

c. Commercial waste

Based on the result of the WACS and CCS, the generation and discharge of commercial wastes (shop waste) is estimated and shown in Fig.4.2-3. The bases of the estimation are described in F. 1 of Appendix F, Supporting Report (1).

d. Other generation sources

According to the interview conducted with the persons concerned in other generation sources, the recycling amount of these sources is neglected. Consequently, the generation ratios of the above-mentioned sources is considered as similar to the discharge ratios.

Based on the results of the WACS conducted in November 1991, the generation and discharge ratios of the following generation sources are estimated as follows:

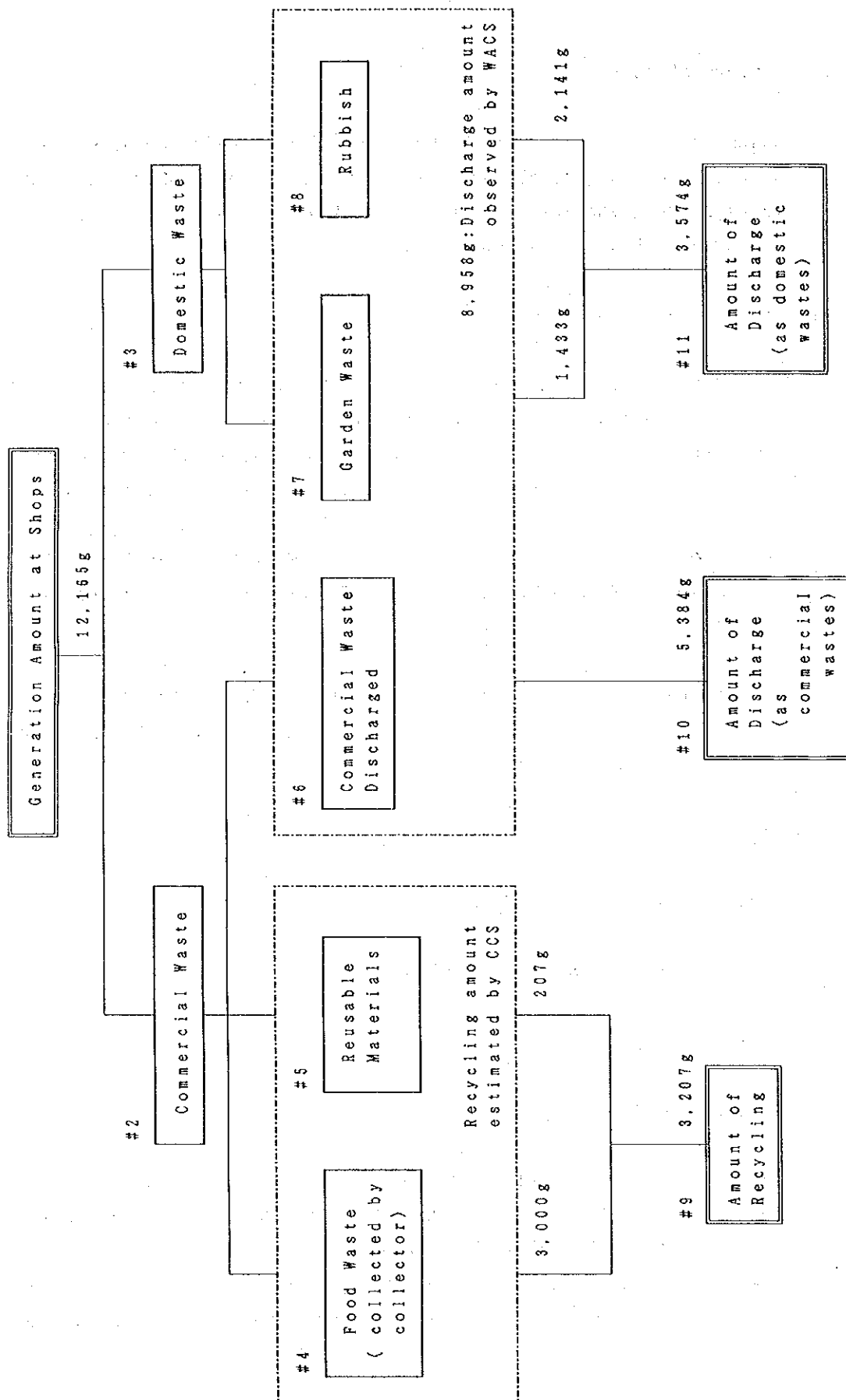
- i. market ; 1,300 g/d/shop (The figure includes daily shops which do not have permanent space in the market)
- ii. office ; 30 g/d/employee
- iii. hospital ; 960 g/d/bed
- iv. road sweeping ; 58,000 g/d/km

3) Service Coverage

a. Actual amount of hauled wastes

At first, the amount of waste hauled to the KM 18-DS was estimated based on the WACS and CCS. The actual amount of waste hauled was observed from November 15th to the end of January 1992 by using the weighbridge installed at the KM 18-DS by the Study Team. Accordingly, a great difference was found between the maximum and

#1



Note:

* Figures indicate amount of waste per day per shop.

Fig. 4.2-3 Generation and Discharge of Commercial Waste in the Collection Area

minimum amount of hauled wastes, as the former indicated 39.36 tons and the latter 3.04, tons showing an average of 17.40 tons. The average number of incoming vehicles was about 8.5 units/day.

Consequently, the estimated amount of waste collected in accordance with the classification was revised, as shown in Table 4.2-1, based on the following;

- i. The estimated amount of institutional, road sweeping and direct hauled wastes to the KM 18-DS could not be changed.
- ii. Then, the collection amount for domestic and commercial wastes was modified in accordance with each ratio of hauled amount.
- iii. The collection amount of domestic and commercial wastes is equivalent to the same amount hauled.

Table 4.2-1 Modification of Hauled Waste Amount

(Unit: ton/day)

Classification of Waste Hauled to KM 18-DS	Hauled Waste Amount Estimated from WACS and CCS	Actual Amount of Hauled Waste
Domestic wastes	<u>17.0</u>	<u>4.3</u>
Commercial wastes	<u>11.7</u>	<u>3.0</u>
Market wastes	4.1	4.1
Office wastes	0.8	0.8
Hospital wastes	0.8	0.8
Road sweeping wastes	0.9	0.9
Directly hauled wastes	3.5	3.5
Total	<u>38.8</u>	<u>17.4</u>

b. Service Coverage; Population

According to the CCS, about 19% of the residents interviewed was covered by collection services.

On the other hand, the actual amount of wastes hauled to the KM 18-DS observed for about two and half months from 15th November to end of January, 1992 indicates that the coverage ratio should be less than 19%, because the actual amount of hauled wastes is 13.9 tons/day while the estimated amount of collected wastes based on the CCS is 35.3 tons/day. The difference between the actual and estimated amount of collected wastes, therefore, is due to the error of the CCS regarding the collection service coverage both in the residential and commercial areas.

Consequently, the population covered by the collection services is about 6,850, an amount equivalent to about 4.8% of the whole population (142,723) of the Study area.

c. Service coverage; Shops

According to the CCS, 87% of the shops in the Study area receive collection services. As described in the former paragraphs, the 87% ratio should be revised to 22.3% in order to coincide with the actual collected amount. Since there are no available data on the number of shops in the Study area, the number of shops in all commercial areas in Vientiane urban area was surveyed and counted by the Study Team. The results of the survey indicate a total of 2,500 shops in the Study area. The number of shops covered by the collection service is estimated at 560.

d. Service coverage; Markets

With the exclusion of temporary and negligible markets, most of the markets in the Study area receive collection services. The total number of the shops, including daily shops which do not have permanent spaces in the market, is 4,000 and the number of shops covered by the collection service is 3,160, because Thong Khan Kham market collects and transports their own waste.

e. Service coverage; Government offices

Almost all of the government offices in the Study area are covered by collection services. Total number of government employees is about 26,700.

f. Service coverage; Hospitals

The number of large hospitals and their beds in the Study area is 5 hospitals and 1,310 beds, respectively based on the answers in the questionnaires distributed to the hospitals surveyed by the Study Team. Among these, the Military Hospital 103 does not receive collection services and disposes their waste by themselves by means of landfill and burning within the compound. Consequently, 66% of the beds in the hospitals are covered by the collection service.

g. Service coverage; Road

Total length of the road which receives road sweeping services is 15 km. This is equivalent to 24.3 % of the total length of the permanently paved road in the Study area.

4) Waste Stream

The present waste stream in the Study area is estimated by the Study Team and illustrated in Fig. 4.2-4.

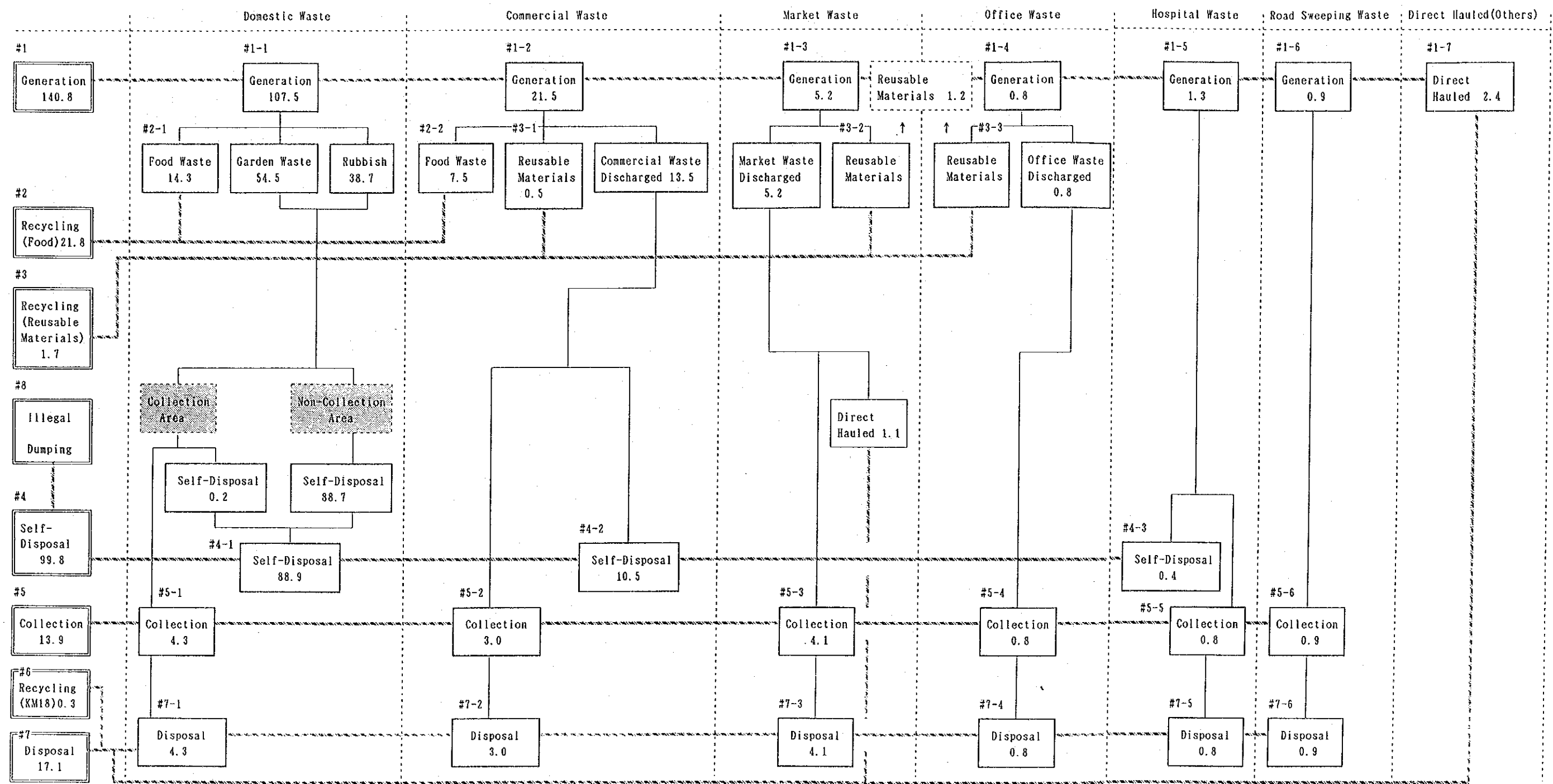


Fig. 4.2-4 Present Waste Stream in The Study Area (Unit: Ton/Day)

a. Amount of Generation (#1)

According to the calculation shown below, the total generation of waste in the Study area is 140.8 t/d.

- domestic wastes (#1-1)	142,723 per.	x	753 g/d	=	107.5 t/d.
- commercial wastes (#1-2)	2,500 shops	x	8,591 g/d	=	21.5 t/d.
- market wastes (#1-3)	4,000 shops	x	1,300 g/d	=	5.2 t/d.
- office wastes (#1-4)	26,700 emp.	x	30 g/d	=	0.8 t/d.
- hospital wastes (#1-5)	1,310 beds	x	960 g/d	=	1.3 t/d.
- road sweeping wastes (#1-6)	15 km	x	58,000 g/d	=	0.9 t/d.
- unclassifiable reusable materials					1.2 t/d.
- directly hauled wastes (#1-7)					2.4 t/d.

Total	140.8 t/d.
-------	------------

b. Amount of recycled food waste at generation sources (#2)

As shown in the following calculation, the amount of recycled food waste at the generation sources is estimated at 21.8 t/d.

- Food waste recycled at residences (#2-1)	
142,723 per.	x 100 g/d = 14.3 t/d.
- Food waste recycled from shops (#2-2)	
2,500 shops	x 3,000 g = 7.5 t/d.

Total	21.8 t/d.
-------	-----------

c. Amount of recycled reusable materials

Based on the surveys of private recyclers and the CCS, the total recycled amount of reusable materials at the generation sources is estimated at 1.7 t/d as shown below.

- reusable materials recycled from shops (#3-1)	
2,500 shops x 207 g	= 0.5 t/d
- unclassifiable reusable materials (#3-2, #3-3)	= 1.2 t/d
<hr/>	
Total	1.7 t/d
<hr/>	

d. Amount of self-disposed wastes (#4)

The total amount of self-disposed wastes is calculated at 99.8 t/d as follows:

i. self-disposed waste at residences (#4-1)	<u>88.9 t/d</u>
- self-disposed waste at residences covered by collection services	
(142,723 per. x 0.048 x 27 g/d)	= 0.2 t/d)
- self-disposed waste at residences uncovered by collection services	
(142,723 per. x 0.952 x 653 g/d)	= 88.7 t/d)
ii. self-disposed waste at shops (#4-2)	
2,500 shops x 0.777 x 5,384 g/d	= <u>10.5 t/d</u>
iii. self-disposed waste at hospitals (#4-3)	
450 beds x 960 g/d	= <u>0.4 t/d</u>
<hr/>	
Total	99.8 t/d
<hr/>	

c. Amount of collected waste (#5)

As shown in the following calculation, the total amount of collected wastes is 13.9 t/d.

- collected waste from residential area (#5-1)	
142,723 per. x 0.048 x 626 g/d	= 4.3 t/d
- collected waste from commercial area (#5-2)	
2,500 shops x 0.223 x 5,384 g/d	= 3.0 t/d
- collected waste from markets (#5-3)	
3,160 shops x 1,300 g/d	= 4.1 t/d
- collected waste from offices (#5-4)	
26,700 emp. x 30 g/d	= 0.8 t/d
- collected waste from hospitals (#5-5)	
860 beds x 960 g/d	= 0.9 t/d
- collected waste by the road sweeping services (#5-6)	
15 km x 58,000 g/d	= 0.9 t/d
<hr/>	
Total	13.9 t/d
<hr/>	

f. Amount of recycling at KM 18-DS

Total amount of recycling at the KM 18-DS is estimated at 0.3 t/d according to the survey on scavengers.

g. Amount of disposed waste at KM 18-DS

The total amount of waste disposed at the KM 18-DS is calculated at 17.1 t/d as follows:

- amount of collected wastes (#5)	13.9 t/d
- amount of directly hauled wastes	3.5 t/d
- amount of recycling at Km 18-DS	- 0.3 t/d

Total	17.1 t/d
-------	----------

h. Amount of illegal dumped waste (#8)

It is difficult to get the amount of illegally dumped wastes. As far as the survey done by the Study Team is concerned, the amount could not be estimated. It shall be included, therefore, in the amount of self-disposed waste.

4.3 Collection and Haulage

1) Discharge and Storage

Present discharge and storage system in the Study area is summarized in Table 4.3-1.

a. Source separation

The source separation at the residential and commercial area is well established and organized. The waste generated in the area is segregated into the following:

- i. waste to be discharged;
- ii. food waste as domestic animal' feed;
- iii. reusable materials for recycling; and
- iv. waste for self-disposal.

Table 4.3-1 Present Discharge and Storage System

Generation Sources		Source Separation	Type of Refuse Bins	Storage & Discharge Points
Residential Area	Collection Area	Separate discharge (Food waste is separated as food for animals.)	Bamboo basket	Premise or its surroundings
	Non-Collection Area	Separate discharge (Food waste is separated as food for animals.)	-	Self disposal at premise or its surroundings
Commercial Area	Collection Area	Separate discharge (Food waste is separated as food for animals.)	Bamboo basket	Premise or its surroundings
	Non-Collection Area	Separate discharge (Food waste is separated as food for animals.)	-	Self disposal at premise or its surroundings
Market		Mixed discharge	Open heap (That Luang market has concrete wall for stock yard.)	Premise
Office		Mixed discharge	Open heap	Premise
Hospital		Mixed discharge (Infectious waste is discharge with other wastes.)	Mahosot : Trailer Sethathirat: Iron container Others : Open heap	Premise (A container is installed outside of the Sethathirat hospital.)
Road Sweeping		Mixed discharge	Open heap	Roadside

In contradiction to the above, the source separation is not established in markets, offices and hospitals. There is segregation at all. In addition, although dangerously infectious waste are segregated at the generation sources, they are discharged together with other wastes without being placed in any special container.

b. Type of refuse bins

A bamboo basket without a lid having 30 to 50 liters capacity is commonly used in residential and commercial areas for storage and as a discharge container. Although it seems to be unsanitary, it attracts few flies and scavenging animals because the waste composition includes less garbage. On the other hand, the scattering of waste around the bamboo basket and road-sides is a common occurrence. This is, however, mainly due to littering and partly due to the uncovered bamboo baskets.

As opposed to the above, generally, institutional wastes have no refuse bins or containers, and they are usually discharged into open heaps. However, wastes of institutions like That Luang Market, Mahosot and Setthathirat Hospitals are discharged into a concrete wall, a trailer, and an iron container, respectively. Due to the open heaps, wastes scatter in the surroundings and loading work becomes difficult, particularly the loading of hospital waste due to the mixture of infectious waste.

c. Storage and discharge points

Wastes in residential and commercial areas covered by collection services are discharged at the premises or its surroundings and then collected. On the other hand, in the non-collection area, waste is self-disposed at the premises or its surroundings, such as road-sides, mainly through open burning and landfilling.

Institutional wastes are also discharged at the premises. Some are self-disposed mainly through open burning and partly by landfilling.

3) Collection and Haulage

Present collection and haulage system in the Study area is summarized in Table 4.3-2.

a. Collection area

At present, waste collection services in the Study area are being carried out by DCTC and three private companies.

Due to the lack of data on the collection area covered by both DCTC and private companies, the study team traced the collection routes of all vehicles in order to know the present collection area. As a result, a map showing the present routes was prepared and is shown in Fig. 4.3-1. As shown in the figure, present collection service is conducted in accordance with the collection routes and residences, shops, offices, etc., along the route instead of collection area. The collection routes covers almost all of the main roads in the commercial area.

Consequently, it is concluded that the present collection service is mainly carried out in the commercial area. The collection area covered by DCTC and three private companies is described below:

- i. DCTC... Commercial area in Namphou Zone
Commercial area in Wattay Zone
Phone Xai Zone
Hal Mahosot Zone
- ii. Private-CRC... Commercial area in Namphou Zone
Pasak Zone

Table 4.3-2 Present Collection and Haulage System

Generation Sources	Survive Coverage(%)	Collection Frequency	Collection System	Collection Time	Collection Tools	Haulage Method	Transfer System
Residential Area	4.8%	Once a week	Curb and Door-to-door (A part of area is adopted bell collection system.)	Day Time	Bamboo basket and hoe	Dump truck Flat truck Trailer	Without transfer
Commercial Area	22.3%	Once a week (A part of commercial area receives collection service more than twice a week.)	Curb and Door-to-door (In a part of area bell collection system is adopted)	Day time	Bamboo basket and hoe	Ditto	Without transfer
Market	* 100%	Every day for Nong Chan, That Luang and Khan Kham Others: 1~3/week	Station	Day time or Evening	Bamboo basket and hoe	Ditto	Transfer from open heap
Office	100%	More than twice a week	Station	Day time	Bamboo basket	Ditto	Ditto
Hospital	66%	More than twice a week	Station	Day time	Bamboo basket and Hoe	Ditto	*** Ditto
Road Sweeping	**100%	Twice a week	Station	Day time	***	Ditto	Ditto

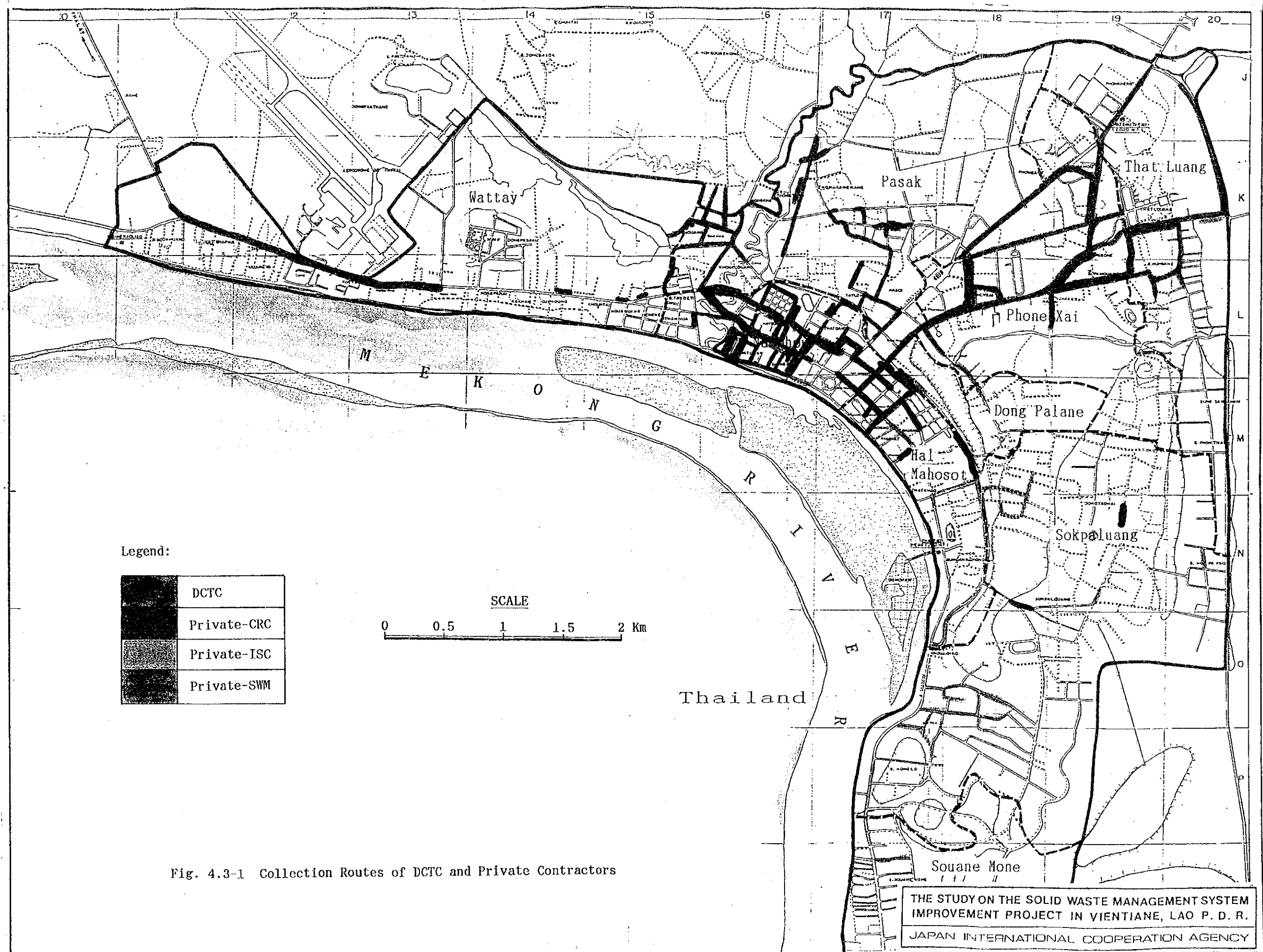
* In Thong Khan Kham market, collection and haulage of waste is managed by the market.

** The length of road sweeping is 15 Km.

*** Collection tools for road sweeping are bamboo basket, handcart, brooms, shovels, hatchets, rakes.

**** In Mahosot Hospital, a transfer system by trailer is adopted.

In Sethathirat Hospital, a transfer system from container is adopted.



iii. Private-ISC... Sokpaluang Zone
Hal Mahosot Zone

iv. Private-SWM... Phone Xai Zone
That Luang Zone

b. Amount of waste collected

The actual amount of waste collected has been observed from November 15th 1991 to the end of January 1992 by using the weigh-bridge installed at the KM 18-DS.

Based on the results obtained, the actual amount of waste collected by each sector is as follows:

- DCTC	:	6.1 ton/day (44%)
- Private Contractors	:	7.8 ton/day (56%)
. Private CRC	:	3.5 ton/day
. Private ISC	:	3.2 ton/day
. Private SWM	:	1.1 ton/day
- Total	:	13.9 ton/day (100%)

c. Service level

i. collection system

The major collection systems applied in the Vientiane urban area are curb and door to door collection system.

In addition to these systems, bell collection system is used in non-accessible commercial and residential areas due to poor road conditions.

ii. collection frequency

Collection is conducted once a week in most of the collection areas except for some parts in the commercial area and institutions, such as markets, offices and hospitals. The areas receiving more than twice a week collection services is, however, very limited.

iii. collection fee

There is no clear tariff on the collection fee of DCTC and the private companies. The collection fee is decided basically by negotiation in consideration of the amount of discharge and collection frequency.

Although the results of the CCS indicated that an average residence pays about 500 kips/month for collection services, the results of the interview to DCTC and three private contractors indicated a collection fee of about 1,000 kips/month for once a week collection services. The Study Team, therefore, concluded that the average collection fee for the average family in terms of family members would be about 1,000 kips/month for once a week collection. Further the collection fee of waste for irregular collection services is 200 kips per bamboo basket.

Most of residents and shop owners, except for some Bans, pay directly to the DCTC and private companies. According to DCTC, about 60% of fee is collected by bill collectors and the remaining 40% is remitted to the bank account of DCTC.

d. Collection Work

i. crew

A collection team with a collection vehicle is formed by 5 crew members, namely a driver and 4 collectors.

ii. loading work

The wastes in the residential and commercial area are directly collected and loaded into the vehicle. On the other hand, institutional wastes which are normally heaped make loading work difficult.

For example, according to the one week observation done by the Study Team at Nong Chanh and That Luang markets, the loading time for one ton of waste was about one hour.

iii. unloading work

Although there are no problems on the trucks with dumping devices, problems on passage due to bad access conditions and the arrangement of wastes dumped hinders the unloading work at the KM 18-DS.

On the other hand, trucks without a dumping device and two trailers, both of which belong to DCTC, required more than one hour for unloading.

e. Haulage

i. haulage method

Open dump trucks are commonly used for the collection and transportation of waste, except for a flat truck without a dumping device and two trailers. A trailer is installed at Mahosot Hospital and the other is connected to a truck.

ii. transfer system

There is no transfer system observed in the waste collection services in residential and commercial areas. As for institutional wastes, most of the wastes generated are primarily collected and heaped at the open station. Then, the collection team loads the heaped waste, except for the trailer used for Mahosot Hospital.

4.4 Road Sweeping, Drain Cleansing and Grass Cutting

1) Road Sweeping

a. Road sweeping length

Road sweeping service is carried out by the Cleansing Section of DCTC. The roads covered by sweeping service are limited to the main street of Vientiane urban area, and the total length of the road covered is 15 km.

Total road length in the Study area is 228.1 km and length of the pavement roads is 61.8 km. It is indicated that 24% of the paved roads in the Study area are covered by sweeping services.

b. Road sweeping system

A total of 18 labourers are in charge of the road sweeping work, of which 11 are female labourers and 12 over 50 years old.

In addition to the 18 labourers, there is a chief road sweeper.

A sweeper is responsible for about 1 km of roads and works 4 to 5 hours every day except Sunday. The tool used in sweeping works are handcarts, bamboo baskets, brooms, shovels, hatchets, rakes, etc.. These tools are kept by the labourers themselves.

Waste swept is heaped at several points of at the road-side without any container. The waste swept is collected and loaded into the collection vehicle about once three days by DCTC.

c. Wage

The average wage of a labour is about 18,000 kips per month.

2) Drain Cleansing

Drain cleansing service is not established in the Study area. However, the DCTC provides drain cleansing service when requested, including collection of waste from the drain, for a certain fee.

3) Grass Cutting

Grass cutting is carried out for the same roads as road sweeping is done by DCTC. Two labourers are assigned to do the work every day, except on Sundays, on a rotation basis.

As for the cleansing equipment, there are two hand-push type grass cutters (4 HP). The manual nature of the equipment limits the cutting place. Cut grass is heaped up by the road sweeper and collected by the collection vehicle like the wastes swept from the road.

4.5 Processing and Final Disposal

1) Processing

There is no processing facility except for an old, dilapidated and small chamber for incineration in Military's Hospital 103, which seems to have been unused for several years.

The construction of an incinerator in Ban That Luang Kang for all hospital waste was recommended in the "Report on disposal of Solid Wastes in Urban Vientiane" by UNDP. However, no action has been taken after the submission of the report in April 1989.

In addition, the site recommended by the report is a private paddy field which seems to be unsuitable for the incineration plant.

In case an incinerator for hospital waste is necessary, its construction is recommended in the Mahosot Hospital as sufficient space is available.

2) Final Disposal

a. General condition

Solid waste in the Study area is finally disposed at the landfill disposal site of Vientiane Municipality (KM 18-DS). Crude open dumping is adopted at the site, causing environmental problems as air pollution due to on-site fires, water pollution due to the seepage of leachate, and littering in the surrounding area. No sanitary landfill is conducted.

In order to improve the solid waste management in Lao P.D.R., a national level workshop was held in Vientiane in August 1990 under the auspices of the WHO. In the workshop, it was recommended that the Municipality of Vientiane, with the support from national government, should upgrade the current landfill practices by adopting more hygienic methods; i.e. to a sanitary landfill. However, no action has been taken since then.

b. KM 18 disposal Site

The present KM 18-DS (KM 18 disposal site) is located 18 km from the urban center. The KM 18-DS is outlined below.

- i. service area : entire Study area
- ii. disposal amount : 17.1 ton/day
- iii. subject solid waste : mostly municipal solid waste plus some types of industrial waste
- iv. site area : more than 60 ha
- v. landfill area : approximately 2.0 ha
- vi. year of commencement: 20 years ago
- vii. life expectancy : more than 30 years from 1991
- viii. former land use : bush and forest
- ix. future land use : undecided
- x. land owner : Vientiane Municipality

c. Management of Km 18-DS

i. organization

The KM 18-DS is under the management of the DCTC of Vientiane Municipality. No management, however, has been done other than the employment of a temporary overseer by a verbal contract, who mainly collects dumping fees from incoming vehicles. His remuneration per month is 15,000 kips. In the middle of November 1991, a weighbridge was installed by the Study Team and two operators were assigned by the DCTC for the inspection of the incoming vehicles.

ii. disposal site staff

- overseer : 1 person
- weighbridge operators : 2 persons

iii. working hours

6:00 am - 6:00 pm

iv. budget

A special budget for final disposal in 1991 was not prepared except for the wage for the overseer ; i.e., 180,000 kips per annum.

3) Illegal Dumping

a. Survey on illegal dumping

According to the "Report on Disposal of Solid Waste in Urban Vientiane" by the UNDP, many clandestine disposal sites were found in the Study area. Except for their locations, however, the actual conditions of these clandestine sites were not mentioned.

The Study Team carried out a field survey including interviews of area residents, to know the actual conditions of sites.

The illegal dumping sites are classified under the following 4 categories:

- dumps along the Mekong river;
- dumps along the Khoua Khao canal;
- dumps along the Nam Pasak canal;
- others.

b. Findings

- The main items illegally dumped are domestic waste and commercial waste according to volume.
- As a whole, a large volume of waste is illegally dumped in the Mekong, canals and drains, causing their frequent blockage and contamination of water quality.
- Illegal dumping is evident throughout the area, most especially in the Mekong river, canals, and vacant spaces along roads.
- The illegally dumped waste is mostly discharged by the area residents and the street stalls. Except for the small amount burned by the residents or collected by the DCTC, no other waste management measure is implemented.
- Illegal dumping is caused by lack of morals on the part of dumpers, loose enforcement of the regulation of 633/VMAC and defective collection services, etc.
- Suggested remedial measures include the implementation of public education, strict enforcement of regulation, and the extension of the appropriate collection services in areas uncovered by collection services.

4.6 Recycling

1) Recycling

a. Surveys on recycling

There has been no reliable and comprehensive study or report on recycling in the Municipality of Vientiane. In order to study the present situation of recycling in the Study area, the following various surveys carried out by the Study Team and the details of the results are described in Section 3.4.2 and 3.4.3.

- survey on scavengers
- survey on private recyclers
- interview survey of residents and shop owners on recycling

2) Recycling System

There are no facilities that will enable the mechanical or manual selection of reusable materials for recycling purposes in the Study area. The recovery of valuable items is mainly conducted by hand by both private recyclers and scavengers at the waste generation sources disposal sites.

Based on the above-mentioned studies and surveys, the present recycling system in the Study area became clear and is summarized in Table 4.6-1. As clearly described in the table, the principal recycled materials is food waste. Although food waste recycled in each household can be considered as a mode of self-disposal, it is defined as recycled waste in the Study.

The total amount of waste recycled is estimated at 23.8 tons/day. Since a self-sustaining system in the society or community still exists and is well organized, the existing recycling system is considered to be much more efficient than in the other countries.

Table 4.6-1 Present Recycling System in the Study Area

Items		Contents	Kinds of Recyclers	Purpose or End User	Recycled Amount (ton/day)	Information Source
Recycled Materials	Place of Salvaging or Collection					
<u>Food Waste</u>	1. Household	Family member		Feed for animal	14.3	CCS
	2. Shop	Food waste collector or farmer		Feed for live-stock	7.5	CCS
<u>Reusable Materials</u>	1. Household	-	-	-	negligible	CCS
	2. Shop	Individual collector		Factory	0.5	CCS
	3. KM 18-DS	Scavenger		Factory	0.3	Survey of scavengers
	4. Unclassifiable	Individual collector		Factory	1.2	Survey of dealers
Total					23.8	

2) Market for Reusable Materials

a. Reusable materials

The above-mentioned surveys reveal the following findings:

- i. The recovery of reusable materials from waste in Vientiane is mostly conducted by individuals or small groups on a door-to-door basis at the sources of waste generation sources, like houses, shops, markets and factories. Scavengers operate at the disposal site to recover valuable items on a small scale.
- ii. Valuable items recovered by private recyclers and scavengers are sold to local and foreign end-users via primary and secondary dealers. The market for recycled materials is well established by the private sector.
- iii. The main items for recycling are metals, paper, glass, bottles and plastics, etc.. Metals, rubber shoes and animal bones are exported in bulk to Thailand, the biggest market for reusable materials recovered in Vientiane through a Thai dealer living in Nongkhai. Plastic and papers are exported to Vietnam, but some of the recovered paper are sold and reprocessed in a paper mill in Vientiane for tissue-paper production.
- iv. Based on the answers of the private recyclers, it is estimated that over 2 tons/day of reusable materials are recovered in the Study area.

b. Food waste recycled

The major waste recycled in Vientiane is food waste and the total amount of food waste recycled is estimated at 21.8 tons/day, based on the results of the CCS.

i. food waste recycled in households

According to the CCS, 75% of the household use their food waste as feed mainly for livestock. The average amount of food waste recycled per person is calculated at 100 g/d/per. Consequently, the total amount of food waste recycled in the Study area is calculated at 14.3 tons/day by multiplying 0.1 kg by the whole population (142,723).

ii. food waste collected from shops

According to the CCS, food waste generated by shops is collected by food waste collectors or farmers and recycled as feed for livestock. The amount of food waste generated by shops and recycled in the Study area is estimated at 7.5 tons/day.

3) Scavenging

The survey on scavengers conducted by the Study Team reveals the following findings:

- i. Almost all of the scavengers live in Phokham village which is located only 300 m from the KM 18-DS. All of the adult scavengers are farmers.
- ii. Average number of scavengers at the KM 18-DS is 30 per day, including children of the farmers. The number, however, fluctuates seasonally.
- iii. All the scavengers have their own means of transportation to transport their goods to local dealers in town.
- iv. Amount of waste recovered by the scavengers at KM 18-DS is estimated at 0.3 ton/day.
- v. Average income of the scavengers is estimated at 20,000 kip/month (28 US \$). Although it is less than a manual workers' earning, they are satisfied with the income they get from scavenging.
- vi. Despite the unfavorable condition of the KM 18-DS, all of the scavengers working at the dump site were healthy. There has never been any report on scavengers suffering from communication diseases, minor diseases or body pains.

4.7 Equipment

1) Equipment

The equipment of the DCTC are presently in very poor condition and 57 percent are out of order.

DCTC has a total of 14 units of the following equipment for cleansing work:

a. Flat Trucks	5 units
b. Dump Truck	1 unit
c. Water Tank Truck	1 unit
d. Pick-up	1 unit
e. Trailer and Water Tanks with Wheel	6 units
<hr/>	
Total	14 units
<hr/>	

Their present conditions, however, are as follows:

- 1 unit is smooth operating;
- 1 unit can operate with light maintenance works such as greasing;
- 4 units require heavy repairs such as overhauling;
- 5 units are being repaired; and
- 3 units are considered as scraps.

In addition, it is very difficult to get spare parts for U.S.S.R. vehicles.

Three private companies have a total of 6 units of dump trucks.

There are only 20 units of cleansing work equipment in Vientiane, 10 of which are out of order.

Neither DCTC nor private companies have a workshop and workshop tools and facilities.

About 55 percent of equipment are more than 10 years old.

2) Operation and Maintenance

a. Operation

The present operational ratio is very poor at only 20%.

Operational capability is very limited, because the Maintenance Section of DCTC does not have any maintenance workshop, data on daily, weekly, monthly inspection sheets, and one year operational records for all equipment.

Three private companies have neither data nor manual for the operation of the equipment.

b. Maintenance

The establishment of the repair, maintenance and back-up services will help the effective use of the equipment and vehicles.

At present, however, the following are not established;

- a. Inspection of equipment before and after use;
- b. Weekly, monthly and yearly inspection sheets;
- c. Numbering system; and
- d. Record for repair specification.

The situation is the same in the private companies and maintenance system. However, basic minor services were made by drivers in the field and heavy duty repair has been done at private workshops.

4.8 Organization

1) National Level

At the national level, no agency is directly designated as responsible for solid waste management. No responsible organization on solid waste management exists in the Ministry of Communication, Post, Transportation and Construction. The MCTPC works closely with the DCTC mainly on the construction, maintenance, operation and management of road-bridges, transportation systems and construction work. The MCTPC is also responsible for the legislation and regulation on houses and building construction in Vientiane Municipality.

There are two related organizations involved in the solid waste management in the Ministry of Health. The Ministry of Health is concerned with solid waste management in terms of the control of communicable diseases and the protection of environmental health. Furthermore, much effort for solid waste management improvement has been made in the past two years by the 2 related agencies in the Ministry of Health, namely the Department of Hygiene and Curative Medicine and the National Institute of Hygiene and Epidemiology. These agencies organized and participated international workshops held in Vientiane in 1990. After the workshop and in response to the recommendation made during the workshop, they prepared and submitted a draft on the laws and regulations regarding solid waste management in the middle of 1991 to the Office of the Prime Minister for approval.

The Ministry of Health consists of 1 cabinet, 4 departments and 2 committees. As previously mentioned, there are 2 related organizations in the Ministry of Health involved in the solid waste management and they are as follows:

a. Department of Hygiene, Curative and Rehabilitation (DHCR)

The DHCR (Department of Hygiene, Curative and Rehabilitation) is composed of the following 7 divisions:

- Environmental Health Division
- Epidemiology Division
- Administration Division
- Curative Division
- Rehabilitation Division
- Health Infrastructure Division
- Health Education Division

The DHCR has a total number of 11 personnels as of November 1991. However, only 3 medical doctors who are working in the Environmental Health Division in the Department are considered to be involved in the environmental health of the country. Their involvement also includes solid waste management, not only in Vientiane Municipality but nation wide.

The main work items of the Environmental Health Division are summarized as follows:

- planning
- collaboration with international organizations
- preparation of guidelines, laws and regulations

b. The National Institute of Hygiene and Epidemiology (NIHE)

The NIHE (National Institute of Hygiene and Epidemiology) consist of the following 4 divisions:

- Administration Division
- Laboratory Division
- Preventive Medicine and Epidemiology Division
- Water Supply and Environmental Health Division

Generally, the NIHE, which has a total number of 65 personnel, is responsible for the training of the public health personnel.

The Water Supply and Environmental Health Division within the NIHE is in charge of environmental health including solid waste management, while the Division pays more attention to water supply. Most of its staff is involved with the water supply works in the rural area.

The Water Supply and Environmental Health Division is divided into 2 Sections, namely the Section of Water Supply and Section of Environmental Health and Sanitation. Only 5 of the total number of 18 staffs of the Water Supply and Environmental Health Division work in the Environmental Health and Sanitation Section which is concerned with solid waste management.

The Section of Environmental Health and Sanitation has 7 main duties. Fig.4.8-1 shows the duties of the Section of Environmental Health and Sanitation.

2) Department of Communication, Transportation and Construction (DCTC),
VM

The organizations responsible for the solid waste management in the Study area are the DCTC (Department of Communication, Transportation and Construction) and the DPH (Department of Public Health) of the Vientiane Municipality.

a. DCTC

i. organization

DCTC (Department of Communication, Transportation and Construction) is mainly responsible for the construction, maintenance, operation and management of roads, bridges, transportation systems, drainage, waste disposal and sanitation in Vientiane Municipality.

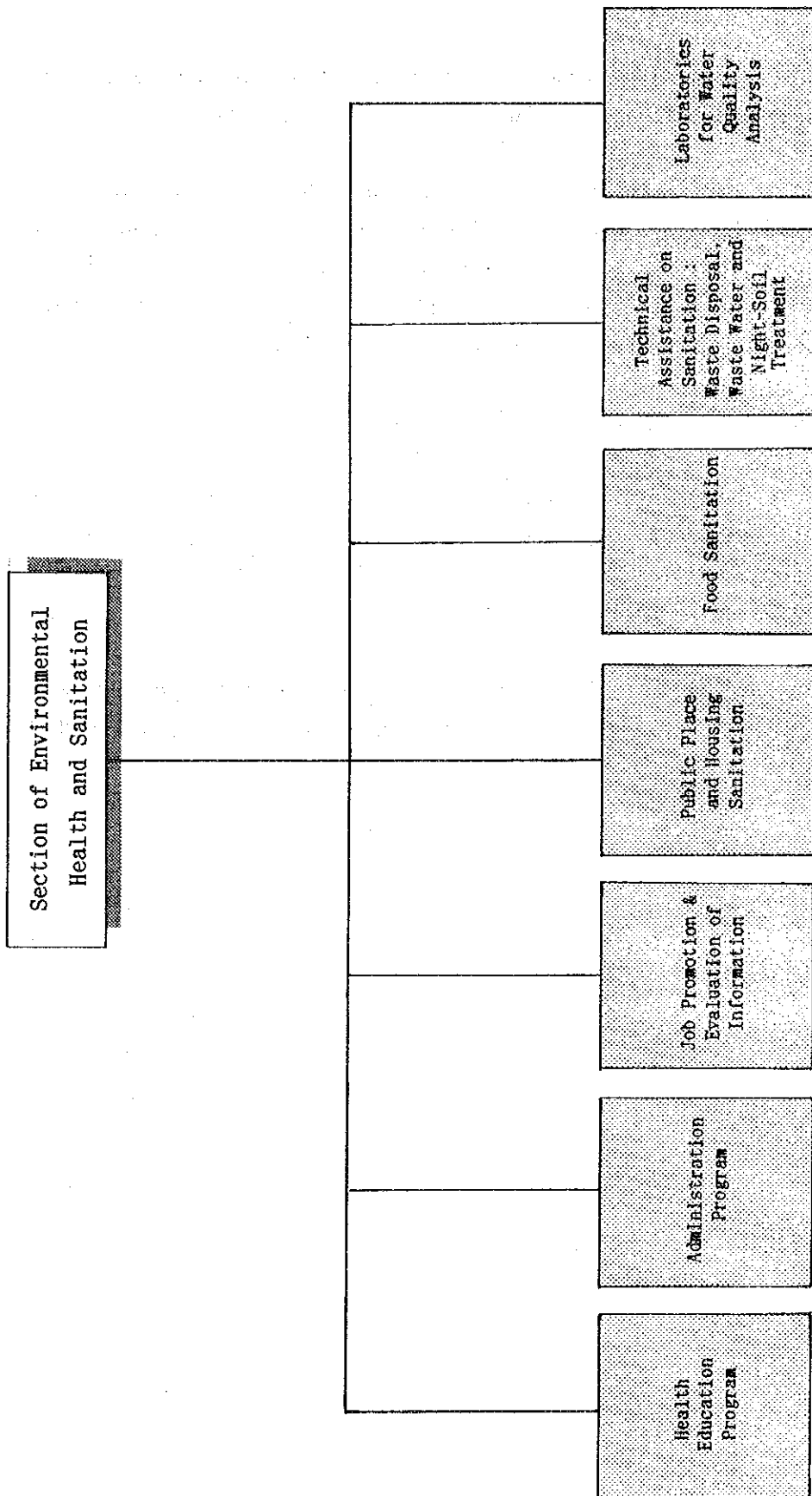


Fig. 4.8-1 Duties of Environmental Health and Sanitation Section, NIHE, MOH

DCTC is also responsible for the solid waste management and night soil management in Vientiane Municipality.

DCTC had a total of 24 bureaus and other organizations in 1990, but at present, it only has 13 bureaus and other organizations. The reduction of the local state enterprises and companies was done under the policy of the State Government to reduce the number of civil workers.

ii. number of personnel

DCTC has a total of 442 employees as of November 1991. Number of staff of the bureaus and the state company of DCTC is tabulated in Table 4.8-1. Among the 442 employees, 67 are involved in solid waste management.

In addition to the 67 employees, the DCTC hires an overseer for the inspection and control of the KM 18-DS by verbal contract.

Table 4.8-1 Number of Staff of the Bureau and State Companies of
DCTC in November 1991

List of Bureau and State Company	Staff
1. Bureau of Planning, Statistics and Finance	7
2. Bureau of Administration and Establishment	11
3. Bureau of Bridges and Roads	5
4. Bureau of Housing and Urban Developments	8
5. Bureau of Transportation	5
6. Bureau of Economic External Relation	3
7. Bureau of Vehicle Registration	25
8. State Enterprise of Rural Roads and Bridges	52
9. State Enterprise of Design and Survey	21
10. State Bus Company	141
11. Cleansing Section	67
12. Workshop of Heavy Equipment	15
13. Factory of Bricks	82
Total	442

Source : Department of Communication, Transportation and
Construction, Vientiane Municipality

c. The Cleansing Section..

The Cleansing Section consists of 3 units, namely the Solid Waste Management Unit, Night Soil Management Unit and Administration Unit.

The head of the Cleansing Section must be a senior technician and is called as the Cleansing Superintendent. He is supported by two Assistant Cleansing Superintendents. One of the two Assistant Cleansing Superintendents is the head of both the Solid Waste Management Unit and the Night Soil Management Unit. The other is the head of the Administration Unit. Each unit has three sub-units as shown in Fig. 4.8-2.

The Solid Waste Management Unit has three sub-units. The Solid Waste Management Sub-unit is directly controlled by the Assistant Cleansing Superintendant, while the other two are under the responsibility of the two overseers. There are 15, 12 and 19 staffs all distributed in the Solid Waste Management Sub-unit, Market Sweeping Sub-unit and Road Sweeping and Grass Cutting Sub-unit, respectively.

c. Number of personnel in the solid waste management

The number of personnel in the solid waste management is summarized as follows:

- Director	1 person
- Deputy Directors	2 persons
- Cleansing Superintendent	1 person
- Assistant Cleansing Superintendents	2 persons
- Clerks	5 persons
- Overseers	2 persons
- Mechanics	2 persons
- Drivers	7 persons
- Labourers	48 persons

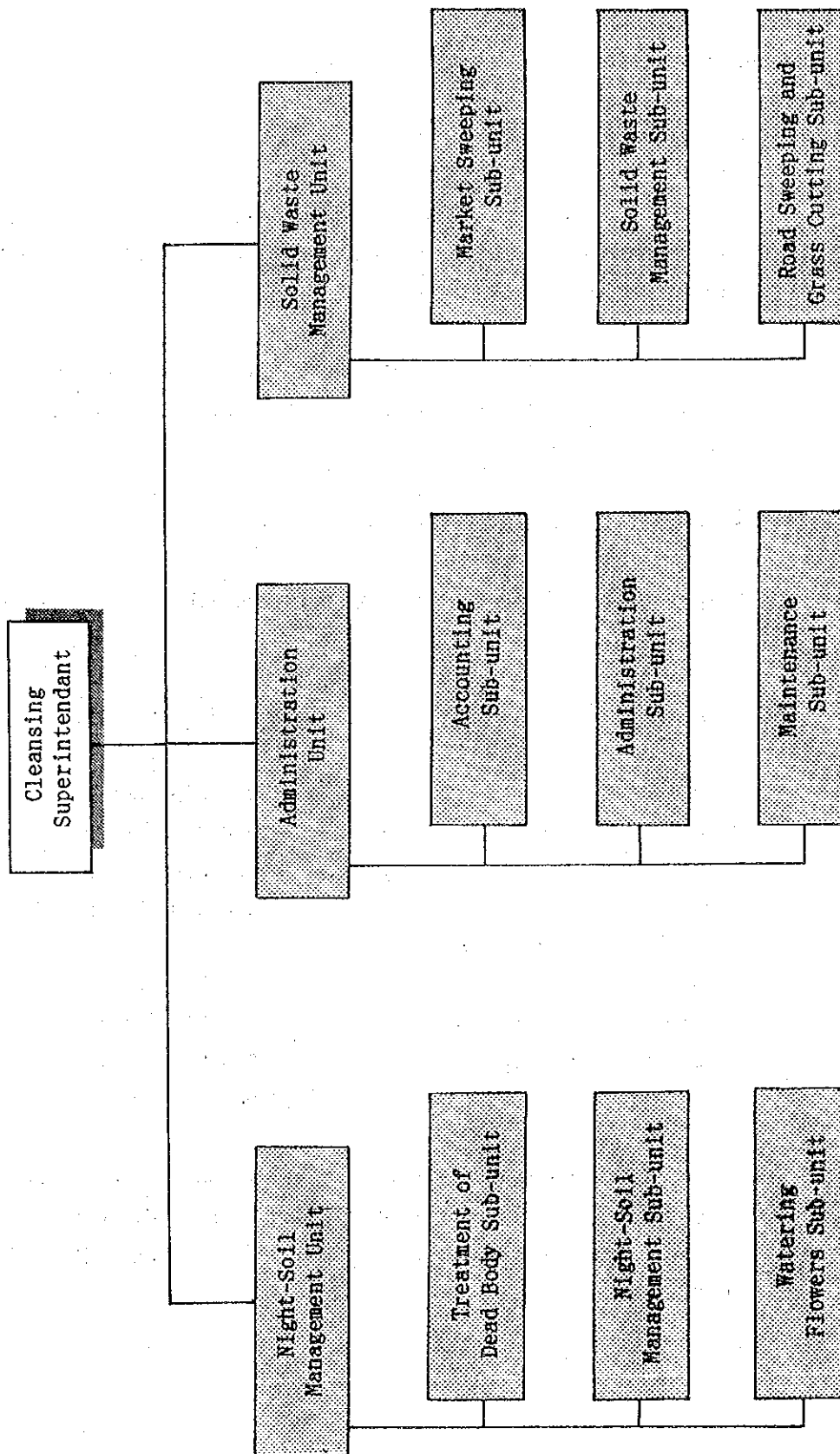


Fig. 4.8-2 Organization Chart of Cleansing Section

d. Labour condition

i. overview

In general, the wage of a government sector employee is lower than that of a private sector employee with similar qualification and experience.

Minimum legal wage in the government sector is 8,000 kips/month while the lowest wage paid to private labourers is 20,000 kips/month.

ii. salary system in government sector

Salary of the government employee in Lao P.D.R. is described as follows:

<u>Position</u>	<u>Minimum Monthly Salary</u>
1. Director	23,000 kips/month
2. Deputy Director	20,000 kips/month
3. Engineer	18,000 kips/month
4. Supervisor	18,000 kips/month
5. Technician, Operator, Mechanic	16,000 kips/month
6. Clerk (Fee Collector)	15,000 kips/month
7. Driver, Overseer	13,000 kips/month
8. Worker	12,000 kips/month

The above-mentioned monthly salary does not include dependency and transportation allowances for directors. It, however, excludes social charges and overtime payments in all levels.

iii. working day and time

All municipal employees work 6 days a week. Basic working hours are 7 hours per day with about 306 working days/year.

e. Reason for the establishment of the Cleansing Section

The Cleansing Section was established in the DCTC in September 1991 as a replacement for the SSC (State Sanitary Company). The following are the reasons for the change:

- i. The collection services provided by the State Sanitary Company were not efficient and did not satisfy the future needs of Vientiane Municipality.
- ii. The waste collection vehicles were defective and dysfunctional, and their maintenance and replacement required a considerable amount of money.
- iii. The lack of budget was identified as the major constraint in the improvement of the present SWM. The lack of capable and numerous staff in the SSC was also included. In addition, the number of waste collection vehicles available for SWM was not enough and their capability decreased to less than 40% according to the Cleansing Section.

3) Department of Public Health (DPH)

a. Organization

The DPH (Department of Public Health) is one of the 12 departments in Vientiane Municipality. The DPH consists of 3 Groups, namely the Technical, Administration, and Business Group.

The Technical Group is the main group and is responsible for the execution of medical and public health services. The Technical Group consists of 6 offices. Among the 6 offices, the Station of Hygiene and Epidemiology is responsible for public health and solid waste management.

b. Station of Hygiene and Epidemiology

Aside from solid waste management, the Station of Hygiene and Epidemiology is also responsible for the inspection of night soil management and other public health control matters. The Station of Hygiene and Epidemiology consists of 7 sectors.

Among the seven sectors, the Cleansing Inspection Sector is responsible for solid waste management.

c. Cleansing Inspection Sector

The head of the sector is a senior overseer and under him is an overseer. Overseers are responsible for the inspection and supervision of all daily cleansing operations. In each district, there is at least an area office with an overseer. The number of senior overseers and overseers totals 8.

Number of personnels involved in the Cleansing Inspection in Vientiane Municipality is 11.

d. Cleansing inspection activities

The cleansing inspection activities in Vientiane Municipality are as follows:

- i. Inspection and control measures of daily cleansing services;
- ii. Issuance of violation tickets;
- iii. Preparation of a weekly report on Mondays to be submitted to the station, and monthly reports to the Vientiane Municipality; and
- iv. Planning of the following week's schedule.

4.9 Financial Situation

1) National Level

The budget of the Ministry of Health was 1,764 million Kips in 1990 and the breakdown is as follows:

Salaries	:	832,000,000 Kips
Administration	:	632,000,000 Kips
Investment	:	300,000,000 Kips

The budget of the Departments of Hygiene Curative and Rehabilitation in 1990 was 30 million kips.

There is none for solid waste management.

2) Vientiane Municipality

Solid waste management of Vientiane Municipality is executed by the Cleansing Section under DCTC. The section was once privatized but is now one of the public service sections.

The trend of its budget is shown in Table 4.8-2. As for revenues, the weight of fee collection has increased relatively. As for expenditure, personnel cost and fuel cost increased.

The budget of DPH (Department of Public Health) for inspection was 220 million kips in 1990 and that of the Cleansing Inspection Section, Station of Hygiene and Epidemiology was only one million kips.

It is difficult to find out the cost of solid waste management according to the category of cleansing work. Rough calculation is done using the present proportion of person and vehicle, and is shown in Table 4.8-3.

Table 4.8-2 Balance Sheet of State Sanitary Company

Unit: Thousand Kips

Year	1985	1985	1987	1988	1989	1990	1991
A. Revenue							
1. Waste collection	4,442	9,221	9,439	7,708	6,195	7,730	16,575
2. Night soil management	1,283	2,233	2,245	2,452	3,913	3,750	8,721
3. Dumping fee	-	-	-	-	-	-	372
4. Others	1,770	1,934	1,247	3,522	2,750	3,158	981
Sub-total	7,495	13,438	12,931	13,682	12,858	14,638	26,649
B. Budget from Vientiane Municipality							
1. Street and market sweeping, treatment of dead body	4,111	9,468	11,166	7,912	7,594	7,890	10,512
2. Grass cutting	1,190	2,205	2,510	1,883	2,850	1,800	-
Sub-total (*A)	5,301	11,673	13,676	9,795	10,444	9,690	10,512
Total Revenue	12,796	25,111	26,607	23,476	23,302	24,378	37,161
C. Expenditure							
1. Personnel expenditure	2,570	4,985	5,950	5,504	7,310	7,318	11,486
2. Office work	2,264	2,083	2,510	4,107	3,922	3,588	2,590
3. Vehicle maintenance cost	2,212	5,706	4,844	5,134	2,150	2,745	5,400
4. Fuel and lubricant	2,827	5,371	5,572	4,950	7,118	7,784	14,100
5. Fire wood	273	410	370	265	345	384	766
6. Development expenditure	1,113	2,209	2,189	1,156	670	622	904
7. Tax	621	3,462	3,887	1,174	1,165	1,463	727
Total Expenditure	11,880	24,226	25,321	22,291	22,678	23,902	35,973
C. Balance	916	885	1,286	1,185	624	476	1,188

Reference

Budget of VM: #B

*A/*B x 100 (%)

Budget of DCTC: #C

*A/*C x 100 (%)

Remarks: 1. Other revenues/mean extra jobs: i.e. cleaning of drain canal, transportation of sand, gravel and construction materials

2. Tax was paid to Vientiane Municipality

3. Balance was returned to Vientiane Municipality

4. SSC was diverted and became a section of the DCTC in November 1991

1,198,563	1,421,700	1,859,700	2,169,700	2,599,200	3,553,200	4,254,500
0.4	0.8	0.7	0.4	0.4	0.3	0.2
70,000	110,000	140,000	160,000	200,000	210,000	345,000
7.6	10.6	9.8	6.1	5.2	4.6	3.0

Table 4.8-3 Solid Waste Management Cost by Work Items

Thousand kips

	Collection	Disposal	Night Soil	Treatment Dead Body	Road Sweeping and Others	Total
Personnel	3,109	122	762	503	2,820	7,316
Expenditure*	(2,561)	(122)	(488)	(360)	(2,683)	(6,219)
	(548)		(274)	(137)	(137)	(1,097)
Vehicle	1,373		686	343	343	2,745
Maintenance						
Fuel and	3,892		1,946	973	973	7,784
Lubricant						
Firewood	-	-	-	384	-	384
sub total	8,374	122	3,394	2,203	4,136	18,229
Development						
Expenditure**	286	4	116	75	141	622
Office Work**	1,648	24	668	434	814	3,588
Tax**	672	10	272	177	332	1,463
Total	10,980	160	4,450	2,889	5,423	23,902
	(45.9)	(6.7)	(18.6)	(21.1)	(22.7)	(100.0)
Reference						
Person	21	1	4	3	22	51
Vehicles	4		2	1	1	8

* 85% of the personnel cost is divided by the proportion of number of persons, and 15% is divided by the proportion of number of vehicles.

** The cost with the mark ** is divided by the proportion of value of sub-total.

3) Private Sector

Three private companies are presently in charge of waste collection in the Study area. The balance of these companies is in the black. A company, which collects wastes from markets, big offices and foreign organizations, is more profitable.

A comparison on the cost of collection services done by DCTC and three private companies, is done and tabulated in Table 4.8-4. The balance of DCTC is in worse conditions due to high taxes.

Table 4.8-4 Cost of Collection Services by DCTC and Three Private Companies

	kips/month			
	PRIVATE -C R C	PRIVATE -I S C	PRIVATE -S W M	D C T C
<u>1. Expenditure</u>				
Personnel Expenditures	360,395	141,000	59,000	1,300,000
(A)	(42.2)	(26.7)	(23.9)	(65.0)
Fuel and Others	237,879	200,000		
	(27.8)	(37.9)		
Maintenance	150,000	70,000		500,000
	(17.6)	(13.3)		(25.0)
Rent of Vehicle			176,000	
			(71.3)	
Depreciation	37,768			
	(4.4)			
Material and Tools	18,753	48,300		50,000
	(2.0)	(9.1)		(2.5)
Tax		23,700	12,000	150,000
		(4.5)	4.9)	(7.5)
Total (B)	854,518	528,000	247,000	2,000,000
	(100.0)	(100.0)	(100.0)	(100.0)
<u>2. Reference</u>				
Number of Employees (C)	25	11	4	66
Personnel Cost				
Per employee (A/C)	14,416	12,818	14,750	19,697
Revenue (D)	987,260	1,360,000	250,000	2,000,000
Balance (D - B)	132,742	832,000	3,000	0
Project Ratio (%)	15.5	157.6	1.2	0
(D - B)/B				

Note; The figure in the parentheses is the percentage.

4.10 Public Cooperation, Legislation and Enforcement

1) Public Cooperation

The Ministry of Health has laid out the primary concern of mass education in the practice of elementary hygiene and sanitation as a preventive measure since 1975. A team of public health officers were sent out all over the country to explain simple hygienic measures necessary to reduce the occurrence of communicable diseases. Basic health education involves the three clean concept campaign; i.e., clean food, clean water and clean houses. The people realized the necessity of the collection and disposal of waste in sanitation for better environmental health and aesthetic conditions.

As for public cooperation with respect to solid waste disposal, a cleansing day or the "Red Saturday" was established in communities, schools, ministries, etc.,. From 1975-1985, increase in public cooperation has been considerably felt all over the country because of a government programme. The organizers of the three clean concept campaign, gave out certificates to villages or individuals for the promotion of the activity. From 1986 upto the present, public cooperation has decreased gradually due to the failure of the government programmes as a result of poor coordination among agencies involved and low economic performance, weakness of the organization structure and lack of continuous policy.

However, cleansing day is still being carried out especially in schools and in the community before any important day, i.e., Lao New Year "Pimai" and national holidays. This, however, highly depends on the enthusiasm, or inertia of the village committee or the leader of the community.

2) Law and Regulation

a. National level

A basic law regarding solid waste management and cleansing activities has not been issued in Lao P.D.R..

However, the Ministry of Health has prepared a draft guideline related to solid waste management and protection of environmental health in accordance with the results of the international workshop which was organized by the National Institute of Hygiene and Epidemiology, Ministry of Health, with collaboration of WHO (Pepas) in August 1990.

The draft guideline has been submitted to the Office of the Prime Minister for approval since the middle of 1991. The guideline is composed of 17 chapters and 58 articles, and only one chapter deals with solid waste management.

Contents of the Guideline is summarized as follows;

- Chapter I - Objectives of the Guideline
- Chapter II - Contents of the Guideline
- Chapter III - Organization and Job Description of Environmental Health
- Chapter IV - Water Supply and Sewage
- Chapter V - Air Pollution Protection
- Chapter VI - Protection of Groundwater
- Chapter VII - Sanitary Housing Conditions
- Chapter VIII - Hygiene of Restaurant, Barber Shop and Beauty Salons
- Chapter IX - Food Sanitation
- Chapter X - Hygiene of Kitchen Utensils
- Chapter XI - Hygiene of Working Conditions in Factory
- Chapter XII - School Hygiene
- Chapter XIII - Vibration and Noise Protection

- Chapter XIV - Protection from Toxic Substances
- Chapter XV - Solid Waste Management
- Chapter XVI - X-ray
- Chapter XVII - Implementation of a Guideline

b. Vientiane Municipality

The Vientiane Municipality has issued a regulation serial No. 633/VMAC on the 13th of October 1988 concerning the environmental health and cleansing services of the Vientiane Municipality.

Although Vientiane Municipality has few rules regarding solid waste management, they are virtually insufficient.

3) Enforcement

Although the draft of the guideline prepared by the Ministry of Health is not legally valid, the SWM regulation No. 633/VMAC issued by the Vientiane Municipality on the 13th of October 1988 is. Based on the regulation, the Cleansing Inspection Committee was organized to control the cleansing services of the Vientiane Municipality. The Cleansing Inspection Committee was headed by the DCTC and consisted of other related agencies, i.e., Department of Public Health, Department of National Defense and Public Security (Police), District Administrative Committee in the urban area and mass organizations.

The activities of the Cleansing Inspection Committee were carried out smoothly in the first year of establishment and was strongly supported by the community. But in the following year, due to poor coordination between related agencies and lack of decision-making participation, the activities of the committee decreased gradually and the task was performed only for important national holidays. Consequently, the Cleansing Inspection Committee was dissolved 2 years after it was organized.

At present, the existing organization controlling the cleansing services in the Vientiane Municipality is the Cleansing Inspection Sector in the Station of Hygiene and Epidemiology, Department of Public Health, Vientiane Municipality.

The Cleansing Inspection Sector consists of 7 overseers, of which 3 come from the sector and the rest from the 4 urban districts of Chanthabouly, Sisattanak, Saisettha and Sikhottabong.

The Cleansing Inspection Sector is vested with legal power. According to the regulation of Vientiane Municipality, they can also fine violators aside from just issuing warnings. Fining, however, is not really effective, as nobody pays and no action is taken against it.

Due to serious problems on littering and illegal dumping, some village committees have made an agreement with their villages to apply the regulation of Vientiane Municipality. They organized the overseers to issue a ticket to the violator who litters or disposes waste in their surrounding.

4) Existing Standards, Codes of Practice and Guidelines

There are no existing standards, codes of practice and guidelines regarding solid waste management both in the country and in Vientiane Municipality.

CHAPTER 5

EVALUATION OF PRESENT SOLID WASTE MANAGEMENT

CHAPTER 5 EVALUATION OF PRESENT SOLID WASTE MANAGEMENT

5.1 Identification of Problems

There are some aspects in the present SWM in Vientiane such as the recycling system and beneficiary-pay-principal on collection of wastes, etc. which should be appreciated. However, virtually all aspects of solid waste management in Vientiane need to be improved. The improvement measures includes strengthening the institutional setting, developing human resource, enhancing refuse collection services, upgrading final disposal to sanitary landfill, securing funds for capital and recurrent expenditure, and encouraging public participation through development of public education programmes.

1) Technical System

a. Discharge and storage

i. source separation

First of all, it should be appreciated that the recycling of domestic and commercial waste at the generation sources is well-established and wastes are segregated into waste for discharge, food waste to be used as domestic animal mainly livestock feed, reusable materials for recycling, and self-disposable waste which can be mainly burned at the backyards. The Vientiane Municipality should encourage source separation and recycling activities. However, it should also take necessary measures to stop open burning of wastes in order to improve air quality in Vientiane.

ii. bamboo basket

Although the use of bamboo baskets involve problems like scattering of wastes, bad smell, etc., they are being widely used in the present discharge and storage system for domestic and commercial wastes. Further, their use helps in the effective execution of collection work, especially waste loading work. Since the amount of garbage is very small, only limited scavenging by animals, even in baskets without lids, is observed. These baskets are locally made and are very cheap at only 500 kips a piece.

iii. institutional wastes

Although a discharge and storage system for domestic and commercial wastes is established, the system for institutional wastes, that is, wastes from markets, hospitals and government offices, is not. For example, waste collected from each market shop is discharged into open heaps. These wastes do not only uglify the surrounding area, but also make loading work difficult (the loading of 1 ton of waste takes about an hour and requires 4 workers). Moreover, source separation is not implemented. Even though infectious wastes are segregated at the source, they are still discharged into open heaps, a trailer or a container, along with the other wastes.

b. Collection and haulage

i. collection points

In view of collection efficiency, the present collection points described below are deemed to be appropriate.

- for residential and commercial areas

- . curb collection;
- . door to door collection; or
- . bell collection.

- for institutions (markets, hospitals and offices)

- . station collection

ii. service coverage

Present ratio of service coverage in the residential area is very limited at only 4.8%. As a result, in most residential areas, self-disposal by means of open burning is commonly done, creating air pollution problems.

iii. lack of collection capability

According to the CCS, more than 90% of the residents in the non-collection area wish to receive collection services and more than 60% of them agreed to pay. However, due to the very limited collection capability of both DCTC and private companies, the collection service area is not expanded. In addition, due to frequent vehicular troubles, the collection service is not stable.

iv. poor condition of equipment

In addition to the lack of collection capability, the present equipment (vehicles and others) are old and dilapidated, and some are even out of order.

v. improper transfer system

As for institutional wastes, the transfer system is adopted. This system entails the transferring of wastes primarily collected and placed in open heaps to the disposal site. However, due to the lack of equipment such as trailers and containers, this system is not efficiently conducted as compared with the direct collection system.

c. Road Sweeping, Drain Cleansing and Grass Cutting

i. limited budget

Since road sweeping, drain cleansing and grass cutting services are conducted in public areas, DCTC finds fee collection hard to implement. However, even with very limited budget, these services are carried out on the main roads, covering a total length of 15 km (refer to Table 4.9-4.).

ii. public cooperation

Regardless of a very limited budget, this system would have survived with public cooperation. However, there is very poor cooperation from the public, in spite of the Cleansing Day activity every Saturday. Littering, scattering, and illegal dumping of wastes on roads and drains are commonly scene in the study area.

iii. poor equipment

Present equipment for road sweeping, drain cleansing and grass cutting is very poor, therefore, resulting in inefficient services. Due to the lack of equipment, drain cleansing and cleaning of litters or illegally dumped waste could not be carried out. This contributes to the further insanitation of the environment of the city of Vientiane.

d. Processing

There is no processing facility in the Study area. In view of the very limited financial resources, the introduction of a processing facility including a composting plant seems to be of little necessity. However, as recommended in the "Report on Disposal of Solid Wastes in Urban Vientiane" by UNDP, the introduction of an incinerator for infectious waste or other safe disposal method shall be examined.

e. Recycling

At present, the total amount of waste recycled is estimated at 23.8 tons/day. Since a self-sustaining system in the society or community still exists and is well organized, the existing recycling system is considered to be much more efficient than that of the other countries. Therefore, Vientiane Municipality should maintain and encourage these existing recycling activities.

f. Final disposal

i. tipping fee

The present KM 18-DS should be thoroughly improved. It is, however, appreciated that DCTC has already commenced to collect tipping fees from incoming vehicles and reserved a large land for final disposal; i.e. KM 18-DS, although the land is not secured. The onset of the collection of tipping fees from incoming vehicles and the reservation of large lands as disposal sites (KM 18-DS) by DCTC is, however, being appreciated.

ii. lack of environmental protection measures

In the existing disposal site, no environmental protection measures are provided. Scattering of solid waste, canal contamination by leachate and fire due to open burning by scavengers are observed in the disposal sites.

iii. lack of a unit responsible for final disposal

Although the Cleansing Section of DCTC, in principle, is responsible for planning, management and operation of disposal sites, there is no unit or personnel responsible for such work. In fact, there is no person in charge of the inspection and recording of incoming vehicles at the KM 18 disposal site until November 1991 since it opened 20 years ago.

iv. strict enforcement of the prohibition of illegal dumping

Small scale illegal dumping and littering of waste are commonly seen in many places. In order to reduce illegal dumping, it is necessary to enforce anti-littering regulations strictly. In addition, the education of local residents and improved waste collection services are required.

g. Equipment operation and maintenance

The present operation and maintenance system of equipment should be thoroughly improved, especially with regard to the following:

- preparation of daily, weekly and monthly inspection sheet;
- preparation of one year operational record;
- preparation of numbering system;
- establishment of a proper operation and maintenance system by obtaining preventive maintenance and repairing tools.

2) Institutional System

According to the results of the survey on the institutional system, two main problems were identified regarding solid waste management, that is uncertain policies and limited budget. Furthermore, the institutional structure, which shall supposedly enable the reduction of problems without the use of any money, is not well established.

a. Organization and management

i. unclear responsibility of concerned agencies

There are various organizations concerned in solid waste management. However, the responsibilities and roles of these agencies are not clearly defined.

ii. poor cooperation between concerned agencies

Cooperation is one of the key issues which can facilitate smooth and effective works. Unfortunately, communication and cooperation among the agencies concerned in solid waste management are not sufficient, resulting in a lot of trouble and the inefficient execution of the works.

iii. lack of planning

Neither a long term nor a short term plan regarding SWM has been set up by the responsible agencies. It seems that make shift measures without a plan have been taken when troubles occurred.

iv. lack of qualified personnel

The lack of numerous and capable staff for the solid waste management is also another serious problem.

In addition, responsible personnel are often changed without apparent reason.

v. poor data management

Poor data management causes poor operation and maintenance. Data management is not properly done.

The data management and monitoring system of various aspects including number of personnel, job description, budget and financial situation, is indispensable for proper planning, study, implementation, operation and maintenance of the solid waste management.

b. Legislation and enforcement

i. weakness of regulation

The existing regulation issued by Vientiane Municipality is not sufficient and effective. It is necessary to revise this regulation, therefore, in accordance with the present situation and to strengthen it for effective enforcement.

ii. lack of a basic law

There is no basic law regarding solid waste management in Lao P.D.R.. Although the Ministry of Health has drafted a law on solid waste management, it is somehow only used as a guideline and is not legally valid.

A basic law is indispensable for setting up a standard guideline, code of practice, etc., regarding solid waste management.

iii. lack of enforcement system

Although the regulation of Vientiane Municipality on punishment imposed on violators is legally valid, it is actually very weak because of a poorly established enforcement system.

c. Finance

i. limited budget

The budget for SWM in Vientiane Municipality is insufficient. The share of SWM budget in the budget of DCTC has decreased from 11 percent in 1986 to 3 percent in 1991. In addition, the ministries have no specific budget for SWM.

ii. non-separated budget for SWM

After the change in the SWM organization, the budget for SWM is not clearly distinguished from that of DCTC, especially budget for the maintenance aspect. This is one of the reasons why service is low and increase in revenue is difficult to achieve.

iii. unclear flow of collected fees

Fee collection system has been introduced but is not being checked systematically. Some of the fees collected seem to disappear during fee collection activities.

iv. poor data management

The document and receipts of bills are only secured in a file and is not analyzed to improve SWM.

v. poor accounting system

The accounting system for solid waste management is not fully well established. Only personnel expenditure is reported to DPF, VM, in accordance with the budget. The collected fees and their uses are not being checked. Customs and system of settlement of accounts and an auditing system are not established.

vi. major problems

The budget for solid waste management, especially for maintenance of vehicles is insufficient. The flow of collected fees intended for the improvement of solid waste collection services is not clear.

d. Public cooperation

For any solid waste management programme, public cooperation is essential. One of the major differences between solid waste management (SWM) and other public services such as water supply and electricity supply is the importance of public cooperation for effect a successful and efficient operation. Other public services do not require public cooperation in such aspects as:

- Waste storage and discharge manner
- Non-littering at public places

Public cooperation is inadequate in Vientiane urban area. Major reasons behind this are;

- i. Vientiane Municipality has not clearly and strongly specified the role of the public to the public.
- ii. The Municipality does not strongly exercise the laws and regulations.
- iii. Inadequate public education for children at home and in schools.

5.2 Improvement Measures

1) Stepwise Improvement Plan

The problems mentioned in the former section are classified into two categories; those which may be possibly improved immediately and those which may only be solved in a certain term due to financial and social constraints.

Improvement plans which do not require large initial investment can be implemented immediately, while those that require a large initial investment may have to be implemented in a longer term.

In view of the present defective SWM, especially with regards to its very limited financial resources, it is necessary to make considerable efforts of improvement in order to achieve the target of the Basic Plan. Therefore, a stepwise improvement plan until 2000 is proposed in the following manner:

Category of Plan	Target Year
- Basic Plan	1992 ~ 2000
- Immediate Improvement Plan	Present to 1994
- Short Term Improvement Plan for Feasibility Study	1995 ~ 1997
- Medium Term Improvement Plan	1998 ~ 2000

Execution of immediate improvement plans including pilot projects will be useful to examine the feasibility of short and medium term plans.

2) Improvement Measures

In order to solve the present problems identified and to realize the goal proposed for the year 2000, the improvement measures in accordance with the stepwise improvement are identified and tabulated in Table 5.2-1. The most important measure is, however, for national and local governments to give high priority to Solid Waste Management especially with regard to the following:

- i. legal and organizational set-up; and
- ii. allocation of more funds.

Table 5.2-1 Improvement Measures (1)

.....1

ITEMS	IMMEDIATE IMPROVEMENT MEASURES	SHORT & MEDIUM TERM IMPROVEMENT
TECHNICAL SYSTEM		
1) Discharge & Storage	① Execution of separate discharge for infectious waste in the hospital.	① Abolition of the open heap in the institutions (markets, hospitals, offices). ② Encouragement of source separation. ③ Discouragement of open burning for self-disposal. ④ Introduction of an appropriate disposal system for the infectious waste.
2) Collection & Haulage	① Preparation of weekly and monthly working schedule. ② Collection of data regarding amount of waste collected.	① Extension of collection service area. ② Improvement of collection frequency. ③ Establishment of appropriate transfer system for the institutional waste. ④ Establishment of efficient collection system.
3) Road Sweeping, Drain Cleansing & Grass Cutting	① Stimulation of community cooperation for the cleaning up of its surroundings.	① Establishment of public cooperation for cleaning up roads and drains. ② Strengthening of cleaning capability.
4) Processing	-	① Examination of a proper treatment system for infectious wastes.
5) Recycling	-	① Encouragement of recycling activities.
6) Final Disposal	① Securing land for the KM 18-DS. ② Authorization of the KM18-DS as a disposal site ③ Control of scavenging activities ④ Provision of records of incoming vehicles. ⑤ Improvement of tipping fee collection system.	① Execution of sanitary landfill. ② Establishment of an organization for final disposal.

Table 5.2-1 Improvement Measures (2)

.....2

ITEMS	IMMEDIATE IMPROVEMENT MEASURES	SHORT & MEDIUM TERM IMPROVEMENT
7) Equipment O&M System	① Preparation of repair and specification record. ② Execution of regular maintenance	① Establishment of proper operation and maintenance system.
<u>INSTITUTIONAL SYSTEM</u>		
1) Organization & Management	① Clarification of the roles of each organization. ② Assignment of person (s) in charge of planning and management.	① Establishment of a definite organization. ② Establishment of a planning section. ③ Improvement of working conditions. ④ Establishment of roles of Vientiane Municipality and private companies. ⑤ Establishment of regulatory system of private companies. ⑥ Establishment of training system.
2) Legislation & Enforcement	① Strengthening enforcement capability.	① Establishment of a law. ② Revision of the present regulation. ③ Establishment of enforcement system.
3) Finance	① Improvement of accounting system. ② Improvement of fee collection system. ③ Collection of data for operational expenditure.	① Establishment of financial sources. ② Establishment of fee collection system. ③ Establishment of auditing system. ④ Establishment of accounting system.
4) Public Cooperation & Education	① Strengthening present public cooperation on the Cleansing Day on Saturday. ② Preparation of an education program for the primary schools.	① Establishment of public education system. ② Encouragement of public cooperation.

PART II

BASIC PLAN

CHAPTER 6

PLANNING FRAMEWORKS FOR A BASIC PLAN

PART II BASIC PLAN

CHAPTER 6 PLANNING FRAMEWORKS FOR A BASIC PLAN

6.1 Goals and Targets

1) Goal

The goal of the Basic Plan is as follows:

"Development and Realization of a Beautiful and Clean Living Environment in Vientiane urban area towards the 21st Century through Citizen's Participation and Establishment of Self-Sustainable Solid Waste Management"

The following should be implemented to attain the above goal.

1. Establishment of a self-sustainable solid waste management system.
2. Provision of a collection service in the whole Vientiane urban area and establishment of a reliable collection system under which regular services can be provided.
3. Construction of a sanitary landfill (Level 3) which employs sufficient measures for environmental protection.
4. Establishment of efficient road sweeping, drain cleansing and grass cutting system through public cooperation.
5. Establishment of Beneficiary-Pay-Principle under which service recipients pay waste collection fees and tipping fees.
6. Establishment of proper legislation and regulations through the modification and revision of the existing ones.

7. Establishment of proper roles of the organizations involved in solid waste management.
8. Strengthening of the management and administration system.
9. Development of public participation and education programs.
10. Development of human resources involved in solid waste management.
11. Securing funds for the capital investment for the equipment and facility necessary for the realization of the goal, specially during the time of take off.

2) Targets

In order to realize the goal, the following targets are set up.

a. Collection service coverage

The entire population in Vientiane urban area will be served by the year 2000 and thereafter.

	unit	1991	1995	2000
- Population	(Person)	142,700	163,100	192,800
- Service Population	(Person)	6,800	81,500	192,800
- Non-Service	(%)	95.2	50	0
Population	(Person)	135,900	81,500	0
- Collection Amount	(t/d)	13.9	68.3	148.2
Vientiane Municipality		(6.1)	(58.3)	(138.2)
Private Contractors		(7.8)	(10)	(10)

b. Road sweeping, drain cleansing and grass cutting

Road sweeping, drain cleansing and grass cutting activities to be carried out by the Urban Service Department (present Cleansing Section of DCTC) of Vientiane Municipality will be conducted at the present coverage roads in 2000; 15 km in road length.

On the other hand, cleansing activity through public cooperation will be established in whole Vientiane urban area by the year 2000. Moreover, sprinkling by water truck to protect roads from dust will be done on the entire road in Vientiane urban area by the year 2000.

	unit	1991	1995	2000
Cleansing Service by VM	(km)	15	15	15
Cleansing Activity through (No.of Ban)		0	48	96
Public Cooperation	(%)		(50%)	(100%)
Length of Road for Sprinkling	(km)	0	150	230
Water	(%)		(65%)	(100%)

c. Recycling

Recycling of food waste and reusable materials should be encouraged. Expected amounts in the Study area are as follows:

	unit	1991	1995	2000
Amount to be recycled (t/d)		<u>23.8</u>	<u>26.9</u>	<u>31.7</u>
- food waste		21.8	24.9	29.4
- reusable materials		2.0	2.0	2.3

Role of residents - source separation of recyclable and reusable materials

Role of recycling agent - to collect reusable materials from source
- to organize recycling agents' association

Role of the Municipality - to encourage recycling activities to residents and recycling agents

d. Final disposal (sanitary landfill)

All the waste collected and hauled directly to disposal sites will be disposed of in a sanitary landfill site from 1995 and thereafter.

	unit	1991	1995	2000
- Disposal Amount	(t/d)	17.1	72.3	152.9
- Sanitary Landfill	(t/d)	0	72.3	152.9
- Ratio	(%)	0	100	100
- Level		Open dumping Level 2		Level 3

e. Strengthening of organization

In order to achieve the goal, the responsible organization for SWM in Vientiane Municipality should be improved and the present Cleansing Section should be replaced with the Urban Service Department (USD) by 1995. In addition, the organizational structure of the USD should be strengthened.

	1991	1995	2000
Responsible Organization	Cleansing Section	USD	USD
Number of Personnels (Total)	<u>67</u>	<u>197</u>	<u>366</u>
- Administration	7	28	48
- Research & Development	0	2	4
- Collection Services	27	81	187
- Cleansing Services	21	39	45
- Disposal Site O & M	2	6	10
- Campaign & Enforcement	0	4	6
- O & M of Equipment	2	10	16
- Night-Soil Management	8	27	50

f. Securing financial resources for SWM

Basically, SWM expenses shall be covered by waste collection fees which will be collected from the beneficiaries as well as by tipping fees collected from disposal service recipients.

Unit : million kips

	1991	1995	2000
Fee collection			
- Basic fee	11.5	241	706
- Extra fee	-	65	167
- Special fee	-	14	27
- Tipping fee	0.4	2	3
Budget from VM	10.5	210	469
Total	22.4	532	1,372

6.2 Approach to the Attainment of Goal and Targets

In order to achieve the goal and targets proposed in the Basic Plan, establishment of a self-sustainable solid waste management system is of key importance. For the attainment of the self-sustainable solid waste management, the establishment of a financial base is most important. The financial base can be established by the establishment of the Beneficiary-Pay-Principle and by securing funds for the capital investment.

The following are the key issues for the realization of the goals and targets:

1) Stepwise (Phased) Improvement

A stepwise improvement method is considered practical and wise to attain the Basic Plan goal since it cannot be attained in a short time. It has been proposed that the Basic Plan period (from present to 2000) be divided into two Phases: Phase 1 (1995-1997), Phase 2 (1998-2000).

2) Immediate Improvement Plan

Some of the improvement plans which do not require much initial investment can be implemented even before the start of Phase 1. The implementation of immediate improvement plans is extremely important in the sense that it would lay a foundation for the smooth execution of subsequent plans.

The immediate improvement needs and plans are described in Chapter 9.

3) Pilot Projects

The execution of pilot projects will be required prior to the implementation of certain improvement plans if their feasibility needs to be proved beforehand. An example of this type of plan includes the provision of collection services in non-collection areas as a collection experiment and the execution of sanitary landfill operation at the KM 18-DS.

In this sense, a pilot project on collection and disposal was proposed and implemented. Details are described in Chapter 10.

6.3 Projection of Future Population

1.) Present Population

Present population and number of families in Vientiane urban area are tabulated in Table H.3-1 of Supporting Report (2), based on the survey done by the Study Team in cooperation with DCTC. The survey was carried out by means of visiting every Ban (villages) in the Study area in October 1991. As shown in the table, the present population and number of families in Vientiane urban area in October 1991 are as follows:

- Present Population: 142,723 persons
- Number of Families: 24,156 families

2) Population Projection

The future population by the year 2000 is projected based on the annual growth rate (3.4%) given by the DPF, VM (Department of Planning and Finance, Vientiane Municipality).

It is tabulated in Table H.3-2 in the Supporting Report (2). As shown in the table, the future population is projected as:

- 163,146 in 1995
- 192,832 in 2000

6.4 Estimation of Future Solid Waste Amount and Composition

1) Solid Waste Amount

Future solid waste amount by the year 2000 is estimated and tabulated in Table 6.4-1. At the same time, the future waste stream in the year 2000 is estimated and shown in Fig. 6.4-1.

The estimation was based on the following conditions:

- a. The entire population in Vientiane urban area will be served by the year 2000.
- b. Collection service ratio in the commercial area will be 60% by the year 1995. The service ratio for the residential area in 1995 will be 50% in order to realize the above-mentioned target by the year 2000; i.e. the service ratio will increase linearly up to 2000.
- c. Generation amount of each generation source will increase according to the ratio of the population growth ; i.e. 3.4% per annum. Generation ratio of road sweeping wastes, however, will not change because service length of the road will be the same as it is in 1991.
- d. Recycling amount of both food waste and reusable materials will also increase in accordance with the ratio of population growth.
- e. Even if the collection service covers the entire Vientiane urban area, some part of self-disposal will be remained. The ratio of self-disposal in the residential area in the year 2000 will be the same as it is in the present collection area. As such the amount of self-disposal will increase with the ratio of 3.4% per annum.

Table 6.4-1 Future Solid Waste Amount

Items	Unit	1991	1995	2000
Population	person	142,723	163,146	192,832
Collection Service Ratio in Residential Area	%	4.8	50	100
Collection Service Ratio in Commercial Area	%	22.3	60	100
Generation Waste Amount	ton/day	140.8	160.8	190.1
Total Recycling Amount	ton/day	23.8	26.9	31.7
- Food Waste	ton/day	(21.8)	(24.9)	(29.4)
- Reusable Materials	ton/day	(2.0)	(2.0)	(2.3)
Self-disposal Waste Amount	ton/day	99.8	61.7	5.2
Collection Waste Amount	ton/day	13.9	68.3	148.2
Disposal Waste Amount	ton/day	17.1	72.3	152.9

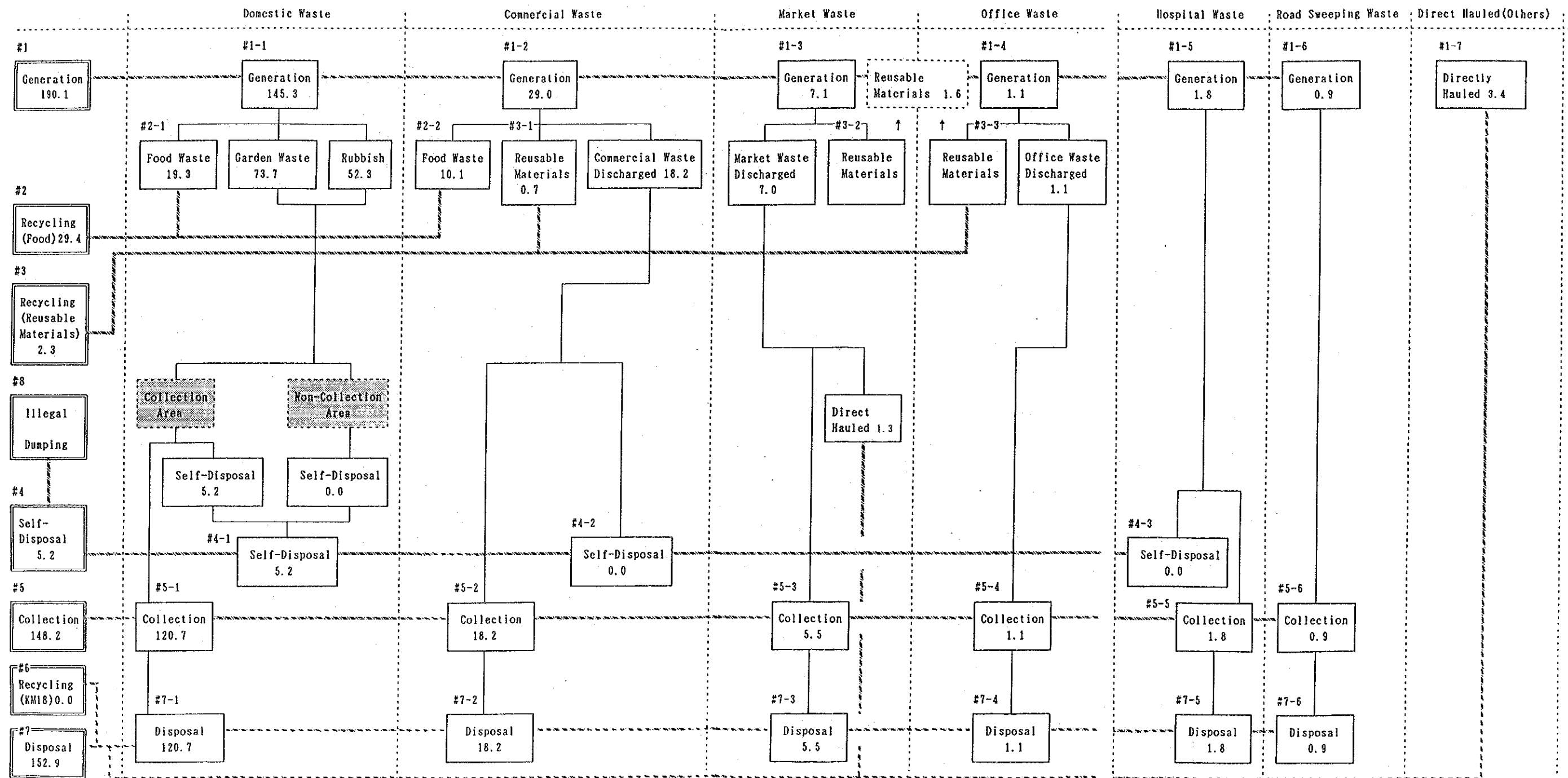


Fig.6.4-1 Future Waste Stream in The Study Area(2000) (Unit: Ton/Day)

2) Solid Waste Composition

The future waste composition will not change much by the year 2000. These changes are negligible based on the reasons described below.

a. Household area

According to the UNDP M/P (Master Plan for Urban Development in Vientiane conducted by UNDP), it is deduced that the household area will not change by 2000.

Consequently, the following conclusions are deduced from the above:

a. Area per household is big (513 m² per household in 1988) enough to generate a lot of garden waste, and this situation will not change by the year 2000.

b. The generation ratio of garden wastes in residential areas will not change by the year 2000.

b. Recycling of food waste

At present, domestic animals are important sources of income for each household, and food waste generated in residential areas is commonly used as animal feed. In addition, food waste collected from shops is important feed for the livestock of the farmers and is normally given for free. Furthermore, the demand for domestic animals' meat will increase by 2000.

Consequently, as long as the economic structure in the Study area will not change drastically, there will be no changes in the recycling ratio of food waste.

c. Future study needs

In the Study, it is concluded that future waste composition will not change much by the year 2000. The changes that may occur are considered as negligible. Changes are expected though after the year 2000 due to the following:

- i. rapid population increase;
- ii. change from sparse land use to dense land use;
- iii. from independent houses to aggregated houses;
- iv. increase in income;
- v. rapid urbanization extending to the surroundings of the Study area;
- vi. improvement of the standard of living and change in life style; and
- vii. expansion of industrial activities.

Consequently, changes in waste composition will be as follows:

- i. The ratio of paper, plastics and incombustible waste will increase;
- ii. The ratio of wood/bamboo and others will decrease; and
- iii. The recycling ratio of food waste may decrease due to lack of space for livestock near the Study area. Accordingly, the ratio of garbage will increase.

Conclusively, Vientiane Municipality is requested to carry out the following studies:

- i. periodical WACS (Waste Amount and Composition Analysis) every several years; and
- ii. review of the Basic Plan before the year 2000.

CHAPTER 7

SELECTION OF AN OPTIMUM ALTERNATIVE FOR TECHNICAL SYSTEM

CHAPTER 7 SELECTION OF AN OPTIMUM ALTERNATIVE FOR TECHNICAL SYSTEM

7.1 Examination of System Components

7.1.1 Selection Method of an Optimum Alternative

1) System Components in SWM

a. Technical system

The SWM (Solid Waste Management) system consists of the technical and institutional systems. The technical system consists of the following sub-systems;

- discharge and storage
- collection and haulage (transportation)
- roads sweeping, drain cleansing and grass cutting
- processing and recycling
- final disposal
- equipment maintenance

Some sub-systems are always necessary, while the necessity of the others such as processing depends on the local financial, geographical and waste conditions.

It is necessary to examine whether or not certain sub-systems are required, and if required, their types, methods, and facilities, too. The following table explains upto what extent each technical sub-system was examined.

Table 7.1-1 Scope of Examination

Sub-systems	Scope of Examination
- Discharge and Storage	C
- Collection and Haulage	C
- Road Sweeping, Drain Cleansing and Grass Cutting	C
- Transfer	B
- Processing	
. Incineration	A
. Composting	A
. Shredding	A
. Sorting	A
- Final Disposal	C
- Equipment Maintenance	C

Note;

A: Examination was made as to:

- whether or not the sub-system is necessary

B: Examination was made as to:

- whether or not the sub-system is necessary
- types, methods and facilities

C: Examination was made on the type, method and facility to be used as the sub-system is absolutely necessary.

b. Institutional system

In addition to the above-mentioned technical sub-systems, SWM system contains the following institutional sub-systems:

- organization and management
- legislation and enforcement
- finance (revenue source)
- public cooperation

2) Selection Method of an Optimum Alternative

An alternative to the SWM system is a combination of various technical sub-systems such as discharge and storage system, collection and haulage system, road sweeping, drain cleansing and grass cutting system, processing system and final disposal system. Many alternatives can be made by the combination of possible sub-systems.

If all combinations of the above sub-systems were to be studied, the total number of combinations would be equal to hundreds of individual SWM systems. Therefore, it can be deduced that a Basic Plan study is the screening work concerning various alternative systems.

The creation of a cost-effective SWM system is the main issue in the generation of alternatives because the implementation of SWM would be very costly.

Consequently, the following method was applied in the Study for the selection of an optimum alternative for the Basic Plan.

a. Selection of an optimum technical system

i. examination of technical sub-systems

Possible sub-system alternatives for each technical sub-system were examined and optimum sub-systems were selected. For example, an optimum bin was selected as a refuse bin based on the comparison of alternatives such as plastic bins, bamboo baskets, etc.

ii. examination of combinations of technical sub-systems

A comparative study on the technical systems of the 3 sites below was carried out by combining each technical sub-system.

Case 1: Final disposal site is at Km 18-DS

Case 2: Final disposal site is at DCDS
(Dongphosi Candidate Disposal site)

Case 3: Final disposal site is at NCDS
(Noensaard Candidate Disposal Site)

iii. selection of an optimum technical system

Upon consideration of the results of the above-mentioned three alternative studies, an optimum technical system was selected by evaluating the following aspects;

- a; technical points of view;
- b; economic and financial points of view;
- c; transactional facilitation points of view; and
- d; environmental points of view.

b. Selection of the optimum institutional system

After the selection of the optimum technical system, a study was also made to generate alternatives for the organizations, institutional and financial aspects which would be suitable to the selected technical system. After the comparative study on the above-mentioned alternatives, an optimum SWM system was finally selected.

7.1.2 Discharge and Storage

1) Solid Waste Separation

The waste discharge method is divided into two categories: mixed discharge and segregated discharge.

Source separation at the residential and commercial areas is well established and organized. Therefore, the present source separation system at the residential and the commercial areas should be encouraged in future.

Almost all institutional wastes are discharged in a mixed manner, except for those collected as reusable materials for recycling.

In the future, refuse bins for institutional wastes shall be properly adopted and the existing mix discharge will be continued. However, infectious wastes generated in hospitals should be discharged separately as much as possible since they are already segregated at the generation sources.

2) Type of Refuse Bins

a. Capacity

Judging from the result of the WACS, the amount of waste discharged from a residence is about 22 liters per day (626 g x 6 persons/168). Consequently, the capacity of the refuse bin should be about 154 liters, assuming a discharge frequency of once a week.

b. Price

A bamboo basket costs less than 500 kips. It is extremely cheaper than the other containers.

c. Convenience for residents

As there are many garden wastes, including twigs and so on, generated in residential areas, the use of bamboo baskets will be very convenient as they are easy to handle.

d. Collection work

In consideration of the present loading work, bamboo baskets or plastic bags are convenient as containers, because the former is shock-proof and the latter is disposable.

e. Sanitary aspect

A plastic basket with lid is sanitarily favourable in terms of the prevention of offensive odor, refuse scattering, etc.

However, the results of the WACS carried out in this Study showed that percentage of household garbage is very low (around 17%) due to the well-established food waste recycling system by private sectors, and that only few flies and scavenging animals were seen around the bamboo baskets with waste.

It can be concluded, therefore, that the use of bamboo baskets does not cause unsanitary conditions.

The problem on the absence of lids was dealt with, and consequently, it was decided that, with the cooperation of the residents, a corrugated paper or a plank should be used as a substitute cover to prevent scattering.

Several elements described above led to the conclusion that it is most effective to use a bamboo basket, which is already widely used, as a refuse bin even in the future (2000).

3) Discharge and Storage Points

Discharge and storage points will be determined on the basis of the future collection system. In the residential and commercial areas within the Study area, curb or bell collection system is to be adopted in relation to the fee collection system. Thus, road sides will be designated as discharge and storage points for domestic and commercial wastes.

On the other hand, institutional waste is to be collected with the use of containers. The container shall be placed within the premises and the waste will be discharged in it.

4) Discharge Frequency

Waste should be discharged on days designated as collection days in residential and commercial areas. Hence discharge frequency shall be equal to collection frequency.

7.1.3 Collection and Haulage

1) Collection Frequency

The current coverage ratio of the collection services is 4.8% in the residential area and only 22.3% in the commercial area. Therefore, the primary objective is not to increase collection frequency but to extend the coverage of the collection services. In view of the foregoing, the collection frequency in the residential area and the commercial area shall be once a week, as a rule, with the exception of some parts in the commercial area where a twice a week collection shall be made.

On the other hand, institutional wastes shall be collected everyday, as a rule. However, the collection frequency in every market, office and hospital will be determined according to scale. This is

calculated based on the number of days in which a container (5 m³) is filled with waste.

2) Mix or Separate Collection

Mixed collection shall be made on the waste discharged from the residential area, commercial area, markets and offices. Waste generated from hospitals, however, shall be separated because infectious wastes will be disposed separately from other wastes at the disposal site.

3) Collection Service

a. Type of collection service

The most common types of residential services used for low-rise detached dwellings in the Study area include;

- i. curb collection;
- ii. alley collection;
- iii. setout-setback collection;
- iv. setout collection;
- v. backyard collection; and
- vi. bell collection.

b. Selection of collection service

In the Study area, as effective collection work is required in spite of little equipment and limited number of workers, the cooperation of the residents will be indispensable. Therefore, curb collection should be adopted for the residences along the collection route and bell collection for the other residences.

4) Collection Time

Since traffic condition was observed to have no effect on the collection work flow, day time collection shall be adopted.

5) Collection Vehicles

a. Type of waste collection vehicles

The 3 types of vehicles for waste collection services are as shown below.

- dump truck type;
- compactor truck type; and
- detachable container truck type.

b. Selection of suitable waste collection vehicles

Based on the comparison, the dump truck type and detachable container truck type are recommended for the Project because:

- It is economical in terms of loadage;
- It is capable of collecting all types of waste and thus can be used for a wide range of services;
- It is compatible with the type of vehicles currently used by the present collection system;
- The dump truck type shall be used in the area where curb or bell collection services are implemented.
- The detachable container truck type shall be used for institutional wastes.

6) Transfer System

a. Means and methods of transport

The following are presently used as the principal means of transportation for solid wastes;

- motor vehicles
- railroads
- vessels
- pneumatic and hydraulic systems

b. Need for Transfer Stations

Transfer and transport operations become a necessity when the distance to available disposal sites or processing plants increase to the point that direct hauling is no longer economically feasible. They also become a necessity when disposal sites or processing plants are in remote locations and cannot be reached directly by highway. Transfer operations and the introduction of transfer stations are necessary in the following cases:

- i. The location of disposal sites is relatively far from collection routes (typically more than 15 km);
- ii. The use of small-capacity collection trucks (generally under 10 m³);
- iii. The widespread use of medium-sized containers for the collection of wastes from commercial sources.
- iv. The use of hydraulic or pneumatic collection systems.

c. Necessity of Transfer system

In the Study area, the distance from the collection area to the disposal site is less than 20 km. Therefore, it is not recommended to adopt a large scale transfer system.

The transfer system using containers is certainly one of the small scale transfer systems. As a matter of fact, it is inconvenient to use in the residential and the commercial area because the collection service is conducted under the Beneficiary-Pay-Principle; the collection fee is collected from each premises.

As for institutional waste, however, this transfer system (i.e., a container is used in order to transfer waste from each generation source in the institution by the primary collection to a disposal site by a container truck.) shall be adopted due to the following reasons:

- i. reduction of loading frequency;
- ii. sanitary control of heaping points; and
- iii. ensuring against risks in loading work.

7.1.4 Road Sweeping and Drain Cleansing and Grass Cutting Activities

1) Road Sweeping

Road sweeping is normally conducted both by hand or machine.

Automatic road sweeping system is the collection of waste accumulated at the road sides by a sweeping vehicle. The use of this system, however, requires the road to be paved.

Although the main road swept is paved in the Study area, the pavement is not well, especially the road sides. In addition, the automatic road sweeping system is expensive not only in terms of machine procurement but also in terms of the operation and maintenance of the machine for the system.

Therefore, the use of an automatic road sweeping system is not applicable in the Study area unless the length of the paved roads will be extended and enough financial source is secured. The existing manual sweeping system will be continually used, therefore, at least until the target year for the Basic Plan (2000).

Since the main roads in the Study area are currently covered by the sweeping service, the same sweeping service is considered adequate even in 2000 in terms of finances. As for roads uncovered by the service, the Municipal Government shall encourage the residents to clean-up the roads by themselves.

2) Drain Cleansing

Residents, school and office workers clean the drains by themselves, but request the Municipality to collect the drain cleansing waste.

Drain cleansing waste will be collected and hauled by using small dump trucks and a wheel loader.

Cleansing of main drains along the main roads to be covered by the road sweeping service will be regularly conducted by the Municipality.

The entire Study area shall be covered by cleansing service. The main drains which are along the main roads covered by the road sweeping service will be especially done by the Municipality.

Frequency of cleansing services will be once every three months. The collection service for the wastes of the drain cleaned by the residents themselves will be done whenever requested, except on Sundays and holidays.

3) Grass Cutting

A shoulder type grass cutter will be used in grass cutting. Grass cutting wastes will be collected and placed together with the road sweeping wastes in the containers to be set at the road side by the road sweeper.

Grass cutting will be conducted on the road sides of the main roads which will be covered by the road sweeping service.

Grass cutting will be conducted every two months.

7.1.5 Processing and Recycling

1) Examination of Possible Methods

The possibility of introducing appropriate processing and recycling methods must be examined in view of the facts that the acquisition of new disposal sites is becoming increasingly difficult and that better environmental conservation measures should be introduced.

a. Selection criteria

The following criteria are considered in the selection of possible processing and recycling facilities.

- i. The facility should be capable of reducing the solid waste volume for final disposal, thereby contributing to extend the life of disposal sites.
- ii. The facility should assist the recycling of resources.
- iii. The facility should contribute to the improvement of environmental conditions.

b. Evaluation of possible processing and recycling facilities

The following seven methods are considered to meet the criteria given in (a.) above and can be employed independently or jointly:

- composting;
- RDF (Refuse Derived Fuel);
- pyrolysis gassification;
- slagging pyrolysis
- incineration;
- crushing and shredding; and
- mechanical or manual sorting.

Each system has their own advantages and disadvantages. It is, therefore, important to select an optimum system or an optimum combination of systems, by taking the following points into account:

- construction, operation, maintenance and repair cost
- acceptability of various kinds of wastes
- volume reduction effects for final disposal
- marketability and price stability in markets of recovered materials
- ease in operation
- reliability and stability of treatment plants (degree of technical development and operation results, etc.)
- impact on surroundings and its intensity
- simplicity in design of plants (pre-treatment, back-end treatment, etc.)

Table 7.1-1 shows the characteristics of possible processing systems.

Table 7.1-2 Examination of Processing Facilities

Processing Facilities	Re-covered Material	Main Target of System	Contribution of Landfill			Special Cautions										Remarks
			Volume Reduction	Harmless	Stabilization	Stability of Technology	Pre-treatment	Back-end treatment	Rejected Substances	Acceptability of Refuse Quality	Initial Cost in Japan US\$/ton	Operation cost in Japan US\$/ton	Marketability of Recovered Material	Environmental Impact		
① Composting	Compost	Conversion to Fertilizer	△	△	△	◎	Necessary	Necessary	Glass, Stone, Plastic, Dry Cell	△	200,000	16,000	△	(Odor) △	-Stability of Market of Products	
② R D F	Solid Fuel	Conversion to Fuel	△	△	△	△	ditto	ditto	Incombustible	△	N.A.	N.A.	?	(Noise & Dust)	-Marketability of Products	
③ Pyrolysis Gasification	Gas or Oil		○	○	○	△	ditto	ditto	Incombustible Carbon	△	N.A.	N.A.	X	○	-Incompletion of Technology -Initial/Running Cost	
④ Slagging Pyrolysis	Gas and Slag	Volume Reduction & Prevention of Water Pollution	◎	◎	○	△	Occasionally Necessary	Not Necessary	None	○	N.A.	N.A.	?	○	-Large consumption of Supplemental Fuel -Difficulty of Operation	
⑤ Incineration (Residue)	Heat/or Electric Power Ash (cover soil) Ferrous (Reusables)	Volume Reduction & Energy Conversion	○	○	○	◎	Not Necessary	Not Necessary	None	◎	350,000	28,000	△	○	-Initial/Running cost -Possibility to get Revenue -Possibility to find User of Heat	
⑥ Crushing & Shredding etc.	Ferrous etc.	Volume Reduction of Bulky Waste	△	△	○	○	Extraction of Explosive Object	ditto	Discarded Material	△	200,000	15,000	△	(Noise & Dust) △	-Large Consumption of Electricity -Much Expense for Maintenance -Possibility of Explosion	
⑦ Sorting (Mechanical or Manual Sorting)	Ferrous, Glass, Paper, Plastic etc.	Recycling	△	△	△	◎	Occasionally Necessary	Necessary	Discarded Material	△	N.A.	N.A.	○	○	-Stability of Market for Salvaged Material	

◎ : Excellent

○ : Good

△ : Fair or () to be considered

X : Poor and () shows reason

The processing systems should be selected according to qualities of waste. Each processing facility and its characteristics are described below:

i. composting

Generally suited for domestic waste, wastes of a similar kind, and some commercial waste.

ii. RDF

Commercial waste especially rich in paper content might be processable.

iii. pyrolysis gassification

Limited only to waste with low moisture content and high calorific value.

iv. slagging pyrolysis

Suited for a wide range of waste including inert materials.

v. incineration

Suited for a wide variety of waste except for incombustible bulky waste. Although waste from hospital and carcass are low in calorific values, they should be incinerated in a special furnace for sanitary purposes.

vi. crushing & shredding

For bulky waste.

vii. mechanical or manual sorting

Suited for inert waste with reasonable content of recyclable components.

2) Conclusion

Upon consideration of the examination of processing systems and the present SWM in Vientiane urban area, especially its very limited financial situation, it is concluded that the introduction of any kind of processing facility including a recycling facility would not be necessary by the year 2000 unless the financial situation changes drastically. Some small scale facilities, however, such as incinerator for hospital waste or corpses might be recommended if their initial cost and operation cost can be secured. The reasons for the conclusion are described as follows:

- a. In view of the present financial status of SWM, it is absolutely difficult to secure the initial cost and operation and maintenance cost of a processing facility and a recycling facility as well.
- b. There is an existing landfill site (KM 18-DS) with an area which can be used for more than 30 years and candidate sites (DCDS and NCDS). The processing facilities are mainly needed to reduce the volume of solid waste in order to extend the life span of the disposal sites. Consequently, the introduction of a processing facility is not urgently required by the year 2000 in terms of the disposal of solid waste.
- c. According to the results of the WACS and CCS described in 2.1 Waste Stream, composting is not recommendable since the composition ratio of food waste and the C/N value is low (i.e., a desirable C/N value is considered as between 30 and 35). In addition, following problems are identified with regard to the composting of solid waste in the Study area.

- i. The market size for compost is limited due to the wide use of various types of organic fertilizer, such as chicken and cow dung.
 - ii. High production and transportation costs for composting and heavy labour in the actual application of compost.
 - iii. The composting of solid waste is not very effective in reducing solid waste volume and weight.
 - iv. Livestock raising, which provides organic fertilizer, is expanding.
- d. In addition to the initial and running cost, the following problems are encountered in each processing systems:
- RDF : restricted by solid waste quality, and technical capability
 - pyrolysis gassification : restricted by solid waste quality, technical capability and difficulties in operation
 - slagging pyrolysis : technical capability and difficulties in operation
 - crushing and shredding : limited generation of bulky waste
 - mechanical or manual sorting: existence of well-established recycling system done by private sectors and limited generation of subject waste
- e. As described in Section 4.6 of Chapter 4, a recycling facility is not necessary since the existing recycling system is well-established.

7.1.6 Final Disposal

1) Possible System Alternatives

The following aspects are to be considered for the possible system alternatives of final disposal.

- location and number of final disposal sites;
- final disposal methods;
- landfill structure;
- recovery of methane gas; and
- level of sanitary landfill development and operation.

2) Location and Number of Final Disposal Sites

The following sites were studied;

- i. the existing KM 18-DS (Kilometer 18 disposal site)
- ii. DCDS (Dongphosi candidate disposal site)
- iii. NCDS (Noensaard candidate disposal site)

Through the examination of combinations of technical sub-systems, a final disposal site for the Basic Plan is selected in this chapter.

3) Final Disposal Methods

There are several final disposal methods as listed below:

- open dumping;
- controlled tipping; and
- sanitary landfill.

Although the crude open dumping method is generally used in the Study area, they shall not be used in the future in view of their adverse effects on the landscape, public health and environment.

Sanitary landfill should be used for final disposal. Sanitary landfill is proven to be the most economical and acceptable method for the disposal of solid wastes. The term sanitary landfill refers to the compaction and covering of disposed wastes with layers of soil at the end of each day's operation.

4) Landfill Structure

There are five types of landfill structure, and they are as follows:

- anaerobic landfill;
- anaerobic sanitary landfill;
- improved anaerobic sanitary landfill;
- semi-aerobic sanitary landfill;
- aerobic sanitary landfill.

The contribution to the mitigation of environmental pollution is improved in accordance with the above list.

The Landfill site in the Study area currently employs the anaerobic landfill structure.

In view of the above advantages and disadvantages of the landfill structure types, it is planned that final disposal sites in the Basic Plan will employ the semi-aerobic sanitary landfill structure with leachate drainage pipes.

5) Recovery of Methane Gas

The recovery of methane gas will not be considered in the alternative study due to the following reasons:

- i. All candidate sites are flat and it is rather difficult to recover the methane gas at the flat and shallow disposal site.

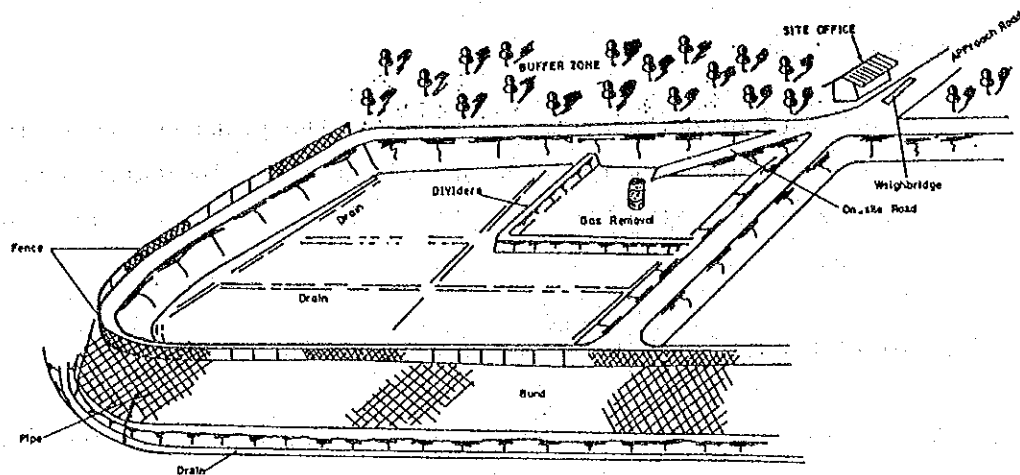
- ii. The user of methane gas recovered at the proposed sites is not located in the surrounding area. This fact indicates that the recovery of methane gas may not be feasible in the proposed sites.

6) Level of Sanitary Landfill Development and Operation

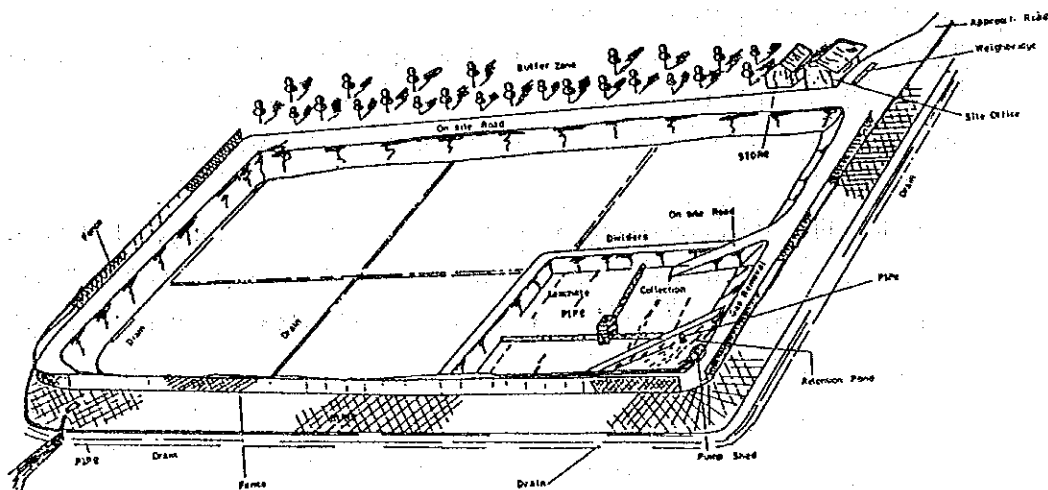
The level of sanitary landfill development and operation can be classified into the following four levels.

- a. Level 1 Controlled tipping
- b. Level 2 Sanitary landfill with a bund and daily soil covering
- c. Level 3 Sanitary landfill with leachate circulation
- d. Level 4 Sanitary landfill with leachate treatment

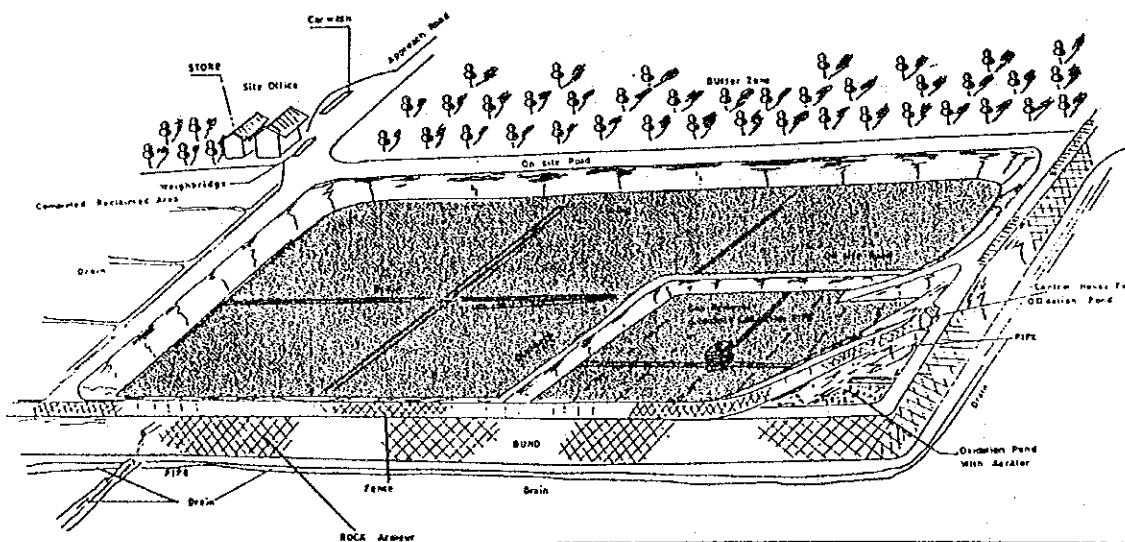
The details of above mentioned level of sanitary landfill development and operation are described below. The prospective levels of sanitary landfill development and operation are illustrated in Fig. 7.1.1.



Level 2



Level 3



Level 4

THE STUDY ON THE SOLID WASTE MANAGEMENT SYSTEM
IMPROVEMENT PROJECT IN VIENTIANE, LAO P. D. R.
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 7.1-1 Prospective Illustration of Sanitary Landfill Development and Operation in Level 2, 3 and 4

a. Level 1; Controlled Tipping

i. objective

- to introduce controlled tipping

ii. level to be achieved

- establishment of access to site;
- introduction of cover materials in order to prevent fire and to lessen blown waste and rank odor; and
- introduction of inspection, control and operational recording system of incoming waste.

b. Level 2; Sanitary Landfill with a Bund and Daily Soil Covering

i. objective

- to introduce sanitary landfill

ii. level to be achieved

- establishment of site boundary in order to distinguish the disposal site and to eliminate scavenging;
- execution of sufficient cover over waste disposed;
- establishment of disposal site by the construction of enclosing bund;
- introduction of divider between present landfill area and future landfill area;
- establishment of drainage system in order to divert stormwater and seepage from surrounding area and to reduce leachate;
- introduction of environmental protection facilities in order to lessen direct impact on surroundings such as buffer zone, litter control and gas removal facilities;

- introduction of semi-aerobic sanitary landfill by the installation of gas removal facilities; and
- introduction of amenities for the staff.

c. Level 3; Sanitary Landfill with Leachate Circulation

i. objective

- to establish leachate control

ii. level to be achieved

- establishment of leachate control by the installation of leachate collection, circulation and monitoring facilities
- establishment of semi-aerobic sanitary landfill in order to facilitate the stabilization of waste disposed through the active decomposition in semi-aerobic condition
- establishment of dust prevention system by sprinkling water.

d. Level 4; Sanitary Landfill with Leachate Treatment

i. objective

- to establish leachate treatment

ii. level to be achieved

- establishment of leachate treatment by the installation of oxidation pond
- establishment of seepage control by the sealant (liner).

7.2 Technical System Alternatives

7.2.1 Summary of Alternative Plans

1) Basic Policy

Like any other services of a public nature, solid waste management is only viable when the necessary technical systems, ranging from the storage system at sources of generation to the final disposal system, and appropriate organizational and financial operation systems are properly provided. Chief characteristic of solid waste management is the constant change in the subject waste in terms of both quality and quantity according to socio-economic development. In addition, attention should be paid to the constraints in the construction method as well as system management imposed by local, natural and socio-economic conditions.

As clearly examined in the previous section 7.1, it is not necessary to introduce a processing facility including a recycling system by the year 2000. Then, proper systems for discharge and storage, collection and haulage, road sweeping, drain cleansing and grass cutting, and final disposal are selected.

In view of the above, it was decided that the present Study should evaluate the 3 alternative plans to examine the possibility of implementing solid waste management in Vientiane Municipality, by considering the geographical and socio-economic conditions of the Municipality.

2) Summary of Alternative Plans

In this Study, three alternative plans are studied for the formulation of the Basic Plan for Vientiane urban area. The summary of alternative plans is shown in Fig. 7.2-1. The concept of each alternative is as follows:

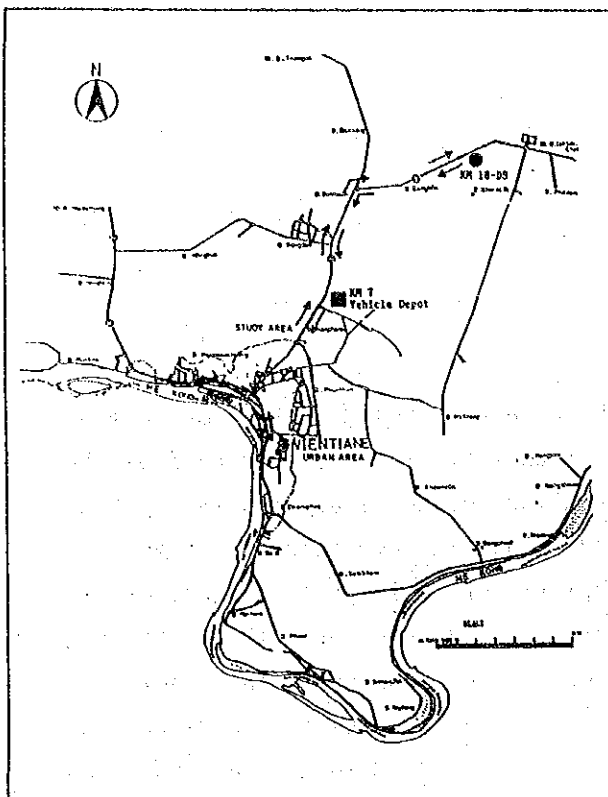


Fig. 4.2-1 Alternative 1: Final Disposal Site at KM 18-DS

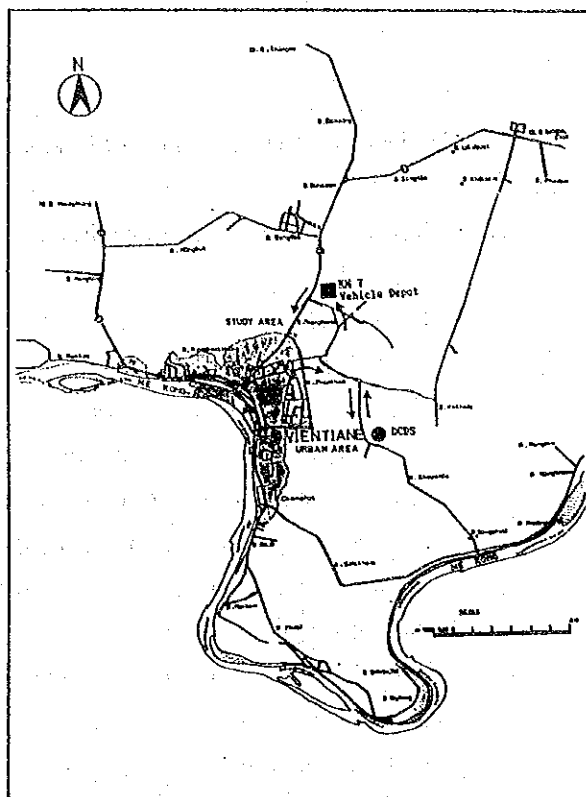


Fig. 4.2-2 Alternative 2: Final Disposal Site at DCDS

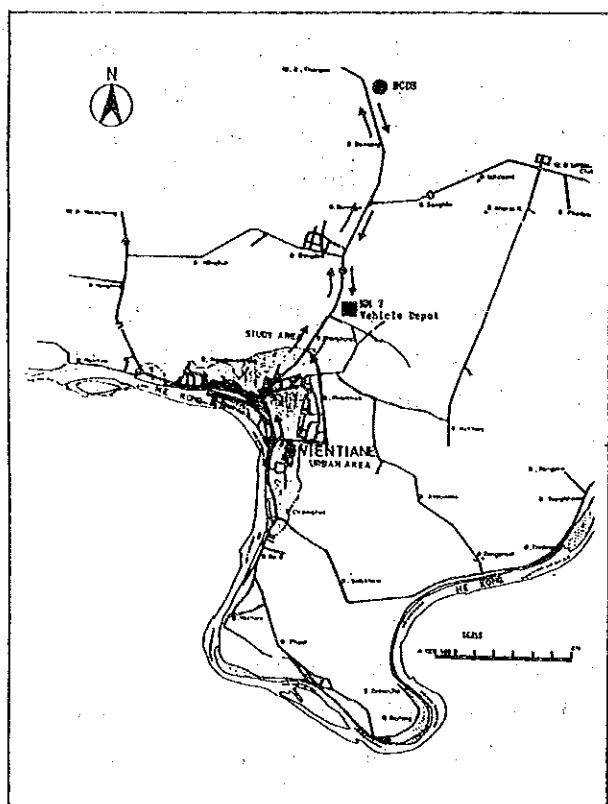


Fig. 4.2-3 Alternative 3: Final Disposal Site at XCDS

LEGEND

- : Disposal Site
- : Vehicle Depot

THE STUDY ON THE SOLID WASTE MANAGEMENT SYSTEM
IMPROVEMENT PROJECT IN VIENTIANE, LAO P. D. R.
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 7.2-1 Summary of Alternative Plan

a. Alternative 1; Final Disposal Site at KM 18-DS

Alternative 1 is presented as a disposal system providing sanitary landfill operation at the existing KM 18 disposal site (KM 18-DS). All wastes would be hauled directly to the disposal site without using transfer stations nor processing facilities.

b. Alternative 2; Final Disposal Site at DCDS

Alternative 2 is presented as a disposal system providing sanitary landfill operation at the Dongphosi candidate disposal site (DCDS). All wastes would be hauled directly to the disposal site without using transfer stations nor processing facilities.

c. Alternative 3; Final Disposal Site at NCDS

Alternative 3 is presented as a disposal system providing sanitary landfill operation at the Noensaard candidate disposal site (NCDS). All wastes would be hauled directly to the disposal site without using transfer stations nor processing facilities.

7.2.2 Preliminary Design

1) Calculation of Required Numbers of Collection Vehicle

a. Dump truck

A dump truck will be used as a collection vehicle for domestic and commercial waste. The number of vehicles required in 1995 and 2000 is 20 and 51 units, respectively.

Bases of calculation are shown in Table 7.2-1.

Table 7.2-1 Number of Collection Vehicles (DT) Required for Domestic and Commercial Waste

Items	Unit	1995	2000	Remarks
a. Amount of waste collected in residential and commercial areas	ton/day	60.3	138.9	b + c
b. Amount of waste collected by the Municipality in residential and commercial areas	ton/day	50.3	128.9	
c. Amount of waste collected by private contractor in residential and commercial areas	ton/day	10.0	10.0	*1
d. Volume of waste collected by the Municipality in residential and commercial areas	m ³ /day	291	740	b/0.173*2
e. Number of collection vehicles required		20	51	d/10*3/0.8*4/2*5x1.1*6

Note;

- *1 ; Details are given in the Supporting Report (1), I.2.2.
- *2 ; Apparent specific gravity
- *3 ; Loading capacity of a dump truck
- *4 ; Loading ratio
- *5 ; Number of trips per day
- *6 ; Spare vehicle ratio (10%)

b. Detachable container truck

Detachable container trucks will be used as collection vehicles for institutional, road sweeping and grass cutting wastes.

i. number of containers

Containers will be placed at main markets, hospitals and offices presently receiving collection services. Some of the containers will also be placed in roads as a dust bin for road sweeping and grass cutting activities.

Number of containers is calculated based on the following:

- Capacity of a container is 5 m^3 .
- Apparent specific gravity is 0.173 ton/m^3 .
- Spare containers required are 10% of the actual number of containers required.

Consequently, number of container required is calculated at 40.

ii. detachable container truck

Number of detachable container trucks required is calculated based on the collection frequency and number of trip.

The frequency of trips is estimated to be twice a week. Consequently, the number of containers hauled per day is calculated at 10 units.

Number of trips of alternative 1 and 3, and 2 is 5 and 6, respectively.

Number of detachable container trucks including a spare vehicle required in 1995 and 2000 is 3 units.

2) Preliminary Design of Disposal Sites

a. Design conditions

The major design conditions are as follows:

- disposal amount : 72.3 ton/day in 1995
152.9 ton/day in 2000
- unit weight of waste disposed : 0.7 ton/m^3
- cumulative amount : 243,100 ton by December 2000
 $347,300 \text{ m}^3$ by December 2000
- required volume of cover soil : 35% of the disposed waste volume
- landfill height : 4.0 m
- level of sanitary landfill development and operation : Level 3
- conditions of candidate site : The conditions for the planning of each candidate site are described and tabulated in Table 7.2-2.

Table 7.2-2 Conditions of Candidate Sites for Final Disposal

Site Items	KM 18-DS	DCDS	NCDS
① Haul distance from main waste generation area (from Namphou) (km)	18.0	18.0	11.0
② Available land area	more than 60 ha	more than 30 ha	more than 30 ha
③ Soil conditions and topography	Clayey soils and flat bush land	Clayey soils and flat bush land	Clayey soils and flat bush land
④ Availability of cover soil	Available at the site	Available at the site	Available at the site
⑤ Climatology conditions	Tropical monsoon	Tropical monsoon	Tropical monsoon
⑥ Surface-water hydrology	Part of larger drainage catchment area and plain land	Part of larger drainage catchment area and plain land	Part of larger drainage catchment area and plain land
⑦ Geologic and hydrogeologic conditions	Quaternary alluvial soil (clay and silt). Groundwater in unconsolidated soil. Alluvium: consisting of stiff reddish brown clay with little of fine gravel.	Quaternary alluvial soil (clay and silt). Groundwater in unconsolidated soil. Alluvium: essentially of stiff reddish brown gravelly clay.	Quaternary alluvial soil (clay and silt). Groundwater in unconsolidated soil. Alluvium: essentially of stiff reddish brown silty clay with fine sand and fine gravel.
⑧ Local environmental conditions	In close proximity to farmer's houses and farm land.	In close proximity to farmer's houses and farm land.	In close proximity to farmer's houses and farm land.
⑨ Ultimate uses	Subsequent study	Subsequent study	Subsequent study