation in Thilafushi in the channel reef adjacent to the Medhu Falhu Kandu. In particular the proposed in-built environmental mitigation measures of this master plan are emphasised.

6.6.2 Baseline Environment at Thilafushi Landfill Site

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, is also prevalent. This inadequate solid waste management results in strong unpleasant odour and severe fly nuisance. Apart from these basic landfill management issues other significant

environmental issues concerned to the present Thilafushi landfill are illustrated in Chapter 3 and Chapter 4. Those significant environmental issues are summarised 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 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 surrounding marine water environment. Dispersal of garbage to surrounding marine water need to be eliminated as the basic technically acceptable means of final solid waste disposal.

(3) Degradation of inner lagoon of Thilafushi

The inner lagoon located along the western face of the existing Tilfushi 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. Mitigation measures against uncontrolled diffusion of leachate into inner lagoon with less assimilative capacity need to be contemplated.

(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. This environmentally hazardous nature of solid waste landfill area needs the review of land use after completion.

6.6.3 Final Solid Waste Disposal System of the Master Plan

The components of the improved final solid waste disposal system in Tilafusih is illustrated in the foregone section 6.3. It is envisaged to develop basically two additional islands in the inner reef-flat of Thilafushi reef to the north-west of the existing Thilafushi island (ref. Figure 6-14). The existing island is referred to as Thilafushi-1, which will cease operation with the commencement of operation of adjacent Thilafushi-2 as the final solid waste reception area. Thilafushi-2 is intended to serve until the year 2003, followed with its closure and subsequent commencement of operation of adjacent Thilafushi-3. Thilafushi-3 is intended to serve the final stage of this master plan until the year 2010.

The anticipated environmental impacts and relevant in-built mitigation measures as envisaged by this improved master plan, categorised as social impacts and ecological impacts, are illustrated in the following sections.

6.6.4 Social Impacts

The proposed future solid waste landfill expansion areas (Thilafushi-2 and 3 of Figure 6-14) are submerged uninhabited reef-flats located at inner reef of Thilafushi. As the areas are uninhabited and belong to the government no resettlement of population or land acquisition issue are involved. Moreover these inner reef areas, in contrast to the outer reef areas adjacent to the Vaadu channel, are not famous for diving and other sea water related recreation by tourism industry. Accordingly, anticipated adverse social impact by the implementation of this final solid waste disposal master plan is evaluated as insignificant.

6.6.5 Ecological Impacts

Anticipated ecological impacts by the master plan could be categorised as irreversible long term (permanent) impacts and impacts amenable to mitigation. The impacts amenable to mitigation may be of long term but not necessarily irreversible.

(1) Irreversible long term impacts

The most significant irreversible long term (permanent) impact inherent to the development of landfill on submerged reef is the very alteration of saline reef aquatic environment into land based terrestrial environment as could be evident from the existing Thilafushi Island (Thilafushi-1). This environmental alteration would result in inevitable loss of coral life and other immobile marine biota in the lost reef-flat areas to reclamation.

Still it is noted that the live coral cover on the inner reef-flat areas of this solid waste landfill plan is only 2-4%, as illustrated in Section 3.2 of Chapter 3, making this inner reef-flat area as the most degraded submerged reef-flat in the entire Thilafushi reef.

Moreover, no peculiar, rare or endangered species of marine biota was noted in the entire reef-flat of the Thilafushi reef.

In fact this inner-reef flat area, for future landfill expansion, is selected from this ecological view point as well, in addition to other benefits, so as to minimise the inevitable loss of coral life. This is a basic in-built mitigation measure of this solid waste landfill development plan, though the loss of reef-flat coral life is inevitable and can not be entirely eliminated.

As the means of enhancing the ecological value of the terrestrial environment generated and also to expedite the treatment of leachate underground, active tree plantation in a completed landfill area is strongly recommended.

(2) Impacts amenable to mitigation

The significant environmental issues concerned to the improper operation of the present landfill in Thilafushi as dealt with under items (1), (2) and (3) of the foregone section 6.6.2 are the important potential adverse environmental impacts on surrounding marine water environment that are amenable to mitigation with proper design and operation (management) of the landfill system.

These issues are basically concerned to the dispersal of dredged material (sediment), solid waste (garbage) and leachate into the surrounding marine water environment and the resultant adverse effect on the marine ecosystem.

The in-built mitigation measures in the design of this landfill development master plan not only targets the future expansion in Thilafushi-2 and 3, but also the improvement of completed, but at present functional, Tilafusihi-1 as well (ref. Figure 6-14).

The in-built integrated design mitigation measures for the protection of the surrounding marine ecosystem by the future landfill expansion plan as well as the developed landfill area in Thilafushi-2 and 3 are summarised below. This is followed with similar protection measures for the existing Thilafushi-1.

a. Design mitigation measures for future Thilafushi-2 and Thilafushi-3

i) Embankment system for coastal protection around landfill

The embankment system provided around the landfill development area with armour stones, referred to as Type-A system in Figure 6-14 , with a clearance of about 0.25m above HHWL (highest high water level of sea tide) would not only ensure the coastal protection of newly created land with solid waste land-filling but also mitigate the dispersal of solid waste (garbage) and other debris including any dredged material to the surrounding marine water environment.

ii) **Revetment system for landfill confinement**

The steel sheet pile (SST) revetment system provided to confine the immediate boundary of the landfill area will extend to a depth of about 3.5m into the reef-flat. This system is intended also at confining the eluted leachate from the landfill to the space provided between the exterior face of SST and the interior face of the armour stone embankment (ref. Figure 6-14). This space will serve as a stabilisation pond to provide additional treatment for the eluted leachate prior to its dispersion to the sea through porous armour stone embankment. This stabilisation pond system will also lead to uniform dispersion of leachate through the embankment. Moreover the attached micro-organisms that would inherently develop in the pores of the armour stones would provide additional treatment for the dispersing leachate to the surrounding marine water environment. This pre-treatment provided to the leachate is expected to mitigate leachte induced adverse effect to the marine ecosystem.

b. Design protection measures for Thilafushi-1

The coastal slope protection system panned as Type-B system (ref. Figure 6-14) with geo-textile sheet and exterior armour stones would mitigate coastal erosion of the existing Thilafushi-1 island following its closure of landfill operation. This will ensure no further dispersion of decaying matter into the surrounding marine water environment as well.

6.6.6 Conclusion

It is emphasised that the envisaged environmental design mitigation measures for the protection of surrounding marine water ecosystem of the future landfill development master plan for final solid waste disposal until the year 2010 are only the first step for realising environmental protection. In fact the design features conform to the basic technical requirements to be met for such a sea reef based final solid waste disposal system that would eventually result in land reclamation from sea.

It is the proper operational management of the landfill system as envisaged in the design that eventually would ensure the adverse effects on surrounding marine ecosystem is mitigated. In this respect training of staff concerned to landfill operational management is very important and strongly recommended.

6.7 Implementation Plan

6.7.1 Proposed Priority of Component Projects

The project components concluded by the master plan are summarized 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

Among these 6 components, i, ii and iii are of the most urgent needs to be implemented.

6.7.2 Project Evaluation

(1) Evaluation on Technical Effectiveness

Evaluation of component projects is conducted from two points of view, namely technical achievement and technical adaptability. The former is to assess if the performance of adopted technique achieves the objectives of the master plan well in comparison with current operation. The latter is to assess whether Maldivian staff and foreign workers in charge can adapt to the proposed technical measures and equipment well. Seven components are thus evaluated hereunder in Table 6-41.

Table 6-41 Evaluation on Technical Effectiveness

Component Project	Technical Achievement	Technical Adaptability
1 Waste Collection System	• 100% coverage of collection service is conserved • Time duration is shortened while the waste is exposed to the open air	• Manipulation of press-type truck is not more difficult than micro-bin
2 Waste Transport System	• Timely transport of collected waste is secured • Dispersion of offensive odor and waste itself is reduced by adoption of press-type truck that confines waste inside the body	• Manipulation of press-type truck is a bit more difficult than dump truck, however, not as difficult as foreign workers can not master
3 Waste Transfer System	• Segregation of waste is secured to promote material recover and effective landfill • Villingili deposit site is conspicuously improved in physical structure and equipment allocation • Waste volume is measured as part of routine which gives fundamental information for management	• Reloading method is succeeded from the current operation • Complex function of new transfer station allows that administration & Operation are conducted more efficiently than ever

Component Project	Technical Achievement	Technical Adaptability
4 Port Area Cleaning	• Mobilization measure for cleaning crew is improved that leads to better efficiency and cleaner port	• Operation on the sea surface becomes easier because motor boat can be operated by only one person; it was handled by two rowers and a cox so far
5 Improvement of Existing Thilafushi	• Stability of the coast is improved in case permanent seawall is adopted • Emission of waster pollution load stays within existing level	• Even if a stone built seawall is adopted, Maldivian has enough experience in construction and maintenance
6 Construction of New Landfill Site	• Stability of the coast is improved • Emission of waster pollution load is reduced from existing level by aeration in the retention ditch and confinement effect by sheet pile wall	• Stone built seawall can be adapted to with no major difficulty • Sheet pile wall might exceed Maldivian experience, however, it can be commissioned to ordinary contractors of neighboring countries
7 Material Recycling	• it contributes to create a possible productive usage of waste and consequently reduces landfill volume that saves the life of final disposal site	• Practice of compost making was once trained in this study and the foreign workers engaged in are found adaptable to the practice

(2) Evaluation on Social Acceptability

a. New SWM System

Most of the people are always sensitive against change of the system and refuse to accept the new system as long as the system is not beneficial to individual person even though the system is beneficial to the society. The improved SWM system contains several new sub-systems to improve effectiveness and efficiency in place of the existing system. Those major discussion topics among the people concerned and the society of Male' include environmental protection measures, establishment of state enterprise, height of finishing level of landfill, and for forth in the long term plan. The discussion topics with regard to social acceptability in the priority projects will be 1) Implementation of Waste Reduction and Recovery/Recycling Programs, 2) New Waste Collection System, and 3) Collection of Waste Charge which are evaluated in the following sections.

b. Implementation of Waste Reduction and Recovery/Recycling Programs

Waste reduction, resource recovery and recycling programs are set at the top of hierarchy in SWM aiming at the environmental conservation in the end.

The programs are not easy to attain the targeted results without participation of all the bodies composing the society. The public awareness survey conducted by the Study Team in July, 1998 shows the bright side to this issue. 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 the aspects, waste reduction as well as waste segregation will be also accepted by the residents. Accordingly, the remaining key issue of the programs will be establishment of marketing routes through a link with foreign recycling markets and the market information will be collected periodically from now on by the SWM service staff for promotion of the programs.

c. New Solid Waste Collection System

Likewise the view mentioned in waste recycling programs, the residents in Male' were co-operative to the interview survey and interested in participation of public services. About 62% of the respondents bring waste to the microbin station or to the Transfer Station and 38 % of respondents discharge wastes through collection services.

The collection vehicle, manually loaded compactor, will park at the centre of the service area two times in a day in the morning and evening for two hours respectively. Then the collection vehicle goes slowly around the designated service area with a melody for notice during the time rest of the day. This is so-called as bell collection. For most of the residents living distant from existing fixed containers, the new system, what is called "vehicle station - go round collection system", will become more convenient since the vehicle station is located not as far as 250 m in radius from each house.

It may cause of decrease of the numbers of collection services for those residents who are now having door-to-door collection services by individual contractors. Though the new system is not adopting a door to door services, it is prospected that the residents who prefer higher level of collection service can chose it by contracting with the private service provider at their cost. Thus the new collection system is defined as that provides minimum level of services in Male'

d. 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 164 Rfs per month or 1.5 % of average monthly income of one house populated with 14 person. Interview of willingness to pay for waste charge indicates 149 Rfs. from the residents and 683 Rfs from the business establishments in average rate per month respectively. As long as the waste charge rate is set at more or less the rate of the willingness to pay, to adopt

collection of waste charge will be accepted by the people having collection service at present.

Accordingly, the discussion shall be addressed for the promotion of solid waste charge system particularly among those who are discharging wastes by themselves, who share approximately 62 % of the respondent. The world wide concepts accepted in the field of the environmental conservation, the Polluters Pay Principle (PPP), shall be discussed among these groups of the people to raise awareness that individual person have to support the environmental conservation projects otherwise the project will fail and lose their benefits as well.

e. Privatization of Solid Waste Collection Services

Collection of household waste is proposed to shift gradually to the services by the private sector(s) in future. The purpose of private sector involvement (PSI) is aiming at the increase of efficiency and the reduction of expenditure through the process of competition.

In order to increase efficiency of the collection services, it will be required to change the conventional system to some extent. However, the proposed collection services, vehicle station and go-round collection service supported by partial door to door services on additional charge, will be the best alternative for Male municipality as long as the street system would not be changed.

In this respect, operation of the private service provider(s) will be also involved in the proposed collection system in the SWM master plan. Accordingly, for most people in the society, the proposed system will be accepted, that is not inconvenient compared with the services being provided under the current system.

(3) Evaluation on Economic Benefit

a. Basic Concept

There are various kinds of economic benefits resulting from the implementation of the SWM master plan projects. People concerned will be freed from unpleasant sight and odour of solid waste not only around their houses, but also in the public spaces. Also, they may have little chance of contracting the diseases related to unsanitary environmental conditions such as diarrhoea, dysentery and skin diseases. In short, the project will contribute to keeping the living environment clean and pleasant.

The problem is how to express those benefits in quantitative terms. Fortunately, the JICA study team conducted the socio-economic survey towards the houses

and establishments/institutions in Male' and vicinities, in which it asked them the willingness to pay for SWM. This willingness to pay can appropriately be regarded to reflect the economic values they attach to the projects.

Thus, the willingness to pay per house multiplied by the number of houses concerned plus the willingness to pay per establishment/institution multilpied by the number of establishments/institutions concerned in a certain year after project implementation can be considered the benefits in that year.

What cannot be ignored is that there is a benefit peculiar to the projects: reclamation of the Thilafushi islands by using the solid waste to be disposed there. Thus, the cumulative area to have been reclaimed up to a certain year during project implementation will be multiplied by rent per unit area to arrive at the benefit in that year.

The first and second types of benefits will be added together in each year during the project life period. This way, the benefit stream will be prepared.

On the other hand, the initial cost and the O & M cost will be converted into economic costs and be distributed over years. In this manner, cost streams will be made.

Using the cost and benefit streams, economic analysis will be conducted. From the resultant values of economic criteria, the feasibility of the projects will be evaluated.

Economic analysis was carried out for the Male' and Vicinities Project only.

b. Overall Conditions/Assumptions

i Opportunity cost of capital will be 10%.

ii. Project life will be 30 years from the start of project implementation.

iii. Bill collection efficiency in connection with solid waste charge will be 95%.

iv. The monthly rent of land plot in the new Thilafushi islands will be Rf. 30 per square meter. This is based on the existing land/room rent in Male' and Villingli. (On average it is around Rf. 100/m³ in Male' and around Rf.34/m³ in Villingili.) Also, two thirds of an island will be used for renting.

v. The standard conversion factor in the Maldives is calculated at 0.9038 based on the imports/exports and import/export duty from 1994 to 1996. It will be applied to initial cost of local goods. The conversion factor for skilled labor was assumed as 1.2 as it is scarce in the Maldives. As a result,

it was revealed that the overall conversion factor to capital cost was very near to 1.

c. Economic Analysis and Evaluation of the Results

Based on the foregoing investigations, cost benefit streams were worked out as shown below:

Male' and Vicinities Project

NPV (Rf. thousand)	B/C	EIRR (%)
133,756	1.38	17.0

Sensitivity analysis was performed to see how EIRR would be affected under unfavourable circumstances.

Case 1 assumes that both capital cost and O & M cost be by 20% higher than the base case. In Case 2 both capital cost and O & M cost will be by 10% higher and at the same time benefits will be by 10% less than the base case. In Case 3 the benefits will be by 20% less than the base case.

The results of sensitivity analysis are shown below:

Results of Sensitivity Analysis

Item	Base Case	Case 1	Case 2	Case 3
Comparison with Base Case	-	Capital Cost: +20% O & M cost: +20%	Capital Cost: +10% O & M cost: +10% Benefits : -10%	Benefits: -20%
EIRR (%)	17.0	12.9	12.6	12.1

It follows from the above that the project is judged to be economically very robust. As the results of sensitivity analysis show, the project will be still sufficiently feasible even under the most unfavourable conditions conceivable.

(4) Evaluation on Financial Sustainability

In preparing the projected financial statements, the following overall conditions/assumptions were set up.

a. Overall Conditions/Assumptions

i. Project life will be 30 years from the start of project implementation.

ii. No tax will be imposed on the surplus of SWM operations.

iii. Bill collection efficiency in connection with solid waste charge will be 95%.

iv. The ratios of solid waste charge to the willingness to pay for SWM and the ratios of budgetary allocations to SWM from 2011 onward will be as follows:

Item	Male'	Villingili	Atolls
Ratios of solid waste charge to willingess to pay	81.6% (88.5%)	163.2% (177.0%)	30.0% (36.0%)

Item	MCPW	MM
Ratios of budgetary allocation	6.15% (6.65%)	7.05% (7.65%)

Note: Figures in parentheses are for 2003 (2001) to 2010.

b. Projection of Financial Statements

Financial statements for the Male' and Vicinities Project and the Atolls Project, consisting of income statement, fund statement and balance sheet are shown in Tables 13 and 14 in Supporting Report G respectively.

The following tables summarize what those statements convey.

Male' and Vicinities Project

Management Indice	Profit Rate	Working Capital to Revenue Ratio	Profit to Total Capital Ratio
Formula	Profit/Revenue x 100	Working Capital/ Revenue x 100	Profit/Total Capital x 100
Value	9.1%	29.2%	0.7%

Atolls Project

Management Indice	Profit Rate	Working Capital to Revenue Ratio	Profit to Total Capital Ratio
Formula	Profit/Revenue x 100	Working Capital/ Revenue x 100	Profit/Total Capital x 100
Value	8.6%	67.7%	0.4%

The tables show that SWM authorities will have a reasonable extent of profit or surplus to cushion unpredictable financial disturbances, a thick reserve of working

capital to prepare for replacement of facilities/equipment and a nominal profit to the total capital invested in the years to come.

(5) Evaluation on Environmental Preservation

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 (Tilafushi-2) from a 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 (Tilafushi-2). Still the effect is minimized, if not entirely eliminated, with the selection of ecologically most degraded reef-flat area as the 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 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 considered as insignificant.

Monitoring of leachate cum seawater quality and overall ecological status of the coral life in and around the project area (Tilafushi-2) on a regular basis is identified as the basic environmental monitoring requirement. The responsible agency for the monitoring of leachate cum seawater quality, twice times a year, be the PHL (Public Health Laboratory) of the MOH (Ministry of Health). The corresponding responsible agency for monitoring the status of coral life on an annual basis be the MRS (Marine Research Section) of the MOFA (Ministry of Fisheries and Agriculture). These agencies shall earmark their own budget to conduct their monitoring work independently.

6.7.3 Proposed Implementation Plan

The implementation schedule of master plan is proposed as shown below.

Table 6-42. 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 Expantion 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 Maldvian 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.

The non-project type actions proposed in the Master Plan are also to be implemented during the planning period. The introduction of waste charge is recommended in accordance with the progress of emergent projects, on the other hand, the preparation of private sector involvement is recommended to be conducted together with medium term projects.

Part II. Feasibility Study

1. INTRODUCTION

1.1 Selection of Priority Projects

(1) Project Description

In the Master Plan, following three projects were considered as the priority projects.

- Improvement of Final Disposal Site in Thilafushi
- Enhancement of Collection and Transport Capacity
- Reinforcement of Sea Cleaning Equipment

i) Improvement of Final Disposal Site in Thilafushi

This project is proposed to consist of the following two measures:

- Construction of New Landfill Site
- Improvement of Existing Island

The proposed New Landfill Site is to comply with the following requirements.

a. to keep the coastline steadily
b. to avoid direct damage to corals such as destruction of colony, silt deposit and waste sediment
c. to keep the aesthetic value of marine environment
d. to improve the sea water quality in the surrounding area

ii) Enhancement of Collection and Transport Capacity

Collection

The current system of self-carry to the depot in Villingili Island is proposed to be kept from now on. In Male', fixed station and bell collection system by using press-type truck is proposed.

Transport

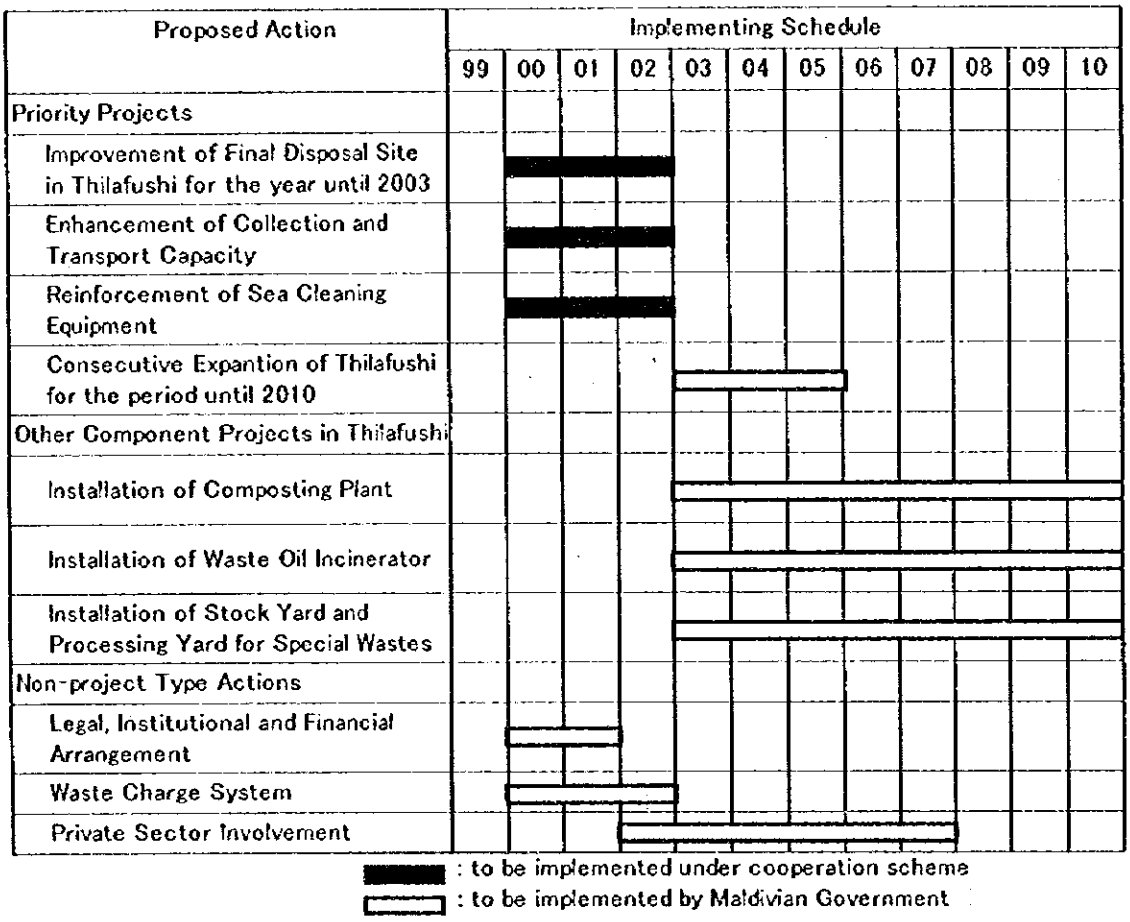
The current transport system is proposed to be kept from now on considering preventive measure against emission of odor and dispersion of wastes.
The transfer station is proposed to be reconstructed.

iii) Reinforcement of Sea Cleaning Equipment

It is proposed to reinforce the port cleaning crew in their equipment.

(2) Time Frame of Projects

The implementation schedule of master plan is proposed as shown below. The priority projects investigated in this report are to be completed by 2003.



1.2 Method of Feasibility Study

Feasibility of a project is usually assessed by comparing expected benefit with cost of the project. This orthodox method requires an assessment of benefit in currency scale, however, there is no established theory to quantify the benefit with currency unit in either economic or financial sense. Therefore a substitute method is adopted for the feasibility study. The method is composed of the following process as shown below:

a. to select possible technical alternatives with equivalent performance on minimum cost basis

b. to assume a suitable institutional arrangement of implementing bodies

c. to evaluate the selected alternatives in view of technical effectiveness whether they complies with the objectives of the master plan

d. to evaluate the selected alternatives in view of acceptability to Maldivian society that is requested to adapt to an innovated SWM system with additional individual expenses

e. to evaluate the selected alternatives qualitatively in view of economic benefit

f. to evaluate the selected alternatives in view of financial affordability within a sustainable extent

g. to evaluate the selected alternatives in view of environmental preservation whether they complies with the objectives of the master plan

With the process mentioned above, the proposed projects are assessed for their feasibility.

2. PRELIMINARY DESIGN OF PRIORITY PROJECTS

2.1 Innovation of Waste Collection System

It is recommended for Male' Municipality to introduce more efficient collection system and provide at least the same level of service as present, which is considered the minimum level to be achieved in the plan.

The solid waste generated in Male' is broadly categorized by four kinds of wastes, i.e. residential, commercial, business and construction waste. The Municipality has responsibility for collection services of the residential waste and supervising & monitoring of waste collection & transportation of all the other types of wastes except construction waste. The collection plan is formulated only for the residential waste under the initiative of the Municipality. The other kind of wastes i.e. commercial, business and industrial waste have to be carried into the transfer station by the waste generator themselves or by the contractors. Therefore, the existing private companies will be able to continue the service contract with the waste generators who require the higher quality services upon full cost recovery charge. Major modification of existing collection system is introduction of new collection system to provide minimum level collection service for all the residents.

2.1.1 Target Load to be Collected

The Municipality has primary duty to collect the residential waste. The Municipality has to collect more than two times of waste amount collected by the system in operation. The Male' Municipality have to improve efficiency of the collection system to provide collection service to all the citizens upon minimum waste charge. The target load to be collected by the Municipality is shown in Table 2-1.

Table 2-1. Target Load to be Collected

Year	Waste Amount t (t/d)	
	Generated Waste Amount (t/day, 365days/year)	Waste Amount to be collected (t/day, 313days/year)
(1999)	51	60
(2000)	54	63
(2001)	57	67
(2002)	61	71
2003	64	75

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

2.1.2 Design of Collection System

(1) Technical Alternatives

The affordable waste charge and the financial capacity of the Municipality decide the level of collection services. The technical system for more efficient collection is selected from the alternatives in consideration of the affordability of the Municipality. The options discussed and considered in the field studies are shown in Table 2-2.

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

Table 2-2. Options of New Collection System

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

(2) Selection of Alternatives of Collection System for Residential Waste

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

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

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

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

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

The collection cost of each option is summarized in Table 2-3. The Table suggests that The Option 3 is the most economical system among the three options.

Table 2-3. Collection Cost of Each Option (2003~2010)

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

2.1.3 Method of Collection

The Option 3 "Vehicle Station Collection System" is proposed for Male' at residential waste collection system.

(1) The Collection System (Original System for Male')

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

(2) Required Number of Collection Vehicles

The required number of vehicles is calculated based on the conditions presented as follows. The result of the calculation is shown in Table 2-4.

a. The calculation conditions

- The compactor type truck of 2.0-ton nominal capacity has an actual loading capacity of 1.8 ton. (The type of collection vehicle has 4.0m^3 container and the compressed waste density is estimated based at 0.5 ton/m^3: loading capacity is 2.0-ton by weight (4.0m^3 x 0.5ton/m^3), the plan will be formulated based on 90 % capacity taking allowance for reliable operation.)
- The normal type 2.0-ton capacity truck has 0.4-ton actual capacity. (Time & Motion Study)

- The two types of collection systems shift the following time for example:

6:00 ~ 7:30	Parks at the fixed place as a container
9:30 ~ 11:00	Goes around the assigned area
14:00 ~ 15:30	Goes around the assigned area
16:30 ~ 18:00	Parks at the fixed place as a container

- The number of trips of each collection vehicle has to be limited 4 times in a day. (each shift has 1 trip x 4 shifts = 4 trips/day)
- The collection vehicle will work 6 hours/day and 6 days/week.

b. The calculation: Compactor Truck

- Required number of vehicles (full working) (60~106)-ton/day/4trips/1.8-ton = 9 ~15 trips
- Required number of vehicles (net working rate is 85%)= 11~18

c. The calculation: Normal truck

- Required number of vehicles (full working) (60~106)-ton/day/4trips/0.4-ton = 38~67
- Required number of vehicles (net working rate is 85%)= 45~79
- The system require more number than door to door collection system. That means the plan is impractical plan, therefore the collection cost estimation will not be carried.

Table 2-4. The Required Number of the Collection Vehicle

Year	Waste Amount t (t/d)		Compactor Truck		Normal Truck	
	Generated Waste Amount (t/day)	Waste Amount to be collected (t/d)	Full working	Net working 85%	Full working	Net working 85%
(1999)	51	60	(9)	(11)	(38)	(45)
(2000)	54	63	(9)	(11)	(40)	(48)
(2001)	57	67	(10)	(12)	(42)	(50)
(2002)	61	71	(10)	(12)	(45)	(53)
2003	64	75	11	13	47	56

(3) Arrangement Plan of New Collection Vehicle

The proposed new collection system is called "Vehicle Station Collection System", the system will arrange the collection vehicle as a container and set up the collection area of each vehicle. The arrangement plan of the vehicle is shown in Figure 2-1 (2003). In 2003, each vehicle covers approx. 20 ha (a radius of 250m circle), the residents can discharge waste at the vehicle collection station within 4 minutes walking (60m/min. speed).

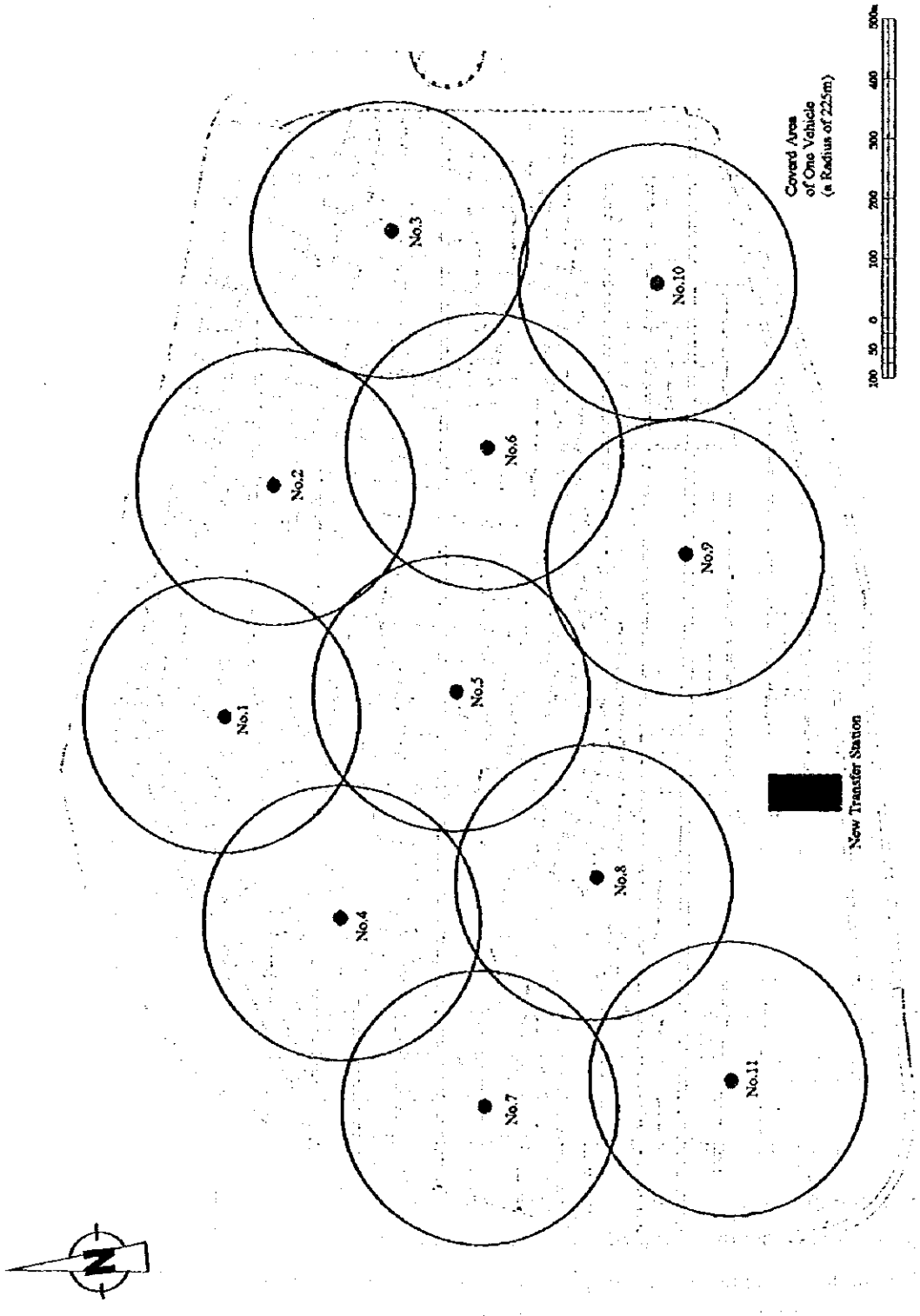


Figure 2-1. Station Plan of the Collection Vehicle (2003)

(4) Collection Cost

Collection cost consists of procurement cost of collection vehicle, personnel expenditure, operation and maintenance cost. The required number of staff and salary of "Vehicle Station Collection System (Option 3)" is shown in Table 2-5.

Table 2-5. The Required Staff and Salary of Collection System

Position	Number	Responsibility	Salary (Rf/month)	Salary (Rf/year)
Assistant Director	1	Responsibility of all activities of the section	Av. 5,500	132,000
Chief Collection Operator	1	Make a collection plan, arrange the vehicle & worker		
Inspector	2	Inspection of sanitary conditions in the city and collection points	Av. 2,500	90,000
Secretary/ Clark	1	Arrange the schedule of manager and deputy manager		
Driver	Same as total trucks (include stand-by)	Drive a collection vehicle		2,500x 12 x (number of total truck)
Worker	Two times of total trucks (include stand-by)	Waste collection	Av. 1,200	1,200x12x2x (number of total truck)
Total	6 + 2 x number of total truck	-	-	-

a. Compactor Truck

The procurement cost of collection vehicle is shown in Table 2-6, the personnel expenditure is shown in Table 2-7 and the operation and maintenance cost are shown in Table 2-8 and Table 2-9. Total collection cost of Option 3 (compactor truck) is summarized in Table 2-10.

Table 2-6. Procurement Cost (Compactor Truck)

Year	(1) Number of Trucks to be Purchased	(2) Unit Cost (Rf)	(3) Total Cost (x 1,000 Rf) (1)x(2)x1.035
1999	-	-	-
2000	-	-	-
2001	-	-	-
2002	13	673,000	9,055
2003	0	673,000	0
Total	13	-	9,055

Table 2-7. Personnel Expenditure (Compactor Truck)

Year	Management Cost (x1000Rf/year)	Number of the trucks	Collection work Cost (x1000Rf/year)	Total Cost (x1000Rf/year)
1999	-	-	-	Existing system
2000	-	-	-	
2001	-	-	-	
2002	-	-	-	
2003	222	13	764	986
Total	222	13	764	986

Table 2-8. Maintenance Cost (Compactor Truck)

Year	(1) Number of Trucks to be Purchased	(2) Unit Cost	(3) Total Cost (x 1,000 Rf) (1)x(2)	Spear Parts and Maintenance Cost (x 1,000 Rf) (3) x 0.06 and 5 years	Total O/M Cost (1,000Rf)
1999	-	-			Existing System
2000	-	-			
2001	-				
2002	13	673,000	8,749		
2003	0	673,000	0	525	525
Total	13	-	8,749	525	9,274

Table 2-9. Operation Cost (Compactor Truck)

(x 1000 Rf)

Year	Number of Trips	Fuel Cost	The others	Total Cost
1999	Existing System	Existing System	Existing System	Existing System
2000				
2001				
2002				
2003	44	413	986	1,399
Total	-	413	986	1,399

1 trip = 3.0 km / 4 km / l x 2.5 Rf = 30 Rf / trip, 30 Rf / trip x 365 x 6/7 = 9,385 Rf / trip / year

Table 2-10. Collection Cost of the Option 3 (Compactor Truck)

(x 1000 Rf)

Year	(1) Procurement Cost	(2) Personal Expenditure	(3) Maintenance Cost	(4) Operation Cost	Total Cost
1999	-			(1,249)	(1,249)
2000	-			(1,249)	(1,249)
2001	-			(1,249)	(1,249)
2002	9,055			(1,249)	(1,249) 9,055
2003	0	986	525	1,465	2,910
Total	9,055	986	525	1,465	11,965

2.2 Enhancement of Waste Transport 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 immediately in order to maintain public health and cleanliness of the islands in the planning area.

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

2.2.1 Target Load to be Transported

The waste amount to be transported is shown in Table 2-11. The amount is estimated by 6-days working per a week.

Table 2-11. Projection of Waste Amount to be Transported (Unit: ton/day)

Year	Residential, Commercial, Business waste	Saw dust (to be separated)	Kitchen waste (to be separated)	Construction Waste	Total (Male')	Residential waste (Villingili)
(1999)	128.2	-	-	82.7	210.9	1.5
(2000)	134.9	-	-	85.3	220.2	1.9
(2001)	141.7	-	-	88.0	229.7	2.1
(2002)	148.9	-	-	90.9	239.8	2.6
2003	151.7	4.0	1.0	93.8	250.5	3.0

Note: 1999~2002 – Existing Transportation System (Preparation term for new system)

2.2.2 Design of Transportation System

(1) Technical Alternatives

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

Table 2-12. Options of Improved Transport System

Item	System	Major Merit	Major Demerit
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.
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.
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.

(2) Selection of Alternative of Transportation System

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

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

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

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

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

The transportation cost of each option is summarized in Table 2-13. The Table suggests that, the Option 2 is the most economical system among the three options.

Table 2-13 Transportation Cost of Each Option (2003~2010)

(Rf)

Year	Option 1	Option 2	Option 3
Total	185,948,000	178,941,000	287,711,000

2.2.3 Method of Transportation

(1) Transportation System

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

(2) The Required Number of Trip

The compactor truck can load almost two times of the waste amount comparing with that of the normal truck. Therefore, the required number of trips of ferry is lesser than the Option 1.

a. Calculation conditions

1991 ~ 2002

- The trucks bring the mixed waste from Male' and Villingili to the site.
- The truck can load 6.0-ton amount of waste (The density of mixed waste is 0.5-ton/m^3).

2003 ~ 2010

- The trucks bring the four categorized waste from Male' and mixed waste from Villingili to the site.
- The density of residential, commercial and business waste is pressed to 0.5-ton/m^3 (The waste can be loaded 7.2-ton/truck. 16m^3 x 0.5 x 90%).
- Saw dust and kitchen waste requires one-truck/day.
- The trucks can load 10-ton amount of construction waste.
- The density of Villingili mixed waste is also 0.3-ton/m^3, the trucks can load 4.0-ton/truck.

Table 2-14 Required Number of Truck and Trip

Year	Residential, Commercial, Business waste (ton-/day)	Saw dust (to be separated) (ton-/day)	Kitchen waste (to be separated) (ton-/day)	Construction Waste (ton-/day)	Residential waste (villingili) (ton-/day)	Number of truck (Number of ferry trip)
1999				36 (210.9)	1 (1.5)	37 (8)
2000				37 (220.2)	1 (1.9)	38 (8)
2001				39 (229.7)	1 (2.1)	40 (8)
2002				40 (239.8)	1 (2.6)	41 (9)
2003	22 (151.7)	1 (4.0)	1 (1.0)	10 (93.8)	1 (3.0)	35 (7)

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

(3) Transportation Cost

The transportation cost of the Option 2 consists of four items i.e., construction cost of transfer station, procurement cost of trucks and heavy machines, operation and maintenance cost, personnel expenditure.

a. Construction Cost of Transfer Station

The details of the construction cost of transfer stations (Male' and Villingili) are presented in "2.3 Improvement of Waste Transfer System". Total construction cost and the timing of the construction is shown in Table 2-15.

Table 2-15. Total Construction Cost and Timing of the Construction (Rf)

Year	The Construction Cost
2001	10,074,000
2002	23,507,000
Total	33,581,000

b. Procurement Cost

Procurement cost and timing of transportation trucks, heavy machines and other equipment are shown in Table 2-16.

Table 2-16. Procurement Cost (Rf)

Year	Truck	Heavy machine	Other equipment	Total
2002	Dump truck (10-ton class) 1,023,000x 7 = 7,161,000 Compactor truck 1,500,000 x 11 = 16,500,000 Sub-total 23,661,000 23,661,000x1.035 = 24,489,135	Wheel loader (1.3m3 class) 886,000 x 3 = 2,658,000 Wheel loader (0.8m3 class) 686,000 x 2 = 1,372,000 Excavator (0.8m3 class) 1,287,000 x 2 = 2,574,000 sub-total 6,604,000 6,604,000x1.035 = 6,835,000	Washing Machine 152,000 Workshop 294,000 Truck scale 3,610,000 Sub-total 4,056,000 (4,056x1.035)= 4,198,000	35,522,135
Total	24,489,135	6,835,000	4,198,000	35,522,135

e. Personnel Expenditure

The required staff and salary of the Option 1 is shown in Table 2-17.

Table 2-17. The Required Staff and Salary of Transportation

Position	Number	Responsibility	Salary (Rf/month)	Salary (Rf/year)
Assistant Director	1	Responsibility of all activities of the section	Av. 5,500	132,000
Chief Transfer Operator	1	Make a transportation plan, arrange the vehicle & worker		
Assistant Account	1	Account the disposal charge	Av. 2,500	300,000
Secretary/ Clark	1	Arrange the schedule of manager and deputy manager		
Truck Scale Operator	3	Measure the waste weight by using truck scale		
Mechanics	3	Maintenance and repair the machines and vehicles		
Assistant Mechanics	2	Assist the mechanics activities		
Machine operator	3	Operate the heavy machines	Av. 2,500	810,000
Barge Captain	3	Drive the barge		
Barge Assistant Captain	3	Assist the captain activities		
Driver	18	Drive transportation vehicle		
Worker for transportation	18	Assist the driver	Av. 1,200	532,800
Worker for operation of the station	10	Cleansing of the transfer station		
Barge Crew	9	Operate the gate		
Security Guard	2	Security guard of the station	1,200	28,800
Total	79	-	-	1,830,600

d. Operation and Maintenance Cost

i) Maintenance Cost

Table 2-18. Maintenance Cost (Rf/year)

Year	Truck	Heavy machine	Other equipment	Total
2003 ~ 2010	Dump truck (10-ton class) 1,023,000x 7 =7,161,000 Compactor truck 1,500,000 x 11 =16,500,000 23,661,000x0.06 = 1,419,660	Wheel loader (1.3m3 class) 886,000 x 3 = 2,658,000 Wheel loader (0.8m3 class) 686,000 x 2 = 1,372,000 Excavator (0.8m3 class) 1,287,000 x 2 = 2,574,000 sub-total 6,604,000 6,604,000x0.06= 396,240	Washing Machine 152,000 Workshop 294,000 Truck scale 3,610,000 Sub-total 4,056,000 (4,056,000x0.06)= 243,360	2,059,260

ii) Operation Cost

Table 2-19. Operation Cost of Truck and Heavy Machine (8hors-10trip)

Item	Truck	Heavy machine	Total
Cost	Dump truck (10-ton class) 1.5kmx2/2x2.5rfx50 = 187.5 Rf	Wheel loader (1.3m3 class) 40 x 2,5 x 2 = 200 Rf Wheel loader (0.8m3 class) 40 x 2.5 x 1 = 100 Rf Excavator (0.8m3 class) 40 x 2.5 x 1 = 100 Rf Total 400 Rf	187.5 +400 = 587.5 587.5/10 = 60 Rf/trip

Table 2-20. Total Operation Cost (include Ferry & Utility)

(x 1000 Rf)

Year	Number of ferry trip	Vessel & Utility	Fuel (Operation)	The others	Total
1999					Existing System
2000					
2001					
2002					
2003	2,191	3,243	131	1,831	5,175
Total	-	3,243	131	1,831	5,175

Note: Vessel & Utility : 2,780,000/6/313=1,480 Rf/trip

c. Total transportation Cost of Option 2

Table 2-21. Transportation Cost (Option 2)

(x 1000 Rf)

Year	Construction cost	Procurement cost	Personal expenditure	Maintenance Cost	Operation Cost	Total
1999	-	-	(1,645)		(3,213)	(4,858)
2000	-	-	(1,645)		(3,213)	(4,858)
2001	10,074	-	(1,645)		(3,213)	10,074 (4,858)
2002	23,507	35,522	(1,645)		(3,213)	59,029 (4,858)
2003	-	-	1,831	2,059	5,175	9,065
Total	33,581	35,522	1,831	2,059	5,175	78,168 (97,600)

2.3 Improvement of Waste Transfer System

2.3.1 Target Load to Be Transferred

(1) Male'

The waste to be transferred from collection routine to transport vehicle is planned to be once brought to the transfer station and stored for some time and reloaded for the transport to Thilafushi. All the wastes brought to the transfer station are classified into the following seven categories for the convenience of successive separate treatment and given an exclusive storage space in the station respectively.

Table 2-22. Classification of Accepted Waste at Transfer Station

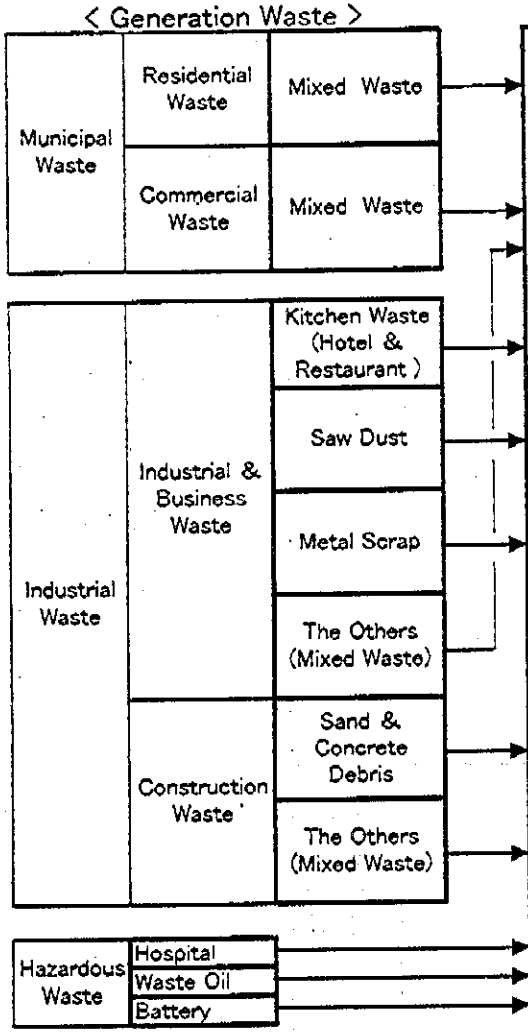
Major Type of Waste	Category
Perishable Waste	Mixed waste out of residential, commercial, industrial and business waste
	Kitchen waste from hotels and restaurants
Non-perishable Waste	Saw dust
	Metal scrap
	Construction waste (sand & concrete debris)
	Construction waste (other than sand & concrete debris)
	Hazardous waste

According to the above classification, the waste volume to be reloaded at the station is estimated as shown in Table 2-23. The average number of vehicles coming and going at the station is forecast proportionally to the waste volume as shown below.

Table 2-23. Estimated Vehicle Number Incoming and Outgoing at Transfer Station

Type of Vehicle	Number of Daily Trips											
	99	00	01	02	03	04	05	06	07	08	09	10
Incoming	386	400	414	430	356	368	380	391	404	415	428	439
Hand cart	63	63	63	63	63	63	63	63	63	63	63	63
Micro-bin	55	55	55	55	0	0	0	0	0	0	0	0
Private car	268	282	296	312	251	260	270	279	289	298	308	317
Compactor truck	0	0	0	0	42	45	47	49	52	54	57	59
Outgoing	36	37	39	40	34	35	36	38	39	40	42	43
Dump truck	36	37	39	40	12	12	12	13	13	13	14	14
Compactor truck	0	0	0	0	22	23	24	25	26	27	28	29
Total	422	437	453	470	390	403	416	429	443	455	470	482

Table 2-24. Estimated Waste Volume to be Reloaded (1999~2010)



<Transfer Station>		Reloading Waste Volume (t/day)											
		1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Retaining House (Loading at Compactor Truck)	Mixed Waste	100.2	105.6	111.2	117.0	122.9	129.1	135.4	141.7	147.9	154.3	160.8	167.2
	Kitchen Waste	3.6	3.7	3.8	3.9	4.1	4.2	4.3	4.4	4.6	4.7	4.8	5.0
Retaining Yard (Loading at Truck)	Saw Dust	4.7	4.8	5.0	5.1	5.3	5.5	5.6	5.8	6.0	6.1	6.3	6.5
	Metal Scrap	1.4	1.5	1.5	1.6	1.6	1.7	1.7	1.7	1.8	1.9	1.9	2.0
	Sand & Concrete Debris	42.2	43.6	44.9	46.4	47.9	49.4	50.9	52.4	53.9	55.4	57.0	58.5
	The Others of Constructio Waste (Mixed Waste)	28.7	29.6	30.5	31.5	32.5	33.5	34.5	35.6	36.5	37.6	38.6	39.7
	Hazardous Waste	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Total	181.0	189.0	197.1	205.7	214.5	223.6	232.6	241.8	250.9	260.2	269.6	279.1

(2) Villingili

Most of solid waste generated in Villingili is identified as domestic waste because the island was developed exclusively for residential area. Only one conspicuous industry in the island is wooden ship repair yard, which discharges saw dust from time to time but the amount is not significant in comparison with domestic waste. The waste volume to be reloaded at the deposit site is estimated as shown in 2-26. The average number of transport vehicle coming and going at the site is forecast proportionally to the waste volume as shown in the same table below.

Table 2-25. Estimated Waste Volume to be Reloaded and Number of Transport Vehicles

Year	Waste Volume (ton/day)	Interval of Transport (trip/week)	Number of Vehicle (number/trip)
1999	1	2	1
2000	2	3	1
2001	2	3	1
2002	2	3	1
2003	3	4	1
2004	3	4	1
2005	4	Everyday	1
2006	4	Everyday	1
2007	5	Everyday	1
2008	6	Everyday	2
2009	7	Everyday	2
2010	8	Everyday	2

2.3.2 Design Condition

(1) Male'

Planned site for new transfer station is now utilized as office, workshop, garage and accommodations of Public Works Section as shown in Figure 2-2. The site is facing the south coast of Male' Island and entirely surrounded by streets on four sides. The approximate size of the site is 200 ft in east-west direction and 400 ft in north south direction. The design condition for the facility is itemized below:

- Capacity of stock volume is secured for an equivalent to 3 day generation except perishable waste.
- Perishable waste is removed in a day or two.
- Facility is enclosed with fence which prevents waste and smell dispersion, and noise emission.

- Entrance for transport vehicles is placed on the side facing the sea to mitigate the negative impact by traffic noise.
- Entrance for collection vehicles is placed in the opposite end to the transport vehicle entrance for the convenience of separate access to the station from the collection area.
- Internal vehicle passages are separately assigned to vehicles by their role of collection, transport and administration.
- Transfer station is accompanied by the same administrative function as is currently provided to the Waste Management Section of MCPW.
- Transfer station has the function of daily maintenance and minor repair for the vehicles and loaders used or coming there. Major repair is expected to be done by the special maintenance section of MCPW, BCMW.

(2) Villingili

Deposit site is located on the west coast and isolated from the residential area as shown in Figure 2-3. It is already in operation and utilized about two times a week for reloading the waste stored there. The site is provided a quay wall for ferry so that it is possible to get a transport vehicle on board without passing through the town. The approximate size of the site is about 40m in east-west direction and 60m in north south direction. The design condition for the facility is itemized below:

- Construction is regarded as improvement of existing site and therefore the work is limited within the site.
- Waste is dumped by individual residents, contracted handcarts and other vehicles with no time restriction.
- All kinds of waste are stored and reloaded as mixed waste, with no particular segregation.
- There is no full time staff assigned and the staff for reloading to transport vehicle is dispatched intermittently when it is needed.
- Loading equipment is always allocated and parked in the site while it is not needed.
- The floor is paved with concrete but the area should be limited in a certain area.
- The boundary facing the inland and the sea is enclosed by wire netting to prevent the waste from blown off.

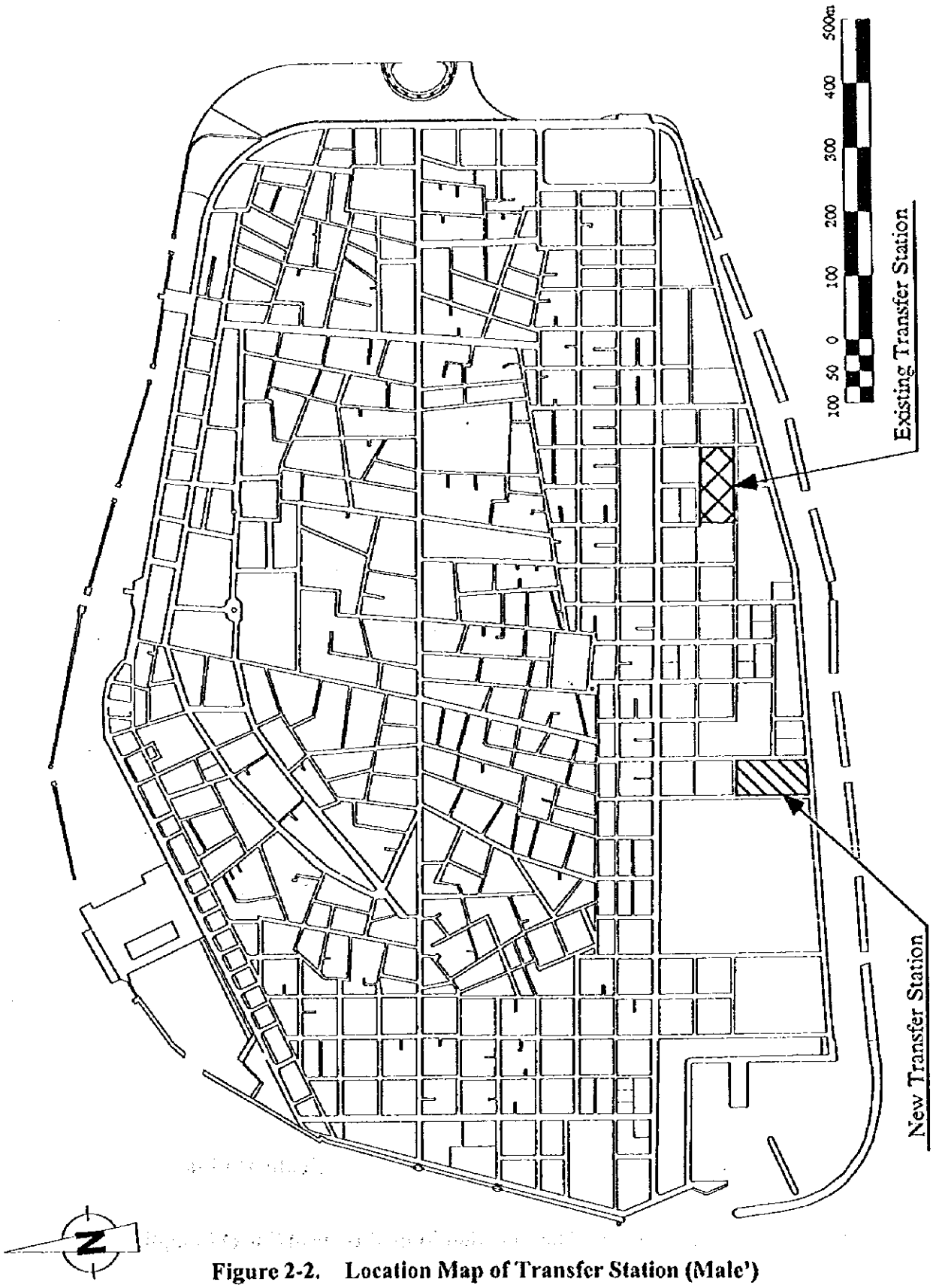


Figure 2-2. Location Map of Transfer Station (Male')

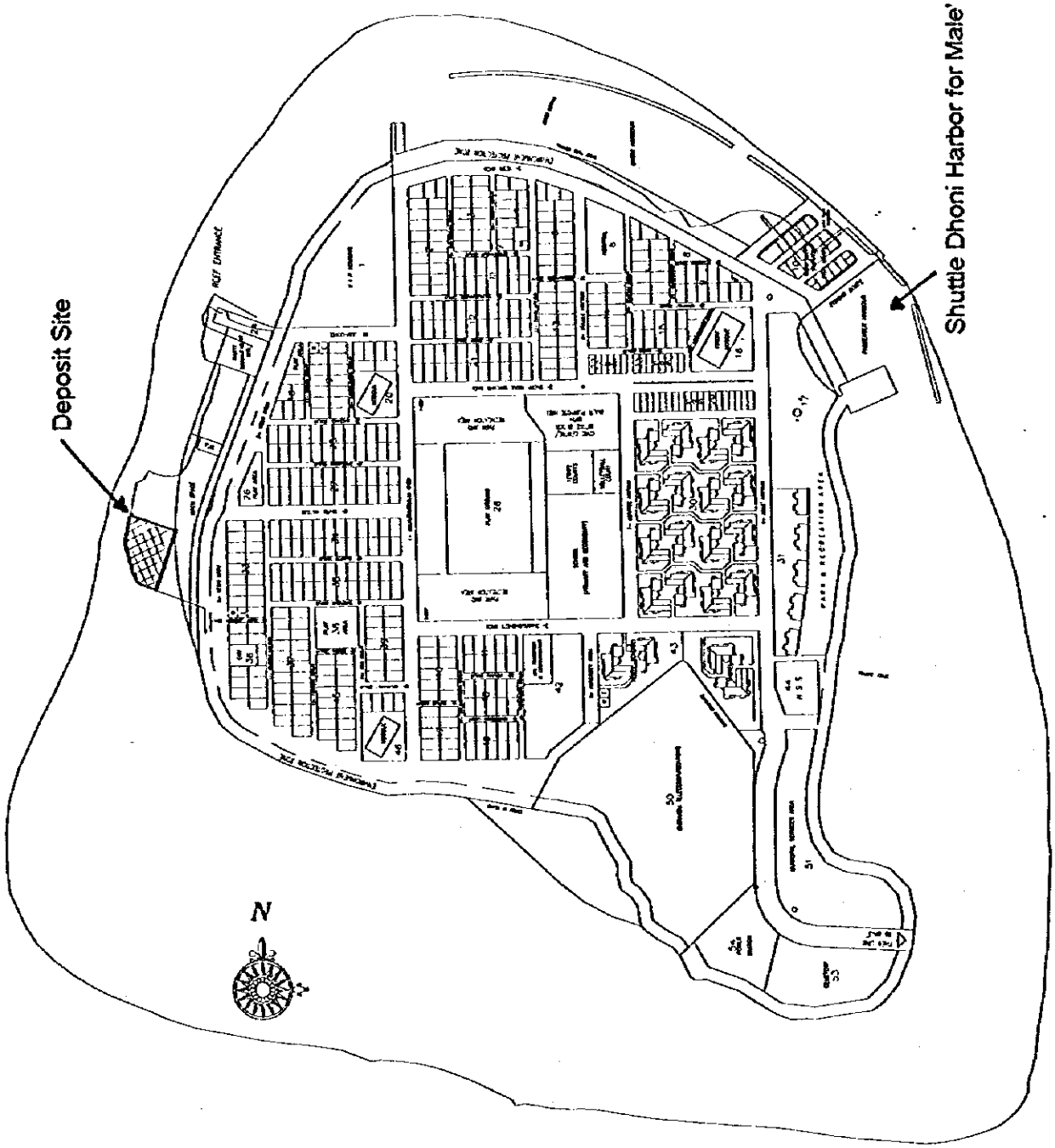


Figure 2-3. The Location Map of Deposit Site (Villingili)

2.3.3 Method of Transfer

(1) Male'

Shovel loading method is adopted to transfer the waste from collection vehicle to transport vehicle. This method is carried out in the following manner:

a. Collection vehicle coming into the station is at first weighed and then the waste is loaded

b. Waste is unloaded on the ground at the designated space by type of waste

c. Stored waste is loaded by shovel loader to transport vehicle by type of waste

d. Transport vehicle is weighed after fully loaded and leaves for Thilafushi

Two types of transport vehicle are used according to the preference to the nature of waste to be loaded as shown below.

Table 2-26. Type of Transport Vehicle and the Suitable Wastes

Type of Vehicle	Suitable Waste to Be Loaded
Compactor truck	Those waste which can be compressed mechanically or emits offensive odor. ・Perishable waste ・Sawdust
Dump truck	Those waste which can not be compressed adequately and causes little smell. ・Metal scrap ・Hazardous waste ・Construction waste (sand & concrete debris) ・Construction waste (other than sand & concrete debris)

It is likely that an offensive odor arises inside the station because kitchen waste is stored even though the time period of storing is controlled in a day or two. The smell of perishable waste may disturb the operation in the station so that spraying of deodorant at an appropriate interval is introduced mainly to the storage of perishable waste.

(2) Villingili

Shovel loading method is adopted to reload the waste to transport vehicle. A shovel loader is exclusively deployed to this site. Because the site is open to the air, spraying of deodorant is also applied to mitigate the negative effect to the residents.

2.3.4 Required Input

(1) Construction

a. Male'

The outline of the new transfer station is planned as shown in Table 2-27 and Figure 2-4 and 2-5.

Table 2-27. Outline of New Transfer Station

Facility/Equipment	Dimension	Remarks
Perishable Waste House	30m×35m×1 floor (5m high)	Storing and reloading of waste is carried out in the house. Floor is paved with concrete to prevent seepage of leachate into the ground.
Non-perishable Waste Yards	15m×20m, 10m×20m, 10m×10m	Divided space by type of segregated waste with concrete floor
Repair House	15m×15m, single floor	Used for repair of vehicles and shovel loader
Garage for Transport vehicle	52m×8m, single floor	Used for 15 dump trucks for Thilafushi
Parking Space		Used for administration vehicle with exclusive entrance
Truck Scale	Capacity 30 ton, 2 units	
Truck Washing Machine	able to wash 15- ton truck	
Water Tank	5m×5m×5m high	
Rest Room	5m×5m	
Administration Building	floor area 680 m^2, 2 floors	office: 120 m^2 parts stock room: 120 m^2 repair room: 100 m^2 lodgings for workers: 340 m^2 (2^{nd} floor)

b. Villingili

The improvement plan of the deposit site is planned as shown in Figure 2-6.

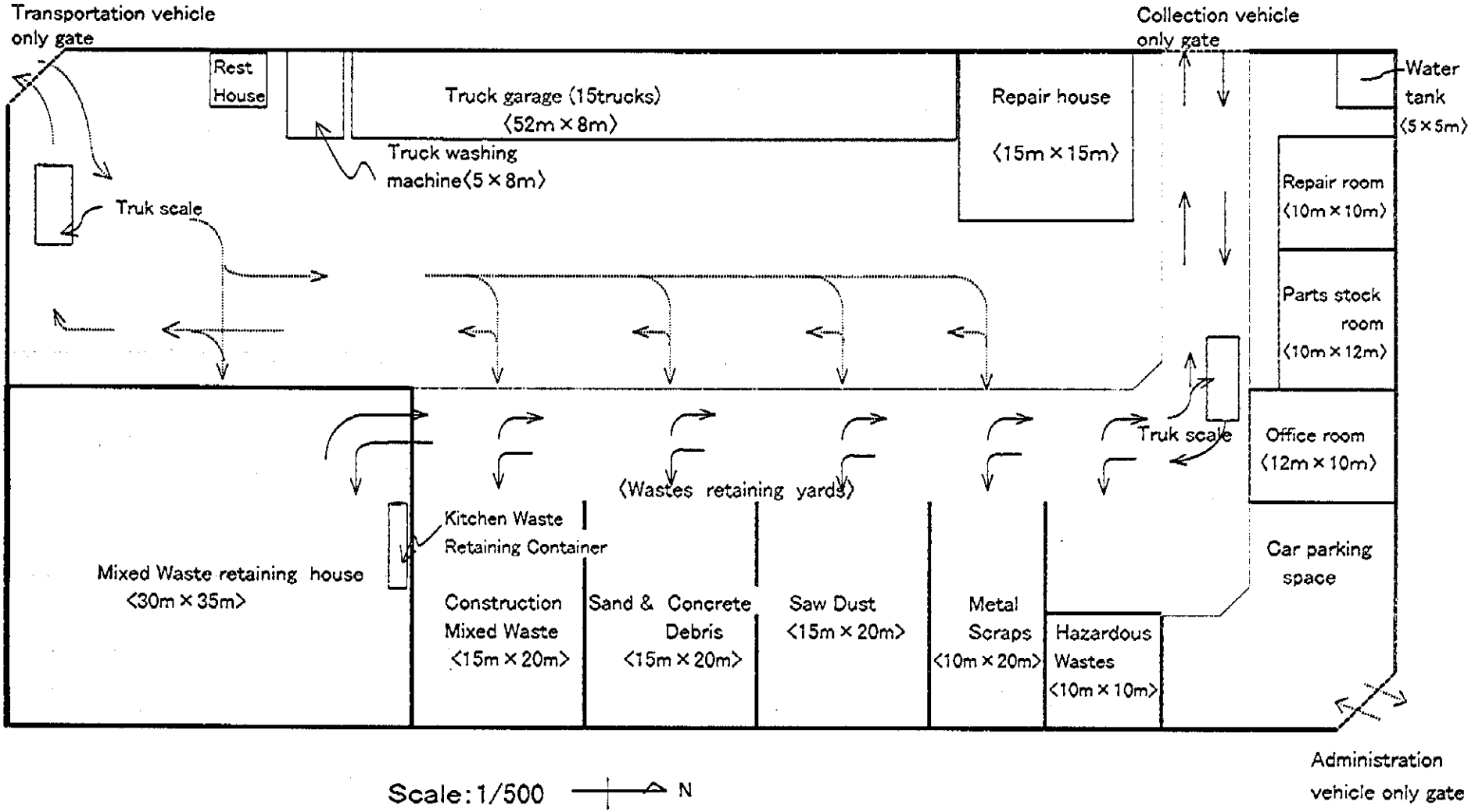


Figure 2-4. Transfer Station Plan (200 feet×400 feet)

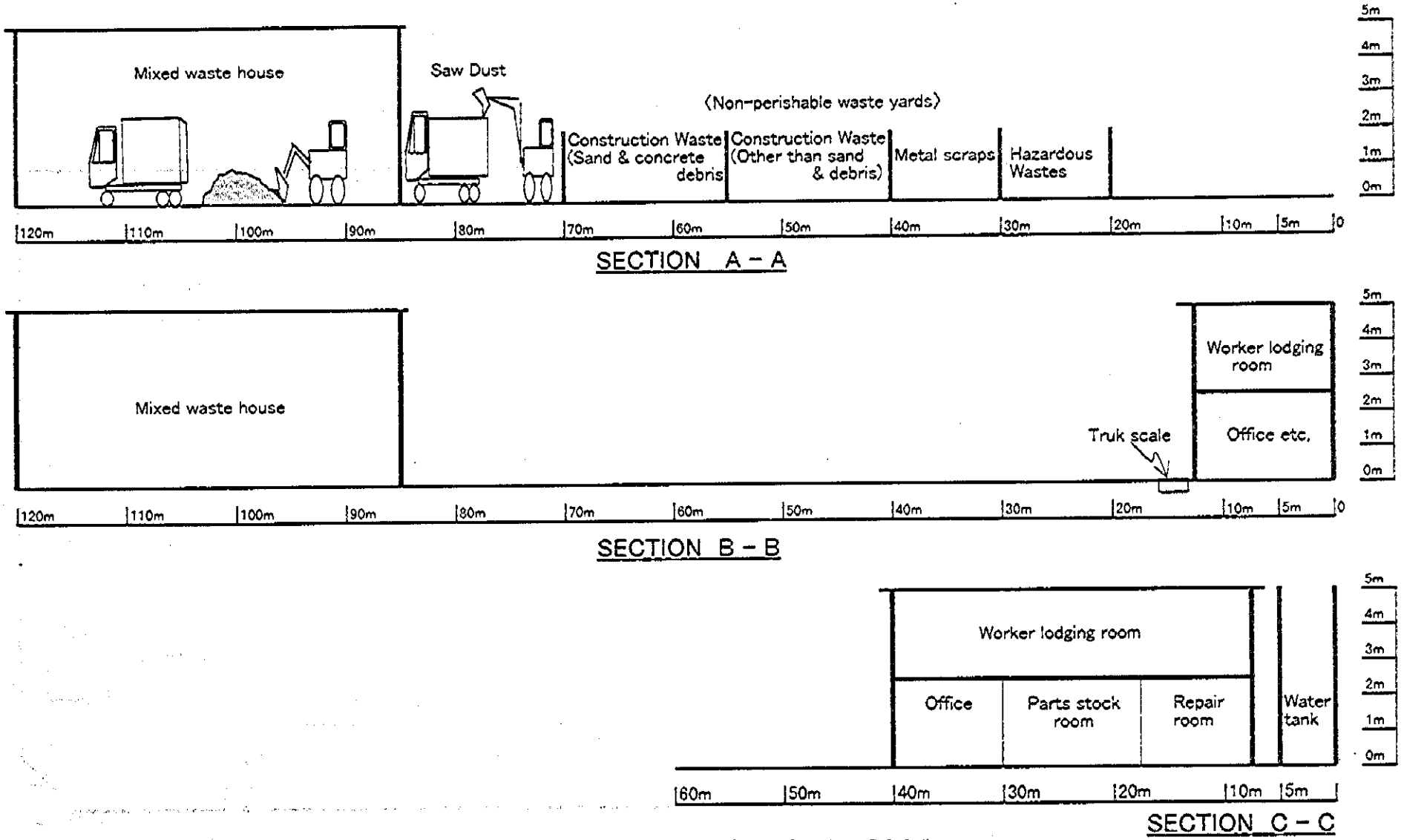


Figure 2-5. Transfer Station Cross Section (Male')

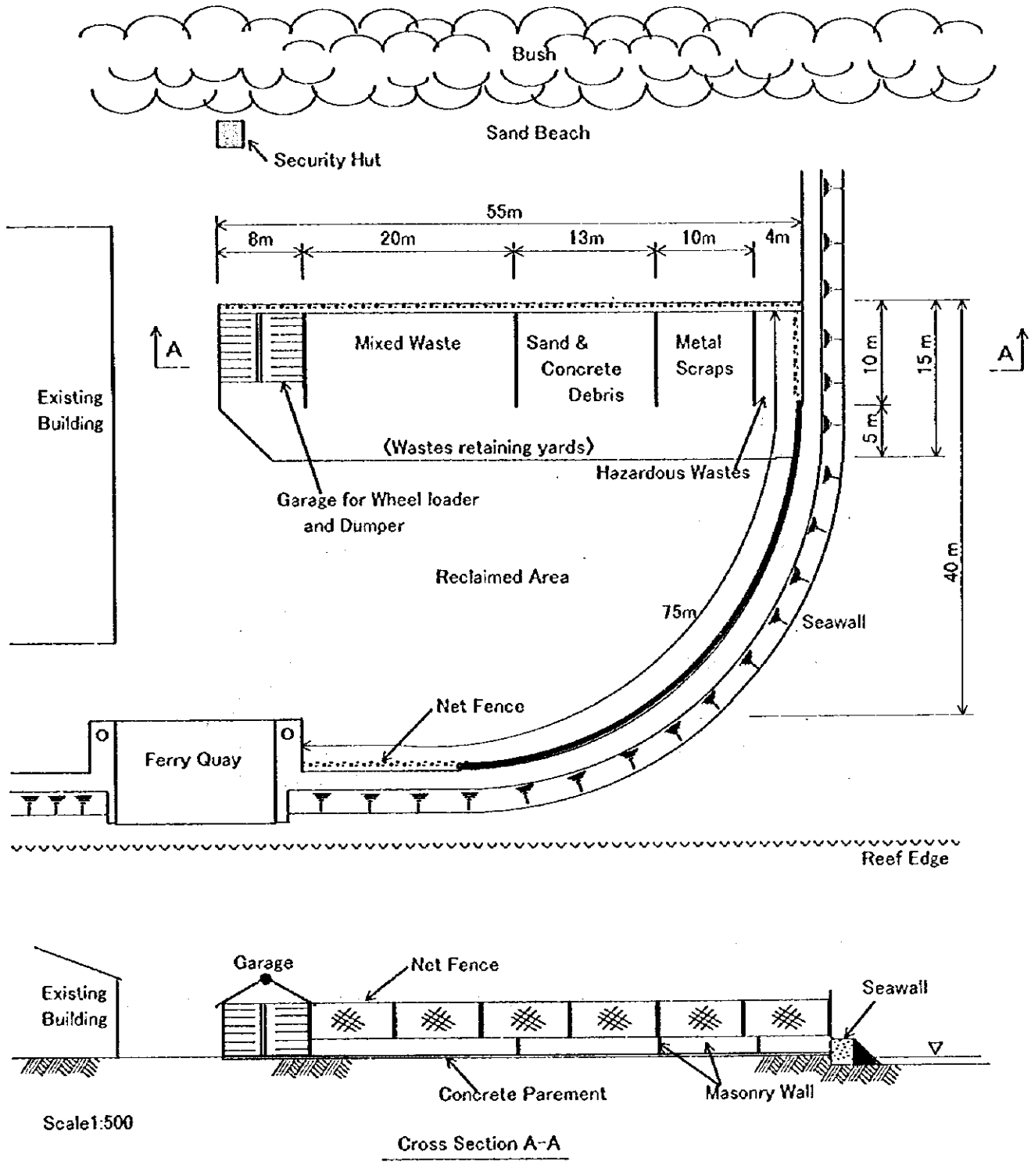


Figure 2-6. Improvement Plan of Deposit Site (Villingili)

(2) Equipment

Equipment to be procured are listed below.

Name of Equipment	Number of Units	Remarks
a. Truck Scale	2	
b. Workshop	1	for minor and major repair
c. Washing Machine	1	capacity : 15 ton class truck
d. Wheel Loader (small)	1	capacity : 0.8 m^3
e. Wheel Loader (large)	2	capacity : 1.3 m^3, one for Villingili
f. Excavator	1	capacity : 0.8 m^3
g. Dumper	1	capacity :0.6. m^3, for Villingili
h. Machining Tool	1	

(3) Personnel

Position	Number of Person	Remarks
a. Deputy Director	1	Transfer & Transport division
b. Assistant Director	1	Transfer Station
c. Clerk	1	Transfer Station
d. Mechanical Engineer	1	Transfer Station
e. Chief Operator	1	Transfer Station
f. Mechanic	2	Transfer Station
g. Assistant Mechanic	2	Transfer Station
h. Assistant Accountant	1	Transfer Station
i. Truck scale Operator	3	Transfer Station
j. Loading Operator	3	Transfer Station
k. Loading Worker	5	Transfer Station
l. Security Guard	2	Transfer Station
Total	23	

(4) Transfer Cost

Transfer cost is included in Transportation cost estimated in Section 2.2 (page v2. 2-11).

2.4 Enhancement of Port Area Cleaning

2.4.1 Target Load to Be Cleaned

Solid waste in the port area is mainly generated by the boat crew mooring for days because they are living on the boat and pass the same daily routine as they do on the ground. At the same time they are usually making a minor repair of their vessel in the port. The composition of floating waste and salvaged waste from the sea bed indicates who are most likely to have thrown those waste into the sea. Target waste volume to be removed from the port area is therefore estimated by analogy to the domestic waste which has a proportional trend to the number of people who generate waste.

The population in the port is related to the number of boats mooring and average number of crew. The number of boats mooring in the port varies every day and number of crew also varies by the type of vessel and usage. However, it is possible to assume the maximum number of boats and average number of crew for the purpose of getting the upper limit of waste generation. The capacity of the port is presumed at about 200 for the south-west and the south port, and about 300 for the north port based on the observation on a congested condition. With this presumption, the target load to be cleaned is estimated as the maximum waste volume generated in the port as shown in Table 2-29.

Table 2-28. Estimated Waste Volume in Port Area

Item	South-west Port + South Port	North Port
Number of mooring boat	200	300
Average number of crew	5	5
Population in the port	1,000	1,500
Per capita waste generation (kg/day)*	0.7	0.7
Total waste generation (kg/day)	700	1,050

* : unit generation rate of domestic waste

The South port is now half closing the gaps between off-shore breakwaters along the seawall. The modification of the breakwater makes the surface of the South port calmer so that the number of mooring boats will increase after completion of on-going work. That leads to the increase of the population in the port therefore the estimated waste generation of 700 kg/day will become bigger in the future. After all the target load to be cleaned is assumed at 1 ton for each port area.

2.4.2 Design Condition

The design condition for the enhancement is itemized below.

- Enhancement of port area cleaning is focused on the reinforcement of equipment for the operation, which are supposed to be utilized by the Harbor Section of MCPW now in charge of the task.
- The activities to be improved are removal of drifting solid waste on the sea surface and other waste generated in the port area.
- Equipment input are given to each crew of cleaning deployed to two port area respectively.
- Discharge of solid waste from the boat moored in the port area is in principle forced to bring the waste to the pier by each generator in the manner not to scatter either on the sea or the ground.
- Equipment input should promote the efficiency of waste removal activity on site and transport to the transfer station.

2.4.3 Method of Cleaning

The legitimate waste discharge manner was already announced through mass media and individual notice to boat owners mooring the port from MCPW and has now come into power . In accordance with the spread of the legal manner in waste discharge from boat, the waste volume collected on the ground where boat crew bring their waste by themselves will increase gradually. Finally all the waste from port area can be collected and disposed by the pier cleaning crew alone, consequently sea cleaning crew will lose regular task, which is now the major part of port area cleaning. By the time the legitimate waste discharge manner comes to ultimate dissemination, two types of cleaning on the sea and on the ground need to be continued.

The conventional method of cleaning is basically manual work with very simple hand made tools, which is not so efficient but sure and cheap. The proposal of improvement assumes that the conventional method is taken over as the prerequisite of advanced equipment introduction. Rowboat is replaced with motor boat and tractor is replaced with dump truck.

2.4.4 Required Input

(1) Equipment

Handmade tools seem to affect the efficiency of removing the waste from the sea surface because the most time consuming practice at present is scooping waste on the sea. Current practice adopts three hand tools, namely straight bar, rake and twin handled scoop net. Workers operate these tools skillfully, but it takes fairly long time to catch the drifting waste. The reach of each tool is limited at about 2 m around the operator to make the matters worse so that to catch the waste beneath the tightly moored boats.

The normal approach to contrive better tools is to encourage the personnel engaged in to propose their ideas based on experience. It is recommended to MCPW to offer a prize contest for better tool of waste removing to its employee and to the public. The cost to adopt an excellent idea may not be significant and therefore be affordable within the regular budget for the Harbor Section. Consequently the improvement of hand tools is not contained in the target project of feasibility study.

On the other hand, small sized motor boat and dump truck are to be procured to raise the efficiency of mobilization of cleaning crew in the congested situation of port area. The number of equipment exactly corresponds to those of preceding equipment as shown below.

a. Year 2001

- Small motor boats 2 units with 15 HP
- Small open dump truck 1 unit with loading capacity of 2 ton

b. Year 2006

This year is not included in the target period of feasibility study, however, it is necessary to renew the truck at the end of depreciation period of 5 years.

- Small open dump truck 1 unit with loading capacity of 2 ton

(2) Personnel

Personnel engaged in port area cleaning belongs to the Harbor Section of MCPW. The task of cleaning is undertaken as part of port administration which is executed strictly by the office staff and on-site supervisors. As the regulation on solid waste discharge in the port prevails, the task of cleaning becomes less troublesome to the personnel in charge. In this context, it is considered that no particular arrangement for institutional reinforcement is required.

2.4.5 Cost Estimates

The procurement cost for the cleaning equipment is estimated as shown below.

• Small motor boats	@ $ 4,400 × 2 units =	$ 8,800
• Small open dump truck	@ $ 42,000 × 1 unit =	$ 42,000
	Total	$ 50,800

2.5 Environmental Improvement of Existing Thilafushi Island

2.5.1 Target Coast to be improved

The governmental bodies or private companies have rapidly developed existing Thilafushi Island. Some of them have already constructed quay walls or seawalls to protect shorelines by use of coral rocks in a traditional way. The Study Team judges that it is not necessary to re-construct seawalls instead of the existing ones by the Solid Waste Management Project. In this feasibility study, the target coast to be improved by the Solid Waste Management Project is limited only to the exposed coast where shore protection is provided as indicated in Figure 2-7.

2.5.2 Design Condition

(1) Waves

As described in section 3.1.4 of Master Plan (page v1. 3-6), waves approaching to Thilafushi are wind waves from NW-NE and swells from SW. Design waves can be summarized as follows:

For north and east coast	:$H_{1/3}$ = 1.2 m	T = 6.4 sec.
For west coast (inner lagoon)	:$H_{1/3}$ = 0.7 m	T = 6.0 sec
For south coast	:$H_{1/3}$ = 3.0 m	T = 16.0 sec

(2) Construction material

1) Import Rock

2) Coral

2.5.3 Method of Improvement

Since existing seawalls employ traditional type of seawall structure utilizing coral rocks and cement mortaring, two types of the structure such as traditional type (Type B) and permanent type (Type A) will be planned in the feasibility study. Although construction cost of Type B is cheaper than Type A, maintenance cost is required every year.

Typical sections of each type are indicated in Figure 2-8.

2.5.4 Required Input

a. Construction

Seawall Construction (Type A or B)	West Coast	970 m
Seawall Construction (Type A or B)	East Coast	350 m

b. Equipment and personnel

Since solid waste filling in existing Thilafushi is expected to be completed in 1999, it is not necessary to provide any equipment and personnel for the solid waste management.

2.5.5 Project Cost

Project cost for the improvement of existing Thilafushi Island will be Rf. 34.63 million in case that imported rocks are utilized for and Rf. 11.86 million in case that traditional type utilizing coral rock is employed.

Table 2-29. Construction Cost for Seawall Type A (using imported rocks)

Item	Cost (Rf 1,000)
Direct Construction Cost	26,432
Indirect Construction Cost	8,194
Total Construction Cost	34,626

Table 2-30. Construction Cost for Seawall Type B (using coral)

Item	Cost (Rf 1,000)
Direct Construction Cost	10,134
Indirect Construction Cost	1,723
Total Construction Cost	11,856

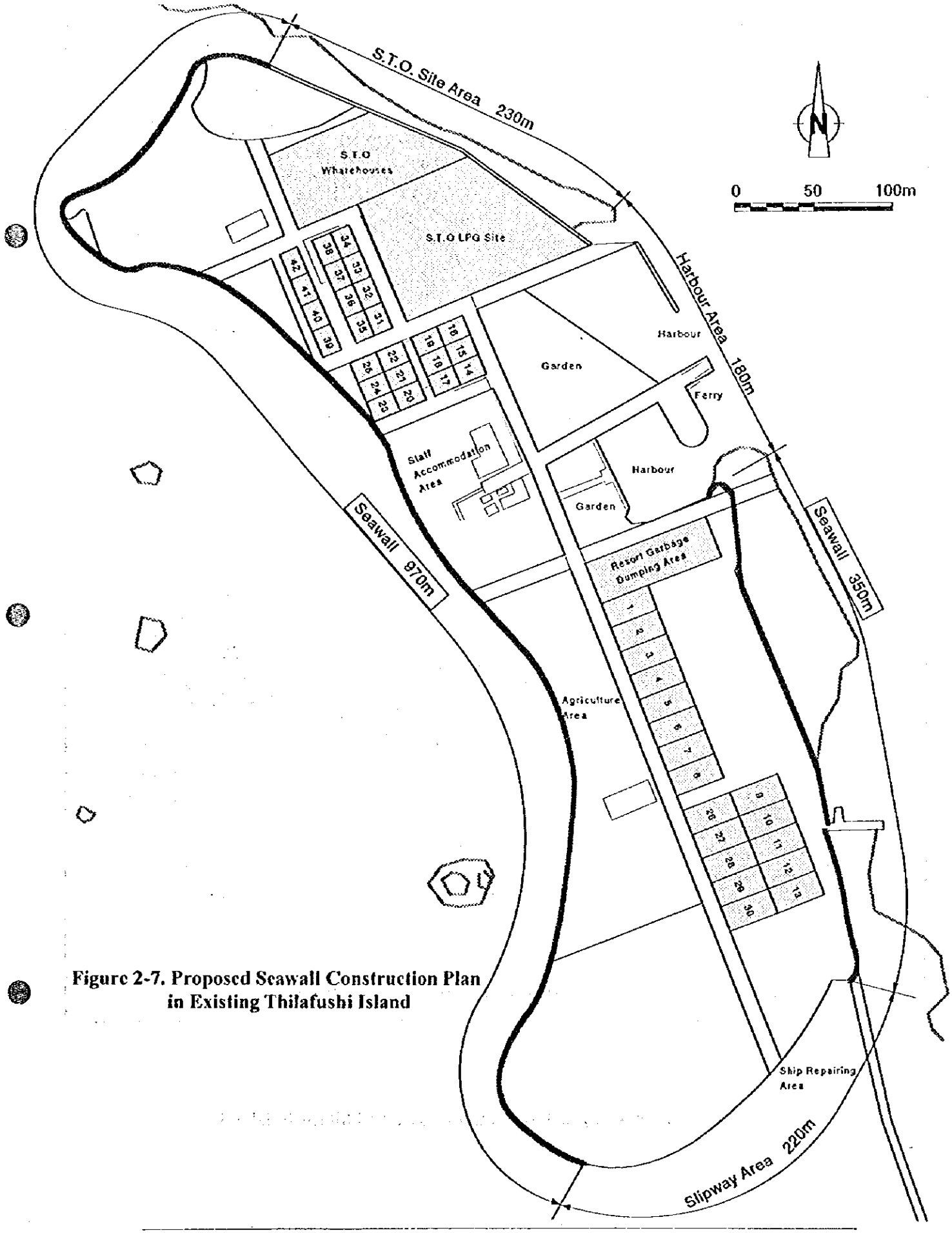
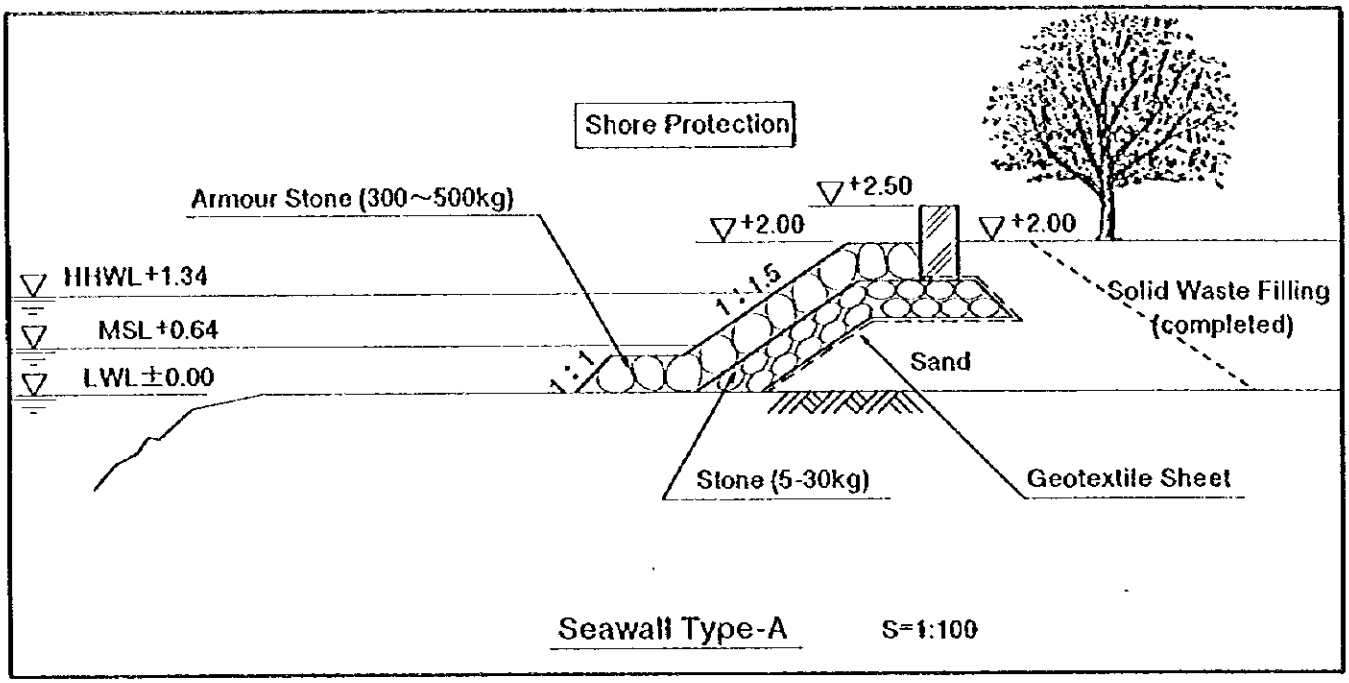


Figure 2-7. Proposed Seawall Construction Plan in Existing Thilafushi Island



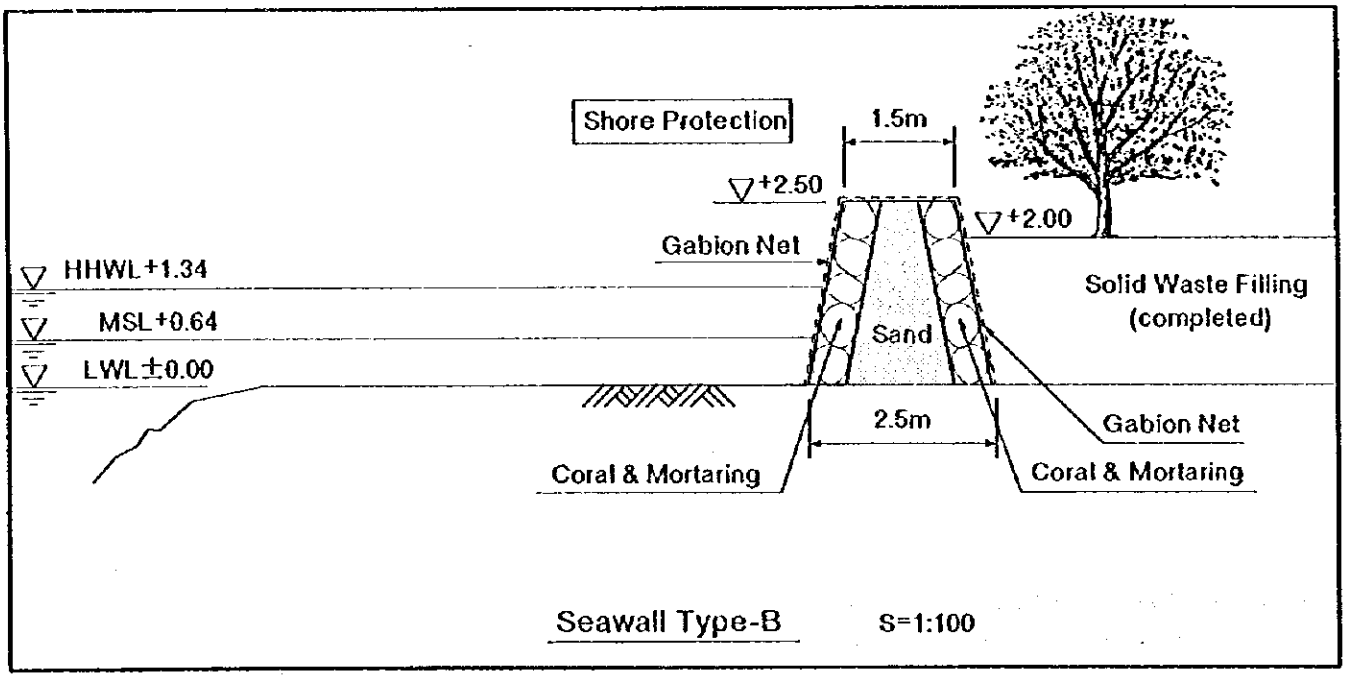


Figure 2-8. Proposed Seawall for Existing Thilafushi Island

2.6 Construction of New Landfill Site in Thilafushi Island

2.6.1 Target Waste to be Disposed

Forecast of solid waste volume to be transported to Thilafushi from 1999 to 2003 can be obtained from Table 2-32 and total volume will be 411,647 tons. Considering the fact that concrete and coral debris among construction waste can be re-utilized for the construction of seawalls or other construction works and then the coral mining material in Male' is about US$ 30, it is recommendable to stockpile and re-use such waste. According to the survey result, the availability for re-use is estimated at about 60 %. Total waste volume to be filled from 1999 to 2003 will be 402,565 cu. M as calculated in Table 2-1. If the project could not start until late in 2000, solid waste to be transported to Thilafushi until then will be filled in the existing Thilafushi and the inside area of the proposed new site. Table 2-33 shows the volume of solid waste filling by the locations. Thirty percent of the waste produced in 1999 will be filled in existing Thilafushi, and the rest (50,523 cu. M) will be filled in the new site. Then ninety percent (68,543 cu. M) of the waste produced in 2000 will be filled in the new site before the Project starts. Therefore target volume to be dumped in the new site will be about 381,000 cu. M (119,066+261,846) as estimated in Table 2-33.

Table 2-31 Target Waste to be Disposed at New Landfill in Thilafushi

Year	Annual Amount	Existing Thilafushi		Before Project at New Site		After Project at New Site	
1999	72,175	30%	21,653	70%	50,523		0
2000	76,159		0	90%	68,543	10%	7,616
2001	80,286				0	100%	80,286
2002	84,691				0	100%	84,691
2003	89,253				0	100%	89,253
Total	402,565		21,653		119,066		261,846
			5%		30%		65%

2.6.2 Design Condition

(1) Development Plan

Three alternatives indicated in Figure 2-9 are discussed between the Maldivian side and the Study Team for the future development of Thilafushi Island.

Alternatives 1: New dumping site will be provided separated from the existing Thilafushi with new landing wharf for the garbage ferry and waste filling will be continued in the same manner in the proposed new site until the project starts.

Table 2-32. Forecast of Solid Waste Volume to be Transported to Thilafushi (1999 - 2003)

Year	Amount of Solid Waste in Male'					Domestic Waste in Villingili	Domestic Waste from Resort Islands	Domestic Waste from Nearby Islands	Domestic Waste from Airport	Total Amount per day	Total Amount per day excluding construction waste (60 %)	Annual Amount	Annual Amount excluding construction waste (60%)	Accumulated Amount excluding construction waste (60%)	Annual Amount excluding construction waste (60%) after Filling	Accumulated Amount
	Domestic Waste	Commercial Waste	Business & Industrial Waste	Construction Waste	Sub Total in Male'											
	A	B	C	D	E=A+B+C+	F	G	H	I	J=E+F+G+H+	K=J-D×0.6	L=J×365	M=K×365	N	O*	P
	t/day	t/day	t/day	t/day	t/day	t/day	t/day	t/day	t/day	t/d	t/d	t/year	t/year	ton	cu.m	cu.m
1998	48	20.4	36.2	68.8	173.4	1.1	19.2	0.2	2.8	196.7	155	71,796	56,728		68,774	
1999	51	21.6	37.3	70.9	180.8	1.3	19.8	0.3	3	205.2	163	74,898	59,371	59,371	72,175	72,175
2000	54.2	23	38.4	73.1	188.7	1.6	21	0.3	3.3	214.9	171	78,439	62,430	121,801	76,159	148,335
2001	57.4	24.4	39.7	75.4	196.9	1.8	22.5	0.3	3.5	225.0	180	82,125	65,612	187,413	80,286	228,621
2002	60.8	25.8	41	77.9	205.5	2.2	24.1	0.3	3.7	235.8	189	86,067	69,007	256,420	84,691	313,312
2003	**64.3**	**27.3**	**42.3**	**80.4**	**214.3**	**2.6**	**25.7**	**0.3**	**4**	**246.9**	**199**	**90,119**	**72,511**	**328,931**	**89,253**	**402,565**
											Total Amount (1999-2003)	**411,647**				

$\alpha 1$= 0.7 : Unit weight / for Filled Domestic Waste (ton / cu.m)

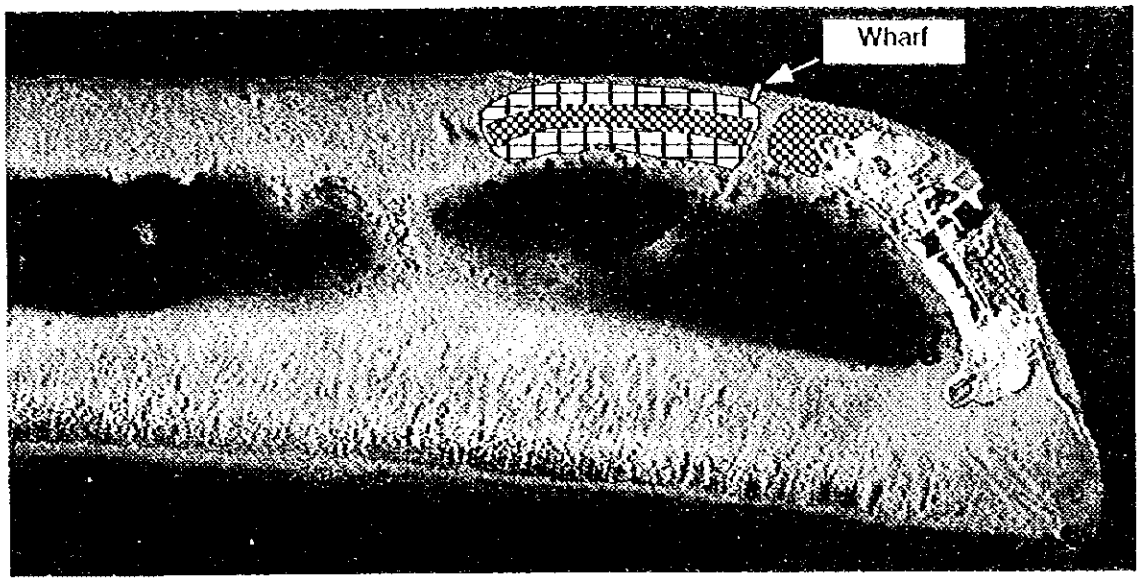
$\alpha 2$= 0.7 : Unit weight / for Filled Commercial Waste (ton / cu.m)

$\alpha 3$= 0.9 : Unit weight / for Filled Business and Industrial Waste (ton / cu.m)

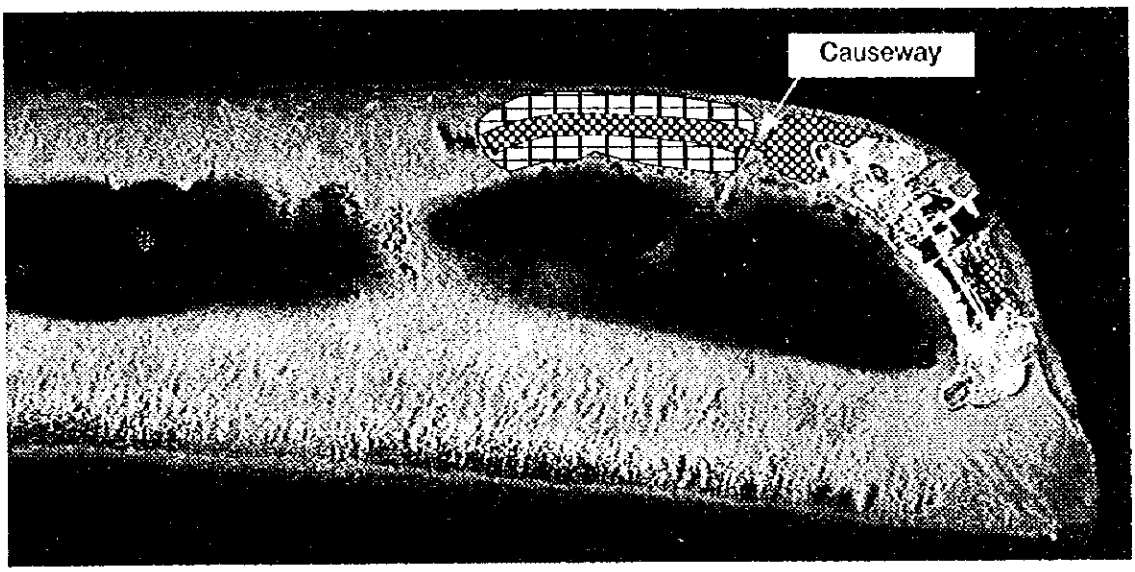
$\alpha 4$= 1.6 : Unit weight / for Filled Construction Waste (ton / cu.m)

$O^* = (A+F+G+H+I) / \alpha 1 + B / \alpha 2 + C / \alpha 3$

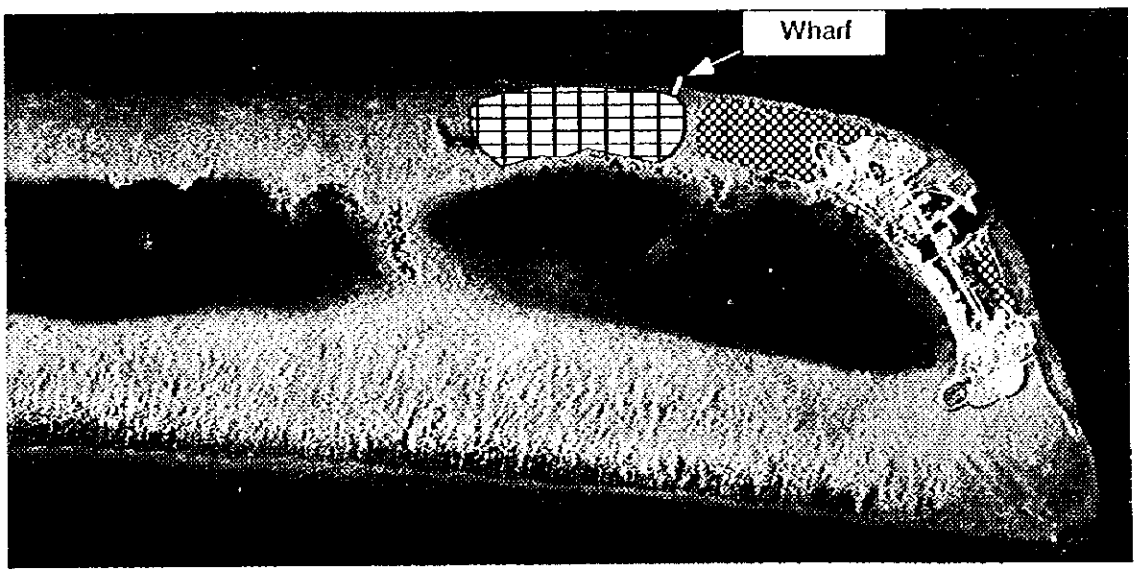
Construction Wast 40%



Altrenative 1



Altrenative 2



Altrenative 3

Before Project (1999～2000) After Project (2001～2003)

Figure 2-9. Alternative Transition Plans from Thilafushi 1 to 2

Alternatives 2: New dumping site will be provided separately from the existing Thilafushi but connected to the existing island by causeway, and waste filling will be continued in the same manner in the proposed new site until the project starts. Garbage ferry will berth at the existing wharf and the waste will be transported to the new island by trucks.

Alternatives 3: Existing Thilafushi will be extended westward by filling waste in the same manner until the project completes. New dumping site will be separately provided by construction of the encircled seawalls. Then solid waste will be filled in the new site after the project completes.

The Maldivian side selected Alternative 1. Because the new landfill area proceeded by the Government of Maldives before the beginning of the Project is better to be incorporated with the project site as the prevention of impact for the environment. Also the excavated channel by the western end of the existing Thilafushi is still utilized for the boats approaching to the inner lagoon. Therefore, the Alternative 1 is selected for this Project.

The project is expected to be started from the end of 2000. However, if the project start is delayed later than 2000, the landfill proceeded by G.O.M. before the Project becomes too long to be surrounded by this project. Therefore, the Alternative 3 would be taken into consideration for this case.

The development plan based on the Alternative 3 is prepared in the Supporting Report for the reference purpose.

(2) Wave condition

As described in paragraph 3.1.4 of Interim Report, waves approaching to Thilafushi are wind waves from NW-NE and swells from SW. Design waves can be summarized as follows:

For north coast	:$H_{1/3}$ = 1.2 m	T = 6.4 sec.
For south coast (inner lagoon)	:$H_{1/3}$ = 0.7 m	T = 6.0 sec

2.6.3 Method of Landfill

(1) Landfill Procedure

a. Landfill at Existing Thilafushi

The solid waste has been filling at existing Thilafushi Island continuously. However, in anticipation of space for filling area at flat reef along the existing shore line, the final spaces at existing Thilafushi will be filled until middle of April, 1999. It is expected to be filled the solid waste volume of 21,653 m^3 (approx. 30% of waste volume as of 1999). The filling would be done as in the past by the government of Maldives.

b. Landfill at New Site

After final filling in existing Thilafushi, the solid waste would be filled at new site, recommended at north west of existing Thilafushi. It is basically recommended to divide into three areas ("A", "B", "C") and two stage (First and Second) as shown in the Figure 2-10 and the Figure 2-11. Before filling the area, the small landfill for the approach of the ferry should be constructed following the same procedure of existing Thilafushi.

For the previous filling which was filled by the government of Maldives before the Project, Area "A" is appropriated at center space having 60m width and 700m length. As the prevention of the silt flowing to the reef edge of living corals, the area shall be located at center of the flat reef and requested to be narrow and long. As explained in the previous chapter 2.6.1 " Target Waste to be Disposed", the solid waste volume of 119,066 m^3 is expected to be filled in the first stage at Area "A" based on the volume calculation. In this case, the space and depth of the excavated pond shall be more widen and deepen than ordinary filling pond as in the past, as shown in the Figure 2-11. ①. The filling method is explained later.

After filling in Area "A", the Project is expected to be started from end of 2000. The Figure 2-11. ② shows that the protection walls for wave dissipation and the prevention of the silt and leachate shall be constructed around the filling site. The area "B" shown in the Figure 2-11. ② is recommended for the next filling area (First Stage up to +2.0 m) which will be excavated and made the ponds by this Project. The excavated material is stockpiled on Area "A" for the covering and bunding material.

Area "C" is excavated and filled up to E.L. +2.0 m by the Government of Maldives same as filling method of area "B". The excavated material shall be

used for covering material of the solid waste, and remaining material shall be stockpiled and bunding for the second stage (up to +4.0 m), as shown in the Figure 2-11. ③.

The second stage shows in the Figure 2-11. ④ and ⑤ that the area filled up E.L. +2.0 m is divided into two areas. The bunds located at center and edges on the first stage shall be made of the excavated material resulted from the first stage operation. The second stage is started to be filled up to E.L+4.0 m from Area "D" shown in the Figure 2-12. (1). The material covered on the solid waste shall be stockpiled on the other area. After the waste filled up to E.L. +3.5m, it shall be covered by the material. Area "E" is also filled up same as Area "D".

The filling volume of the solid waste in the areas were calculated in the Table 2-33.

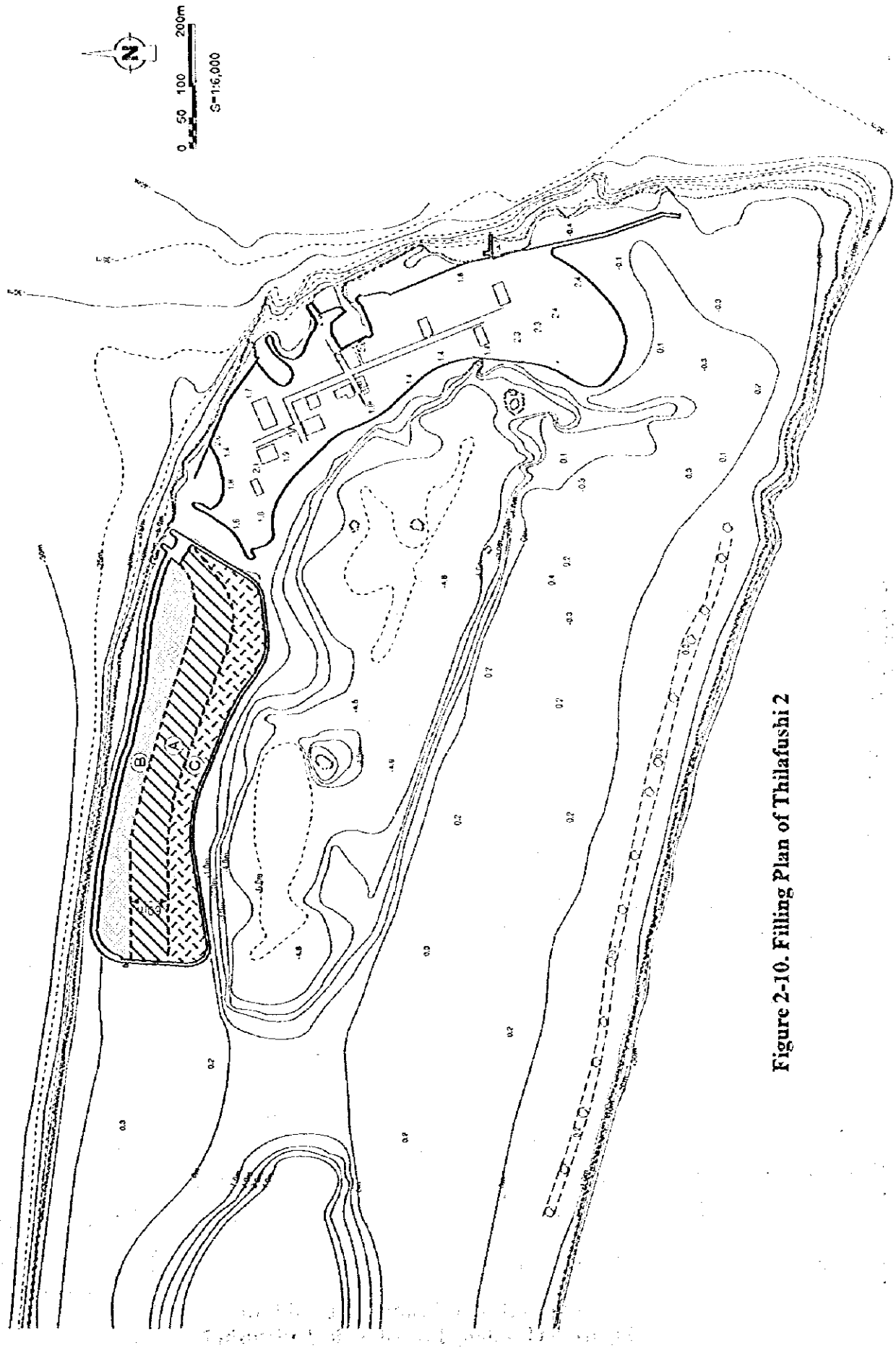
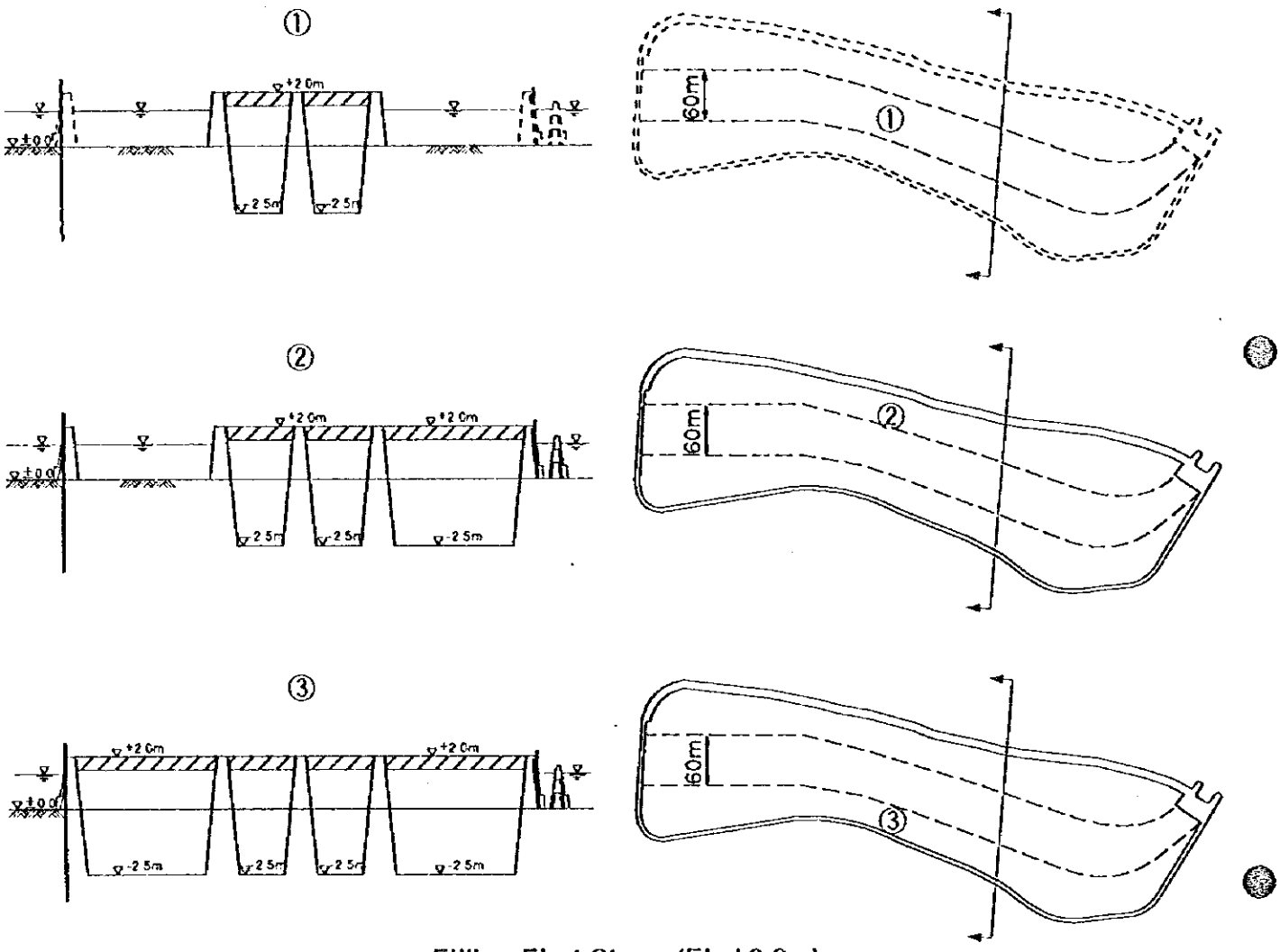
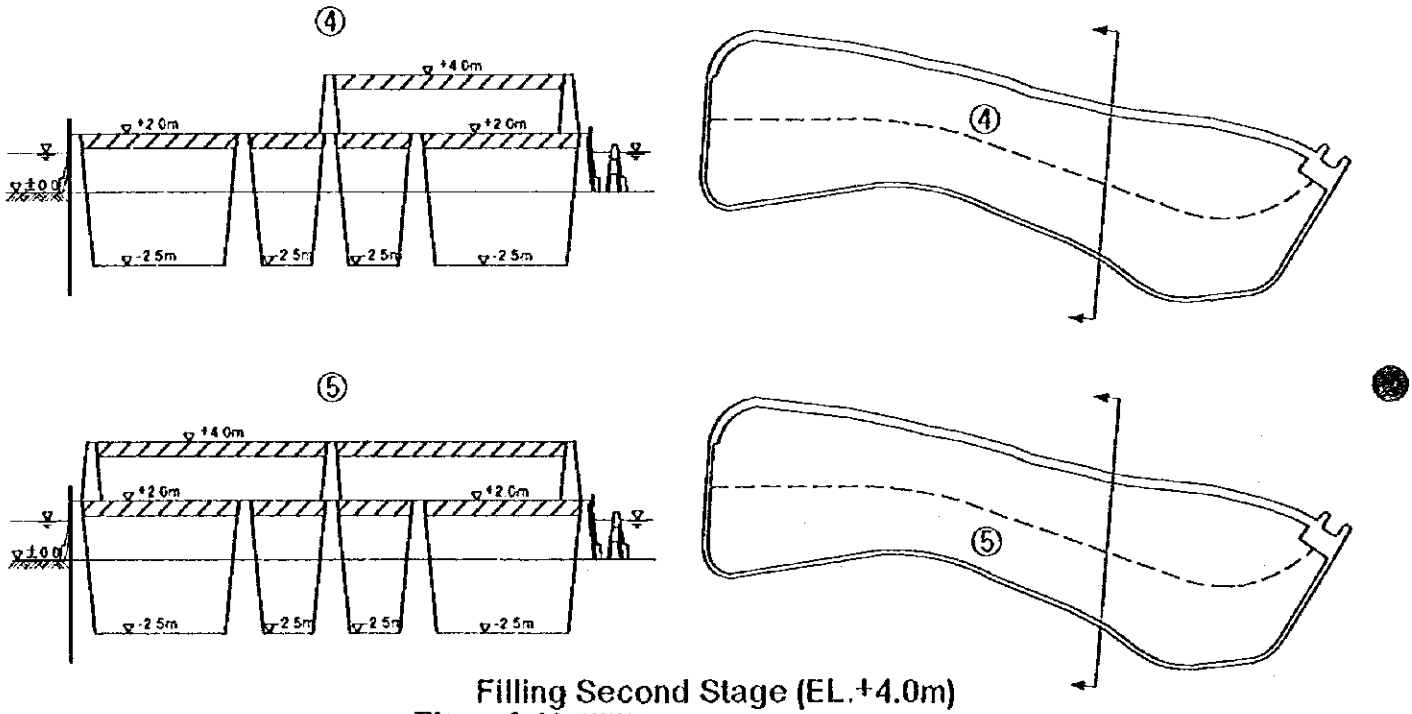


Figure 2-10. Filling Plan of Thilafushi 2



Filling First Stage (EL.+2.0m)



Filling Second Stage (EL.+4.0m)

Figure 2-11. Filling Procedure in Thilafushi 2

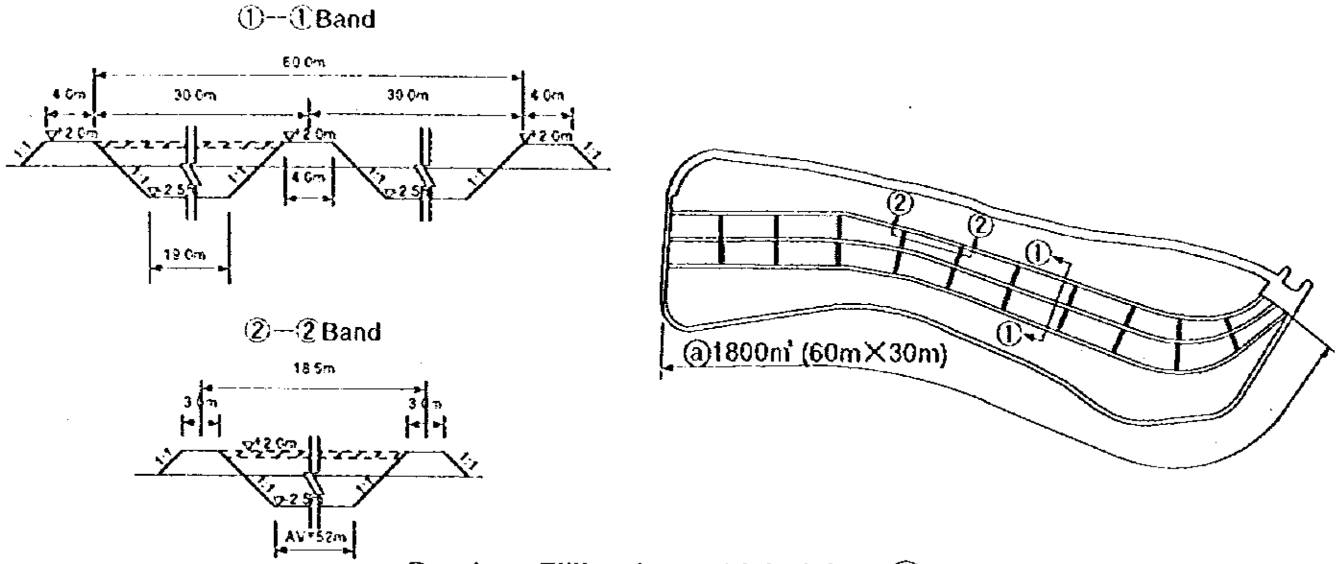
Table 2-33. Filling Volume in New Thilafushi

Area		First Stage					
Area No.	m^2	Waste Filling (m^3)	Excavation (m^3)	Bunding Sand (m^3)	Covering Sand(m^3)	Stockpile (m^3)	Stockpiled Area
A	41,000	120,000	59,700	31,000	18,800	9,900	A
B	32,000	88,000	58,200 (by Project)	15,800 (by Project)	14,500	27,900	A
C	32,000	88,000	58,200	15,800	14,500	27,900	B
Sub-Total	105,000	296,000	176,200	62,600	47,800	65,700	
Area		Second Stage					
D	48,000	66,000	0	14,000	21,000	30,700	E
E	48,000	66,000	0	8,700	21,000	1,000	D
Sub-Total	96,000	132,000	0	22,700	42,000		
Total		**428,000**	**176,200**	**85,300**	**89,800**	**1,000**	

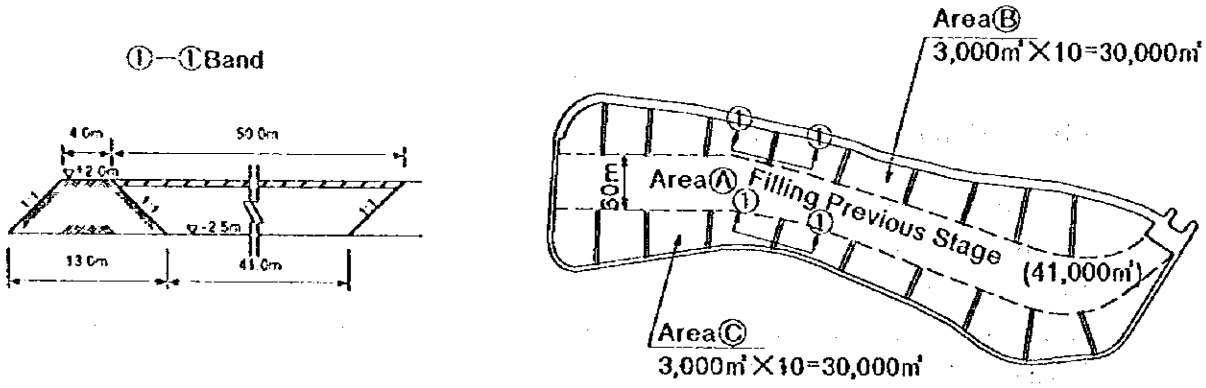
(2) Method of Landfill

As explained above, Area "A" (First Stage) would be proceeded by Government of Maldives. The ponds in Area "A" shall be taken into consideration for the prevention of leachate flowing out of the bund. The pond is planned to be surrounded by the bund which is made of excavated sand of the pond. Area "A" should be divided into 22 ponds having 1,800 m^2 (60 m × 30 m) in area as described in the Figure 2-12. (1) " Previous Filling". Scale of the pond was determined based on the waste volume to be disposed at new site before the Project. The ponds would be made and filled one by one. The method of the excavation of pond, filling of the waste and covering is shown in the Figure 2-12. (2).

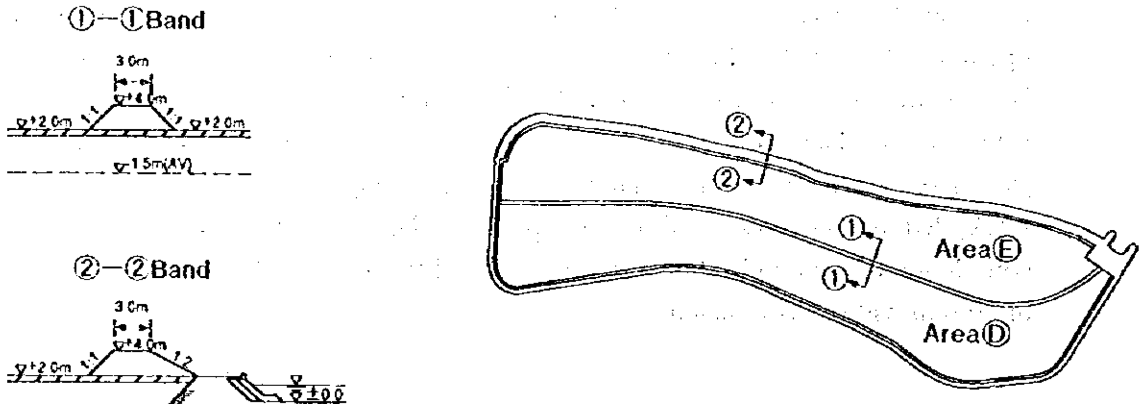
At first, the ferry approach shall be excavated from reef edge of the north east of the new site. The excavated material shall be used for the landfill which is a base for the operation. The bund making is started from north to south, and the material for the bund is excavated from inside of the area. After bunding, the excavation in the pond is started from the base land side, The excavated material shall be used for the basement of the excavator, and the remaining material for the covering the waste shall be removed and stockpiled on the base land by dump track. This operation will be continued till completion of the pond. The waste disposal and filling could be started after excavation of 20m in width is completed.



Previous Filling (up to +2.0m) Area Ⓐ
(First Stage)

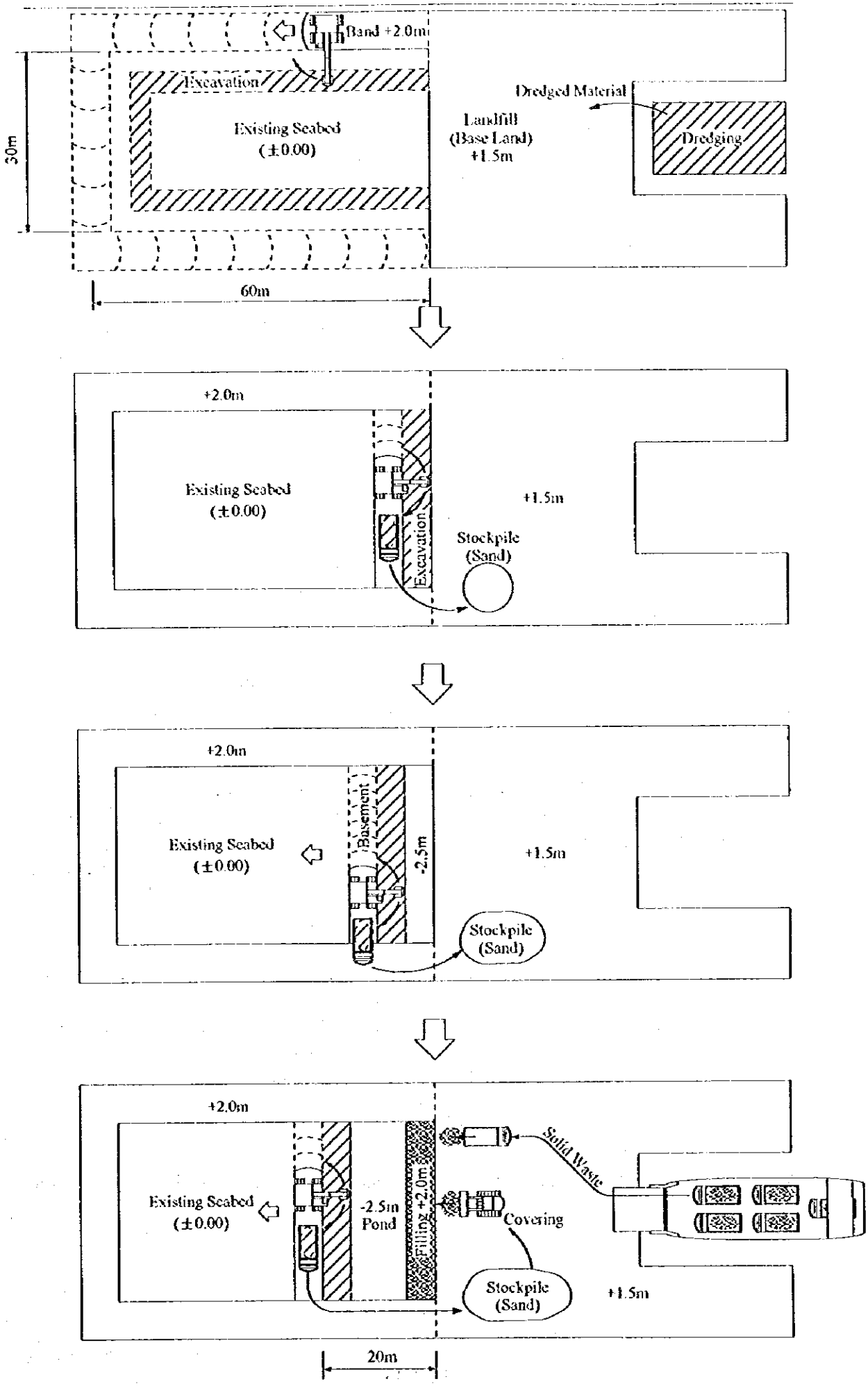


First Stage (up to +2.0m)



Second Stage (up to +4.0m)

Figure 2-12. (1) Filling Method


Band +2.0m
Excavation
Existing Seabed
(±0.00)
30m
Dredged Material
Landfill
(Base Land)
+1.5m
Dredging
60m
+2.0m
Existing Seabed
(±0.00)
Excavation
+1.5m
Stockpile
(Sand)
+2.0m
Existing Seabed
(±0.00)
Basement
-2.5m
+1.5m
Stockpile
(Sand)
+2.0m
Existing Seabed
(±0.00)
-2.5m
Pond
Filling +2.0m
Solid Waste
Covering
Stockpile
(Sand)
+1.5m
20m

Before completion of First Stage in Area "A", the project would be started from the construction of the seawall and breakwater around the site. For the construction, the temporary road shall be made along the planned seawall. The material of the temporary road is obtained from the excavation along the road. Consideration of the environmental aspects, the silt protector shall be installed around the both side of the temporary road during construction. After construction of north seawall, the ponds in the Area "B" are planned to be made by the Project.

Area " B" and Area "C" is divided into 10 ponds having 3,000 m^2 (50 m × 60 m) in area respectively. The method of the ponds is same as Area " A". The excavated material of the pond shall be stockpiled on the Area "A" for the covering material of the waste filling and bunding for the Second Stage.

Plan for the areas are shown in the Figure 2-12. (1).

(3) Effects and necessity of cover soil

Cover soil is very effective for prevention of offensive odor, scattering and flowing out of wastes, increase of sanitarily harmful insects and animals, and outbreak and propagation of fire as well as preservation of peripheral environment.

Additionally, it is effective also for control of landfill ground such as carrying –in, leveling and compacting of wastes, and prevention of rainwater penetration (reduction of leachate).

Table 2-34. Types and Effects of Cover Soil

Type	Daily cover	Intermediate cover	Final cover
Definition	Applied when landfilled wastes have reached a specific thickness, or at the, end of the day's landfill work.	Applied on the part of the site which will be left for a long time after daily cover is executed.	Applied on the top when landfill work has finished.
Main effects	*prevention of flying wastes *prevention of bad odor generation *sanitary measure to flies, etc *prevention of harmful insect generation etc.	*road ground for hauling trucks. *rainwater blocking in landfill portion left standing for rather a long time.	*sight improvement *ground application *leachate reduction
Material	*soil taken on the site	*soil taken on the site	*soil taken on the site

2.6.4 Required Input

a. Construction

i) Seawall

Layout and typical sections of proposed seawalls are indicated in Figure 2-13 and 2-14 respectively. Total length of seawalls will be 700 m for Type A and 970 m for Type B.

ii) Wharf

Since new site for solid waste filling will be provided separately, new wharf should be constructed for accommodating Ro-Ro ferry which carries solid waste from Male'. Proposed type of structure is indicated in Figure 2-15. In addition wharf for dhoni which carry solid waste from resort island, airport and other inhabited islands also should be provided.

iii) Excavation for landfill

It is recommendable to include about 51,000 cu. M of excavation (dredge up to –2.5 m) for solid waste filling.

iv) Workshop

Workshop and garage (375 sq. m) for repairing equipment should be provided.

v) Fresh Water Supply

Fresh water should be utilized for washing equipment and portable water in New Thilafushi Island. Demand of the water is calculated as follows.

1) Water Demand

General requirement of the water for cleaning the equipment is 200 litter per day per unit (200 l / day / unit). 5 units of equipment are to be procured in all. Hence, the required water for cleaning equipment is 1.0 m^3 / day.

Consumption of portable water is calculated as below.

(Demand of Water) = (Number of workers) x 0.15 m^3 x 1.1 (particular factor)

12 workers are to be employed in new Thilafushi. Therefore 2.0 m^3 / day is necessary for portable water.

Also, it is taken some additional quantity (1.0 m^3) to reserve into account.

Therefore, the demand of the water per day is calculated as 4.0 m^3 in total.

2) Reservoir Tank in New Thilafushi

The reservoir tank made of polyethylene (capacity of 2 ton) which is black color, is available to be procured in Maldives. Three of the tanks will be used for the

reservoir tank in Thilafushi. The tanks will be set up 3 m height to take natural water head for water distribution. The basement of the water tanks would be made by concrete structure and provided distribution pipes for the yard of washing equipment and the worker's accommodation.

3) Alternatives for Water Supply

Following three alternatives are considered as the water supply for New Thilafushi Island.

System 1. : Daily supply from Male' by truck with water tanks and small engine pump. (2 m^3 tank x 2 units with 4 ton truck)
System 2. : Daily supply from Male' by water truck (4 m^3 capacity)
System 3. : Water desalination plant (4 ton / day)

The system 3 involves high procurement and maintenance cost than other systems. Hence, the system 1 and 2 is considered. After costs comparison, the system 1 is adopted in this project, and the total cost of water system is shown in the Supporting Report F.

vi) Compost Yard

Pavement (420 sq. m) and shed (200 sq. m) for composting should be provided.

vii) Stockyard

Paved stockyard (60 sq. m) for temporary stockpile from resorts should be provided.

viii) Battery Box

b. Equipment

To carry out solid waste filling at the new Thilafushi Island, equipment listed in Table 2-35. will be required. Excavator will be utilized to dredge the existing reef flat up to –2.5 m. Bulldozer will be utilized to push sand for stockpile. Dump truck will be utilized to transport sand to stockpile yard. Generator will be installed at workshop. Incinerator will be utilized to burn waste oil from vessels and automobiles.

Table 2-35. List of Equipment to be procured

Equipment	Capacity	Unit
Excavator	0.8 cu. m	1
Bulldozer	20 ton class	1
Dump truck	10 ton	1
Wheel Loader	1.3 cu. M	1
Tractor Trailer	2 ton	2
Generator for workshop	35 KVA	1
Incinerator	0.5 t / day	1
Dump truck	4 ton	1
Water tank	2 ton	2
Engine Pump	-	2
Reservoir tank	-	3
Distribution pipe	-	1
Washing machine	-	1

c. Personnel

To conduct solid waste filling at new Thilafushi Island, workers listed in Table 2-36. are required.

Table 2-36. List of Personnel required for Operation at New Thilafushi

Position	No.	Position	No
Manager	1	Waste Disposal Machine Operator	3
Deputy Manager	1	Waste Transfer Driver	2
Secretary	1	Security Guard	2
Chief Waste Disposal Operator	1	Assistant Mechanics	1
Site Inspector	1	Common labour	12
Mechanic	1		

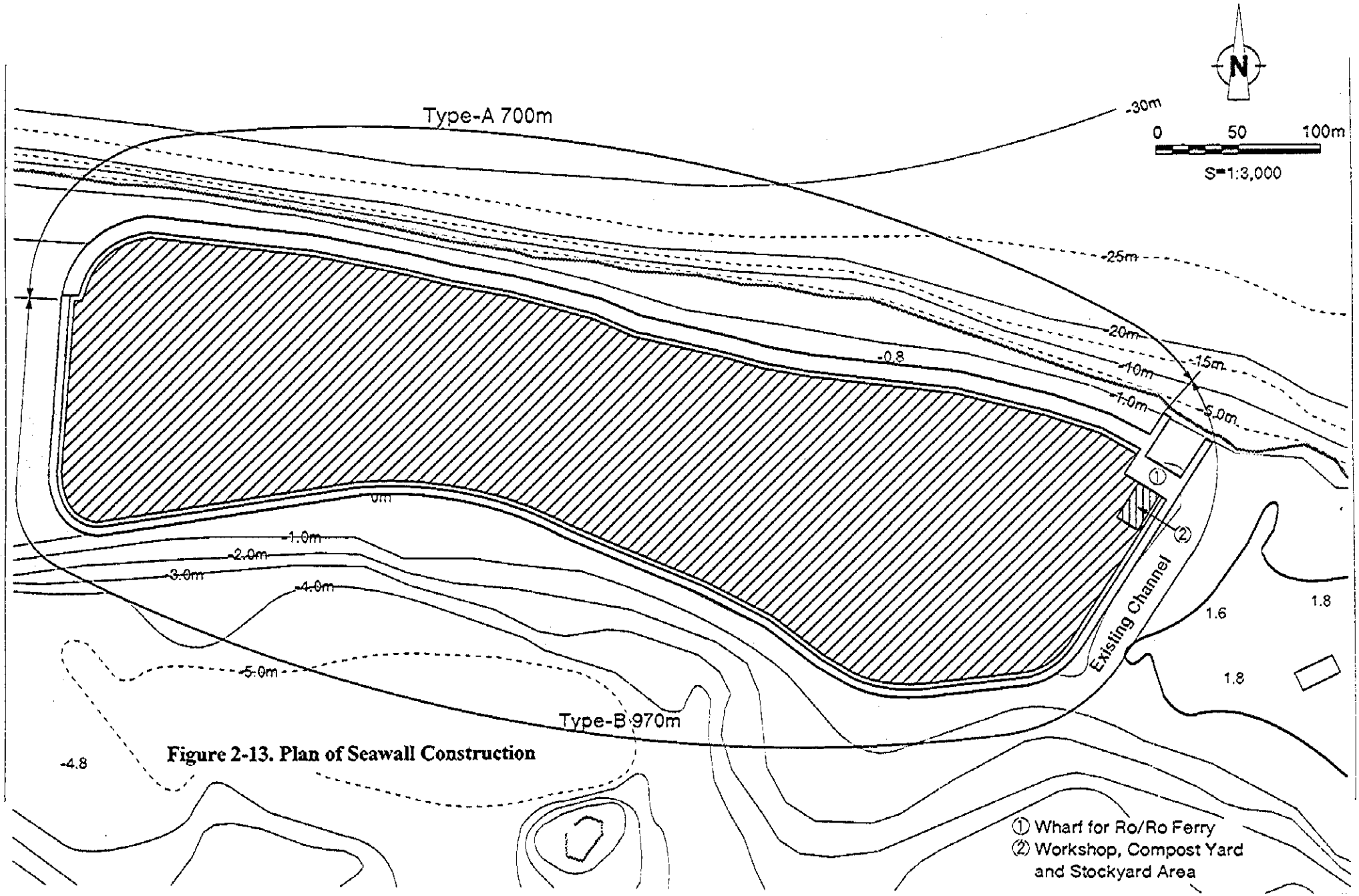


Figure 2-13. Plan of Seawall Construction

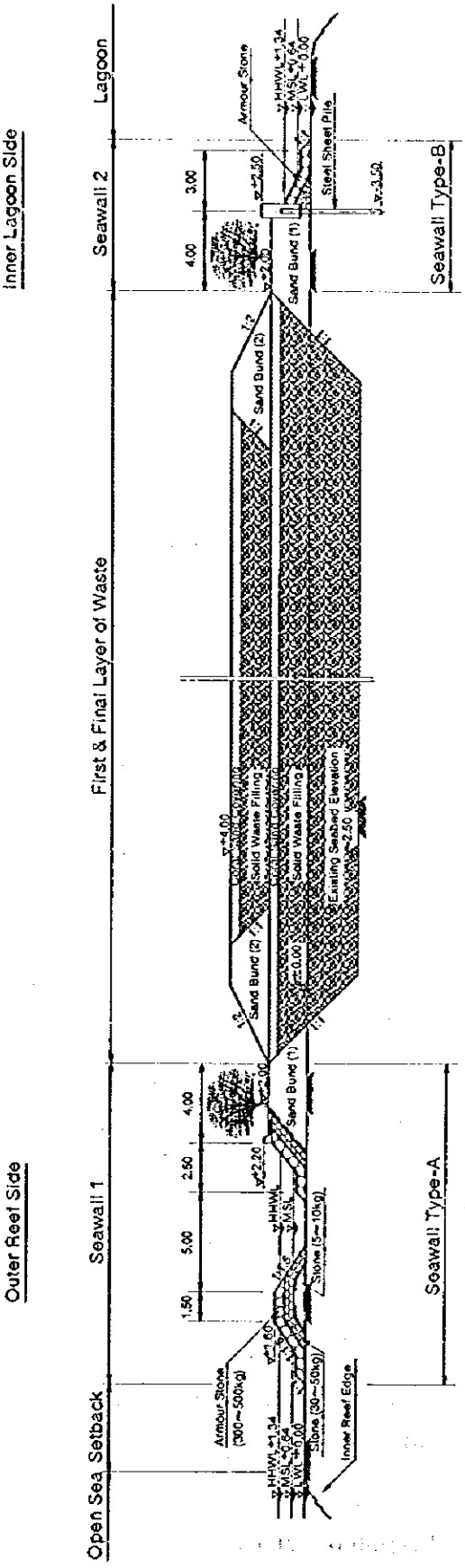
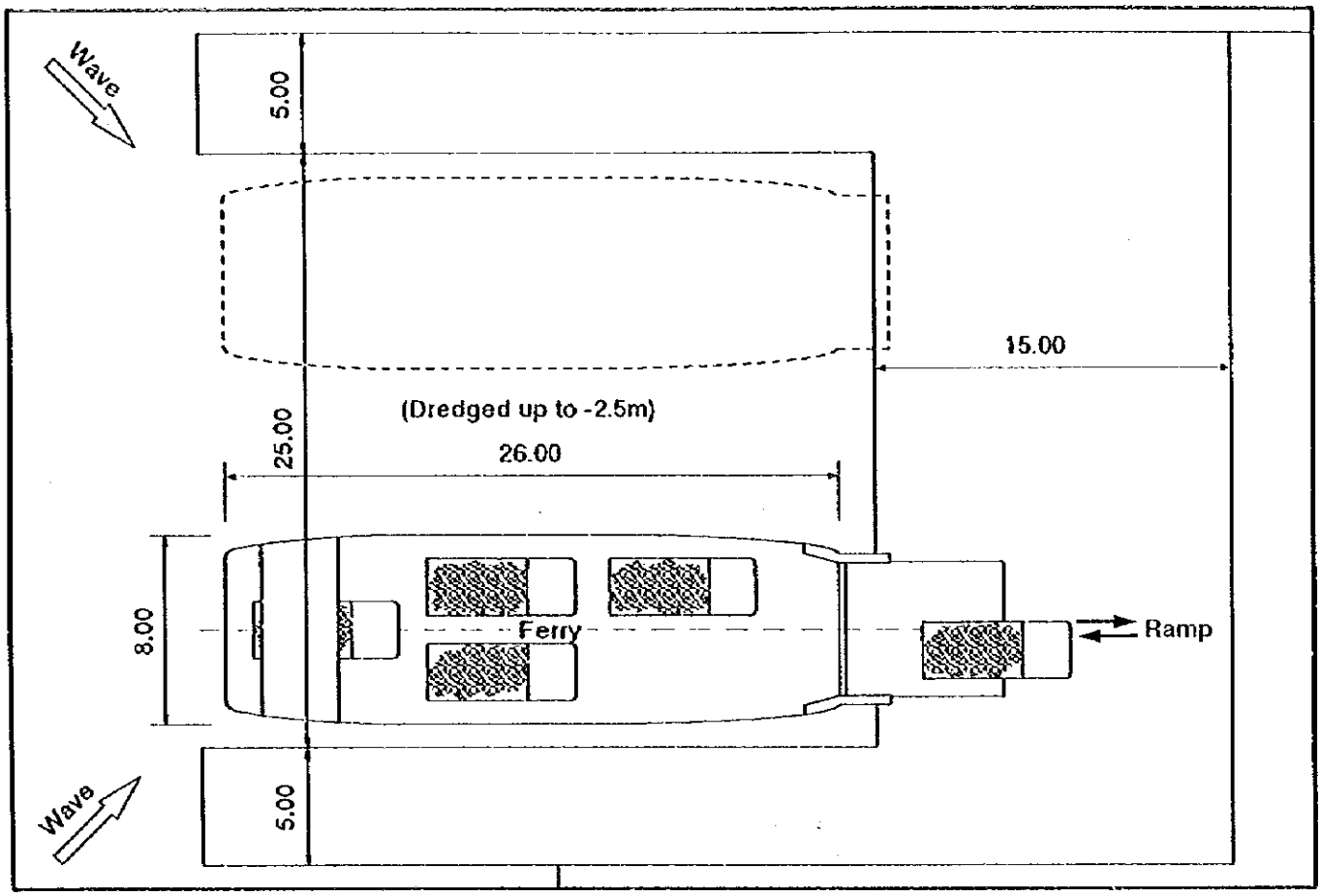
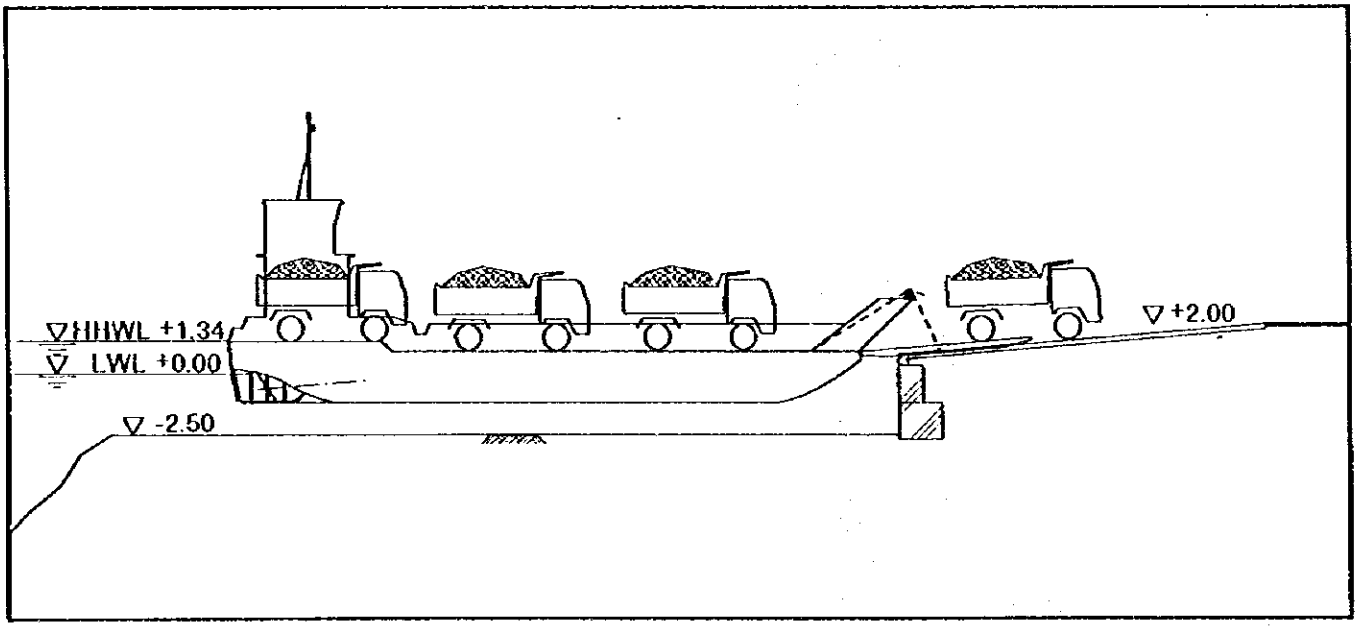


Figure 2-14. Section of New Landfill Site in Thilafushi-2



Plan



Section

Figure 2-15. Plan / Section of Wharf

2.6.5 Project Cost

Project costs for new Thilafushi comprise of two categories. One is for the construction of seawalls, wharf and dredging and another is the procurement of equipment. These costs are summarized in Table 2-37 and Table 2-38.

Table 2-37. Construction Cost for New Thilafushi

Item	Works	Cost (Rf 1,000)
Direct Cost	Breakwater (700 m)	15,070
	Revetment for Waste (970 m)	26,561
	Protection for Waste (740 m)	8,669
	Wharf	4,629
	Excavation	10,149
	Others (Workshop, Compost, etc.)	4,203
	Direct Temporary Work	5,113
	Basement & Installation for Water Distribution System	90
Indirect Cost		23,062
Total Cost		97,546

Table 2-38. Procurement Cost for Equipment

Equipment	Cost (Rf. 1,000)
Excavator (0.8 cu. m): 2 units	2,664
Bulldozer (20 t): 1 unit	1,501
Dump truck (10 t): 2 units	2,118
Wheel Loader (1.3 cu.M): 1 unit	886
Tractor Trailer (2 t): 2 units	722
Generator (35 KVA)	328
Incinerator (0.5 t/d): 1 unit	656
Dump truck (4 t): 1 unit	293
Water tank (2 t): 2 units	10
Engine Pump : 2 units	30
Reservoir tank : 3 units	15
Distribution pipe : 1 set	11
Washing machine : 1 unit	152
Total	9,386

2.7 Promotion of Material Recycling

2.7.1 Target Waste to be Recycled

The types of wastes to be recovered were studied based on the results of the Waste Composition Survey, Recycling Market Survey and Resource Recovery Survey conducted at the existing Transfer Station and proposed as shown in the following items.

(1) Target Wastes Recovered at Generation Sources

Domestic and Commercial wastes

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

(2) Target Wastes Recovered at Transfer Station and Thilafushi

Business & industrial wastes

- food wastes from hotels and restaurants, saw dust from carpentry factories, metal & non-metals, electric wire

Construction wastes

- concrete debris and sand, metal & non-metals, electric wire, sacks

Wastes from Resort Islands and Airport Island

- live bottle bins, tins & cans, aluminium cans, PET bottles, Plastic bottles, etc.

(3) Target Amount of Waste Reduction and Recovery/Recycling

Amount of waste reduction, recovery/recycling is estimated based on the waste flow from waste generation to disposal and the target ratio of 5 % and 2.5 % by 2005 for waste reduction and recovery/recycling respectively and indicated in Table 2-39. Estimated waste reduction amount reach at 7.4 tons per day in 2005. Waste recovery/recycling amount is estimated at 62.4 tons in total including the amount of concrete debris and sand at 54.6 tons and 7.8 tons from domestic, commercial, business and industrial wastes and other construction wastes in 2005.

Table 2-39. Expected Amount of Waste Reduction and Recycling (2005)

Waste Categories	Domestic & Commercial Wastes		Business & Industrial Wastes		Construction Waste		Total	
	Weight (t)	Ratio (%)	Weight (t)	Ratio (%)	Weight (t)	Ratio (%)	Weight (t)	Ratio (%)
1) Waste Generation Amount								
Total Organic Waste	81.7	80.0	40.4	90.0	16.9	19.8	139.0	61.8
Total In-organic Waste	20.2	19.8	4.4	9.8	68.3	80.0	92.9	38.0
Total Hazardous Waste	0.2	0.2	0.1	0.2	0.2	0.2	0.6	0.2
Total Weight (ton)	102.2	100.0	44.9	100.0	85.4	100.0	232.5	100
Total Waste Volume (m^3)	693.7		324.6		89.0		1,107.3	
Bulk Density (ton/m^3)	0.212		0.159		1.104		0.210	
2) Waste Reduction Amount	Target	5%	Target	5%	Not applicable			
Total Organic Waste	4.1	80.0	2.0	90.0	for construction		6.1	83.1
Total In-organic Waste	1.0	19.8	0.2	9.8	wastes		1.2	16.7
Total Hazardous Waste	0.01	0.2	0.00	0.2			0.01	0.2
Total Weight (ton)	5.1	100.0	2.2	100.0			7.4	100.0
3) Waste Discharge Amount								
Total Organic Waste	77.6	80.0	38.4	90.0	16.9	19.8	132.9	59.1
Total In-organic Waste	19.2	19.8	4.2	9.8	68.3	80	91.7	40.7
Total Hazardous Waste	0.2	0.2	0.1	0.2	0.2	0.2	0.5	0.2
Total Weight (ton)	97.0	100.0	42.6	100.0	85.4	100.0	225.1	100.0
Total Waste Volume (m^3)	458		268		89.0		815	
Bulk Density (ton/m^3)	0.212		0.159		1.104		0.276	
4) Waste Recovery Amount	Target	2.5%	Target	2.5%	Target	2.5/80%		
Total Organic Waste	3.9	80.2	1.9	90.2	0.8	1.5	6.6	10.6
Total In-organic Waste	1.0	19.8	0.2	9.8	54.6	98.5	55.8	89.4
Total Hazardous Waste	0	0	0	0	0	0	0	0
Total Weight (ton)	4.8	100.0	2.1	100.0	55.5	100.0	62.4	100.0
5) Waste Disposal Amount (Male' & Villingili)								
Total Organic Waste	73.8	80.0	36.5	90.0	16.1	53.7	126.3	56.1
Total In-organic Waste	18.3	19.8	4.0	9.8	13.7	45.7	35.9	15.9
Total Hazardous Waste	0.2	0.2	0.1	0.2	0.2	0.6	0.5	0.2
Total Weight (ton)	92.2	100.0	40.5	100.0	29.9	100.0	162.6	72.3
Total Waste Volume (m^3)	435		255		89		778	
Bulk Density (ton/m^3)	0.212		0.159		1.104		0.209	

Remarks : Due to utilisation of recovered concrete debris & sand for covering material or temporary dike for landfill operation, the total waste amount carried in to the Thilafushi amount to 217.2 tons (162.6 + 54.6) in 2005.

2.7.2 Method of Recycling

(1) Waste Reduction and Materials Recovery Plans

Eight (8) staff of The Special Task Team (STT) established in Male Municipality shall initiate the waste reduction and recovery/recycling programs by obtaining the supports from the government and the society and through linking with community groups. The

configurations of the major activities to implement the programs are proposed in the following sections.

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 indicated in Table 2-40 and as summarised in the followings.

Generation Source Control

- Production Control *
- Distribution and Sale Control
- Consummer 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 in response to the progress of the activities in the initial stage.)

Table 2-40. Action Programs for Waste Reduction and Recovery/Recycling

Planning Purposes	Actions by Male Municipality & SWMS/MCPW	Actions by the Communities
Generation Source Control		
Production Control		
• Use of returnable bottles	• Encouragement/Assistance to makers	• Development/Production of returnable bottle goods
• Use of echo-friendly goods	• Encouragement/Assistance to makers	• Development/Production of echo-friendly goods
Distribution & Sale Control		
• Marketing of returnable bottle goods	• Control of non-returnable bottle goods	• Establishment of bottle deposit system
• Reduction of packaging wastes	• Control of over-packaging import goods	• Sale/Purchase of simple packaging goods
Consumer Control		
• Reduction of domestic waste generation rate	• Public education on SWM	• Previous habit change in discharging waste
• Reduction of waste shopping bags	• Campaign for reduction of waste plastics	• Participation to use own shopping bag
Waste Charge Control		
• Application of progressive waste charge rates	• Establishment of fair waste charge rates	• Payment for the extra waste charge by the large amount waste generators
• Penalty to unpaid bills	• Billing and monitoring of unpaid bills	• Payment of the unpaid bills
Commercial Waste Control		
• Reduction of commercial waste generation rate	• Public campaign/ monitoring/control	• Participation to the SWM services
• Application of progressive rates to commercial wastes	• Survey/Establishment of commercial waste charge rates	• Payment by the large amount waste generators
Waste Discharge Control		
Promotion of Self-disposal		
• Reduction of discharge amount at generation sources	• Campaign for reduction of waste discharge amount	• Participation to SWM services
• Reduction of wastes from broken appliances/ instruments	• Encouragement/Training/Introduction of repair technology	• Repair of Broken Appliances/Devices and sales at bazaar
• Exchange/Sale of second hand goods	• Encouragement/Assistance for reusable goods bazaar	• Organization of reusable goods bazaars at schools, mosques, etc.
Recovery/Recycling of Materials		
Recovery by Junk Dealers & Community		
• Establishment of the resource saving	• Campaign for saving the resources	• Participation to the activities
• Securing the sales routes of recovered materials	• Establishment/Operation of buy-back center at Transfer Station	• Recovery of reusable materials by junk dealers
Recycling of Recovered Materials		
• Stable supply of recyclable materials	• Recovery/Storage of recyclable materials at Transfer Station/ Thilafushi	• Participation to recovery of recyclable materials
• Reuse of concrete debris and sand for waste disposal operation	• Storage and transportation of concrete debris and sand to Thilafushi	• Unloading of concrete debris and sand at the designated storage area
• Recovery of recyclables in the wastes from resort islands	• Recovery of bottles, PET, tins & cans from the resort islands wastes	• Separation and transportation of recyclable wastes to Thilafushi by resort
• Production of compost derived from wastes	• Construction/Operation of pilot scale compost plant in Thilafushi	• Use of compost, separation of food waste and saw dust by hotels, restaurants and carpentry
• Promotion of recycling industries	• Study of recycling technology, encouragement, assistance to recycling industries	• Investment to recycling center, development of recycling technology, use of recycled goods
• Securing regular market for recovered materials	• Linkage/Encouragement with buyers / exporters	• Development of sale routes with domestic and overseas dealers

b. Implementation of Waste Reduction and Materials Recovery Plans

i) Raising Awareness of the Society for Waste Reduction Programs

Firstly, the action plan shall be commences with raising awareness of the people by means of public campaign and education through mass media, school education, non-formal education and/or co-operation by the mosques. The details of public campaign and the texts for education shall be prepared by the Special Task Team (STT) in collaboration with Department of Planning, Ministry of Planning and National Development, Non-formal Education Centre, Ministry of Education.

ii) Division of Waste Recovery/Recycling Districts

Male' Municipality area shall be divided into 22 districts based on the location of the poll stations. The STT shall organise and maintain a link with at least one volunteer group in each waste recovery/recycling district. The poll station in each district shall be utilised as a centre for the temporary stock area of recovered materials on the operation day to function as the District Waste Recovery Center on the day of operation.

iii) Reusable Goods Bazaars and Buy-back Centres

Reusable Goods Bazaars mainly dealing with second hand clothes and old books shall be opened every other month by rotation of 6 primary schools in Male'. In addition, permanent Buy-back Centre shall be set up within the compound of the Transfer Station. The second hand goods and recovered materials shall be taken to the Reusable Goods Bazaars for sale and/or to the Buy-back Centre for exchange of money by the standard rate set by the STT.

iv) Encouragement of Scavengers and Junk Dealers

Utilisation of the function of scavengers and junk dealers will be effective to improve and activate resource recovery activities in the future. STT have to study the current activities regarding the flow of the recovered materials to realise a regulated and enhanced resource recovery programs for Male' Municipality.

v) Co-operation by Residents and Enterprises for Waste Separation

Separation of the recyclable materials and hand it to the collectors by the waste generators are the key factors to structure the effective and efficient system for waste recovery. Co-ordination, guidance and instruction for asking co-

operation of the people by STT shall be made actively for all the parties involved.

(2) Waste Recycling Plan

a. Overview

The first types of materials recovery is wash and reuse type to recover the materials such as coconut shells, live glass bins, sacks, clothes, 5 gallon cans, etc. and reuse , which are simple and commonly practised currently in male in Male'. The second types need waste conversion through biological, chemical and/or manufacturing processes for reuse. .Due to no recycling industries operated in the Maldives, most of the recovered materials of the second type must be exported to the foreign countries. The following plan and programs are the key issues tackled by STT and the agencies concerned to promote the waste recycling activities for Male'.

b. Implementation of Waste Recycling Plan

i) Storage of Recyclable Materials at Transfer Station and Thilafushi

Recyclable materials shall be unloaded separately by types at the designated storage area of the Transfer Station. As the storage yard filled up, the recyclable wastes shall be transported to the Thilafushi for longer storage period until the materials are reused or sold. Recyclable materials commingled in the wastes from resort islands and the Airport Islands shall be separated at the generation sources and transported directly by the waste generators and unloaded/stored separately at the Thilafushi.

ii) Link with Buyers and Recycling Industries

Collection of market information must be made through maintaining close relation with the buyers and recycling industries in foreign countries. On the contrary, the information of the recovered materials such as an amount and types stored in Male' must be circulated among the interesting buyers and the recycling industries. Research of recycling market shall be conducted to collect information and to make a close link with the buyers and the recycling industries in India, Indonesia and Singapore by the staff of STT by 2003.

iii) Food Waste and Saw Dust Composting

Approximately 4 tons of wastes are discharged from hotels and restaurants and 5 tons are discharged from carpentry factories every day. Most of these wastes are available as raw materials for composting.

Pilot study for composting is proposed to carry out at the Thilafushi using of food waste, saw dust and other organic wastes. The composting yard of Windrow type composting shall have a capacity to receive raw materials about 2 to 3 tons twice in a week. The composting yard shall have concrete slabs, roofing , rain water tanks, pre-treatment area and sieving area for final products as shown in Figure 2-16. Composting by manual operation shall be carried out in accordance with the procedures prescribed in the Compost Manual attached in the Supporting Report E.

The final products of the pilot compost will be able to distributed easily due to the limited amount. At first, the compost shall be used at the test farm prepared in the Thilafushi to study the effects of the final products. After proved at the test farm, the final products shall be packed and shipped by the return trip of the garbage dhoni from the resort islands for further test application by the interesting resort islands.

Composting yard shall be expanded or replaced by the mechanical type composting facilities to enlarge the production capacity subject to the successful results of the pilot composting facilities.

2.7.3 Required Input

Physical facilities, equipment or materials required for waste reduction and recovery /recycling plan and programs are listed below. These tools for implementation include stock yard of recovered materials, pilot compost facilities, public campaign and education materials, cost for accumulating information of recycle markets as shown in the following sections.

(1) Construction

a. Stock Yard in the Transfer Station

- Included in the Transfer Station design

b. Stock Yard in the Thilafushi

- Included in the design of Thilafushi new disposal site

(2) Equipment and Marketing Study

a. Public Campaign Materials

- Education Video Programs for Adult, 20 minutes video tape in Dhivehi, consist of 1 master tape and 20 copy tapes
- Education Video Programs for Children, 20 minutes video tape in Dhivehi consist of 1 master tape and 20 copy tapes
- Campaign Posters, 1,000 sheets, A2 size color poster

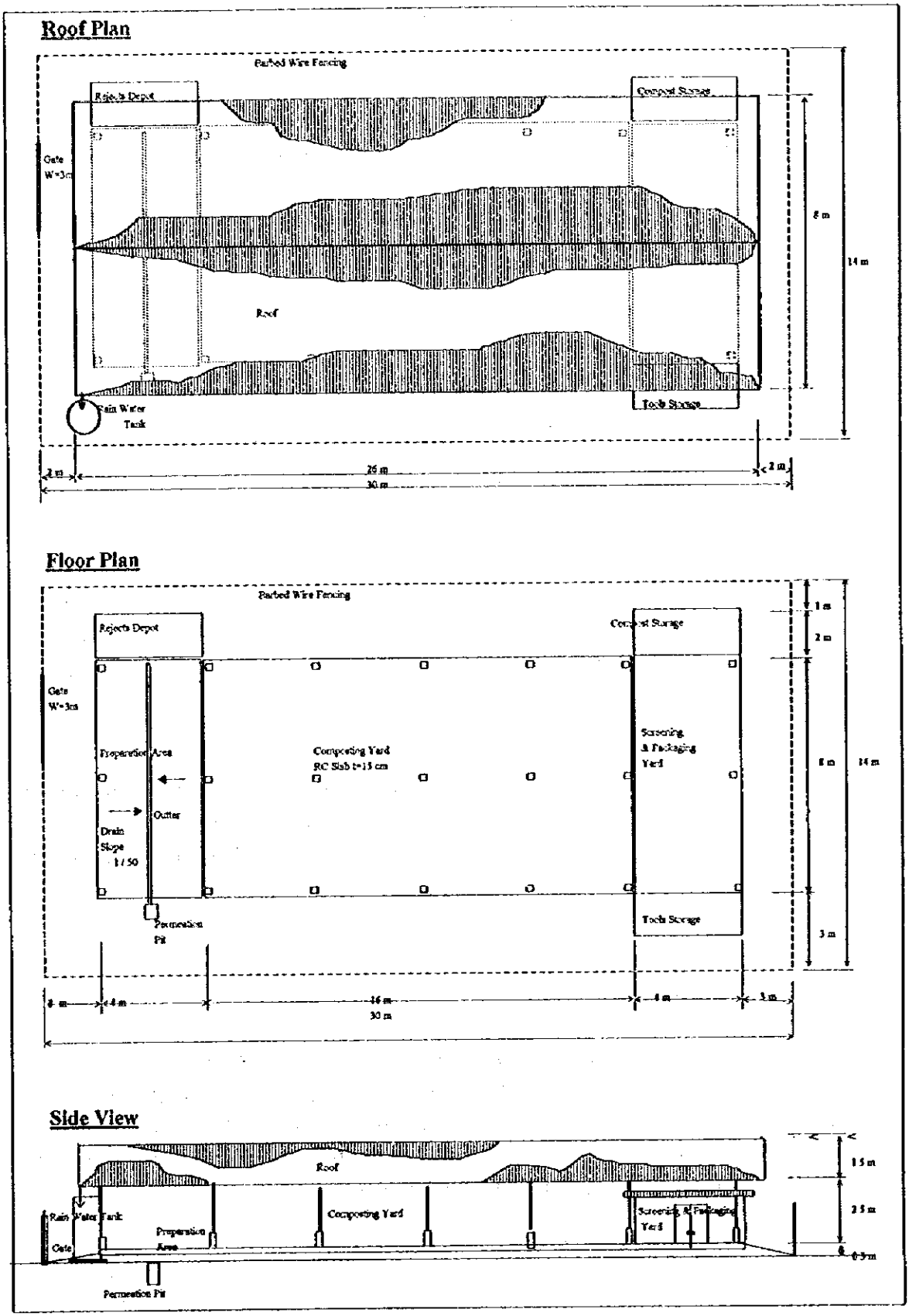


Figure 2-16. Conceptual Design of Pilot Composting Yard in Thilafushi

b. Public Education Materials for Adult

- Text for Non-formal Education, 7,000 sets pamphlets

c. School Education Materials for Children

- Text for School Education 10,000 sets for the primary school children age 9-10 years old, and 10,000 sets for the secondary school children 14-15 years old

d. Promotion of Recycling Industries

- Visiting Recycle Markets in Inia, Indonesia and Singapore to make a link with buyer and recycling industries, 3 person for 7 days each in each country

e. Study for Recycling Technologies

- Accumulation of technical data, information and study on appropriate technology for the Maldives by STT staff

(3) Personnel

Waste reduction and recover/recycling programs must be implemented under the involvement of various types of people and agencies in the society, the programs must be implemented as the social movement in other words. In the centre of the activities, Special Task Team (STT) established in Male Municipality shall have responsibilities to play a leading role of the activities in collaboration with and supports from the Government agencies, residents and enterprises.

The STT shall be organised with 8 staff member comprised of one (1) assistant director to manage the STT, two(2) engineers to study an appropriate method for implementation, one (1) secretary or clerk to maintain smooth office work and four (4) staff to make a link with ward office and community groups.

2.7.4 Cost Estimates

Most of the activities of waste reduction and recovery/recycling programs are conducted through participation of the volunteers of the community groups, enterprises and the facilities are constructed as one of the function of the Transfer Station and the Disposal Site. Accordingly, the cost estimation made for the waste reduction and recovery/recycling plans consist of the following item.

(1) Construction and Procurement Cost

Construction/ Equipment	Contents/ Quantity	Cost (Rf)
Stock Yard in the Transfer Station	Included in the Transfer Station design	--
Stock Yard in the Thilafushi	Included in the design of Thilafushi new disposal site	--
Preparation of Education Video	Education Video Programs for Adult and Children 20 minutes 2 master tapes and 40 copy tapes	240,000
Preparation of Posters	Color Posters, 1,000 sheets, A2 size	200,000
Education Text for Adult	Text for Non-formal Education, 7,000 sets Pamphlets	140,000
Education Text for Children	Text for School Education 10,000 sets	400,000
Promotion of Recycling Industries	Visiting Recycle Markets, travelling and accommodation for 3 person, 7 days, 3 places	144,000
Study for Recycling Technologies	Accumulation of technical data and study	200,000
Total Investment Cost		1,324,000

(2) O & M Cost

a. Personnel Cost

Staff	Quantity (person)	Salary per month per person (Rf.)	Annual Cost (Rf.)
Assistant Director	1	5,000	60,000
Engineer	2	3,500	84,000
Secretary/Clerk	1	2,500	30,000
Staff Member	4	2,500	120,000
Total Operation Cost			294,000

The total investment was estimated at Rf 1,324,000 for the cost to be disbursed in 2001. Operation cost was estimated for the salary of the Special Task Team (STT). The total annual personnel cost of STT amount to Rf 294,000 in 2003.

All the details under this section are presented in the Supporting Report E.

2.8 Summary of Cost Estimates

2.8.1 Conditions of Cost Estimates

As explained and stated in the cost estimation for the Master Plan, the basic assumptions for the Master Plan are also adopted for this short term development. Some of materials such as coral sand, coral aggregate and small equipment will be able to procure in Maldives. However, it is quite difficult to be supplied the large quantities of the materials and equipment in timely manner for this scale project. Therefore, all of the materials for the construction and procurement shall basically be imported from other countries.

For the improvement of the existing Thilafushi, the seawall would be taken into consideration as a alternative implementation plan to be constructed using the coral materials by the local contractor. Because of the construction scale is not so large and to be divided into several parts.

2.8.2 Summary of Cost Estimates

Based on the study results, explained in the previous sections for the project components of the Short Term Development Plan (for 2003) as well as the Master Plan (for 2010) the costs were estimated. The construction costs and procurement costs are summarized in the Table 2-41 and the Table 2-42.

The breakdown of the construction cost is shown in the Supporting Report

The construction cost is estimated at Rf 162,451,000 in total, and the procurement cost is at Rf 56,362,000 in total. Thus, the Project cost is totaled at Rf 218,813,000.

Table 2-41. Summary of the Construction Cost

(Short Term Development Plan for 2003)

	Items	Cost (1000 Rf)	Cost (1000US$)	Remarks
I	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	
4)	Construction in Villingili	2,525	215	
	Sub- total	**137,670**	**11,746**	
2	Engineering Services	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 2-42. Summary of the Procurement Cost

	Items	Cost (1000 Rf)	Cost (1000US$)	Remarks
I	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)	Dust Bin 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**	