Japan International Cooperation Agency (JICA)

Ministry of Construction and Public Works
Male' Municipality

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

FINAL REPORT

SUPPORTING REPORT

May 1999

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Environmental Technology Consultants Co., Ltd

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Foreign Currency Exchange Rates Applied in this Report

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

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

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A. Collection

A. COLLECTION

1. Present Situation of Collection System

1.1 General

The field studies of collection system was carried out for the areas in (1) Male', (2) Adjacent Island to Male', (3) Resort Island and (4) Inhabited Island. Collection system is not required in most of the inhabited islands except for Male' and some large islands of the Atoll centres, because most of islands are very small and the short distance to the disposal site. Solid waste is brought into the site easily by the residents by themselves. The current conditions and problems of the collection system in these islands are mentioned as below.

1.2 Legal Basis of Collection System

The national level laws and the Male Municipality By-law concerned with SWM is described in "Master Plan, Section 2.1 Legal Bases of SWM". The laws and By-laws related with waste collection are as follows.

(1) Law (National Level)

National Laws and regulations on SWM are not enacted, however there are some provisions related with solid waste in the relevant laws such as tourism, etc.

(2) By-law (Male Municipality)

The Male' Municipality prescribes a regulation for cleansing and SWM of Male'. There is not any legal provision for SWM in local inhabited islands. The By-law of Male Municipality includes the following clauses;

- Male Municipality is responsible for cleansing of public spaces and collection of waste from public areas;
- No one is allowed to throw away solid waste onto the ground except for the places other than the refuse containers or the Transfer Station (the depot.);
- Any one have to clean the street in front of his/her house at least once in a day;
- Any one if breaches the laws will be punished by the by-laws.

1.3 Present Situation of Collection System

1.3.1 Male'

(1) Condition of Waste Discharged

In the Male Municipality area, the municipal waste from house, office, shop, market, restaurant and etc. is not separated. There are two major reasons why there is no regulation and system of the waste separation as mentioned in the following;

- There is not recycling industry, therefore the separated waste will be brought into the disposal site finally and activities are not effective for reduction of the waste and
- The site condition is not suitable to store some kinds of separated waste.

The major separation activities are observed with the industrial waste and public work waste because these activities will produce a large volume and homogeneous waste. The wastes are brought into and stored at the transfer station for reuse and sell. The major separated waste is construction waste and iron-scraps. The construction waste will be used for cover material or the land reclamation material at the disposal site. However, the iron-scraps are retained at the station for several years. International markets are not interested in the recovered materials in Male' and the materials will be brought into the disposal site finally. The waste discharge condition is shown in Table 1.3.1.

Table 1.3.1 Condition of Waste Discharged

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

(2) Main Bodies of Collection and Their Equipment

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

a. Male' Municipality

Community Service Section (CSS) of Male' Municipality provides two types of collection services for residents, the first service is container collection service with free of charge and the other service is door to door collection service to all the requesters upon payment. There is not legal arrangement as to the payment service, the door to door collection service is considered as a trial activity. And the Section is responsible for cleansing of the public spaces (park, market, and etc.).

The detail organization of Community Service Section (CSS) is described in " Master Plan, Section 2.2 Responsible Body for SWM and Organization". The CSS consists of 11 positions and 96 persons. The names of the position and the number of the persons are shown in Table 1.3.2.

Table 1.3.2 The Member of Community Service Section

Office Work	Field Work
- Chairman (1) - Deputy Director (1) - Special Duty Officer (1) - Assistant Under Secretary (1) - Secretaries (2) - Clerks (2)	- Inspector (3) - Foreman (3) - Labors (70) - Drivers (9) - Mechanics (3)
Total 6 positions and 8 persons	Total 5 positions and 88 persons

The numbers of persons who work at the collection service in CSS are shown in Table 1.3.3.

Table 1.3.3 The Persons Engaged in Collection Service

Position	officer	driver	mechanic	worker
Number	1	9	3	70

The CSS's equipment of collection services is shown in Table 1.3.4 and Table 1.3.5. CSS has two trucks for door to door collection services, five Micro-bin trucks for container collection services and has two tractors for cleansing of public space. In addition, CSS has a little more than a hundred numbers of $2m^3$ micro-bins and some number of plastic bins.

Table 1.3.4 Equipment for Collection Services

Vehicle	Truck	Micro-bin truck	Tractor
Number	2	5	2
Specification	- 4t capacity - special covered roof - 1996 made	- made in Ireland - for container collection -1990 made (4) from UNDP - 1996 made (1)	- Massey-Ferguson 240
Service	Door to door collection service	Container collection service	Public cleansing service

Table 1.3.5 The Container and Plastic Bin

Type	Plastic bin	Container	Plastic bin
Number	Unknown	22 or 21 (9 points), Total 100	25
Specification	- 25l - for houses	- 2 m^3 (from UNDP) - Out side road - 3 time trip per day	-1.5l^3 (made in Singapore) - park, market - 1994 made
Service	Door to door collection service	Container collection service	Public Cleansing service

b. Private Company

The collection services by private companies are categorized four types of services. The contents of the services are shown in Table 1.3.6.

Table 1.3.6 Collection Services by Private Company

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

The detail information of the private companies is as follows.

i) IHF (Ibraham Hassan Fulham) Carpentry

This company provides a door to door collection services to anyone who pay waste charge. The collection service is the same system provided by CSS, therefore the two companies are competing each other in solid waste collection service. The company provided collection service prior to the services by CSS in the central area government offices, hence CSS increase the number of customers in recently. The number of worker and equipment are shown in Table 1.3.7 and Table 1.3.8. The owner of the company is considering about the future of this business, because the Private Sector Involvement (PSI) policy of the government is not clear and the collection vehicle of the company is old.

Table 1.3.7 The Persons Engaged in Collection Service

Position	Administration	Driver	Worker
Number	1	1	4

Table 1.3.8 Equipment for Collection

Vehicle	Pick-Up
Number	1
Specification	1.5t Capacity (More than 15 years age)

ii) Individual Hand-cart Collectors

According to the hearing survey, there are about 25 persons working for collection service by handcart. The handcart can be loaded to appox.2~3 m^3. They provide a collection service to houses and shops on the monthly contract base. Most of the persons who engaged in this service are almost older than 60 years old. The handcart services would be reduced in the future.

iii) MULTILINKS Pvt., Ltd.

The company provides building maintenance services and services for Janitorial Services, solid waste collection and transportation service are sidelines. The company is not interested to provide only the waste collection service.

vi) Taxi Companies

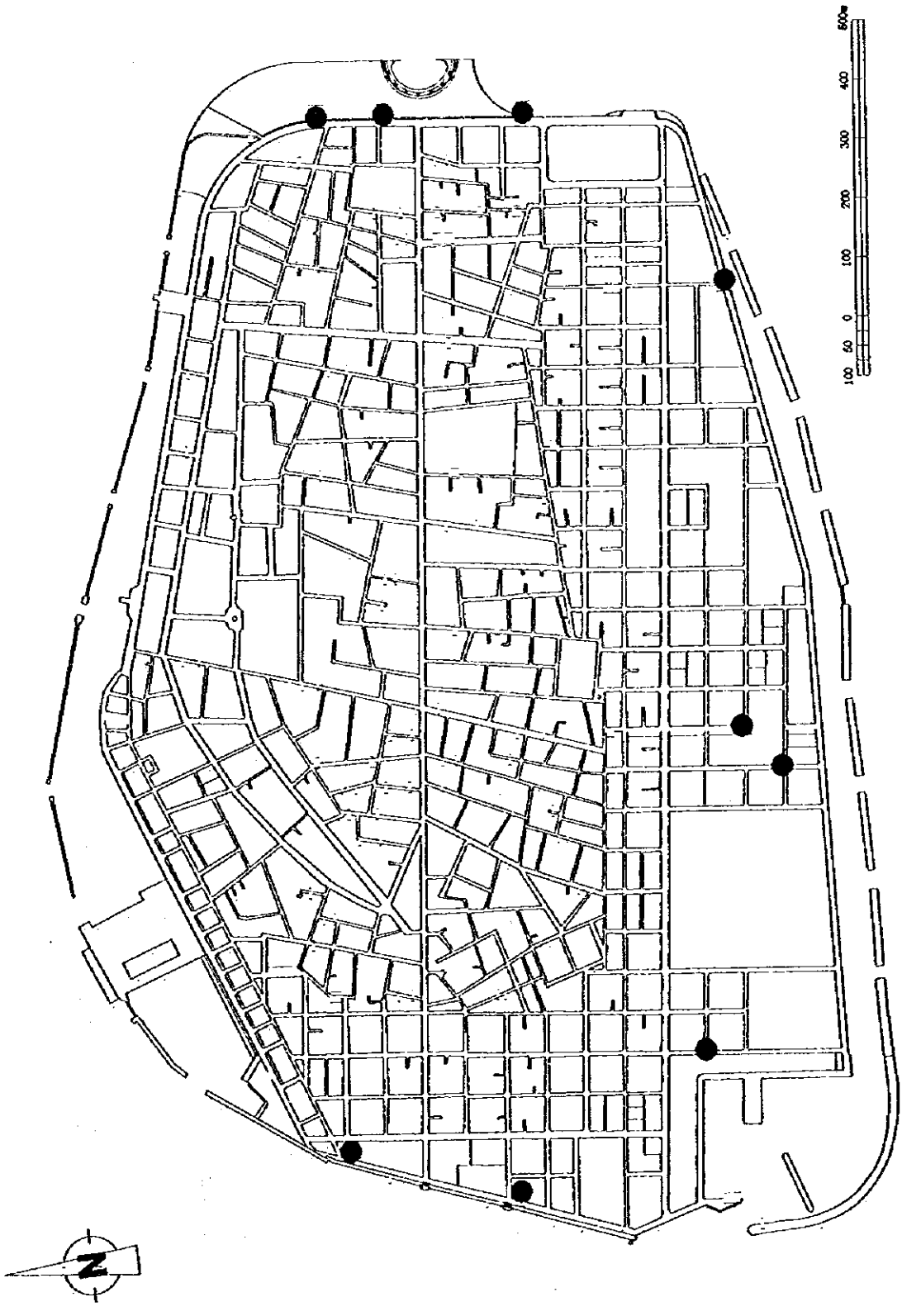
Some taxi companies provide luggage transportation service by pick-up. Residents, offices and shops use this service for transportation of large amount of waste. The service is temporary and payment each time.

(3) The Outline of Collection Services

a. Container Collection System

Male' Municipality introduced the container collection system as a minimum level collection service for residents upon free of charge. Twenty two (22) number of containers are installed at 9 stations along the out side road in the southern part of the island. The collection stations are shown in Figure1.3.1. The capacity of each container is 2 m^3. The Municipality rotates the containers in making their round three times in a day. The collection time is from 5 a.m. to 10 p.m. o'clock. The residents can discharge waste into the containers at any time in a day. The system has started almost 10 years ago, therefore the system is familiar to the residents.

Figure 1.3.1 The Location Map of the Containers



b. Door to Door Collection System

Main bodies of the collection service and their customers are summarized as Table 1.3.9. Male' Municipality has 417 clients, and IHF has 120 clients upon payment.

Table 1.3.9 Main Bodies of Collection Service and Their Client

Main Bodies of Collection Service		Client
Male Municipality		House 294, Government Office 72, Business 41, **Total 417**
Private Company	IHF (Ibraham Hassan Fulham) Carpentry	House 80, Government Office 15, Industry 25, **Total 120**
	MULTILINKS Pvt., Ltd.	Building 16, **Total 16**
	Individual Collection Persons	House, shop, restaurant, others 10~50 client/Cart, **Total Unknown**
	Taxi companies	Unspecified number of the general public

The services is provided with collection charge. The collection charge is different by the frequency of collection times and the amount of the waste. The detail is shown as following **Table 1.3.10.**

Table 1.3.10 Collection Charge of Door to Door Collection Service

Provider		Collection Time	Charge
Male Municipality		Week day (a.m. 7:00 – p.m. 5:30/6:00)	Frequency (Collection/Rental bin) Once/week (120 Rf / 96 Rf) Twice/week (160 Rf /124 Rf) Thrice/week (200 Rf /160 Rf) Daily (400 Rf /320 Rf)
Private Company	IHF (Ibraham Hassan Fulham) Carpentry	Week day (a.m.8:00 - p.m. 3:00/4:00), Friday (a.m. 8:00 – 9:30 and p.m.7:00 – 7:30), The requested time by client	Frequency (House, Business/office) Once/week (150 Rf , 175 Rf) Thrice/week (225 Rf, 250 Rf) Daily (360 Rf, 400 Rf)
	MULTILINKS Pvt., Ltd.	-	Free (One of the service of Building Maintenance)
	Handcart Collectiors	Every day (a.m. 6:00 –12:00/16:00)	3~10 Rf/day 150~300 Rf/month
	Taxi Companies	Temporary	50 Rf/one time

c. Self-carry by Generators

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

(4) The Collection Ratio and Collected Waste Amount

Whatever may be the collection modes, the existing collection system collects 100% of the generated waste of Male' Island. The present total generated waste amount is 173.7 ton per day and the classification and each amount of collected waste is shown in Table 1.3.11. The amount of industrial waste is 105-ton/day and account for 60.4 % of the total waste. The residential waste amount to 48.2 t/d, and account for 27.8 % of the total waste. The detail collection system of the municipal waste and residential waste are shown in Table 1.3.12. The Table shows that the minimum collection service system (micro-bin collection system) collect only 43.2 % of the total residential waste. The other waste is carried to the transfer station by generators or contractors.

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

Table 1.3.11 Collected Waste Amount of Each Collection System (1998)

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

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

Table 1.3.12 The Collected Waste Amount of Each Collection System (1998)

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

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

(5) The efficiency of the Existing Collection Systems

The efficiency of the existing collection systems is studied through the Time Motion Study (TMS) conducted in the first field survey period. The detail analysis of TMS is attached in Data Book 4, the results of the study is summarised in Table1.3.13. The item 12) Working Time Efficiency makes clear the efficiency of each collection system. The coefficient indicates that the most efficient collection system is Micro-bin system. The system can collect waste at the rate of 80 min./ton/person. The door to door collection system by the Municipality require 1176 min./ton/person which shows the lowest efficiency. The system can work 7% effective of the Micro-bin system. The working efficiency of the system is almost same efficiency of handcart system. Male' Municipality has to improve the efficiency of the system at least up to the same level of IHF's efficiency.

Table 1.3.13 The Comparison of Each Collection System

Item	M.C.V.	Micro-bin	IHF	Tractor	Hand-cart
1) Total Operation Time	5:15'27	5:04'54	4:21'52	5:09'22	5:58'05
2) Moving Time (to collection point) and Distance	22'23 4.9km	9'10 2.0km	8'28 4.9km	15'05 1.7km	26'26 2.4km
3) Collection Time	3:19'16	33'00	2:05'15	2:31'35	2:24'50
4) Nos. of Collection Points	39	20	40	31	47
5) Traveling Time and Distance	1:00'21 12.3km	-	1:11'10 13.1	1:35'24 10.4km	1:15'03 4.8km
6) Haulage time and Distance	24'41 5.1km	3:52'18 47.1km	9'54 1.8km	23'17 2.4km	36'25 3.1km
7) Dumping Time	6'39	17'04	25'57	14'21	44'03
8) Moving Time (to garage) and Distance	5'24 1.3km	8'25 1.5km	13'41 2.1km	12'01 1.7km	18'42 1.6km
9) Collected Waste	1.17	8.15ton	2.80ton	3.74ton	0.4ton
10) Total Distance	23.4km	50.7km	18.3km	16.4km	10.9km
11) Collection Time Efficiency 3)+5)+6)/ 8) min/ton (/person)	251 (1004)	34 (64)	92 (368)	73 (292)	868 (868)
12) Working Time Efficiency 1)/8) min/ton	294 (1176)	40 (80)	118 (472)	84 (336)	1148 (1148)
13) Collection Time min./point	5'14	1'40	3'07	4'57	3'18
14) Haulage Time Velocity 6) Km/h	2.8km	12.3km/h	4.0km/h	2.5km/h	1.4km/h

1.3.2 Neighbouring Islands of Male'

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

There is not any waste collection system or own final disposal site. Residents bring waste to the transfer station by themselves. Waste Management Section (WMS) transfers and transports the waste to the Thilafushiu disposal site. The transfer station located at the northern part of the island and the residents who live in the southern area have to walk maximum 500m to discharge waste. It is considered that the distance, 500m in maximum, would not require the collection service by the Municipality. WMS will continue the existing SWM system even in the future, the system is evaluated as a suitable system for Villingili.

1.3.3 Resort Island

Ministry of Tourism is responsible for the management of Resort Islands. The Ministry enacted a law concerned with SWM in resort islands. According to the law, each resort island is responsible for solid waste management and the island have to construct a suitable capacity incinerator to treat a combustible waste. However, some islands do not equipped with incinerator and carry waste to Thilafushiu disposal site.

1.3.4 Inhabited Island

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

2. Problems Observed and Proposed Solution

2.1 Male'

(1) Problem

The collection system of Male' island can be evaluated to have the level achieving not bad public health and cleansing of the public space. The level is kept by the effort of the residents, because a half of the municipal waste is carried to the site directly by the residents. The Municipality collects only 44.2% of the total residential waste, the container system collects 43.2% and the door to door collection system collects 1.0%. The container system has started almost 10 years ago, therefore the system get used to the residents. However, the equipment of the system got old and the system is not even-handed to all the residents. Therefore, the Municipality has to consider about introduction of total collection system in Male'. The problems of Male' collection system is summarised as shown below;

- The collection system of the Municipality covers only 44.2% of residential waste;
- The vehicles and equipment of the container collection system have aged;
- Door to door collection services of the Municipality is not effective;
- Private Sector Involvement (PSI) for the collection service is not enough because the policy of the central and the local government is not decided yet. Private company can not invest to purchase the vehicles and employ the staffs for collection services and
- There is not future plan of collection system in Male' Municipality.

In fact, there are many persons who are not satisfied with the container collection system, which shoulders major waste collection from residents, the reasons are as following;

- The container collection service is unfair to the northern area residents because the containers are located along with the south side road of the island;
- The maintenance cost of container collection system increased, because the container collection vehicle (Micro-bin truck) become old and need expenditure for the special ordering of spare parts;

- The Micro-bin drivers complain about hard seat because the vehicle has not a shock absorber;
- The neighbouring residents of the stationary containers complain about smell of the waste in the container and
- The private company dumps a lot of waste to the container, especially at night-time.

(2) Proposed Solution

The primary objective of the waste collection plan is to enhance the collection service for the purpose to maintain public health and cleanliness and to protect the City's environment. The Male' Municipality is responsible for the management of municipal waste. The existing collection system has some week points therefore the Municipality has to introduce a new collection system. A collection system which is the economical and efficient as well as the least socially and environmentally acceptable, shall be adopted, in comparison with possible technical options such as station type (include container type) and door to door type (include bell collection type) collection. Male' municipality shall promote and make the greatest use of private sector involvement in terms of collection services with full control of the private sector.

a. Legal Arrangements

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

b. Effective Organisation and Management

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

c. Technical Arrangement

The Municipality should provide the minimum level services equally to all the residents throughout the Male' island until private sectors will grew up to collect all the waste generated in the island. Technical options for collection is considered of two systems, the station (include container system) and the door to

door collection (include bell collection system) system. In consideration of the merits and demerits of the two options, the mixed type system of door to door collection and station system will be proposed. The new system proposed in Chapter 3 is socially and environmentally acceptable for Male' City.

2.2 Other Islands

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

3. New Collection System

3.1 Objective

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

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

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

3.2 Planning Concept

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

3.3 The Responsibility of the Male' Municipality

The solid waste generated in Male' is broadly categorized by four kinds of wastes, i.e. residential, commercial, business and construction waste. The responsibility for each type of waste is defined in Table 3.3.1. The Municipality has responsibility for collection services of the residential waste and supervising & monitoring of waste collection & transportation of all the other types of wastes except construction waste. Therefore, the waste construction plan dealt under this section shall be formulated with the residential waste.

Table 3.3.1 The Types of Waste and the Responsibility

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

The types of solid wastes and the present generation waste are tabulated in Table 3.3.2. The table shows that the Municipality deliver the collection services by the ratio at 46.0 % of the total waste amount. The other types of wastes account for 54% of the total waste amount. Supervising and monitoring of haulage activities by the waste generators will be very important job for the Municipality accordingly.

Table 3.3.2 The Types of Waste and Generated Amount

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

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

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

- Residents have to carry waste to the collection station/vehicle at the designated time and place by the Municipality or transfer station. The entrepreneurs have to carry waste to the transfer station by themselves. All must clean the street in front of the house at least once a day.
- Residents have to carry bulky waste to the transfer station by their responsibility;
- Male' Municipality is responsible for cleansing of public spaces and collection of waste from the public area. Male' Municipality provides minimum collection services to all the residents upon minimum waste charge;
- Male' Municipality can provide high quality collection services on request of all the parties upon full cost recovery charge and
- Male' Municipality will permits the registered private companies to provide high quality collection services to all the parties upon payment.

3.4 New Collection System for the Residential Waste

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

(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 3.4.1. The detail considerations of each option are discussed below.

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

Table 3.4.1 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

a. Option1: Road Side Station Collection System

i) The Collection System

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

ii) Required Number of Collection Vehicle

The required number of collection vehicles are calculated based on the following conditions and the results were summarised in Table 3.4.2.

(The calculation conditions)

- The collection vehicle of 2.0-ton nominal capacity compactor type truck have an actual loading capacity of 1.8 ton. (The type of collection vehicle has 4.0 m^3 container and the compressed waste density estimated 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 Number of Station Point: 6,000 households/30 = 200 stations.
- The waste amount of each station: (60~106t/d)/200 stations = (0.30~0.53) ton/station.
- The collection will be carried out at once in a day.

(The calculation: Compactor Truck)

- Required number of trips:1.8-ton actual capacity/(0.30~0.53) ton/station = 6.0~3.4 stations/vehicle/trip, 200 stations/(6.0~3.4) stations/vehicle/trip = (33~59) trips
- Haulage time to transfer station: 25min. /trip x (33~59) trips = 825~1475min.
- Collection time (including cleansing time of the station) 10~20 min./station x 200 stations = 2,000~4,000 min.
- Traveling time: 5min.x(200-33) stations=835min., 5min. x(200-59) trips=705 min.
- Total (Collection, Haulage and Traveling): 3,660~6,180=61~103hours
- Required number of vehicle (full working) (61~103)/6 = 11~18
- Required number of vehicle (net working rate is 85%)=13~22

(The calculation: Normal Truck)

- Required number of trips:0.4-ton actual capacity/(0.3~0.53) ton/station = 1.3~0.8 stations/vehicle/trip, 200 stations/(1.3~0.8) stations/vehicle/trip = (154~250) trips
- Haulage time to transfer station: 25min. /trip x (154~250) trips = 3850~6,250min.
- Collection time (including cleansing time of the station) 10~20 min./station x 200 stations = 2,000~4,000 min.
- Traveling time: 5min.x(200-154) stations=230min., 5min.x (200-250) trips=0 min.
- Total (Collection, Haulage and Traveling): 6080~10250=102~171hours

- Required number of vehicle (full working) (102~171)/6 = 17~29
- Required number of vehicle (net working rate is 85%)=20~35

Table 3.4.2 The Required Number of the Compactor Truck

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	(11)	(13)	(17)	(20)
(2000)	54	63	(11)	(13)	(18)	(22)
(2001)	57	67	(11)	(13)	(19)	(23)
(2002)	61	71	(12)	(14)	(20)	(24)
2003	64	75	13	15	21	25
2004	68	79	13	15	22	26
2005	72	84	14	17	24	29
2006	75	88	15	18	25	30
2007	79	92	16	19	26	31
2008	83	97	17	20	27	32
2009	87	102	18	22	28	33
2010	91	106	18	22	29	35

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

iii) 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 "Road Space Station Collection System (Option 1)" is shown in Table 3.4.3.

Table 3.4.3 The Required Staff and Salary of Collection System

Position	Number	Responsibility	Salary (Rf/month)	Salary (Rf/year)
Deputy Director	1	Responsibility of all activities of the section	Av. 5,500	198,000
Assistant Director	1	Assist to the Manager activities and worker management		
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 (number of total truck)
Worker	Three times as total trucks (include stand-by)	Waste collection	Av. 1,200	1,200x12x3x (number of total truck)

Total	6 + 4 x number of total truck	-	-	-

(Compactor Truck)

The procurement cost of the collection vehicle is shown in Table 3.4.4, the personnel cost is show in Table 3.4.5 and the operation and maintenance cost are shown in Table 3.4.6 and Table 3.4.7. Total collection cost of Option 1(compactor truck) is summarized in Table 3.4.8.

Table 3.4.4 Procurement Cost of Collection Vehicle (Compactor Truck)

Year	(1) Number of Truck to be Purchased	(2) Unit Cost	(3) Total Cost (x 1,000 Rf) (1)x(2)x1.035
1999	-	-	-
2000	-	-	-
2001	-	-	-
2002	15	673,000	10,448
2003	-	-	-
2004	2	673,000	1,393
2005	1	673,000	697
2006	1	673,000	697
2007	16	673,000	11,145
2008	2	673,000	1,393
2009	2	673,000	1,393
2010	1	673,000	697
Total	40	-	27,862

Table 3.4.5 Personnel Cost (Compactor Truck)

Year	Management Cost (x1000Rf/year)	Number of trucks	Collection work Cost (x1000Rf/year)	Total Cost (x1000Rf/year)
1999	-	-	-	Existing system
2000	-	-	-	
2001	-	-	-	
2002	-	-	-	
2003	288	15	1,098	1,386
2004	288	15	1,098	1,386
2005	288	17	1,244	1,532
2006	288	18	1,318	1,606
2007	288	19	1,391	1,679
2008	288	20	1,464	1,752
2009	288	22	1,610	1,898
2010	288	22	1,610	1,898
total	2,304	-	10,833	13,137

Table 3.4.6 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)	Spare 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	15	673,000	10,095	-	
2003	-	-		606	606
2004	2	673,000	1,346	606	606
2005	1	673,000	673	606+80	686
2006	1	673,000	673	606+80+40	726
2007	16	673,000	10,768	606+80+40+40	766
2008	2	673,000	1,346	80+40+40+646	806
2009	2	673,000	1,346	80+40+40+646+80	886
2010	1	673,000	673	40+40+646+80+80	886
Total	40	673,000	-	5,968	5,968

Table 3.4.7 Operation Cost (Compactor Truck)

Year	Number of Trip	Fuel Cost	The others	Total Cost
1999	Existing System	Existing System	Existing System	Existing System
2000				
2001				
2002				
2003	42	394	1,386	1,780
2004	44	413	1,386	1,799
2005	47	441	1,532	1,973
2006	49	460	1,606	2,066
2007	52	488	1,679	2,167
2008	54	507	1,752	2,259
2009	57	535	1,898	2,433
2010	59	554	1,898	2,452
Total	-	3,792	13,137	16,929

1trip=3.0km/4km/1x2.5Rf=30Rf/trip, 30Rf/tripx365x6/7=9,385Rf/trip/year

Table 3.4.8 Collection Cost of the Option 1

Year	(1) Procurement Cost	(2) Personnel Expenditure	(3) Maintenance Cost	(4) Operation Cost	Total Cost
1999	-			(1,249)	(1,249)
2000	-			(1,249)	(1,249)
2001				(1,249)	(1,249)
2002	10,448			(1,249)	(1,249) 10,448
2003	-	1,386	606	1,780	3,772
2004	1,393	1,386	606	1,799	5,184
2005	697	1,532	686	1,973	4,888
2006	697	1,606	726	2,066	5,095
2007	11,145	1,679	766	2,167	15,757
2008	1,393	1,752	806	2,259	6,210
2009	1,393	1,898	886	2,433	6,610
2010	697	1,898	886	2,452	5,933
Total	27,862	13,137	5,968	16,929	63,897 (68,893)

(Normal Truck)

The procurement cost of the collection vehicle is shown in Table 3.4.9, the personnel expenditure is shown in Table 3.4.10 and the operation and maintenance cost are shown in Table 3.4.11 and Table 3.4.12. Total collection cost of Option 1(Normal truck) is summarized in Table 3.4.13.

Table 3.4.9 Procurement Cost of Collection Vehicle (Normal Truck)

Year	(1) Number of Truck to be Purchased	(2) Unit Cost	(3) Total Cost (x 1,000 Rf) (1)x(2)x1.035
1999	-	-	-
2000	-	-	-
2001	-	-	-
2002	25	270,000	6,986
2003	1	270,000	279
2004	3	270,000	838
2005	1	270,000	279
2006	1	270,000	279
2007	26	270,000	7,266
2008	2	270,000	559
2009	5	270,000	1,397
2010	1	270,000	279
Total	65	-	18,162

Table 3.4.10 Personal Expenditure (Normal 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	288	25	1,830	2,118
2004	288	26	1,903	2,191
2005	288	29	2,123	2,411
2006	288	30	2,196	2,484
2007	288	31	2,269	2,557
2008	288	32	2,342	2,630
2009	288	33	2,416	2,704
2010	288	35	2,562	2,850
total	2,304	-	17,641	19,945

Table 3.4.11 Maintenance Cost (Normal Truck)

Year	(1) Number of Trucks to be Purchased	(2) Unit Cost	(3) Total Cost (x 1,000 Rf) (1)x(2)	Spare 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	25	270,000	6,750	-	
2003	1	270,000	270	405	405
2004	3	270,000	810	405+16	421
2005	1	270,000	270	405+16+49	470
2006	1	270,000	270	405+16+49+16	486
2007	26	270,000	7,020	405+16+49+16+16	502
2008	2	270,000	540	16+49+16+16+421	518
2009	5	270,000	1,350	49+16+16+421+32	534
2010	1	270,000	270	16+16+421+32+81	566
Total	66	-	-	3,902	3,902

Table 3.4.12 Operation Cost (Normal Truck)

Unit : Rf 1,000

Year	Number of Trips	Fuel Cost	The others	Total Cost
1999	-	-	-	-
2000	-	-	-	-
2001	-	-	-	-
2002	-	-	-	-
2003	188	1,764	2,118	3,882
2004	198	1,858	2,191	4,049
2005	210	1,970	2,411	4,381
2006	220	2,065	2,484	4,549
2007	230	2,159	2,557	4,716
2008	243	2,281	2,630	4,911
2009	255	2,393	2,704	5,097
2010	265	2,487	2,850	5,337
Total	-	16,977	19,945	36,922

1trip=3.0km/4km/1x2.5Rf=30Rf/trip, 30Rf/tripx365x6/7=9,385Rf/trip/year

Table 3.4.13 Collection Cost of Option1(Normal Truck)

Unit : Rf 1,000

a. Year	(1) Procurement Cost	(2) Personnel Expenditure	(3) Maintenance Cost	(4) Operation Cost	Total Cost
1999	-			(1,249)	(1,249)
2000	-			(1,249)	(1,249)
2001				(1,249)	(1,249)
2002	6,986			(1,249)	(1,249) 6,986
2003	279	2,118	405	3,882	6,684
2004	838	2,191	421	4,049	7,499
2005	279	2,411	470	4,381	7,541
2006	279	2,484	486	4,549	7,798
2007	7,266	2,557	502	4,716	15,041
2008	559	2,630	518	4,911	8,618
2009	1,397	2,704	534	5,097	9,732
2010	279	2,850	566	5,337	9,032
Total	18,162	19,945	3,902	36,922	78,931 (83,927)

(iv) Cost Comparison between Compactor Truck and Normal Truck

The collection cost of the Option 1 is shown in Table 3.4.14. The Table suggests that the introduction of compactor track for collection activities is more economical than that of the normal truck.

Table 3.4.14 Comparison of Collection Cost (Option 1)

Unit : Rf 1,000

Year	Compactor Truck	Normal Truck
1999	(1,249)	(1,249)
2000	(1,249)	(1,249)
2001	(1,249)	(1,249)
2002	(1,249) 10,448	(1,249) 6,986
2003	3,772	6,684
2004	5,184	7,499
2005	4,888	7,541
2006	5,095	7,798
2007	15,757	15,041
2008	6,210	8,618
2009	6,610	9,732
2010	5,933	9,032
Total	63,897 (68,893)	78,931 (83,927)

b. Option2: Door to Door Collection System

i) The Collection System

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

ii) Required Number of Collection Vehicle

The required number of collection vehicles is estimated on the following conditions. The result of the calculation is shown in Table3.4.15.

(The calculation conditions)

- The collection vehicle of 2.0-ton nominal capacity compactor type truck have 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 Number of Collection Point: 6,000 households
- Collection time efficiency is 70kg/3min. (Time & Motion Study)
- Moving time efficiency is 70kg/1.8min. (Time & Motion Study)
- The collection will be carried out at once time in a day.
- The collection vehicle will work 6 hours/day and 6 days/week.

(The calculation: Compactor Truck)

- Collection time: (60~106)-ton/day/0.07-tonx 3min. = 2571~4543 min.
- Moving time: (60~106)-ton/day/0.07-tonx1.8min. =1543~2726min.
- Haulage time: 25min.x(60~106)-ton/day/1.8-ton=833~1472 min.
- Total time (Collection, Moving and Haulage time): 4,947~8741min./60min =83~146hours
- Required number of vehicle (full working) (83~146)hours/6hours x 1.2 = 17~30
- Required number of vehicle (net working rate is 85%)= 20~36
- Note: The coefficient of collection efficiency is based on the private sector's activities, the target of activity is business and commercial offices that discharge many waste compare with the residential house. Therefore, the plan will count the 20% excess for on safety operation.

(The calculation: Normal truck)

- Collection time: (60~106)-ton/day/0.07-tonx 3min. = 2571~4543 min.
- Moving time: (60~106)-ton/day/0.07-tonx1.8min. = 1543~2726 min.
- Haulage time: 25min.x(60~106)-ton/day/0.4-ton = 3750~6625 min.

- Total time(Collection, Moving and Haulage time): 7864~13894/60=131~232hours
- Required number of vehicle (full working) (131~232)hours/6hours x 1.2 = 27~47
- Required number of vehicle (net working rate is 85%)= 32~56
- Note: The coefficient of collection efficiency is based on the private sector's activities, the target of activity is business and commercial offices that discharge many waste compare with the residential house. Therefore, the plan will count the 20% excess for on safety operation.

Table3.4.15 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	(17)	(20)	(27)	(32)
(2000)	54	63	(18)	(22)	(29)	(35)
(2001)	57	67	(20)	(24)	(31)	(37)
(2002)	61	71	(21)	(25)	(32)	(38)
2003	64	75	22	26	34	40
2004	68	79	23	28	36	42
2005	72	84	25	30	38	45
2006	75	88	26	31	40	48
2007	79	92	27	32	42	50
2008	83	97	28	33	43	51
2009	87	102	29	35	45	53
2010	91	106	30	36	47	56

iii) 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 "Door to Door Collection System (Option 2)" is shown in Table3.4.16.

Table3.4.16 The Required Staff and Salary of Collection System

Position	Number	Responsibility	Salary (Rf/month)	Salary (Rf/year)
Deputy Director	1	Responsibility of all activities of the section	Av. 5,500	198,000
Assistant Director	1	Assist to the Manager activities and worker management		
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 (number of total truck)
Worker	Three times as total trucks (include stand-by)	Waste collection	Av. 1,200	1,200x12x3x (number of total truck)
Total	6 + 4 x number of total truck	-	-	-

(Compactor Truck)

The procurement cost of collection vehicle is shown in Table3.4.17, the personnel expenditure is show in Tabl3.4.18 and the operation and maintenance cost are shown in Table3.4.19 and Table3.4.20. Total collection cost of Option 2 (compactor truck) is summarized in Table3.4.21.

Table3.4.17 Procurement Cost (Compactor Truck)

Year	(1) Number of Truck to be Purchased	(2) Unit Cost	(3) Total Cost (x 1,000 Rf) (1)x(2)x1.035
1999	-	-	-
2000	-	-	-
2001	-	-	-
2002	26	673,000	18,110
2003	2	673,000	1,393
2004	2	673,000	1,393
2005	1	673,000	697
2006	1	673,000	697
2007	27	673,000	18,807
2008	4	673,000	2,786
2009	3	673,000	2,090
2010	1	673,000	697
Total	67	673,000	46,670

Table3.4.18 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	288	26	1903	2191
2004	288	28	2050	2338
2005	288	30	2196	2484
2006	288	31	2269	2557
2007	288	32	2342	2630
2008	288	33	2416	2704
2009	288	35	2562	2850
2010	288	36	2635	2923
Total	2,304	-	18,373	20,677

Table 3.4.19 Maintenance Cost (Compactor Truck)

Year	(1) Number of Truck 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	26	673,000	17,498		
2003	2	673,000	1,346	1050	1050
2004	2	673,000	1,346	1050+81	1131
2005	1	673,000	673	1050+81+81	1212
2006	1	673,000	673	1050+81+81+40	1252
2007	27	673,000	18,171	1050+81+81+40+40	1292
2008	4	673,000	2,692	81+81+40+40+1090	1332
2009	3	673,000	2,019	81+40+40+1090+162	1413
2010	1	673,000	673	40+40+1090+162+121	1453
Total	67	673,000	-	10,135	10,135

Table3.4.20 Operation Cost (Compactor Truck)

Unit : Rf 1,000

Year	Number of Trip	Fuel Cost	The others	Total Cost
1999	Existing System	Existing System	Existing System	Existing System
2000				
2001				
2002				
2003	42	394	2191	2,585
2004	44	413	2338	2,751
2005	47	441	2484	2,925
2006	49	460	2557	3,017
2007	52	488	2630	3,118
2008	54	507	2704	3,211
2009	57	535	2850	3,385
2010	59	554	2923	3,477
Total	-	3,792	20,677	24,469

1trip=3.0km/4km/lx2.5Rf=30Rf/trip, 30Rf/tripx365x6/7=9,385Rf/trip/year

Table3.4.21 Collection Cost (Compactor Truck)

Unit : Rf 1,000

b. Year	(1) Procurement Cost	(2) Personnel Expenditure	(3) Maintenance Cost	(4) Operation Cost	Total Cost
1999	-			(1,249)	(1,249)
2000	-			(1,249)	(1,249)
2001				(1,249)	(1,249)
2002	18,110			(1,249)	(1,249) 18,110
2003	1,393	2191	1050	2,585	7,219
2004	1,393	2338	1131	2,751	7,613
2005	697	2484	1212	2,925	7,318
2006	697	2557	1252	3,017	7,523
2007	18,807	2630	1292	3,118	25,847
2008	2,786	2704	1332	3,211	10,033
2009	2,090	2850	1413	3,385	9,738
2010	697	2923	1453	3,477	8,550
Total	46,670	20,677	10,135	24,469	101,951 (106,947)

(Normal Truck)

The procurement cost of collection vehicle is shown in Table3.4.22, the personnel expenditure is show in Table3.4.23 and the operation and maintenance cost are shown in Table3.4.24 and Table3.4.25. Total

collection cost of Option 2 (compactor truck) is summarized in Table3.4.26.

Table 3.4.22 Procurement Cost (Normal Truck)

Unit : Rf 1,000

Year	(1) Number of Truck to be Purchased	(2) Unit Cost (Rf)	(3) Total Cost (x 1,000 Rf) (1)x(2)x1.035
1999	-	-	-
2000	-	-	-
2001	-	-	-
2002	40	270,000	11,178
2003	2	270,000	559
2004	3	270,000	838
2005	3	270,000	838
2006	2	270,000	559
2007	41	270,000	11,457
2008	4	270,000	1,118
2009	6	270,000	1,677
2010	3	270,000	838
Total	104	-	29,062

Table 3.4.23 Personal Expenditure (Normal Truck)

Unit : Rf 1,000

Year	Management Cost (x1000Rf/year)	Number of trucks	Collection work Cost (x1000Rf/year)	Total Cost (x1000Rf/year)
1999	-	-	-	-
2000	-	-	-	-
2001	-	-	-	-
2002	-	-	-	-
2003	288	40	2928	3216
2004	288	42	3074	3362
2005	288	45	3294	3582
2006	288	48	3514	3802
2007	288	50	3660	3948
2008	288	51	3773	4061
2009	288	53	3880	4168
2010	288	56	4099	4387
Total	2,304	-	28,222	30,526

Table 3.4.24 Maintenance Cost (Normal Truck)

Year	(1) Number of Trucks to be Purchased	(2) Unit Cost	(3) Total Cost (x 1,000 Rf) (1)x(2)	Spare Parts and Maintenance Cost (x 1,000 Rf) (3) x 0.06 and 5 years	Total O/M Cost (1,000Rf)
1999	-	-	-	-	-
2000	-	-	-	-	-
2001	-	-	-	-	-
2002	40	270,000	10,800	-	-
2003	2	270,000	540	648	648
2004	3	270,000	810	648+32	680
2005	3	270,000	810	648+32+49	729
2006	2	270,000	540	648+32+49+49	778
2007	41	270,000	11,070	648+32+49+49+32	810
2008	4	270,000	1,080	32+49+49+32+664	826
2009	6	270,000	1,620	49+49+32+664+65	859
2010	3	270,000	810	49+32+664+65+97	907
Total	104	-	-	6,237	6,237

Table 3.4.25 Operation Cost (Normal Truck)

Unit : Rf 1,000

Year	Number of Trip	Fuel Cost	The others	Total Cost
1999	-	-	-	-
2000	-	-	-	-
2001	-	-	-	-
2002	-	-	-	-
2003	188	1,764	3,216	4,980
2004	198	1,858	3,362	5,220
2005	210	1,971	3,582	5,553
2006	220	2,065	3,802	5,867
2007	230	2,159	3,948	6,107
2008	243	2,281	4,061	6,302
2009	255	2,393	4,168	6,561
2010	265	2,487	4,387	6,874
Total	-	16,978	30,526	47,464

1trip=3.0km/4km/lx2.5Rf=30Rf/trip, 30Rf/tripx365x6/7=9,385Rf/trip/year

Table 3.4.26 Collection Cost (Normal Truck)

Unit : Rf 1,000

Year	(1) Procurement Cost	(2) Personnel Expenditure	(3) Maintenance Cost	(4) Operation Cost	Total Cost
1999	-			(1,249)	(1,249)
2000	-			(1,249)	(1,249)
2001	-			(1,249)	(1,249)
2002	11,178			(1,249)	(1,249) 11,178
2003	559	3216	648	4,980	9,403
2004	838	3362	680	5,220	10,100
2005	838	3582	729	5,553	10,702
2006	559	3802	778	5,867	11,006
2007	11,457	3948	810	6,107	22,322
2008	1,118	4061	826	6,302	12,307
2009	1,677	4168	859	6,561	13,265
2010	838	4387	907	6,874	13,006
Total	29,062	30,526	6,237	47,464	113,289 (118,285)

(iv) Cost Comparison between Compactor Truck and Normal Truck

The collection cost of the Option 2 is shown in Table3.4.27. The Table suggests that the introduction of compactor track for collection activities is more economical than that of the normal truck.

Table3.4.27 Comparison of Collection Cost (Option 1)

Unit : Rf 1,000

Year	Compactor Truck	Normal Truck
1999	(1,249)	(1,249)
2000	(1,249)	(1,249)
2001	(1,249)	(1,249)
2002	(1,249) 18,110	(1,249) 11,178
2003	7,219	9,403
2004	7,613	10,100
2005	7,318	10,702
2006	7,523	11,006
2007	25,847	22,322
2008	10,033	12,307
2009	9,738	13,265
2010	8,550	13,006
Total	101,951 (106,947)	113,289 (118,285)

c. Option3: Vehicle Station Collection System

i) 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 for 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.

ii) Required Number of Collection Vehicles

The required number of vehicle is calculated based on the conditions presented as follows. The result of the calculation is shown in Table3.4.28.

(The calculation conditions)

- The collection vehicle of 2.0-ton nominal capacity compactor type truck have 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/m3), 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 trip 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.

(The calculation: Compactor Truck)

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

(The calculation: Normal truck)

- Required number of vehicle (full working) (60~106)-ton/day/4trips/0.4-ton = 38~67
- Required number of vehicle (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.

Table3.4.28 The Required Number of the Compactor Truck

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
2004	68	79	11	13	50	59
2005	72	84	12	15	53	62
2006	75	88	13	16	55	65
2007	79	92	13	16	58	69
2008	83	97	14	17	61	72
2009	87	102	15	18	64	76
2010	91	106	15	18	67	79

iii) 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 Table3.4.29.

Table3.4.29 The Required Staff and Salary of Collection System

Position	Number	Responsibility	Salary (Rf/month)	Salary (Rf/year)
Deputy Director	1	Responsibility of all activities of the section	Av. 5,500	198,000
Assistant Director	1	Assist to the Manager activities and worker management		
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	-	-	-

(Compactor Truck)

The procurement cost of collection vehicle is shown in Table3.4.30, the personnel expenditure is show in Table3.4.31 and the operation and maintenance cost are shown in Table3.4.32 and Table3.4.33. Total collection cost of Option 3 (compactor truck) is summarized in Table3.4.34.

Table3.4.30 Procurement Cost (Compactor Truck)

Year	(1) Number of Truck to be Purchased	(2) Unit Cost	(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
2004	0	673,000	0
2005	2	673,000	1,393
2006	1	673,000	697
2007	13	673,000	9,055
2008	1	673,000	697
2009	1	673,000	697
2010	2	673,000	1,393
Total	33	-	22,987

Table3.4.31 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	288	13	764	1,052
2004	288	13	764	1,052
2005	288	15	882	1,170
2006	288	16	941	1,229
2007	288	16	941	1,229
2008	288	17	1,000	1,288
2009	288	18	1,058	1,346
2010	288	18	1,058	1,346
Total	2,304	-	7,408	9,712

Table3.4.32 Maintenance Cost (Compactor Truck)

Year	(1) Number of Truck 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
2004	0	673,000	0	525+0	525
2005	2	673,000	1,346	525+0+0	525
2006	1	673,000	673	525+0+0+81	606
2007	13	673,000	8,749	525+0+0+81+40	646
2008	1	673,000	673	0+0+81+40+525	646
2009	1	673,000	673	0+81+40+525+40	686
2010	2	673,000	1,346	81+40+525+40+80	766
Total	33	673,000	-	4,925	4,925

Table3.4.33 Operation Cost (Compactor Truck)

Unit : Rf 1,000

Year	Number of Trip	Fuel Cost	The others	Total Cost
1999	Existing System	Existing System	Existing System	Existing System
2000				
2001				
2002				
2003	44	413	1,052	1,465
2004	44	413	1,052	1,465
2005	48	450	1,170	1,620
2006	52	488	1,229	1,717
2007	52	488	1,229	1,717
2008	56	526	1,288	1,814
2009	60	563	1,346	1,909
2010	60	563	1,346	1,909
Total	-	3,904	9,712	13,616

1trip=3.0km/4km/lx2.5Rf=30Rf/trip, 30Rf/tripx365x6/7=9,385Rf/trip/year

Table3.4.34 Collection Cost of the Option 3

Unit : Rf 1,000

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	1,052	525	1,465	3,042
2004	0	1,052	525	1,465	3,042
2005	1,393	1,170	525	1,620	4,708
2006	697	1,229	606	1,717	4,249
2007	9,055	1,229	646	1,717	12,647
2008	697	1,288	646	1,814	4,445
2009	697	1,346	686	1,909	4,638
2010	1,393	1,346	766	1,909	5,414
Total	22,987	9,712	4,925	13,616	51,240

(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 Option3 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 Options 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 Table3.4.35. The Table suggests that the Option 3 is the most economical system among the three options.

Table3.4.35 Collection Cost of Each Option

Unit : Rf 1,000

Year	Option 1	Option 2	Option 3
1999	(1,249)	(1,249)	(1,249)
2000	(1,249)	(1,249)	(1,249)
2001	(1,249)	(1,249)	(1,249)
2002	(1,249) 10,448	(1,249) 18,110	(1,249) 9,055
2003	3,772	7,219	3,042
2004	5,184	7,613	3,042
2005	4,888	7,318	4,708
2006	5,095	7,523	4,249
2007	15,757	25,847	12,647
2008	6,210	10,033	4,445
2009	6,610	9,738	4,638
2010	5,933	8,550	5,414
Total	63,897 (68,893)	101,951 (106,947)	51,240 (56,236)

(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. Waste amount to be collected and the required number of truck in the period of Master Plan is shown in Table 3.4.36. The arrangement plan of the vehicle is shown in Fig.3.4.1 (2003) and Fig. 3.4.2 (2010). In 2003, each vehicle covers approx. 20ha (a radius of 250m circle), the residents can discharge waste at the vehicle collection station within 4 minutes walking (60m/min. speed). In 2010, each vehicle covers approx. 15ha (a radius of 220m circle), the required time is shorter than that of the 2003. The service area covered by one vehicle become smaller gradually year by year and the residents will be able to enjoy more convenience for carrying waste to the vehicle.

Table3.4.36 The Waste Amount and Required Collection Vehicles

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

Fig. 3.4.1 Station Plan of the Collection Vehicle (2003)

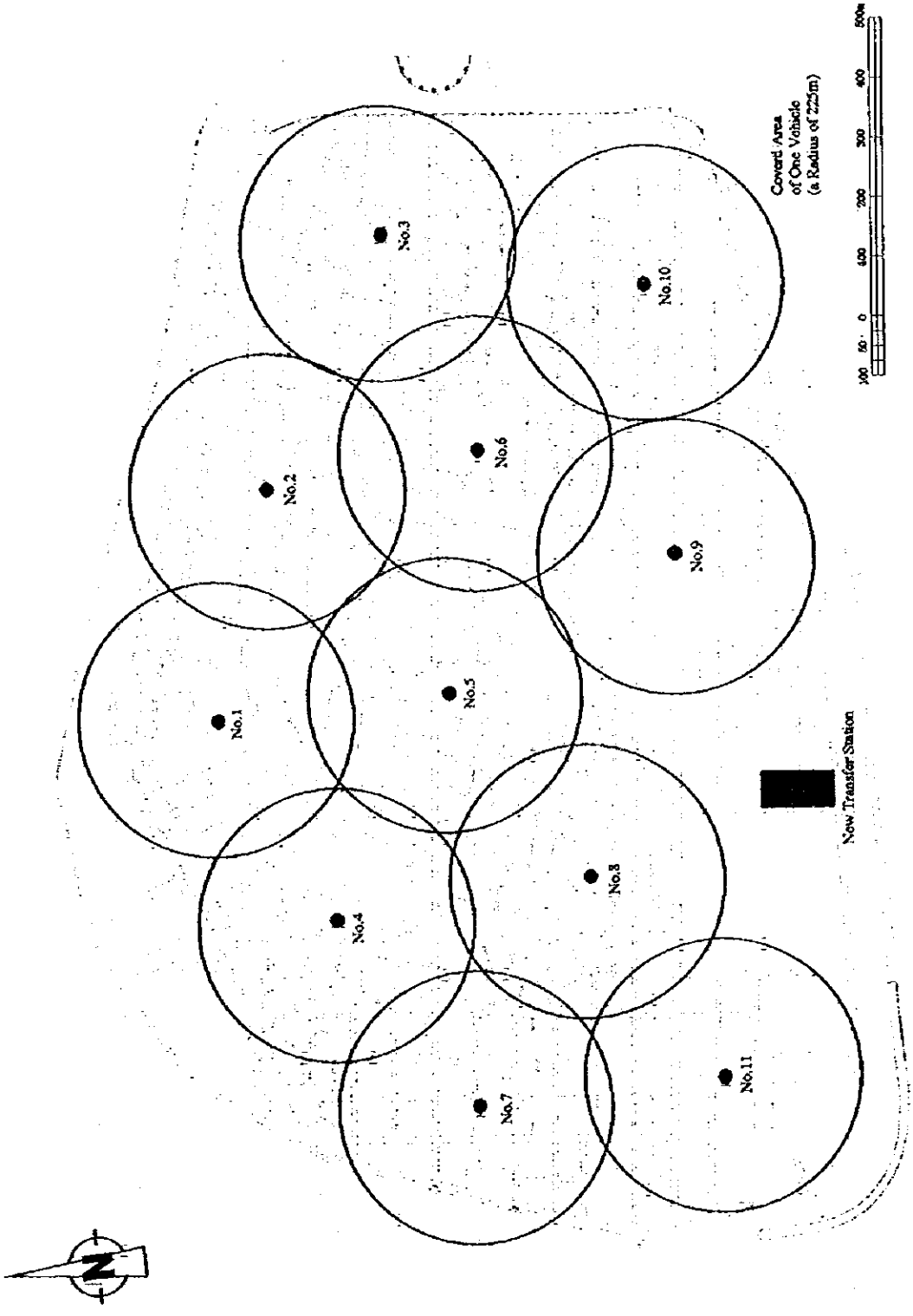
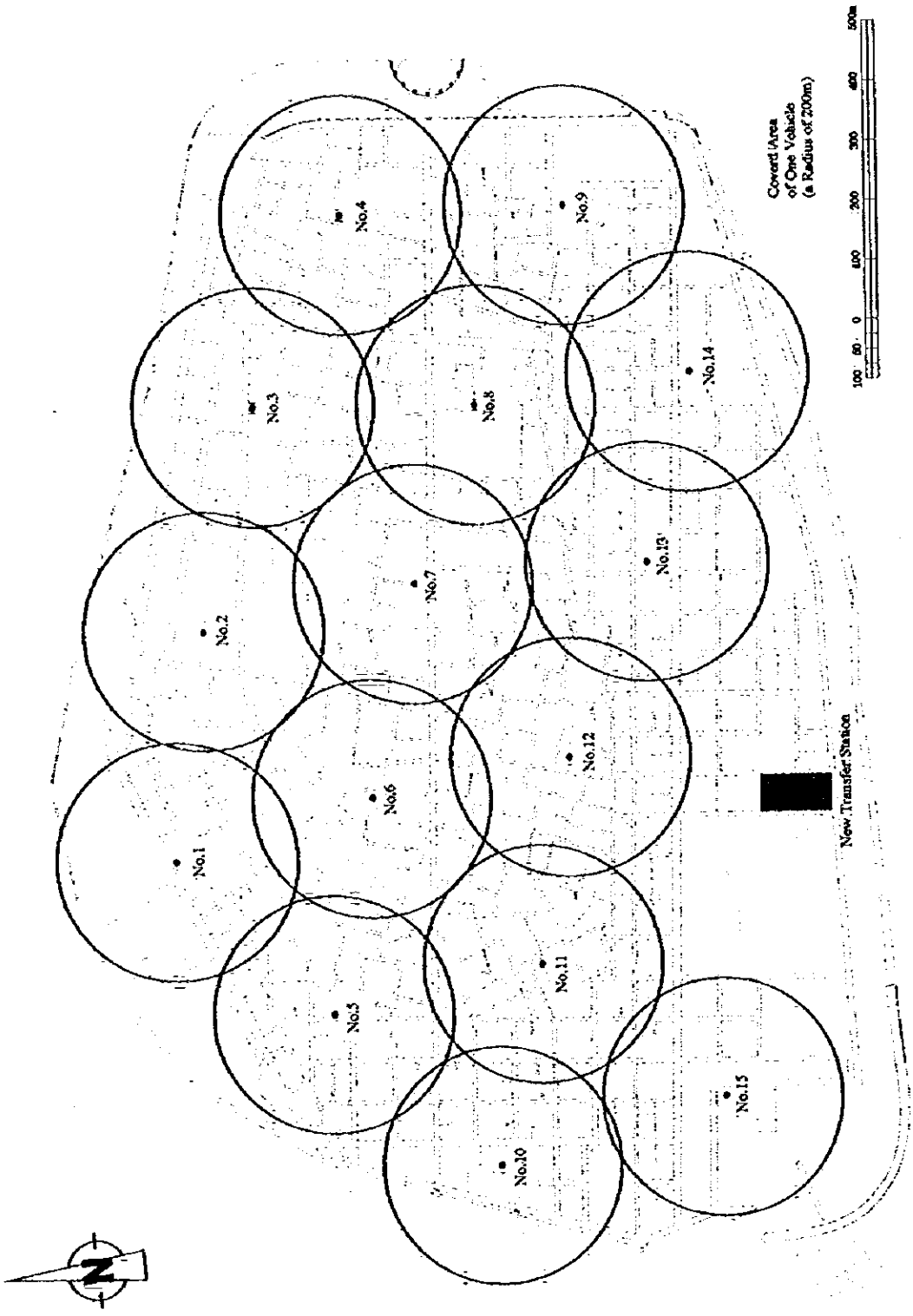


Fig. 3.4.2 Station Plan of the Collection Vehicle (2010)



3.5 Collection System for the Commercial and Business Waste

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

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

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

3.6 Collection System for Construction Waste

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

B. Transportation

B. TRANSPORTATION

1. Present Situation of Transportation System

1.1 General

Ministry of Construction and Public Works (MCPW) is responsible for transportation (from the Transfer Station in Male' and Villingili island to the Thilafusi disposal site) of solid waste generated in the Metropolitan area and management of the final disposal site. Waste Management Section (WMS) of MCPW carry out the practical activities of the transportation and final disposal of the waste.

1.2 Legal Basis of Transportation System

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

1.3 Present Situation of Transportation System

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

(1) Organisation of WMS

The details of organization is shown in "Master Plan, Section 2.2 Responsible Body for SWM and Organization"

The outline of the organisation is as shown in Table1.3.1.

Table1.3.1 The Organisation of WMS

Name of the Section	Position and Number	Subtotal
Workshop	Driver(25), Helper(25)	50
Administration	Senior administration officer(1)	1
VILLINGILI Depot	-	0
THILAFUSHIU	Supervisor (1),Operator (3),Operator-helper (3),Labor (25)	32
MALE' Depot	Supervisor (1), Operator (3), Operator Helper (3), Labor (4)	11
Ferry	Captain (3), Crew (24)	27
Ground Total	-	120

(2) Equipment

The equipment of WSM for transportation is shown in Table1.3.2 and Table1.3.3.

Table 1.3.2 Heavy Machines of WMS

Heavy Machine	Excavator (Transfer station)	Excavator (TILAFUSHI)	Hoilloader	Bulldozer
Number	1	3	1	1
Specification	- Sam Song	-Komatu 30t Capacity (2), Australia-Aid - Kobelco 10t Capacity	-Kobelco 8t capacity,1990 made	- Caterpillar

Table 1.3.3 Transfer Equipment

Name	Dump-truck	Vessel
Number	10	3
Specification	- 10 t Capacity	- UFULI 1 1991 - UFULI 2 1993 Donated by UNDP - UFULI 3 1995 UNDP-Aid

(3) Transportation Record

Transportation record of solid waste from Male' to Thilafushi is shown in Table1.3.4 to Table1.3.7.

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

Table1.3.4 Number of Trucks/Month

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

Table1.3.5 Number of Trucks/Day

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Av.
1992	-	-	-	6.2	12.0	11.9	7.8	10.9	8.8	9.7	12.3	13.2	10.9
1993	16.8	16.5	8.4	16.6	9.8	11.2	12.0	11.8	14.3	8.4	11.5	14.4	12.8
1994	9.0	11.7	13.1	7.2	2.1	8.1	15.3	14.6	13.4	13.3	14.0	11.3	11.4
1995	17.3	16.3	16.0	15.3	8.6	12.7	13.3	13.5	11.1	5.5	14.7	14.5	13.4
1996	13.3	16.3	22.5	24.6	25.5	23.7	22.6	35.9	32.5	24.9	27.2	33.1	25.9
1997	28.5	27.0	40.7	31.7	27.9	28.3	27.6	27.0	27.8	18.8	23.9	24.6	28.4
1998	16.9	23.4	26.6	32.7	25.8								25.3

Table1.3.6 Number of Trips/Day

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Av.
1992	-	-	-	2	3	3	2	2	2	2	3	3	3
1993	4	4	2	4	2	3	3	3	3	2	3	3	3
1994	2	3	3	2	1	2	4	3	3	3	3	3	3
1995	4	4	4	4	2	3	3	3	3	2	3	3	3
1996	3	4	5	5	6	5	5	8	6	5	6	7	6
1997	6	6	9	7	6	6	6	6	6	4	5	5	6
1998	4	5	6	7	6								6

Table1.3.7 Number of Trucks /Year

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

(4) Time Motion of Waste Transportation

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

2. Problems Observed and Proposed Solution

2.1 Male'

(1) Problem

Transportation under this section stand for transportation of waste from the transfer station to the Thirafusi disposal site. There are four major problems of the existing transportation system described as follows;

- The environmental problems at the transfer station is that the waste heap at the transfer station cause of the source of secondary pollution. Smoke, odor and dust will affect health of the people reside near by the transfer station. And the transfer work of the dumped waste loading to trucks makes noise and dust;

- The transportation capacity is limited due to only one ferry in service therefore some amount of waste is always remained in the transfer station;
- The management of the transfer station is not suitable. The private companies and the individual waste generator carry waste to the transfer station for 24 hours and dump the wastes without control of WMS and
- According to the city plan, the existing transfer station area will be used for the residential area. The new transfer station should be constructed as soon as possible.

(2) Proposed Solution

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

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

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

2.2 Other Islands

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

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

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

3. Transportation Plan

3.1 Objective

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

3.2 Planning Concept

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

3.3 Waste Amount to be Transported

The waste amount to be transported is shown in Table 3.3.1. The amount is estimated by 6-days working per a week.

Table3.3.1 Projection of Waste Amount to be Transported (Unit: ton/day)

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

3.4 Technical Alternatives

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

identify the most appropriate system from both economic and environmental viewpoints.

Option 1: Improvement of transfer station

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

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

(1) Option 1: Improvement of Transfer Station (Dump Truck System)

a. Transportation System

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

b. The Required Number of Trip

In the case the two ferries are used to transport the trucks, it is possible to make 10 times (50times) of trips in 8 hours (net work time) by assuming the working time schedule as shown in Fig.3.4.1. In addition, it is possible to increase four trips more (20 trucks) by the working time by two hours. This modified transportation schedule is shown in Fig.3.4.2. In average, required number of trip is estimated for the trucks as shown in Table3.4.1. The Table suggests that two ferryboats have a enough transportation capacity during the planning period until 2010. Therefore, MCPW has to prepare the required number of trucks only. From the year 2003, when the proposed transportation system begin operation, total required number of trucks are 18 (5trucks x 3 teams and 85% of the net working ratio).

Fig.3.4.1 Proposed Working Schedule of Ferry and Trucks (10.5 hours)

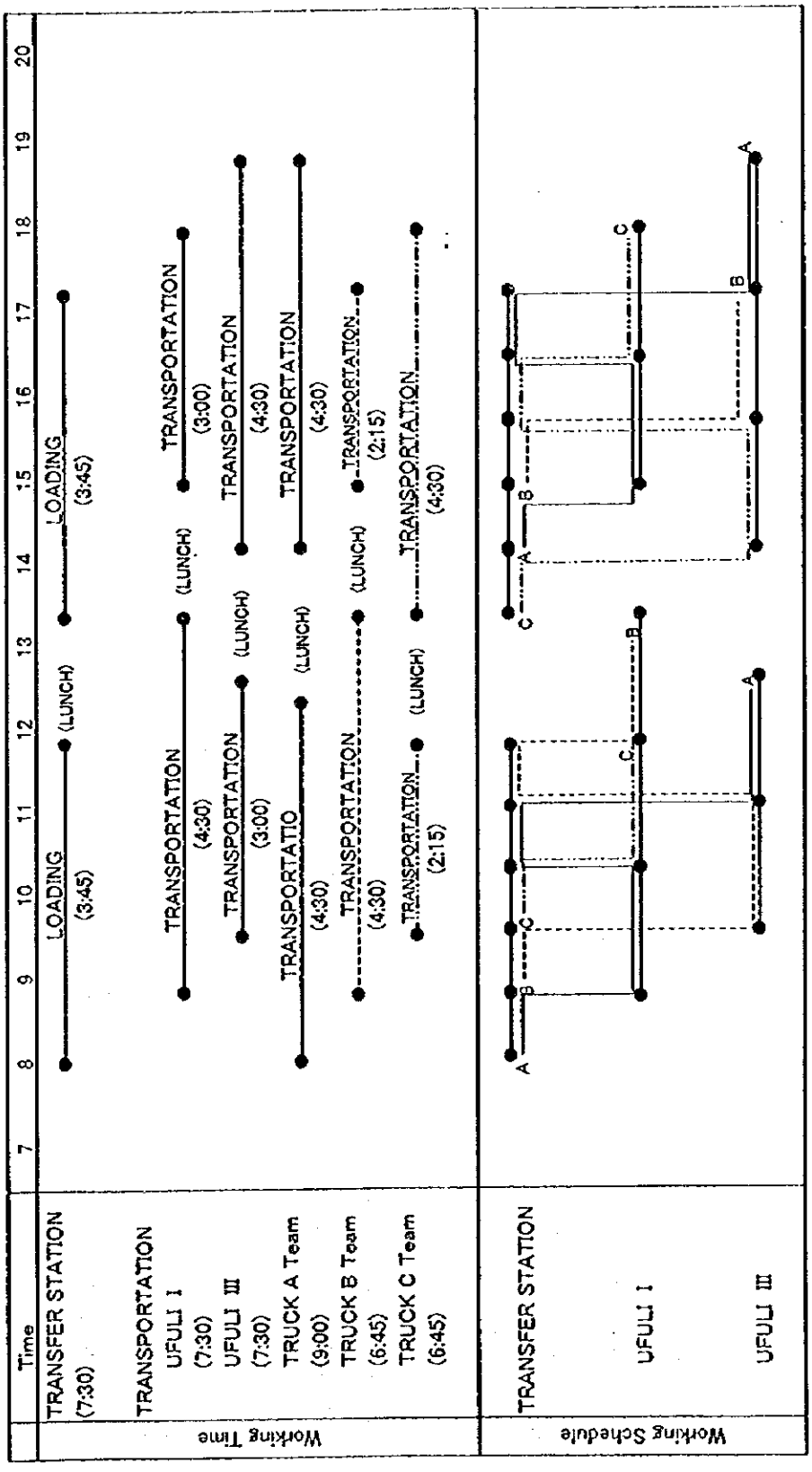
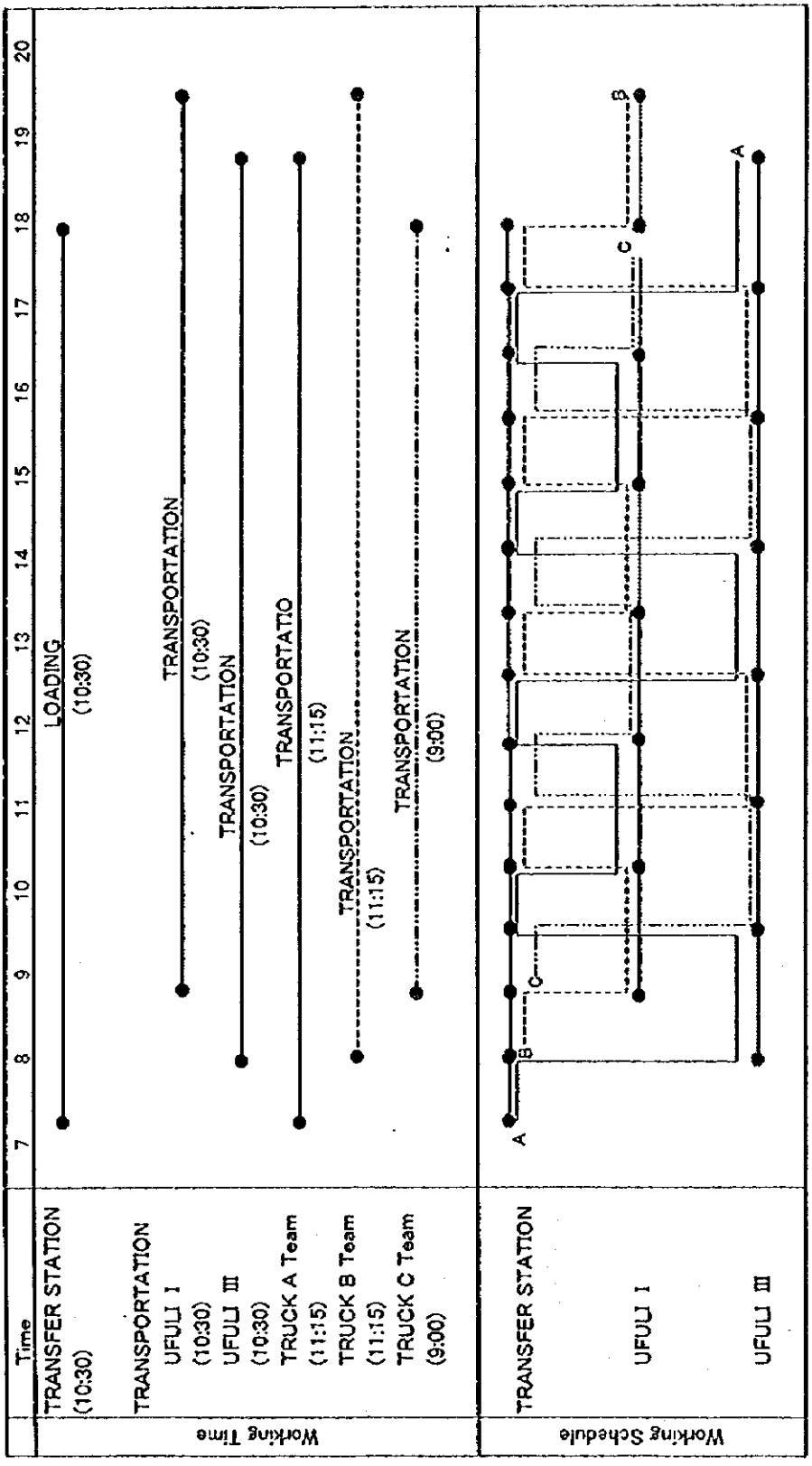


Fig 3.4.1 Proposed Working Schedule of Ferry and Trucks (10.5 hours)

Fig.3.4.2 Proposed Working Schedule of Ferry and Trucks (12.0 hours)



(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 0.3-ton/m^3 (The waste can be loaded 4.0-ton/truck).
- Saw dust and kitchen waste requires one-truck/day.
- The tracks 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.

Table3.4.1 Required Number of Trucks and Trips

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	38 (151.7)	1 (4.0)	1 (1.0)	10 (93.8)	1 (3.0)	51 (11)
2004	40 (158.8)	1 (4.0)	1 (1.0)	10 (96.7)	1 (3.5)	53 (11)
2005	42 (166.5)	1 (4.0)	1 (1.0)	10 (99.6)	2 (4.2)	56 (12)
2006	44 (174.0)	1 (4.0)	1 (1.0)	11 (102.6)	2 (4.9)	59 (12)
2007	46 (182.4)	1 (4.0)	1 (1.0)	11 (105.0)	2 (5.7)	61 (13)
2008	48 (189.8)	1 (4.0)	1 (1.0)	11 (108.5)	2 (6.8)	63 (13)
2009	50 (197.8)	1 (4.0)	1 (1.0)	12 (111.5)	2 (7.9)	66 (14)
2010	51 (205.8)	1 (4.0)	1 (1.0)	12 (114.6)	3 (9.3)	(14)

c. Transportation Cost

The transportation cost of the Option 1 consists of four items i.e., construction cost of transfer station, procurement cost of trucks and heavy machines, operation and maintenance cost, personnel expenditure.

i) Construction Cost of Transfer Station

The details of the construction cost of transfer stations (Male' and Villingili) are presented in "Supporting Report, Section C Improvement of Transfer Station ". Total construction cost and timing is shown in Table 3.4.2.

(a) Construction in Male' (Transfer Station) Rf 25,742,000

(b) Construction in Villingili (Transfer Station) Rf 2,525,000

(c) Subtotal ((a) + (b)) x 1.08 x 1.10 = Rf 33,581,000

(d) 2001-30%(Rf 10,074,000), 2002-70%(Rf 23,507,000)

Table 3.4.2 Total Construction Cost and Timing of The Transfer Stations (Rf)

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

ii) Procurement Cost

Procurement cost and the timing of transportation trucks, heavy machines and other equipment are shown in Table 3.4.3.

Table 3.4.3 Procurement Cost

Year	Truck	Heavy machine	Other equipment	Total
2002	Dump truck (10-ton class) 1,023,000x18=18,414,000 18,414,000x1.035 = 19,058,500	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 152,00 0 Workshop 294,00 0 Truck scale 3,610,000 Sub-total 4,056,000 (4,056x1.035)= 4,198,000	30,091,500
2007	Dump truck (10-ton class) 1,023,000x18=18,414,000 18,414,000x1.035 = 19,058,500	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	-	25,893,500
Total	38,117,000	13,670,000	4,198,000	55,985,000

iii) Personnel Expenditure

The required staff and salary of the Option 1 is shown in Table1-43 and Table3.4.4.

Table3.4.4 The Required Staff and Salary of Transportation

Position	Number	Responsibility	Salary (Rf/month)	Salary (Rf/year)
Deputy Director	1	Responsibility of all activities of the section	Av. 5,500	198,000
Assistant Director	1	Assist to the Manager activities and worker management		
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	810,000/10 trip
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	532,800/10 trips
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	-	-	526,800 + 134,280 x trips

Table3.4.5 Personnel Expenditure

Year	Number of the trips	Total Transportation Cost (x1000Rf/year)
1999	-	Existing system
2000	-	
2001	-	
2002	-	
2003	11	2,004
2004	11	2,004
2005	12	2,138
2006	12	2,138
2007	13	2,272
2008	13	2,272
2009	14	2,407
2010	14	2,407
Total	-	17,642

iv) Operation and Maintenance Cost

(Maintenance Cost)

Table 3.4.6 Maintenance Cost (Rf/year)

Year	Truck	Heavy machine	Other equipment	Total
2001 ~ 2010	Dump truck (10-ton class) 1,023,000x18=18,414,000 18,414,000x0.06 = 1,104,840	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	1,744,440

(Operation Cost)

Table 3.4.7 Operation Cost of Truck and Heavy Machine (8 hours-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 3.4.8 Total Operation Cost (include Vessel & Utility)

Unit : Rf 1,000

Year	Number of ferry trip	Vessel & Utility	Fuel (Operation)	The others	Total
1999				-	Existing system
2000				-	
2001				-	
2002				-	
2003	3,443	5,096	207	2,004	7,307
2004	3,443	5,095	207	2,004	7,307
2005	3,756	5,559	225	2,138	7,922
2006	3,756	5,559	225	2,138	7,922
2007	4,069	6,022	244	2,272	8,538
2008	4,069	6,022	244	2,272	8,538
2009	4,382	6,485	263	2,407	9,155
2010	4,382	6,485	263	2,407	9,155
Total	-	46,324	1,878	17,642	65,844

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

v) Total Transportation Cost

Table3.4.9 Transportation Cost (Option 1)

Unit : Rf 1,000

Year	Construction cost	Procurement cost	Personal expenditure	Maintenance Cost	Operation Cost	Total
1999	-	-	(1,645)		(3,213)	(4,858)
2000	-	-	(1,645)		(3,213)	(4,858)
2001	10,074	-	(1,645)		(3,213)	10,074 (4,858)
2002	23,507	30,092	(1,645)		(3,213)	53,599 (4,858)
2003	-	-	2,004	1,744	7,307	11,055
2004	-	-	2,004	1,744	7,307	11,055
2005	-	-	2,138	1,744	7,922	11,804
2006	-	-	2,138	1,744	7,922	11,804
2007	-	25,893	2,272	1,744	8,538	38,447
2008	-	-	2,272	1,744	8,538	12,554
2009	-	-	2,407	1,744	9,155	13,306
2010	-	-	2,407	1,744	9,155	13,306
Total	33,581	55,985	17,642	13,952	65,844	187,004 (206,436)

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

a. 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.

b. 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.

(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 tracks 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.

Table3.4.10 Required Number of Trucks and Trips

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

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

c. 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.

i) 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 procurement is shown in Table 3.4.11.

Table 3.4.11 Total Construction Cost and Timing of The Transfer Stations (Rf)

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

ii) Procurement Cost

Procurement cost and timing of transportation trucks, heavy machines and other equipment are shown in Table 3.4.12.

Table 3.4.12 Procurement Cost

Unit : 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 152,00 0 Workshop 294,00 0 Truck scale 3,610,00 0 Sub-total 4,056,00 0 (4,056x1.035)= 4,198,000	35,522,135
2007	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	-	31,324,135
Total	48,978,270	13,670,000	4,198,000	66,846,270

iii) Personnel Expenditure

The required staff and salary of the Option 1 is shown in Table3.4.13.

Table3.4.13 The Required Staff and Salary of Transportation

Position	Number	Responsibility	Salary (Rf/month)	Salary (Rf/year)
Deputy Director	1	Responsibility of all activities of the section	Av. 5,500	198,000
Assistant Director	1	Assist to the Manager activities and worker management		
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	-	-	1,896,600

iv) Operation and Maintenance C

(Maintenance Cost)

Table 3.4.14 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	2,059,760

(Operation Cost)

Table 3.4.15 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 3.4.16 Total Operation Cost (include Ferry & Utility)

Unit : Rf 1,000

Year	Number of ferry trip	Vessel & Utility	Fuel (Operation)	The others	Total
1999					Existing System
2000					
2001					
2002					
2003	2,191	3,243	131	1,897	5,241
2004	2,504	3,706	150	1,897	5,753
2005	2,504	3,706	150	1,897	5,753
2006	2,504	3,706	150	1,897	5,753
2007	2,817	4,169	169	1,897	6,235
2008	2,817	4,169	169	1,897	6,235
2009	2,817	4,169	169	1,897	6,235
2010	3,130	4,632	188	1,897	6,717
Total	-	31,500	1,246	15,176	47,922

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

v) Total transportation Cost of Option 2

Table 3.4.17 Transportation Cost (Option 2)

Unit : Rf 1,000

	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	-	-	1,897	2,059	5,241	9,197
2004	-	-	1,897	2,059	5,753	9,709
2005	-	-	1,897	2,059	5,753	9,709
2006	-	-	1,897	2,059	5,753	9,709
2007	-	31,324	1,897	2,059	6,235	41,515
2008	-	-	1,897	2,059	6,235	10,191
2009	-	-	1,897	2,059	6,235	10,191
2010	-	-	1,897	2,059	6,717	10,673
Total	33,581	66,846	15,176	16,472	47,922	179,997 (199,429)

(3) Option 3: Introduction of Compactor-container System

a. Transportation System

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

b. The Required Number of Trip

(Calculation conditions)

1999 ~ 2002:

- The trucks carry 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 truck carry the four types of wastes from Male' and mixed waste from Villingili to the site.

- The residential, commercial and business waste is pressed to the bulk density at 0.5-ton/m3 (The waste can load 8.1-ton/truck. 18m^3 x 0.5 x 90%).
- Saw dust and kitchen waste requires one-truck/day.
- The tracks can load 10-ton of construction waste.
- The bulk density of the Villingili mixed waste is also assumed at 0.3-ton/m^3, the trucks can load 4.0-ton/truck.

Table3.4.18 Required Number of Truck and Trip

Year	Residential, Commercial, Business waste (ton-/day)	Saw dust (to be separated) (ton-/day)	Kicin 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	19 (151.7)	1 (4.0)	1 (1.0)	10 (93.8)	1 (3.0)	32 (7)
2004	20 (158.8)	1 (4.0)	1 (1.0)	10 (96.7)	1 (3.5)	33 (7)
2005	21 (166.5)	1 (4.0)	1 (1.0)	10 (99.6)	2 (4.2)	35 (7)
2006	22 (174.0)	1 (4.0)	1 (1.0)	11 (102.6)	2 (4.9)	37 (8)
2007	23 (182.4)	1 (4.0)	1 (1.0)	11 (105.0)	2 (5.7)	38 (8)
2008	24 (189.8)	1 (4.0)	1 (1.0)	11 (108.5)	2 (6.8)	39 (8)
2009	25 (197.8)	1 (4.0)	1 (1.0)	12 (111.5)	2 (7.9)	41 (9)
2010	26 (205.8)	1 (4.0)	1 (1.0)	12 (114.6)	3 (9.3)	43 (9)

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

c. Transportation Cost

The transportation cost of the Option 3 consists of four items i.e., construction cost of transfer station, procurement cost of trucks and heavy machines, operation and maintenance cost, personnel expenditure.

i) 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 procurement is shown in Table 3.4.19.

Table 3.4.19 Total Construction Cost and Timing of The Transfer Stations (Rf)

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

ii) Procurement Cost

Procurement cost and timing of transportation trucks, heavy machines and other equipment are shown in Table 3.4.20.

Table 3.4.20 Procurement Cost (Rf)

Year	Truck	Heavy machine	Other equipment	Total
2002	Dump truck (10-ton class) 1,023,000x 7 = 7,161,000 Container truck 1,392,000 x 11 = 15,312,000 Container 907,000 x 11 =9,977,000 Sub-total 32,450,000 32,450,000x1.035 = 33,586,000	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 3,946,000 3,946,000x1.035 = 4,084,000	Compactor System 59,303,000 Washing Machine 152,000 Workshop 294,000 Truck scale 3,610,000 cleaning equipment 255,000 Sub-total 63,614,000 63,614,000x1.035= 65,840,000	103,510,000
2007	Dump truck (10-ton class) 1,023,000x 7 = 7,161,000 Container truck 1,392,000 x 11 = 15,312,000 Container 907,000 x 11 = 9,977,000 Sub-total 32,450,000 32,450,000x1.035 = 33,586,000	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 3,946,000 3,946,000x1.035 = 4,084,000	-	37,670,000
Total	67,172,000	8,168,000	65,840,000	141,180,000

iii) Personal Expenditure

The required number of staff and salary of the Option 1 is shown in Table3.4.21.

Table3.4.21 The Required Staff and Salary of Transportation

Position	Number	Responsibility	Salary (Rf/month)	Salary (Rf/year)
Deputy Director	1	Responsibility of all activities of the section	Av. 5,500	198,000
Assistant Director	1	Assist to the Manager activities and worker management		
Chief Transfer Operator	1	Make a transportation plan, arrange the vehicle & worker		
Assistant Account	1	Account the disposal charge	Av. 2,500	390,000
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		
System operator	3	Operate the container system		
Machine operator	3	Operate the heavy machines	Av. 2,300	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	82	-	-	1,986,600

iv) Operation and Maintenance Cost

(Maintenance Cost)

Table 3.4.22 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 1,392,000 x 11 =15,312,000 Container 907,000x11=9,977,000 Sub-total 32,450,000 **32,450,000x0.06 = 1,947,000**	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 3,946,000 **3,946,000x0.06= 236,760**	Compactor System 59,303,000 Washing Machine 152,000 Workshop 294,000 Truck scale 3,610,000 Cleaning equipment 255,000 Sub-total 63,614,000 **(63,614,000x0.06)= 3,816,840**	6,000,600

(Operation Cost)

Table 3.4.23 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 3.4.24 Total Operation Cost (include Ferry & Utility)

Unit : Rf 1,000

Year	Number of ferry trip	Vessel & Utility	Fuel (Operation)	The others	Electricity for Compression	Total
1999						existing
2000						
2001						
2002						
2003	2,191	3,243	131	1,987	480	5,841
2004	2,191	3,243	131	1,987	480	5,841
2005	2,191	3,243	131	1,987	480	5,841
2006	2,504	3,706	150	1,987	480	6,323
2007	2,504	3,706	150	1,987	480	6,323
2008	2,504	3,706	150	1,987	480	6,323
2009	2,817	4,169	169	1,987	480	6,805
2010	2,817	4,169	169	1,987	480	6,805
Total	-	29,185	1,181	15,896	3,840	50,102

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

v) Total Transportation Cost of Option 3

Table 3.4.25 Transportation Cost (Option 3)

Unit : Rf 1,000

Year	Construction cost	Procurement cost	Personal expenditure	Maintenance Cost	Operation Cost	Total
1999	-	-	(1,645)		(3,213)	(4,858)
2000	-	-	(1,645)		(3,213)	(4,858)
2001	10,074		(1,645)		(3,213)	10,074 (4,858)
2002	23,507	103,510	(1,645)		(3,213)	127,017 (4,858)
2003			1,987	6,001	5,841	13,829
2004			1,987	6,001	5,841	13,829
2005			1,987	6,001	5,841	13,829
2006			1,987	6,001	6,323	14,311
2007		37,670	1,987	6,001	6,323	51,981
2008			1,987	6,001	6,323	14,311
2009			1,987	6,001	6,805	14,793
2010			1,987	6,001	6,805	14,793
Total	33,581	141,180	15,896	48,008	50,102	288,767 (308,199)

(4) Cost Comparison of each Transportation Option

The calculation result of each option is shown in Table3.4.26.

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

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

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

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

Table3.4.26 Transportation Cost of Each Option

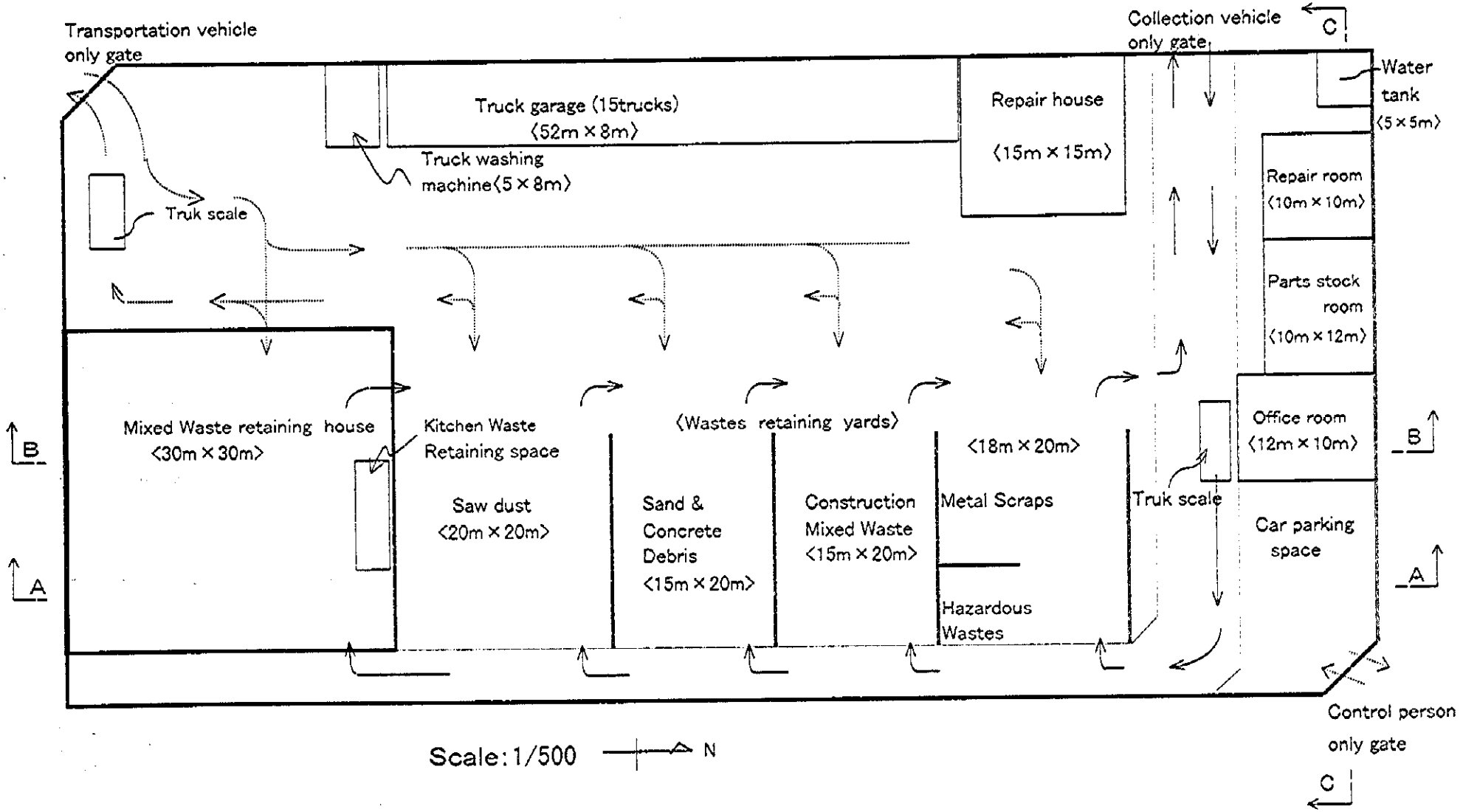
Unit : Rf 1,000

Year	Option 1	Option 2	Option 3
1999	(4,858)	(4,858)	(4,858)
2000	(4,858)	(4,858)	(4,858)
2001	10,074	10,074	10,074
	(4,858)	(4,858)	(4,858)
2002	53,599	59,029	127,017
	(4,858)	(4,858)	(4,858)
2003	11,055	9,197	13,829
2004	11,055	9,709	13,829
2005	11,804	9,709	13,829
2006	11,804	9,709	14,311
2007	38,447	41,515	51,981
2008	12,554	10,191	14,311
2009	13,306	10,191	14,793
2010	13,306	10,673	14,793
Total	187,004	179,997	288,767
	(206,436)	(199,429)	(308,199)

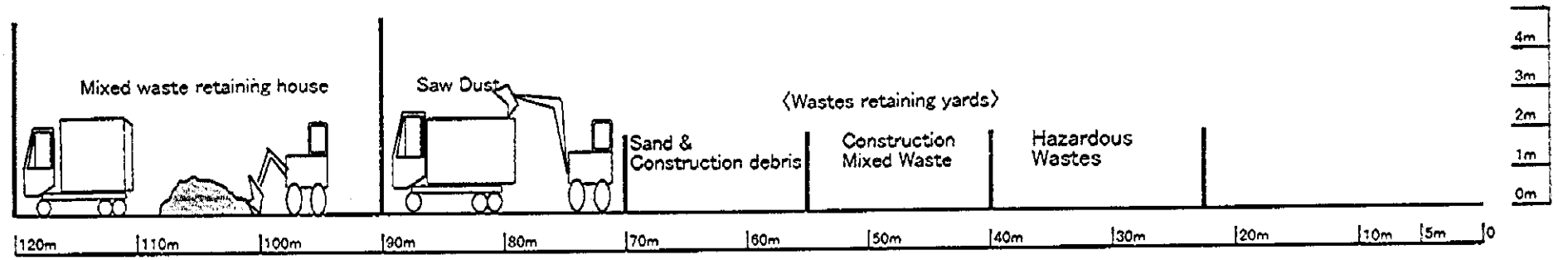
3.5 Proposed Transportation System

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

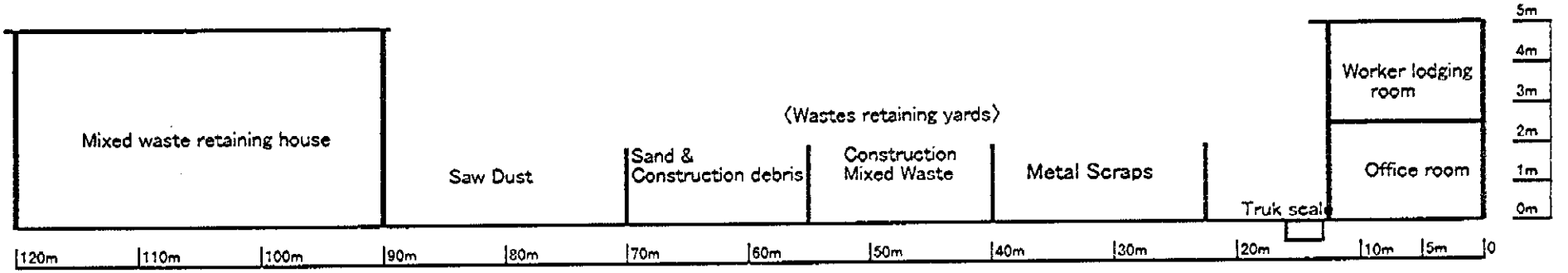
C. Transfer System



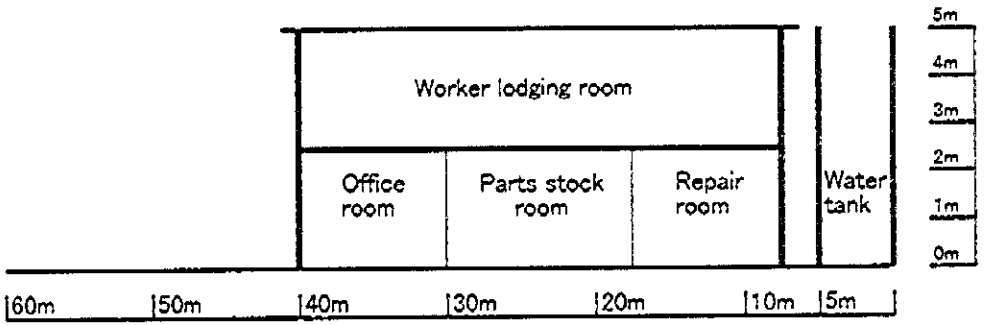
Plan 1. TRANSFER STATION PLAN (200ft × 400ft)



SECTION A – A

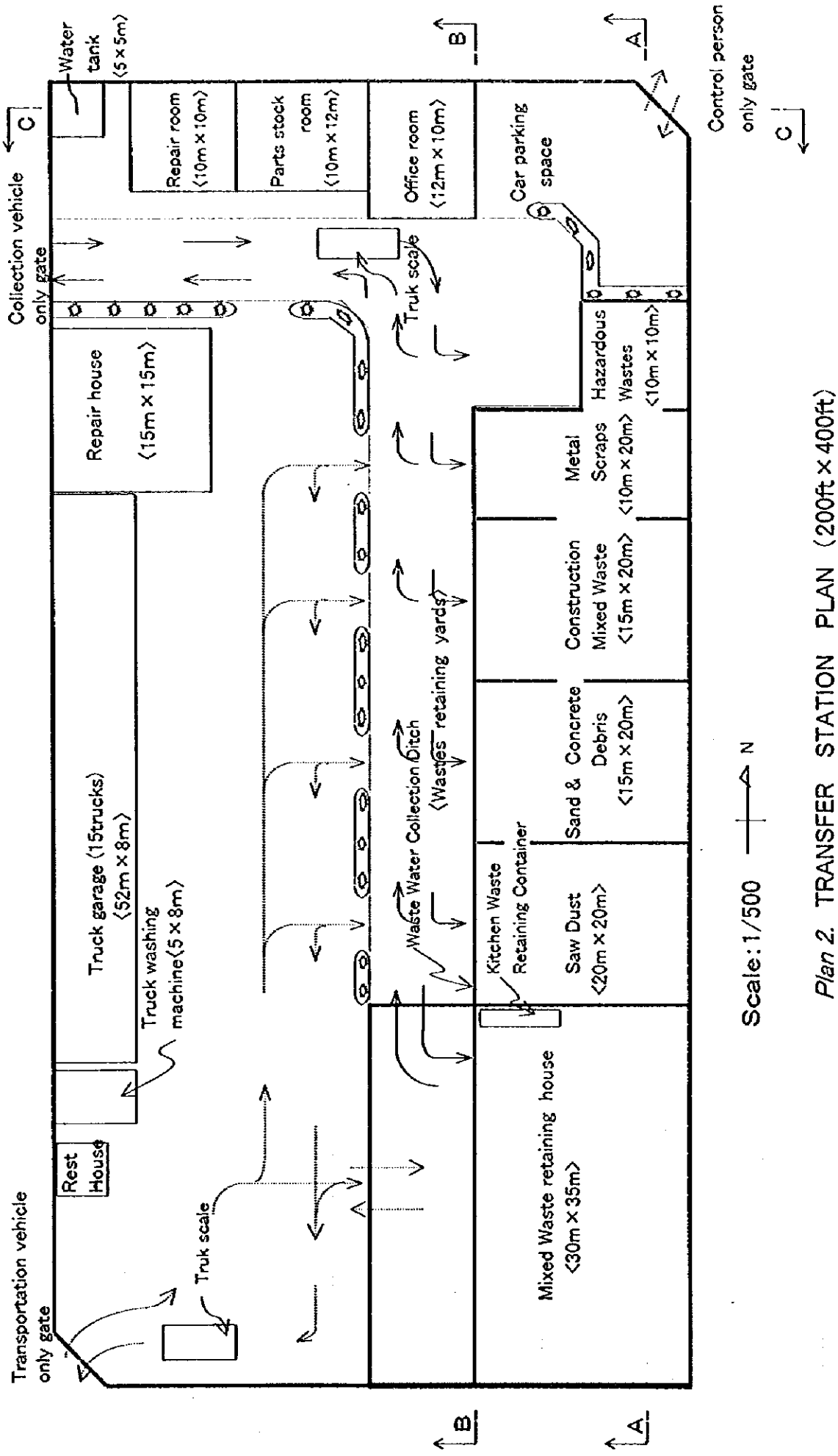


SECTION B – B

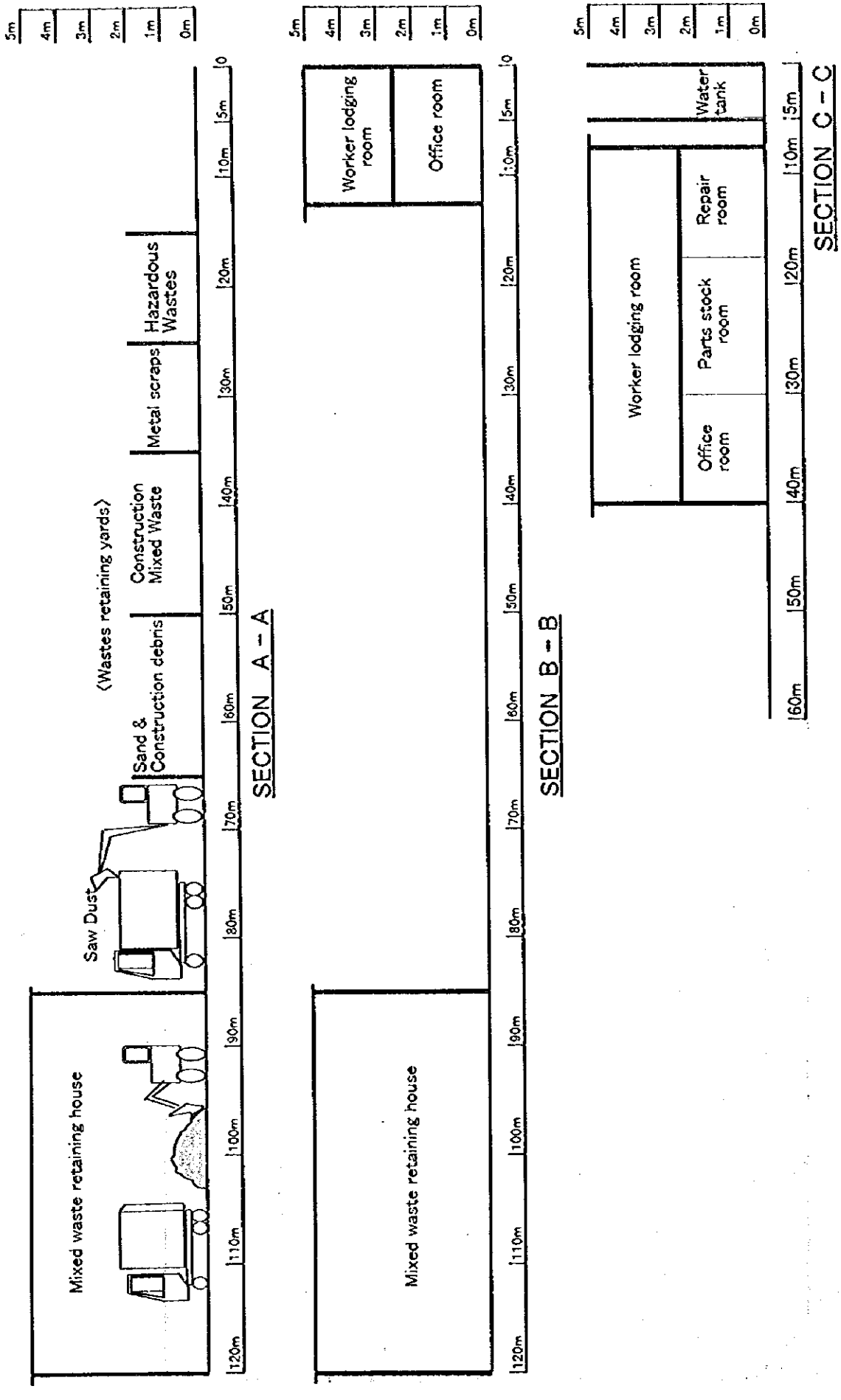


SECTION C – C

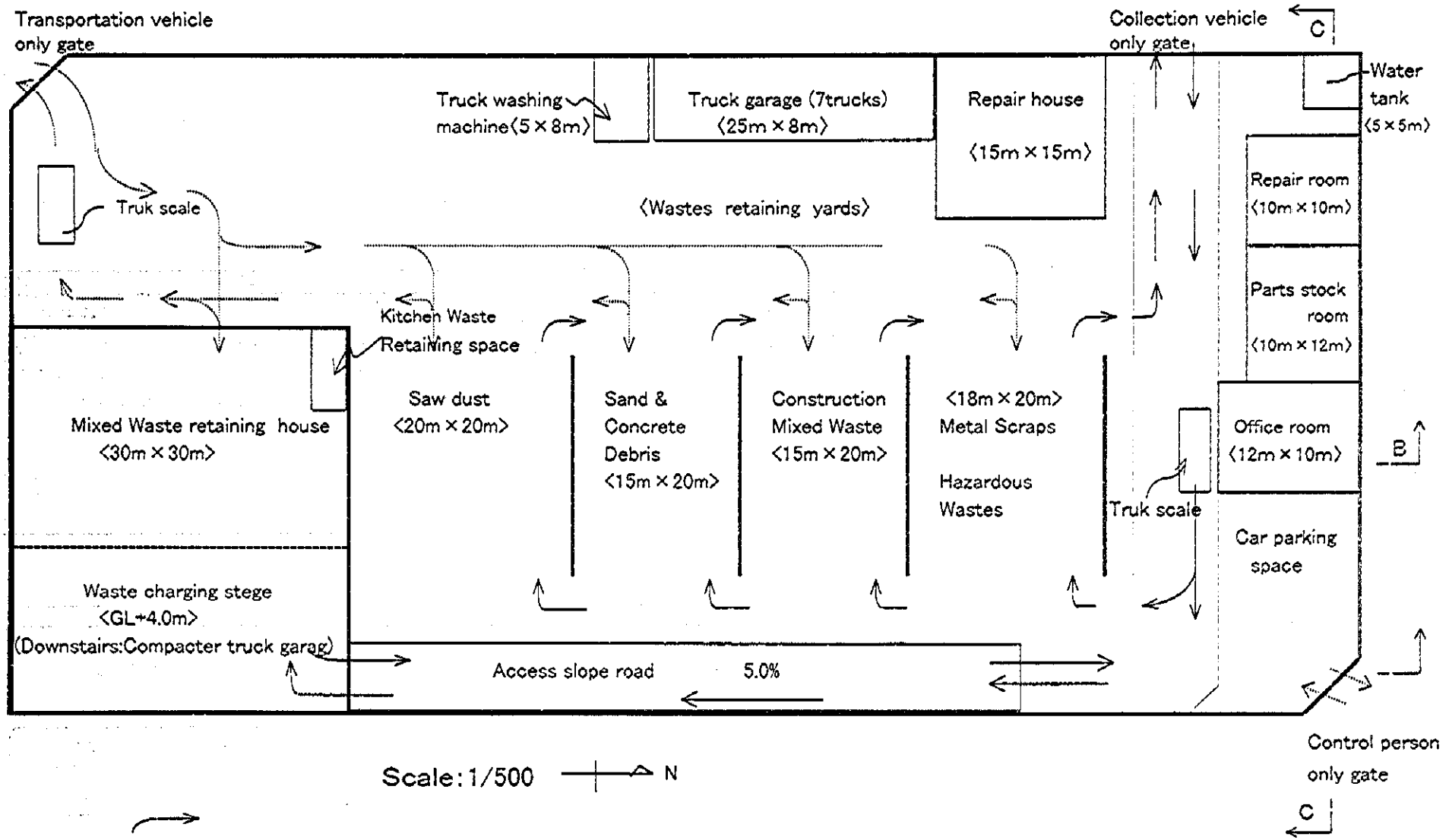
Plan 1. TRANSFER STATION CROSS SECTION



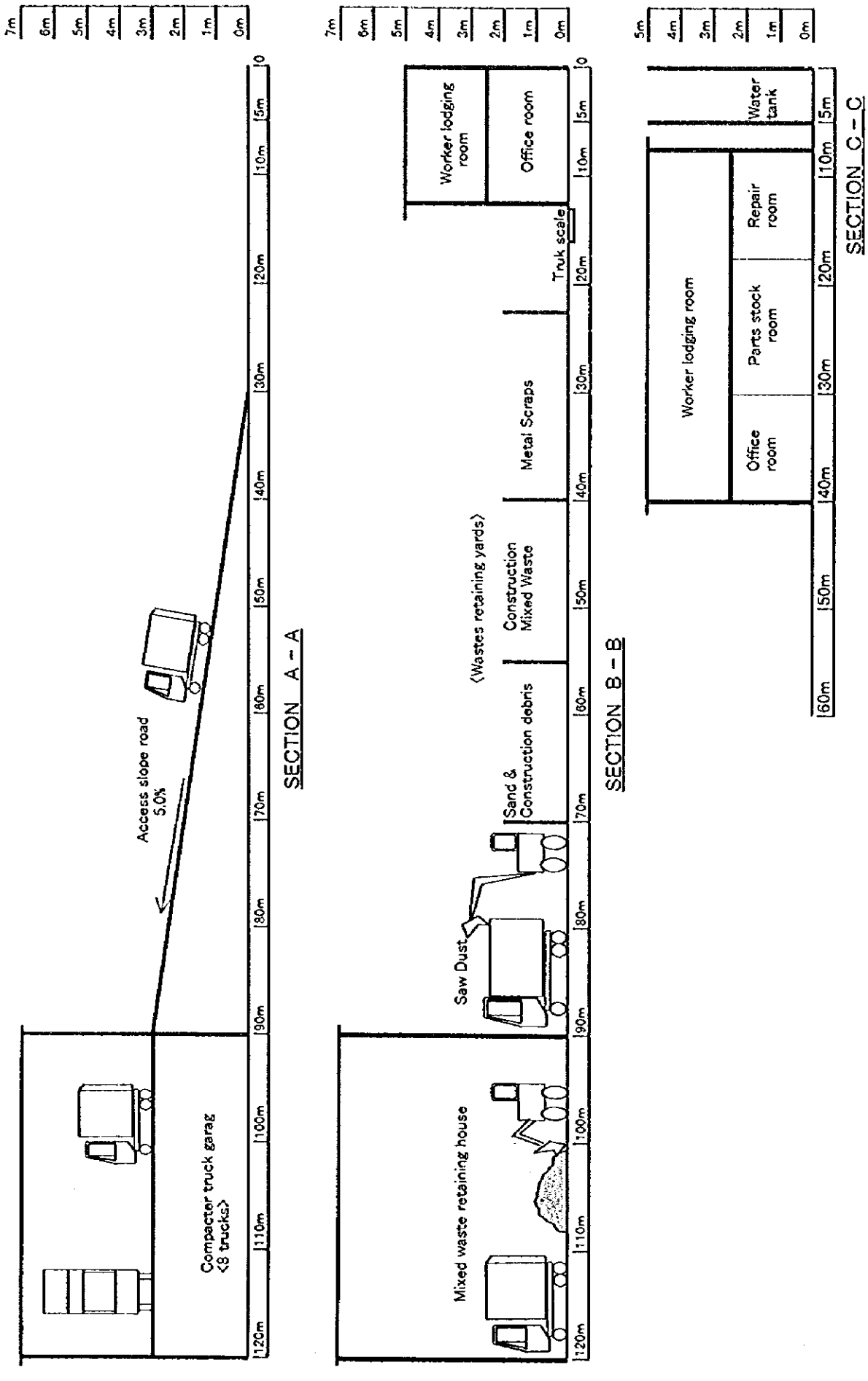
Plan 2. TRANSFER STATION PLAN (200ft×400ft)



Plan 2. TRANSFER STATION CROSS SECTION



Plan 3. TRANSFER STATION PLAN (200ft×400ft)



Plan 3. TRANSFER STATION CROSS SECTION

D. New Landfill Site in Thilafushi

The Development Plan of New Thilafushi (Alternative 3)

As explained in the Main Report, 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. Assuming that the following development plan, which consists of the shore protection of the previous landfill site and new landfill project, will be started at the end of 2001, the layout of the development plan is shown in the attached figure.

The development plan is described as below.

(1) The Protection of the Previous Landfill Site (Thilafushi-2)

The landfill by G.O.M before the Project starts is proceeded from 1999 to 2001, which the total volume of the solid waste is estimated as approximately 207,000 m^3 to be filled. The filling height is also requested up to E.L. +4.0 m with 2 layers based on the same method for the previous filling mentioned in the Main Report. The area for the filling shall be requested as approximately 60,000 m^2. The prevention of the leachate by the landfilling and the silt protection for the excavation is effective only before landfilling. Therefore, only the shore protection for the previous landfill site is incorporated in the Project. The structure of shore protection for the previous landfill site is recommended as same as the shore protection for existing Thilafushi Island indicated in Main Report.

(2) New Landfill Project (Thilafushi-3)

The new landfill site is expected to be filled with the solid waste for 4 years (2002 to 2005) based on the project scale, the volume of which is estimated as approximately 360,000 m^3. The required elevation of landfilling is also up to E.L. +4.0m with 2 layers. The area to be filled is calculated as approximately 95,000 m^2 and the structure of the seawall should be same as new landfill site mentioned in the Main Report.

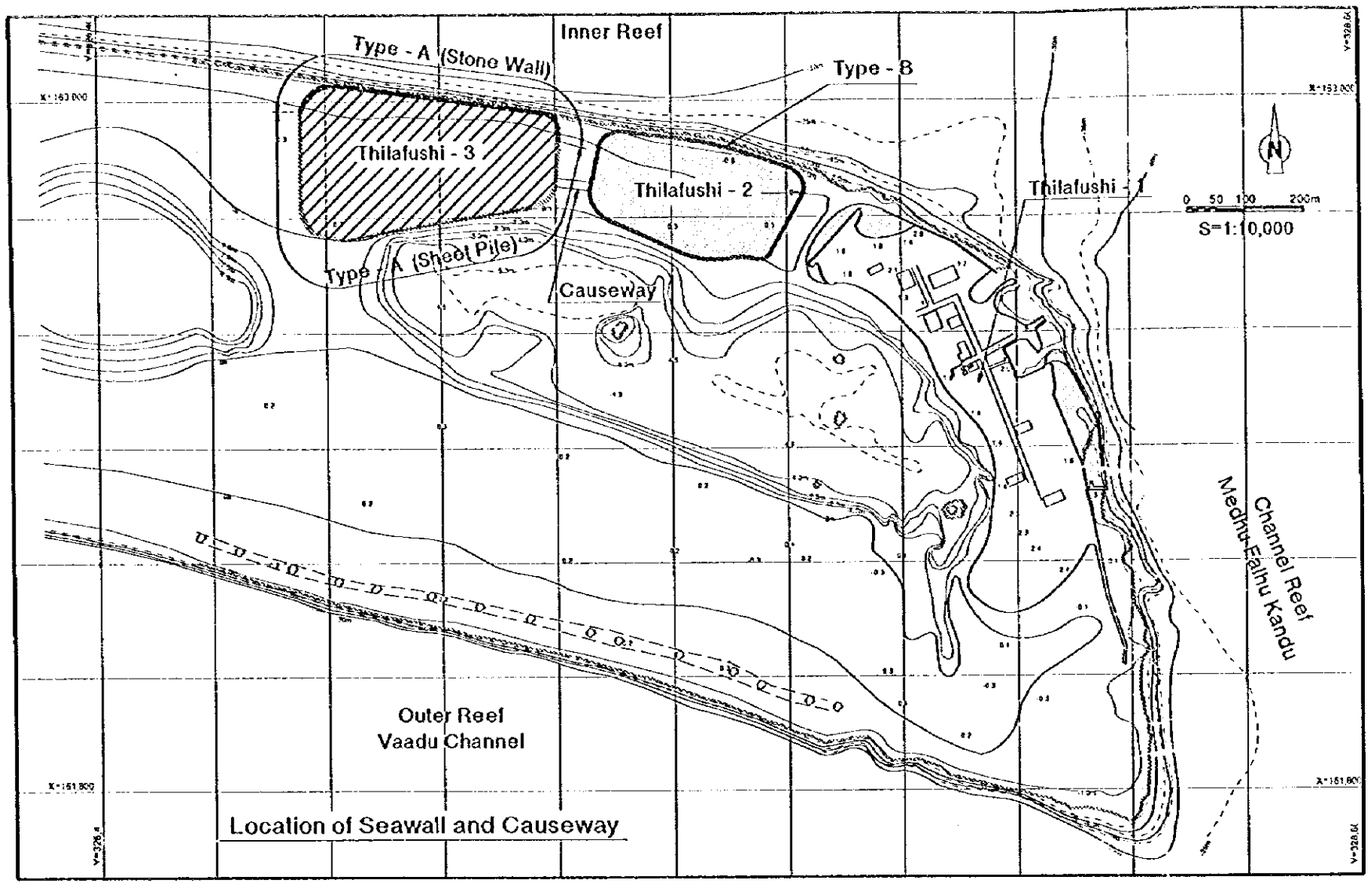
(3) Cost Estimates

The summary of cost for the development plan is shown in the following table.

Table: Summary of Cost for the Development Plan

Previous Landfill Site (Thilafushi 2)	26,232,000 Rf
New Landfill Site (Thilafushi 3)	90,852,000 Rf
Total	117,084,000 Rf

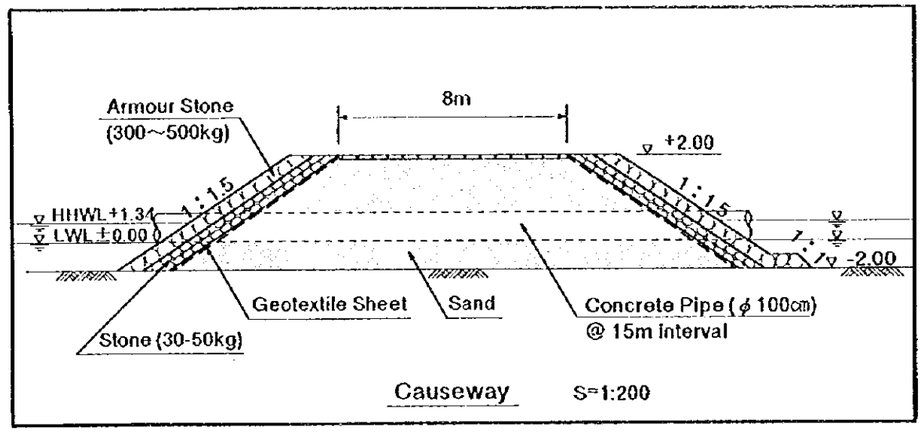
The breakdown of project cost is shown in the attached tables.



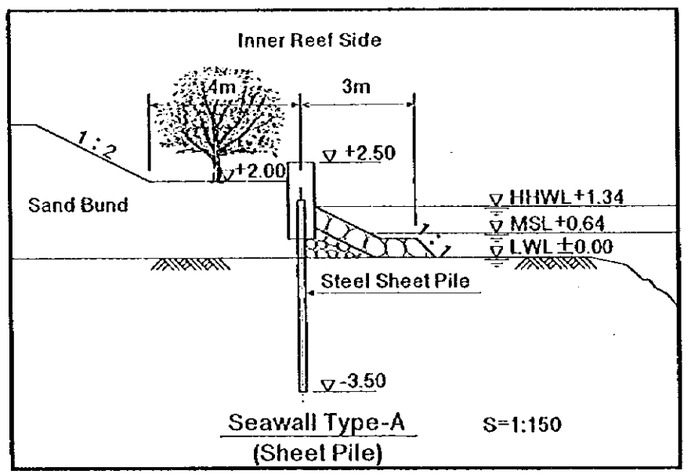
Location of Seawall and Causeway

Length of the Proposed Structure (m)

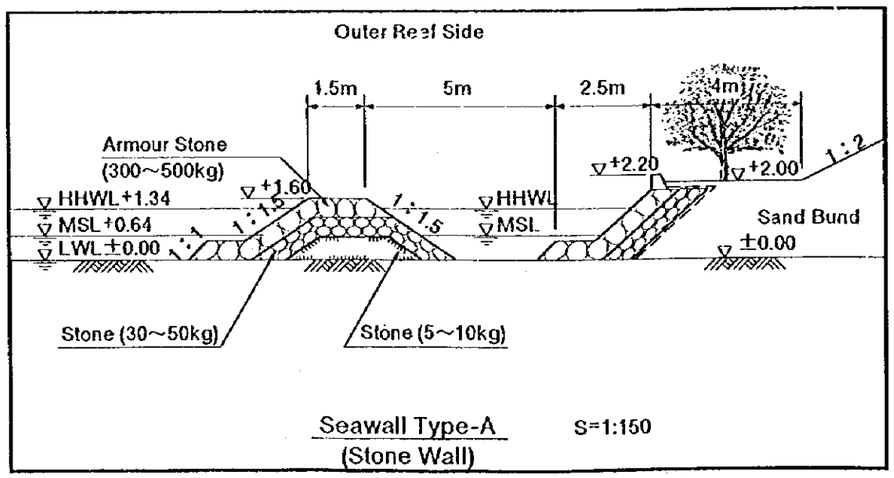
Location	Type-A		Type-B	Causeway
	Stone wall	Sheet Pile		
Thilafushi-2	—	—	1,000	—
Thilafushi-3	500	800	—	50
Total	500	800	1,000	50



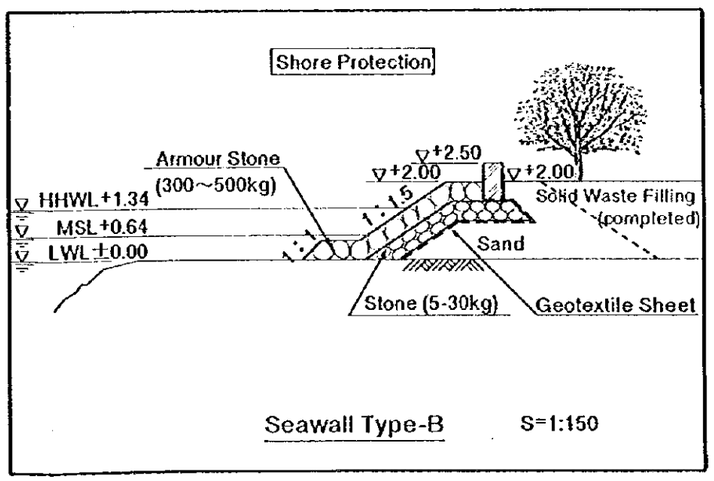
Causeway S=1:200



Seawall Type-A (Sheet Pile) S=1:150



Seawall Type-A (Stone Wall) S=1:150



Seawall Type-B S=1:150

Fig. Development Plan of Final Disposal Site (Alternative 3)

Construction Cost in Alternative 3 for Thilafushi(2)
(Imported Rock Protection System)

Unit: 1,000Rf

Description	Unit	Quantity	Unit Price	Amount	Remarks
1 Direct Construction Work				19,931	
(1) Seawall					
1) Armor Stone	m	1,000	8,356	8,356	2.4 m^3/m
2) Rubble Stone	m	1,000	6,341	6,341	2.05 m^3/m
3) Insitu Concrete	m	1,000	2,649	2,649	0.5 m^3/m
4) Filter Sheet	m^2	6,500	293	1,905	6.5 m^2/m
5) Filling/Backfilling	m	1,000	680	680	6.5 m^3/m
2 Direct Temporary Work					
(1) Temporary Road for Construction					
1) Road	m	1,000	94	94	Grading 8 m^2/m
Total Direct Cost				20,025	
Indirect Construction Cost					
(1) Common Temporary Work	%	10	D.C	2,002	
(2) Site Expenses	%	13	D.C	2,603	
(3) Overhead	%	8	D.C	1,602	
Total Indirect Cost				6,208	
Total Construction Cost				26,232	

Construction Cost In Alternative 3 for Thilafushi(3)
(Development for 2005)

Unit: 1,000Rf

Description	Unit	Quantity	Unit Price	Amount	Remarks
Direct Construction Work in New Thirafushi					
1 Direct Construction Work (New Area)					
(1) Breakwater					(Seabed Level=0.0 m)
1) Rubble Stone (5~10kg)	m	500	4,981	2,491	1.61 m^3/m
2) Protection Stone (30~50kg)	m	500	7,606	3,803	2.46 m^3/m
3) Armor Stone (300~500kg)	m	500	8,942	4,471	2.57 m^3/m
(2) Revetment for Waste					(Seabed Level= -0.5 m)
1) Steel Sheet Pile (FSP3H)	m	800	13,056	10,445	4.5 m × 2.5 pcs
2) Coping Concrete	m	800	7,525	6,020	1.4 m^3/m
3) Reinforcing Steel	t	28	17,650	494	35 kg/m
4) Armor Stone (100~300kg)	m	800	9,275	7,420	3 m^3/m
(3) Protection for Waste					(Seabed Level=0.0 m)
1) Rubble Stone	m	540	4,641	2,506	1.5 m^3/m
2) Armor Stone	m	540	4,019	2,170	1.3 m^3/m
3) Concrete Revetment	m	540	1,055	570	0.2 m^3/m
4) Filter sheet	m^2	2,160	293	633	4 m^2/m
(4) Providing of PVC Pipe (D=200)	set	400	1,289	516	set/225 m^2
Sub-Total				41,538	
(1) Quay Wall for Dhonni					
1) Base Gravel (5~10kg)	m	50	141	7	1.0 m^3/m
2) Concrete Block	m	50	41,922	2,096	7.3 m^3/m
3) Insitu Concrete	m	50	4,114	206	0.78 m^3/m
4) Filter Sheet	m^2	500	293	147	10 m^2/m
5) Backfill Stone (5~10kg)	m	50	19,127	956	6.8 m^3/m
(2) Work Shop & Garage					
1) Soil Replacing	m^3	1,000	199	199	
2) Pavement	m^2	600	1,934	1,160	0.25 /m^2
3) Work Shop Building	m^2	375	4,102	1,538	
4) Utilities	L.S	1	58,600	59	
(3) Quay Wall for Ferry					
1) Base Gravel (5~10kg)	m	15	140	2	1.0 m^3/m
2) Concrete Block	m	15	41,922	629	7.3 m^3/m
3) Insitu Concrete	m	15	4,114	62	0.78 m^3/m
4) Filter Sheet	m^2	150	293	44	10 m^2/m
5) Backfill Stone (5~10kg)	m	15	19,127	287	6.8 m^3/m
6) Pavement	m^2	100	1934	193	
(4) Compost yard					
1) Pavement	m^2	420	1,934	812	
2) Roof Work	m^2	200	1,113	223	
3) Brick Wall	m^2	64	762	49	
(5) Stock Yard					
1) Wall	m	32	762	24	
2) Pavement	m^2	60	1,934	116	
(6) Battery Box	L.S	1	23,440	23	
(7) Causeway					
1) Concrete Pipe (D=1,000)	m	73	3,282	240	24.3 m × 3 sets
2) Road Filling	m^3	2,800	199	557	56 m^3/m
3) Filter Sheet	m^2	750	293	220	15 m^2/m
4) Protection Stone (30~50kg)	m^3	360	3,094	1,114	7.2 m^3/m×50 m
5) Armor Stone (300~500kg)	m^3	365	3,094	1,129	7.7 m^3/m×50 m
(8) Excavation	m^3	50,000	199	9,950	
Sub-Total				22,042	
2 Direct Temporary Work					
(1) Temporary Jetty for Construction	L.S	1	1,992,400	1,992	
(2) Temporary Road for Construction					
1) New Landfilling area	m	2,000	1,735	3,470	16.5 m^3/m
(3) Silt Protection	m	40	5,500	220	
1) Placing	Time	100	900	90	
Sub-Total				5,772	
Total Direct Cost				69,353	
Indirect Construction Cost					
(1) Common Temporary Work	%	10	D.C	6,935	
(2) Site Expenses	%	13	D.C	9,016	
(3) Overhead	%	8	D.C	5,548	
Total Indirect Cost				21,499	
Total Construction Cost				90,852	

Reference for the Model Test with Impermeable Steel Sheet Piles

(1) Objective of Model Test

The purpose of this model test is to verify the impermeable effects by adopting the steel sheet pile to the retaining wall for the final disposal site.

(2) Method of Model Test

The concept of this model is shown in the following figure (Scale: 1/20) and the following conditions are applied.

The difference of water head between the final disposal site (described as A in the figure) and the open sea (described as B in the figure) is set 1 m.

After poring water with ink into "A", the observation is carried out at regular intervals.

With above conditions, the model test is carried out for two cases, which are the model without sheet pile under ±0.0 m (Model No.1) and the model with sheet pile installed to –3.5 m (Model No.2).

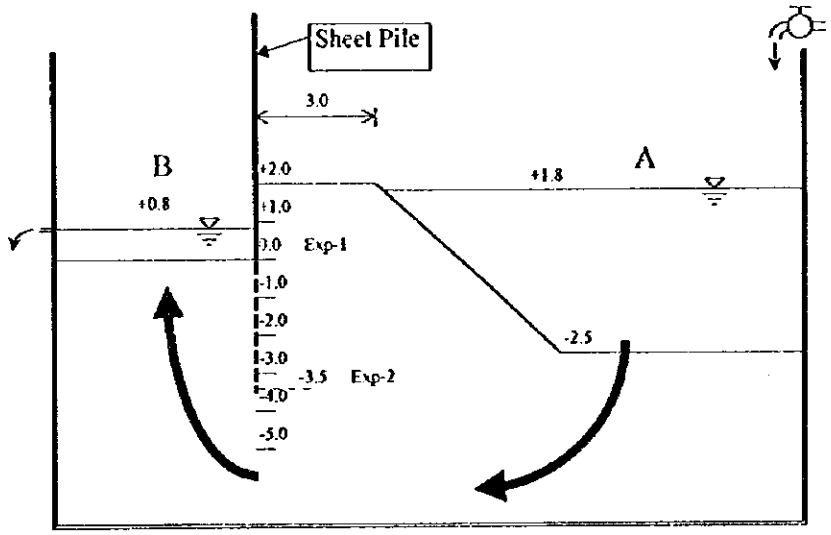


Fig. Concept of Model

*: The difference of water head between the final disposal site and the open sea is set 1 m since it is considered that mean maximum range of the tide during the spring tides is 0.8 m and the maximum rainfall is 200 mm/6hrs.

(3) Method of Evaluation of Model Test

1) According to the measurement of ground water level and tidal level in Thilafushi, the period was verified that the ground water level is higher than the tidal level in a day. Since the ground water level is changed same as of the tidal level and there are two times for the ebb and flow, the cycle of the ebb and flow of ground water level is estimated as 12 hours as well as of the tidal level. Therefore, the ground water level in Thilafushi is higher than the

tidal level for about 6 hours in a day.

2) Since the sand on the spot is utilized for the model test, the particle size of sand is not different by scales and the coefficient of permieability is not different as well. The unit of coefficient of permieability is [cm/sec] so 1 hour as real time is 3 minutes for this model test. (60 min/hour ÷ 20 = 3 min/hour)

With considering above two points, if the time that the inked water of A is exuded to B is more than 18 minutes (6 hour × 3 min/hour = 18 min), the impermeable effects are judged.

(4) Result of Model Test

1) Model Test of Case without Steel Sheet Pile
As the experiment No.1 is shown in photos A①~A⑥, the inked water of A is exuded to B after 13 minutes of the starting time of experiment.

2) Model Test of Case with Sheet Pile installed up to –3.5 m
As the experiment No.2 is shown in photos B①~B④, the inked water of A is exuded to B after 50 minutes of the starting time of experiment.

3) Result of Model Test
As mentioned above, it is mentioned that leachate will be exuded to the open sea by the ebb and flow without steel sheet pile and expected fully the impermeable effects with steel sheet pile.

Impermeable Wall Model Test Photograph (Wall installed E.L 0.0 m)

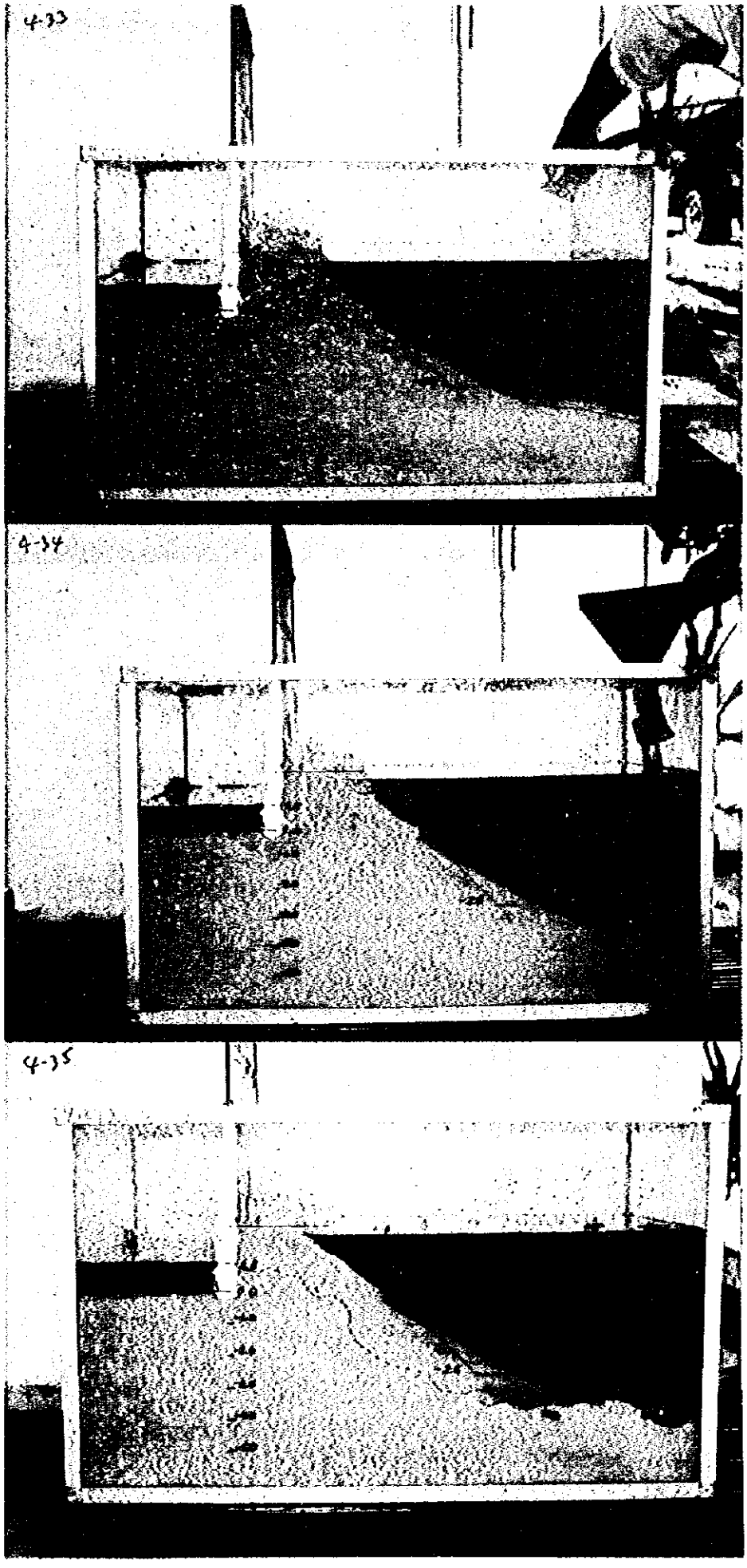
A ①

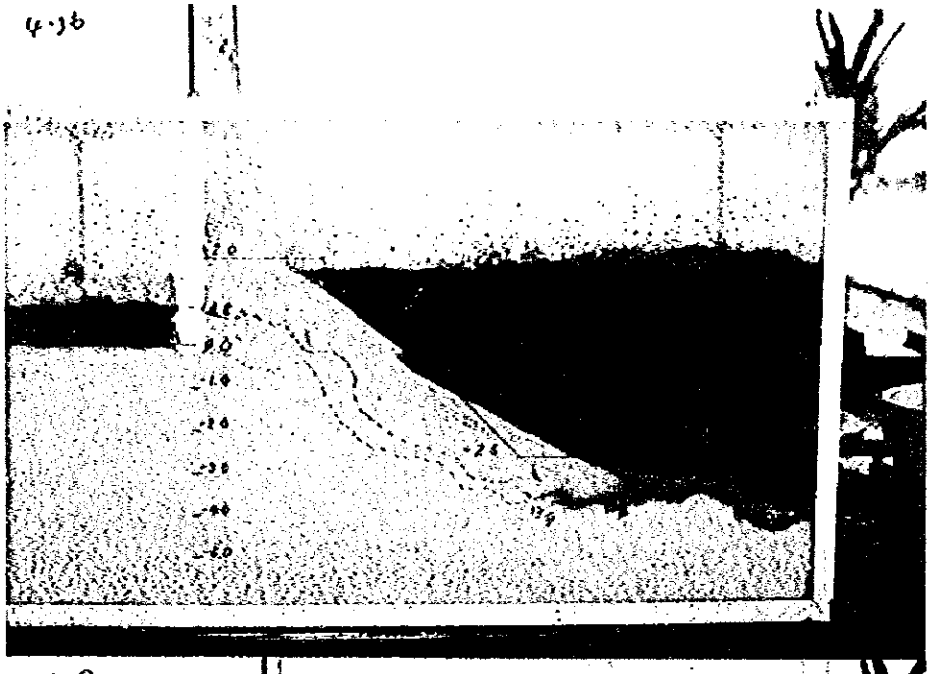
A ②

Start

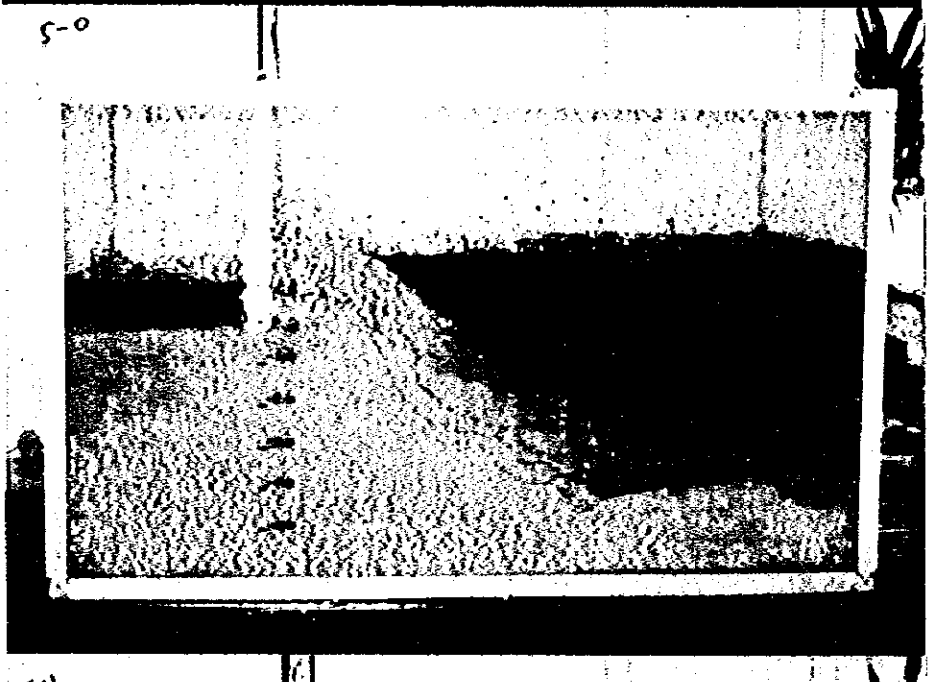
A ③

10 minutes

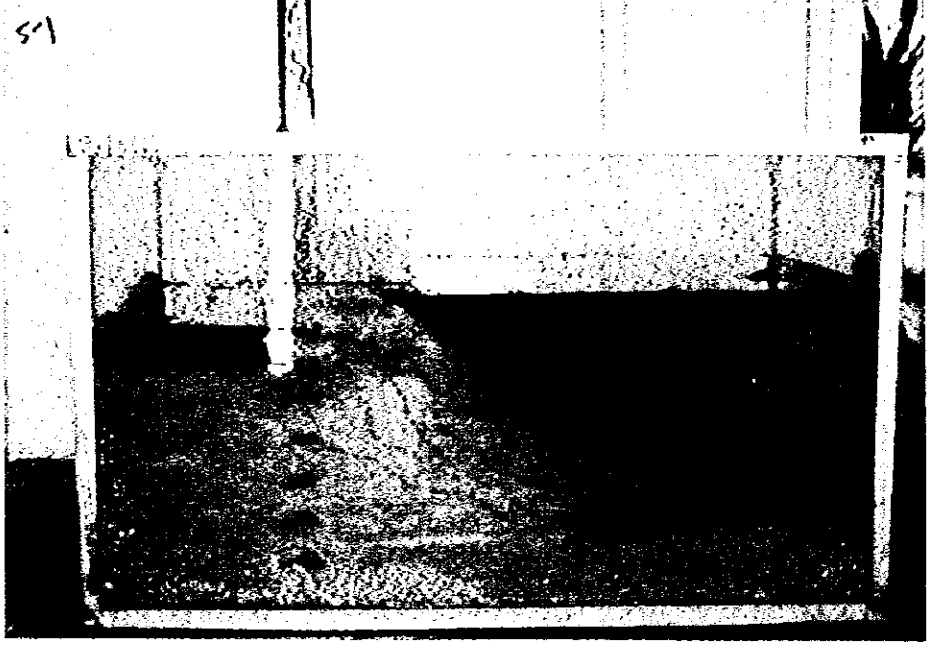




Λ ④ 13 minutes reached out



Λ ⑤ 20 minutes



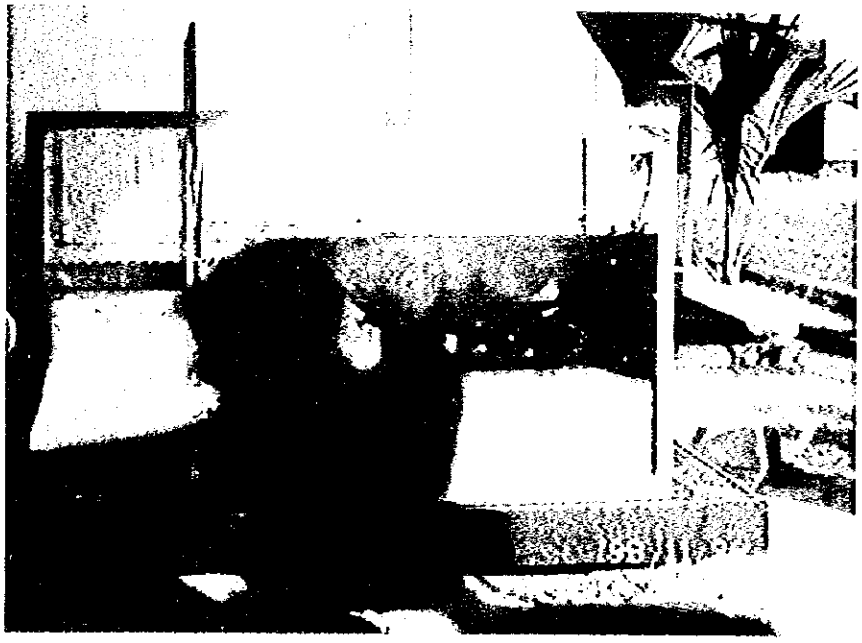
Λ ⑥ 30 minutes

Impermeable Wall Model Test Photograph (Wall installed E.L. -3.5 m)

B ①

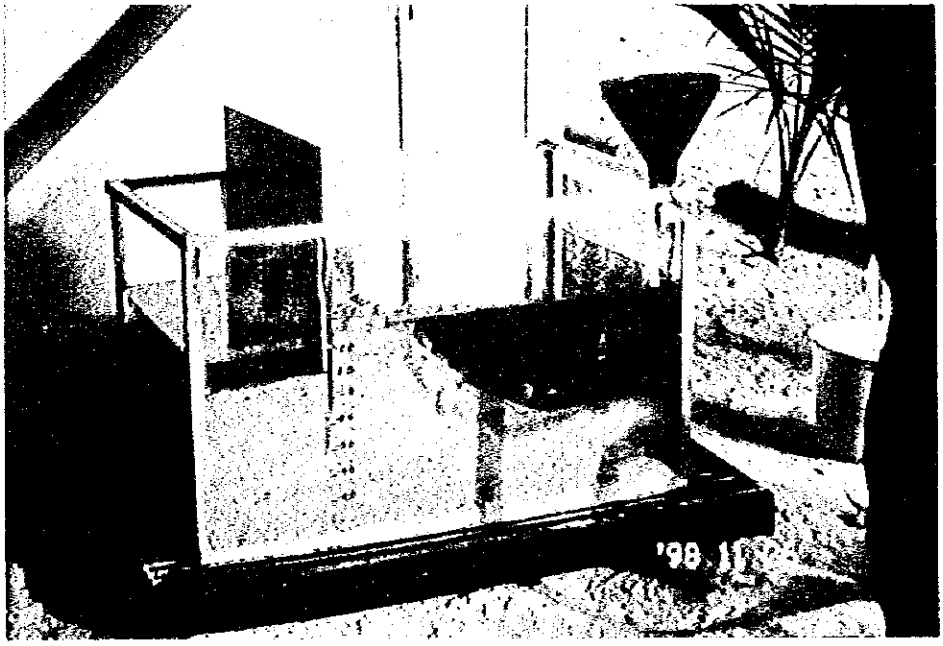
Start

B ②



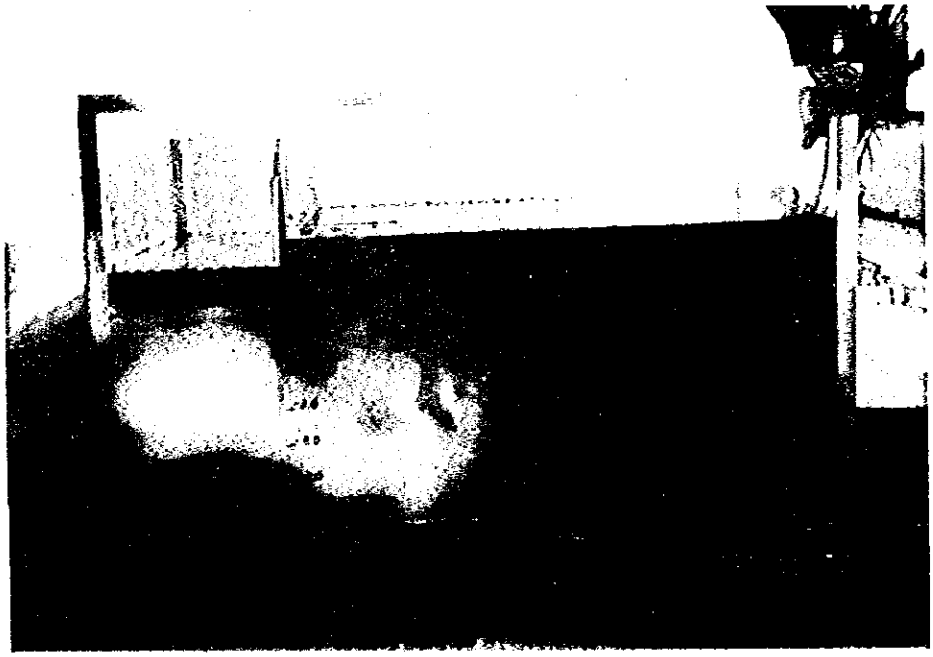
10 minutes

B ③



30 minutes

B ④



50 minutes
reached out