b. Prediction of Average Household Income

Household income in AMSS is predicted to grow in proportion to the growth rate of GRDP/capita (see the table below).

Table K-26: Prediction of Average Household Income

Unit: colones/year in 1999 price

Year / City	1999	2005	2010
San Salvador	76,110	96,464	116,518
Mejicanos	60,340	73,326	87,132
Delgado	46,901	56,018	65,671
Cuscatancingo	46,355	51,127	56,305
Ayutuxtepeque	57,500	59,629	63,414
San Marcos	50,212	63,506	77,849
Nueva San Salvador	81,776	89,867	97,201
Antiguo Cuscatlan *	149,969	149,625	148,945
Soyapango	56,757	74,265	88,016
Ilopango	47,871	54,386	61,306
San Martin	37,264	35,569	35,618
Apopa	40,705	44,151	47,985
Nejapa	32,089	37,459	44,432
Tonacatepeque	31,718	35,216	39,435

Note: * The increase rate of population is higher than that of GRDP.

c. Current Financial System of Municipalities

The status quo of municipal financial system is assessed as shown in the table below, based on the information received by the Team through inquiries and on the data forwarded by C/P.

Table K-27: Current Financial System of Municipality

	Separate accounting	Fee collection through CAESS/ DELSUR	Computerized DB for fee collection	Financial Analysis
San Salvador	Sufficient	Cleansing fee & S/L	Exist	Sufficient
Mejicanos	Not sufficient	S/L	Not sufficient	Not sufficient
Delgado	Sufficient	S/L	Not sufficient	Not sufficient
Cuscatancingo	Not sufficient	Cleansing fee	No	Not sufficient
Ayutuxtepeque	Not sufficient	S/L	Not sufficient	Not sufficient
San Marcos	Not sufficient	S/L	Not sufficient	Not sufficient
Nueva San Salvador	Sufficient	Cleansing fee & S/L	Not sufficient	Not sufficient
Antiguo Cuscatlan	Not sufficient	No	Not sufficient	Not sufficient
Soyapango	Sufficient	S/L	Exist	Sufficient
Ilopango	Sufficient	S/L	Not sufficient	Sufficient
San Martin	Not sufficient	No	Exist	Not sufficient
Apopa	Not sufficient	S/L	Not sufficient	Not sufficient
Nejapa	Sufficient	No	No	Not sufficient
Tonacatepeque	Not sufficient	No	No	Not sufficient

d. Current Financial Dimensions of OPAMSS

OPAMSS's budget in 2000 is reduced approximately to 70% of that in 1997. Personal cost accounts for about 80% in both years.

Table K-28: Budget of OPAMSS

Unit: 1000 colones

	2000	1999	2000/1999(%)
Personnel Cost	5,041	7,597	66.4
Goods & Services	776	1,047	74.1
Financial Cost	363	353	102.8
Current Transfer	0	10	0.0
Investment	155	176	88.1
Amortization	200	200	100
Total	6,535	9,383	69.6

Source: Financial Department of OPAMSS

Revenue/expenditure balance of OPAMSS in years 1997, 1998, and 1999 are summarized in the table below.

Table K-29: Balance of OPAMSS

Unit: 1,000 colons

Item		1999	1998	1997
Revenue	Sales of goods and services *	6,082	8,598	10,261
	Current transfer	476	950	0
	Financial revenue	173	471	356
	Adjustment	70	1	24
	Total	6,801	10,020	10,641
Expenditure		9,368	10,720	7,457
Surplus/Deficit		-2,567	-700	3,184

Note : * including permission services
Source : Financial Department of OPAMSS

K.3.2 Condition for Cost Estimation

This section sets basic prices and key design data that are used for "Comparative Examination of Technical Alternatives".

The prices and foreign exchange rates are based on them in April 2000.

a. Exchange Rates

US$1.00 = 8.75 colones = JP¥105.00

b. Basic Prices

Personnel

The following salaries include social securities (ISSS and AFP) and bonuses.

Manager: 70,000 colones/year

Engineer: 60,000 colones/year

Supervisor:	40,000 colones/year
Mechanic:	50,000 colones/year
Mechanic Assistant:	40,000 colones/year
Driver:	35,000 colones/year
Worker:	32,000 colones/year
Secretary:	30,000 colones/year

Note: These personnel costs would be reconsidered, when a feasibility study is carried out.

Fuel

Gasoline:	15 colones/gallon (3.96 colones/liter)
Diesel:	9 colones/gallon (2.38 colones/liter)

c. Service Life

Vehicles:	7 years
Transfer Station *:	20 years

* Integrated service life of the facilities including buildings, machines and so on necessary.

d. Interest Rates

Interest rate is assumed at 5% per year. Loan payback period is supposed to correspond to the service lives.

e. Key design Data

Bulk density at generation source:	200 kg/m^3
Bulk density in dump truck:	300 kg/m^3
Bulk density in compactor truck:	450 kg/m^3
Working hour:	7.5 hours/day

K.4 Comparative Examination of Technical Alternatives

K.4.1 Storage and Discharge System

Waste is generated on a somewhat continuous basis. However, collection occurs intermittently, a few times a week or perhaps daily, depending on the quantity generated at a specific location and climatic conditions. Therefore, it is necessary to provide proper storage of waste at home until it is collected. Storage is quite important because it can have a significant effect on:

- Public health and aesthetic conditions
- Subsequent functional elements such as collection
- Material recovery (recycling)

The effects on these aspects vary depending on the generation source, i.e., detached houses, apartments, shops, office buildings, etc.

Public Health and Aesthetic Conditions

Public health concerns are primarily related to the infestation of solid wastes with vermin and insects that often serve as potential vectors of diseases. By far the most effective control measure for both rats and flies is proper sanitation. Typically, this involves the use of paper, plastic bags, or containers with tight lids, the periodic washing of the containers as well as of the storage areas, and the frequent removal of biodegradable materials, which is especially important in areas with a warm climate.

Aesthetic considerations are related to the production of odors and the unsightly conditions that can develop when adequate attention is not given to the maintenance of sanitary conditions. Most odors can be controlled through the use of sealed containers and the timely discharge with punctual waste collection services. To maintain aesthetic conditions, the container should be scrubbed and washed periodically.

Subsequent Functional Elements

Storage and collection are separate operations but must be closely coordinated. The type, size and location of containers are very important factors in determining the most efficient collection system. Large communal containers are favorable in terms of raising collection efficiency, but it has considerable adverse effect such as odor on around the container. Small containers are quite convenient for loading waste but reduce collection efficiency because they require more frequent stops for loading.

Material Recovery (Recycling)

If reusable and/or recyclable material is separately stored at the source and if a material collection system works, irrespective of whether it is formal or informal, such material could be recovered from the vein and delivered into the artery of the material flow.

a. Problem Recognition

According to the results of POS, 89.0% out of 420 houses are using a plastic bag as a recipient of waste, 20.7 % uses metal/plastic/wood container, a small population uses paper bag (1.0%) and carton box (1.4%) and 3.1% answered that they use other containers.

Generally speaking, the higher income houses have enough space to store waste, the lower income houses are in short of such space. Furthermore, waste storage areas of the lower income houses are more vulnerable to infestation of insects and animals due to their housing conditions such as no floor, poor airtightness and easy access by dogs due to no walls. Therefore, it can be said that the needs for appropriate storage are higher in the lower income houses than the higher income houses.

Separation of waste at source is not common. Almost of recyclable and reusable material, such as cans, bottles and papers, is mixed with other wastes, discharged and disposed of. However, some people separate such reusable/recyclable material in order to hand them to collectors according to POS.

b. Potential Technical Alternatives

In this section, technical alternatives listed in Table K-30 regarding the storage and discharge system are examined taking into account the aforementioned effects.

Table K-30: Potential Technical Alternatives of Storage and Discharge

Technical system	Subsystem	Subsystem components
Storage and Discharge	• Type of storage recipient	• Plastic sack • Dustbin
	• Discharge Manner	• Mixed • Separate

c. Screening of the Alternatives

c.1 Type of Storage Recipient

i. Plastic Sacks

The plastic sack system generally entails the use of 20 to 80 liter sacks for the storage of waste, that is later picked up by the collection service.

Advantages

- The system is very sanitary because the sacks are disposable.
- The system is easy to handle because the sacks are light in weight and disposable when discharging.
- The system does not require any initial investment.

Disadvantages

- The system requires the continuous purchase of sacks.
- The use of disposable sacks increases the waste generation amount.
- Sacks can easily be torn by domestic animals or children or when too full.
- Contents of the sacks when left untied may scatter at pick-up points.

Applicability

As the result of POS shows, the use of plastic sacks for storage of waste is common place in the Study Area. Most plastic sacks used are shopping bags, but some large discharges such as shops and some high-income households use bigger plastic garbage sacks that are sold in shops.

The use of shopping bags has no effect on the waste generation amount because they are distributed by shops for shoppers to carry their purchases.

One problem, which needs to be taken account, is the infestation by insects and animals. Attention should be paid to this more in the lower income households than the higher income due to the housing conditions.

ii. Dustbins

Dustbins refer to all small-size containers with lids, ranging from 30 liters to about 120 liters in size. One man can reasonably lift and empty containers weighing up to

about 28 kg (70 liters), while two men are required to lift a 48 kg (120 liters) container. The dustbins may be made of galvanized steel or high density polyethylene and must be weather resistant.

Advantages

- This system provides good sanitary conditions because waste stored can be completely covered.
- This system maintains aesthetic conditions.
- This system lasts for more than several years.

Disadvantages

- This system requires an initial investment for the purchase of dustbins.
- Dustbins require periodic washing to maintain their sanitary condition.
- Dustbins are easily stolen because of their usefulness.

Applicability

The result of POS says that about 20% of households in the Study Area employ this kind of containers.

The metal container is more corrosive by water and leachate from garbage than the plastic container. That is, the plastic container is more lasting than the metal containers, and the former is cheaper choice than the later in long term. Furthermore, the plastic container is easy to handle as it is light.

As for the issue of easily stolen, this should be paid attention in discharging. Leaving the container for a long time out of houses attracts a theft.

c.2 Discharge Manner

i. Mixed Discharge

Mixed discharge means that almost all types of wastes are commingled when they are discharged. It's advantages and disadvantages on SWM are as follows.

Advantages

- This system does not require purchase of a pair of recipients for storing reusable/recyclable material and others separately.
- This system does not cause trouble to separate reusable/recyclable material.
- This system does not require special collection, i.e., separate collection.

Disadvantages

- This manner makes reusable/recyclable material contaminated by other wastes and reduces its value.
- This system makes recovery of reusable/recyclable material difficult.

ii. Separate Discharge

Separate discharge means that some reusable/recyclable materials are separately discharged from other wastes at the same days or other days. It's advantages and disadvantages on SWM are as follows.

Advantages

- This system avoids reusable/recyclable material contaminated by other wastes and keeps its value.
- This system makes recovery of reusable/recyclable material easy.

Disadvantages

- This system may require purchase of recipients for storing reusable/recyclable material.
- This system causes trouble to separate reusable/recyclable material.
- This system requires special collection, i.e., separate collection.

d. Conclusion

As the POS shows that the use of the plastic sack is widely accepted in the Study Area, this is favorable in view of sanitation and handling. The problem is that it is vulnerable to animal infestation. Therefore, the best recommendable storage method is combination use of the plastic bag and the plastic dustbin.

When discharging, only the plastic bag containing waste should be taken out of the dustbin. This helps the discharger to carry the waste to a collection point as it is light, and avoids the dustbin to be stolen.

As stated above, advantages and disadvantages of the mixed and separate discharges are obviously opposite. The mixed discharge is the cheapest way in view of costs. The separate discharge, however, would be a cheaper alternative than mixed discharge in such circumstances as reusable/recyclable material market is established and waste minimization saves considerable costs of disposal.

Separation at source is not common but practiced by some people according to POS who store reusable and/or recyclable waste for collectors. This shows that a reusable and recyclable material market potentially exists.

Although no formal separate collection system at present exists other than a few pilot projects such as one carried out in San Salvador, it is preferable that source separation should be encouraged in order to strengthen the existing reusable/recyclable material market and prepare separate collection in the future, and moreover, in view of resource conservation being one of global issues.

K.4.2 Collection and Transport System

In this section, technical alternatives of collection and transport system are examined. Technical terms used in this report are defined as shown in Table K-31.

Table K-31: Definition of Collection and Transport System

Technical system	Definition	Application
Primary collection	to carry discharged waste to temporary storage.	This primary collection is applied to areas where there is no accessible road to collection vehicles.
Temporary storage	to store the waste for a certain period until collected.	When the primary collection is employed, this temporary storage inevitably becomes necessary.
Collection (secondary collection)	to collect waste at each house or temporary storage.	This is always necessary in SWM.
Transport	to carry the collected waste from the collection area to a treatment facility or a landfill.	This is also always necessary in SWM. In case that transport distance is long, a transfer transport would be employed.

K.4.2.1 Primary Collection and Temporary Storage

In areas with inaccessible roads to collection vehicles, waste has to be carried to designated points for collection. People living near the designated points find it easy to discharge waste by themselves, but those further away have difficulties doing so. Therefore, a primary collection service, which is the haulage of waste from residences to collection points, should be established for the latter.

Temporary storage is a system that works as a transfer point from the primary collection to the secondary collection (which will be discussed in the following section). Containers and stations work as the temporary storage. Waste is stored there for a certain period, a few hours, one day or a few days depending on the secondary collection system. Collection vehicles sometimes function as the temporary storage by stopping on the road to wait for collectors bringing waste, where there are no space to install a container or station.

Table K-32: With/Without Primary Collection

Primary collection	Flow
with (inaccessible area for collection vehicles)	primary collection → temporary storage → collection → transport
without (accessible area for collection vehicle)	collection → transport

a. Problem Recognition

In the Study Area, many marginal or low-income communities have no accessible roads for collection vehicles, where the waste collection service is not provided in many cases. It causes illegal dumping especially to ravines and rivers, and degrades the environment of the Study Area.

Containers and stations have been nuisances in the Study Area, as waste is piled and scattered around them and it makes unsanitary conditions. Therefore, people have negative impression about them.

b. Potential Technical Alternatives

In this section, technical alternatives listed in Table K-33 regarding the primary collection and temporary storage system are examined. Besides the technical aspect, institutional consideration is important for the system. This is taken into account in this section as well.

Table K-33: Potential Technical Alternatives of Primary Collection

Technical system	Subsystem	Subsystem component
Primary Collection	• collection method	• communal storage (containers or stations) • house to house collection
	• Type of collection equipment	• handcart • pedal cart
Temporary Storage	• Type of temporary storage	• station • container • handcarts wait for collection vehicles • collection vehicles stop for handcarts

Table K-34: Institutional Consideration of Primary Collection

Type of Institutional
• community-based collection
• private sector (micro-enterprise)

c. Screening of the Alternatives

c.1 Collection Method

i. Communal Storage

This system requires dischargers to carry their waste to designated collection points, i.e., containers or stations. Therefore dischargers' active participation and cooperation are crucial for successful implementation of this system. To raise such awareness education and propagation about sanitation and proper manner of waste discharge is important, but also the distance that the dischargers need to carry the waste has a serious effect on whether this system works well or not.

Advantages

- This is the cheapest way to carry the waste to containers or stations.
- This system helps the dischargers to be aware of their role in the waste collection system.

Disadvantages

- This system may lead the dischargers to dump their waste to nearby ravines and rivers if the designated collection point is far away.

Applicability

The system is certainly the cheapest alternative in terms of cash requirements. However, the containers and stations to which the dischargers need to carry their waste should be within a reasonable distance, otherwise the system causes illegal dumping. Such reasonable distance may be about 80m according to the experience in the Study Area.

ii. House to House Collection

This system, refuse collectors pick up waste from each house, is the most costly but reliable. This house to house collection with the use of handcart by micro-enterprises is fairly popular in the Study Area.

Advantages

- This system is reliable as the refuse collectors have commercial incentive to carry the waste.
- The dischargers' contribution to this system is the minimum such as just putting their waste in front of their house.

Disadvantages

- This system is expensive.
- The service range is limited due to the manually operated handcart.

Applicability

This system would be suitable, where the containers or the designated collection points are far more than 80m from the houses. Meanwhile, a route of house-to house primary collection should be within around 1km.

The dischargers or responsible municipalities must be affordable to pay the collection fee for the service. Also the size of service area should be such that the refuse collectors can gain profit and such that the collection fee become reasonable for users.

c.2 Type of Collection Equipment

i. Handcart

Several types of handcarts are widely used in economically developing countries as well as in the Study Area. Barrel type is the most popular one in the Study Area. It is also used for manual street sweeping extensively.

Advantages

- Low investment, operation and maintenance costs.
- Produced and maintained locally.
- Simple design and easy operation.

- Flexible to road conditions; steep, narrow, bump, etc.

Disadvantages

- Small capacity
- Limited service radius

Applicability

As the advantages show, handcarts are sustainable and appropriate technology for developing countries. This can also apply to the Study Area. Especially, flexibility to road conditions is advantageous to the Study Area, as there are a lot of narrow and steep streets. Small capacity and limited service radius are not so serious disadvantages because such inaccessible roads (pasajes) to collection vehicle are not so long, generally 100 to 500m.

ii. Pedal Cart

Advantages/disadvantages/applicability

Pedal carts are combination of handcarts and bicycle or tricycle. The pedal cart generally has bigger capacity and longer radius than the handcart, but more expensive and less flexible to road conditions. In the Study Area, the pedal cart is not so common due to the road conditions mentioned before.

c.3 Type of Temporary Storage

i. Station

Stations are designated collection points where wastes from 5 to 20 houses are put for collection in order to make the collection work efficient. Such stations usually do not have any facility, residents and refuse collectors know where those are as a daily practices. In Japan, this station collection system is widespread, and the stations often have signs that announce collection days, collection time and discharge manner.

Advantages

- This system does not require capital investment.
- This system does not require special places nor large space.

Disadvantages

- This system often meets with opposition from residents nearby. Especially, when the houses near to the stations do not use them, such opposition is very serious.
- Small quantity of waste should be dealt with and storage period should be a minimum, because unsanitary conditions have serious adverse effect if the waste scattered by animal scavenging or other causes.

Applicability

In the Study Area this system is also seen. The stations that work well deal with small quantity of wastes and located in commercial areas. In such case, aesthetics and environment are not deteriorated seriously, even though some wastes are scattered,

because mutual surveillance by shops may be well working and the shops are usually motivated to keep clean around them to make their business successful.

On the other hand, the stations that gather huge amount wastes become serious nuisances over the Study Area. They are called "Botadero." Such "Botadero" often exists outside the community that uses it, lack of sense of ownership and responsibility leads to improper use of the stations.

ii. Container

There are two types of containers used in the Study Area, one is made of metal and the other is concrete. The former is widespread over the study area, 11 municipalities are making use of it. The size and shape of the container are almost the same, $2m^3$ ($3yd^3$) and compatible with $18yd^3$ and $25yd^3$ compactor trucks having winch to lift the container. This is the standard container in the Study Area.

The concrete containers are found in a few municipalities. Those are much bigger than the metal container and contain a large amount of waste, therefore, the negative impacts of containers such as odor and unaesthetic are serious.

In this section, discussion is only on the metal container as the concrete container is obviously inappropriate for the populated and urbanized Study Area.

Advantages

- This system can store lager volume than the station.
- This system makes the loading work efficient.
- This system is effective to avoid animal scavenging.

Disadvantages

- This system needs a certain space to install the container.
- This system requires capital investment for the container. In case that a new collection vehicle for this system is necessary, the investment cost will be huge.
- As well as the station, this system often meets with opposition by residents nearby.
- If the number of containers is small for the target collection area, the waste is spilt out from the containers and cause unaesthetic and unsanitary conditions.

Applicability

This system is suitable for lager amount of waste than the station, and makes the collection system more efficient. This means that large amount of collection costs could be reduced. However, the citizens in the Study Area have negative impression about containers as they have seen unaesthetic and unsanitary conditions around the containers.

In order to promote proper use of the container, the collection area should be defined clearly and enough number of containers to meet the generation amount of waste from the area should be provided. Besides this technical aspect, the containers should

be placed within the community that uses them to raise ownership and responsibility on the container.

iii. Handcarts Stop for Collection Vehicles

This system means that the primary collector with the filled handcart after collection wait for the collection vehicle at a certain point, and the waste is transferred from the handcart to the collection vehicle. This is employed in an area of Mejicanos.

Advantages

- This system does not require any space for storing waste.
- This system does not cause opposition like ones to the station and the container.
- This system does not require any capital investment for the temporal storage.

Disadvantages

- This system makes the primary collection inefficient.
- The filled handcart can not be used until the waste is transferred to the collection vehicle.

Applicability

This system requires reliable relationship between the primary collector and the secondary collector (the collection vehicle). Once such relationship is lost, the system also does not work.

In terms of keeping aesthetic and sanitary conditions well, this system is effective. However, the efficiency of the primary collection is doubtful.

iv. Collection Vehicles Stop for Handcarts

This system means that the collection vehicle waits for handcarts coming back on the road for a while. This is often seen in the Study Area such as San Salvador and Nueva San Salvador. In the case of those municipalities, the primary collector is the same as the secondary collector.

Advantages

- This system does not require any space for storing waste.
- This system does not cause opposition like ones to the station and the container.
- This system does not require any capital investment for the temporal storage.

Disadvantages

- This system makes the secondary collection inefficient.

Applicability

In this system, the primary collector should be controlled by the secondary collector, otherwise the secondary collection will be seriously inefficient. As seen in Nueva San

Salvador and San Salvador, it is preferable that the same actor carries out both the primary and the secondary collection.

c.4 Institutional Consideration

i. Community-based Collection

This system is that communities manage the primary collection by themselves. The community collects small money from each house and hires a few persons to collect and carry waste to the designated collection point.

Advantages

- This system is not directly reliant on the municipal service.
- The community can control the primary collection service directly.

Disadvantages

- This system is vulnerable as it is often operated by a few people. If such people lose the responsibility, the system would easily fail.
- A lack of formal control may lead to corruption and mismanagement of funds.
- This system can not cover a large extent due to its limited management capability.

Applicability

This system is self-reliant, so that it is advantageous where the municipality has not enough capability to render the collection service to the community. On the other hand, a key person(s) is required to run the system properly. Such key person(s) may be a motivated community leader(s). The collection area should be small, as the capability of this system is usually limited.

ii. Private Sector (micro-enterprises)

This system introduces the private sector into the primary collection such as micro-enterprises. The collection work may be contracted out by the municipality or the private sector gets concession from the municipality.

Advantages

- Operational efficiency of this system is generally higher than the community-based collection due to its commercial approach.
- This system is not vulnerable, as the workers are motivated by gaining benefit.

Disadvantages

- The municipality is required to have enough capability to supervise the micro-enterprises.
- Users' (waste dischargers) involvement is limited.
- The service quality is prone to decline, if the supervision by the municipality is insufficient.

Applicability

A clear advantage of this system is its commercial approach. This makes the operational efficiency be high and sustainable. On the other hand, the service quality is prone to degrade as the private sector seeks profit rather than keeps the quality. Therefore, the municipality's role to supervise them is crucial for the successful implementation of this system. The supervision by the municipality and clear statements of the private sector's obligations in the contracts are definitely necessary.

d. Discussion on Technical Interfaces

The primary collection and the temporary storage are, of course, interdependent, moreover the secondary collection is not independent of those systems. If the relation among them does not work well, the total collection system must fail.

This can be often seen at the temporary storage such as stations, or "Botaderos," and containers. Delayed collection and lack of collection trips result in full containers, spilt and scattered wastes and unsanitary/unaesthetic conditions. Finally this situation gives the citizens negative impression on the temporary storage.

The temporary storage is a technical interface of the two systems i.e., primary and secondary collection systems. At such interface, if the ownership and responsibility of the temporary storage become ambiguous, then this often causes the unfavorable situation.

In order to avoid such situation, the followings would be solutions.

- In order to promote users' (waste dischargers) ownership and responsibility to the station and the container, furthermore, to avoid the opposition, such temporary storage should be located in the community that uses it.
- Obligations of actors in the system should be defined clearly. For example, if the primary collector is a micro-enterprise, his obligations should be stated in the contract for smooth implementation of the system.
- If the same actor carries out both the primary and secondary collection, then the ambiguous temporary storage would not be necessary.

e. Conclusion

The types of the primary collection and the temporary storage are various, and the applicability of those is depending on situations; topography, road conditions, income level of residents, etc. Taking into account such situations in the Study Area, some alternatives are presented below.

i. Communal Storage (station)

In case that one collection point can be located within a community for **less than** around 20 users (houses), and if the distance from the farthest house to the point is within around 80m, the station collection system would be the best option.

Table K-35: Communal Storage (station)

Technical system	Primary collection	Temporary storage	Secondary collection
Application	communal storage (station)	communal storage (station)	
Equipment/facility	-	station	collection vehicle
Actor	dischargers (residents)	dischargers (residents)	municipality

ii. Communal Storage (container)

In case that one collection container can be located within a community for **more than** around 20 users (houses), and if the distance from the farthest house to the point is within around 80m, the container system would be the best option.

The area subject to the container should be clearly defined and enough number of containers to hold the waste amount generated from the area should be provided.

Table K-36: Communal Storage (container)

Technical system	Primary collection	Temporary storage	Secondary collection
Application	communal storage (container)	communal storage (container)	
Equipment/facility	-	container	collection vehicle
Actor	dischargers (residents)	dischargers (residents)	municipality

iii. House to House Collection by Community-based Collection

In case that there is no space for the station or for the container within the community, and if the community can not afford enough money for the primary collection or the responsible municipality has not enough capability to provide the primary collection service to the community, the community-based collection would be applied.

Generally the community-based collection is less capable than the micro-enterprises as financial resources are limited. It is difficult for them to bear the work of the secondary collection or the transport. Therefore, the responsible municipality needs to arrange such works.

Table K-37: House to House Collection by Community-based Collection

Technical system	Primary collection	Temporary storage	Secondary collection
Application	house to house	handcarts wait for collection vehicle	
Equipment/facility	handcarts	handcarts	collection vehicle
Actor	community-based collector	community-based collector	municipality

iv. House to House Collection by Micro-enterprise

In case that there is no space for the station or for the container within the community, and if the community can afford enough money for the primary collection, or if the responsible municipality has obligation to provide the collection service to the community because of e.g., the cleansing fee collection by municipality, the scheme of the private sector participation to the collection service can be applied.

As the private sector is generally more capable than the community-based collection, they could in some cases bear the work of the secondary collection or the transport. Then, the problematic technical interface, or the temporary storage, can be deleted.

Table K-38: House to House Collection by Micro-enterprise

Technical system	Primary collection	Temporary storage	Secondary collection
Application	house to house collection	collection vehicle stop for handcarts	
Equipment/facility	handcart	collection vehicle	collection vehicle
Actor	private sector (micro-enterprise)	private sector (micro-enterprise)	private sector (micro-enterprise)

K.4.2.2 Collection

The objective of collection is to eliminate waste from living environment. To achieve this objective, enormous expenditure is necessary. Collection occupies the major part of Solid Waste Management costs, approximately 40% is spent on the collection in Latin America. This means that small improvement results in significant cost savings in the overall cost. Therefore, it is important to bear in mind to hold down the costs along with keeping the living environment when considering technical alternatives of the collection system.

a. Problem Recognition

In the Study Area various collection systems are working depending on municipalities, as the waste collection is inherent obligations to the municipalities that have own autonomies. Some municipalities provide the collection service every day, the others 3 times a week. Some municipalities have three working shifts in a day, others one or two.

On the other hand, as for type of collection vehicle, compactor trucks are widespread in the study area. Almost of them are ones donated by Japan in 1989 and 1996. Problem about the trucks is that serious degradation of working efficiency of trucks donated in 1989 due to their old age. Also the service life year of trucks in 1996 will be running out in 2003, suppose that it is seven years.

The other problem is the long transport distance. It reduces the time used for really picking up waste. This is the issue discussed in the next section, Transfer and Transport.

b. Potential Technical Alternatives

In this section, the technical alternatives shown in Table K-39 are discussed.

Table K-39: Potential Technical Alternatives of Collection

Technical system	Subsystem	Subsystem component
Collection	• collection frequency	• number of collection times per week, e.g., 2, 3, 6 times a week
	• mix or separate collection	• mix • separate
	• collection method	• point collection (station/container) • curbside collection • bell collection
	• collection vehicle	• compactor truck • dump truck
	• working shift	• number of working shift, e.g., 1,2 or 3 shifts a day

c. Screening of the Alternatives

c.1 Collection Frequency

Collection frequency is basically determined by the objective of waste collection. That is, the waste should be eliminated before it becomes hindrance to keep sanitary living environment. Decomposition period of organic waste, especially food waste, and incubation period of fly eggs are often taken as an indicator.

Table K-40: Development Period of Fly

Temperature	From egg to pupa	From egg to imago
20C°	10.1 days	20.5 days
27C°	5.6 days	10.8 days
35C°	5.6 days	8.9 days

Source: WHO, Programa Regional de Mejoramiento de los Servicios de Aseo Urbano

The more frequent collection is carried out, the better sanitary condition is achieved. However, it should be kept in mind that the more frequent collection the higher cost.

Consideration of Cost

Cost for collection is determined by time required for collection. The collection time consists of loading time of waste and moving time between collection points.

In case of reducing collection frequency from 6 times a week to 3 times a week, the distance of collection would simply become half, 0.5, and the loading time might go up 1.5 times as larger amount should be picked up at each collection point. This results in reduction of 25% of collection cost (0.5 x 1.5 = 0.75, 1-0.75=0.25).

As the discussion above shows, the collection frequency enormously affects the collection cost.

Applicability

Considering the mean monthly temperature in the Study Area ranges from 22 to 25 Celsius, high portion of food waste and high population density, collection frequency should be more than twice a week in view of sanitation. However, every day

collection is not recommendable as it results in high collection cost. Consequently, twice or three times a week collection frequency is recommendable.

c.2 Mix or Separate Collection

A separate collection system is required when processing or recycling is introduced. Introduction of incineration technology requires separate collection of combustibles and non-combustibles. Composting requires separate collection of organic and inorganic materials. And material recovery facility (MRF) requires separate collection of recyclable and non-recyclable materials.

A separate collection system requires additional costs, because it may require other type of vehicle and crews for recyclable material than non-recyclable waste.

Another issue to be kept in mind is people's willingness to cooperate in source separation. Because this requires the change in people's habits, way of living and the social system by conducting public education and motivation programs, it would take some time until it is adequately implemented.

Applicability

In principal, employment of separate collection for over the Study Area is still too early. For municipalities that have low collection coverage, to raise collection coverage with mixed collection is more urgent issue than separate collection. As mentioned in the section of Storage and Discharge, however, it is preferable to promote source separation in order to encourage the existing reusable/recyclable material market. Then, separate collection should be introduced along with the promotion of source separation. It would be good way that the separate collection is executed by the existing informal sector such as ex-pepenadores. Target areas for separate collection would be high-income areas in San Salvador, Nueva San Salvador and Antiguo Cuscatlan.

c.3. Collection Method

Table K-41 shows descriptions of collection methods that have been applied or could be applied to the Study Area.

Table K-41: Description of Collection Method

Collection method	Description
Point collection (station/container)	Dischargers carry their waste to designated collection points (stations/containers). Later the discharged waste is picked up by collection vehicles. Dischargers' burden is heavy, but collection efficiency is high.
Curbside/house to house collection	Dischargers are responsible for placing their waste on curbside in front of their houses on collection day, and collection vehicles pick them up. Dischargers' burden is light, but collection efficiency is lower than the point collection.
Bell collection	Collectors call dischargers to bring their waste out by ringing a bell on the arrival at designated collection points.

Determinatives of selecting collection method are collection efficiency, town structure, road conditions and preset applied collection method.

As for the inaccessible area to collection vehicles, the discussion is deeply hold in the section of Primary Collection and Temporary Storage. Point collection (station/container) or house to house collection by community-based collection or micro-enterprises is chosen depending on community's conditions.

Regarding accessible area to collection vehicles, curbside collection is widespread in the Study Area. Most municipalities employ bell ringing with the curbside collection in order to let dischargers know the arrival of the collection vehicle. This is fairly effective as somebody stays in almost of houses even in the daytime.

Applicability

- Point collection (station/container), house to house collection by community-based collection or micro-enterprises are applicable for the inaccessible area to the collection vehicle.
- Curbside collection with bell ringing are applicable for the accessible area to the collection vehicle.

c.4 Collection Vehicle

Type of Vehicle

Types of collection vehicles are various and selection of it should be determined quantity and quality of waste, and town structure and road condition of a target area. Table K-42 shows vehicles used widely for waste collection.

Table K-42: Description of Collection Vehicles

Type of vehicle	Description
Compactor truck	• designed exclusively for waste collection. • compact low density waste to high density in order to realize high collection efficiency, normally 400 to 500 kg/m^3 of density is achieved, a state of art compactor trucks is designed for around 750 kg/m^3. • relatively high level of maintenance skill is required.
Dump truck	• designed for multipurpose. • compaction device is not equipped.
Detachable container truck (2 to 10 m^3)	• designed for waste collection. • large amount of waste is collected in a few minutes. • compaction device is not equipped. • capital cost for containers is required other than the truck itself.

i. Compactor Truck

In the Study Area, the compactor truck has widely been used from the arrival of Japanese donation in 1989. Moreover, the use of the compactor truck has been spread

by the 2nd Japanese donation in 1996. The trucks are fairly used well as found in the analysis of the current situation of collection.

At present, 25yd^3 (19m^3), 18yd^3 (14m^3), 16yd^3 (12m^3) and 11yd^3 (8m^3) of compactor trucks are working in the Study Area. According to C/Ps, most of them selected the 18yd^3 compactor truck as the first preference, and the reason is its high efficiency for waste collection. As for the 25yd^3 compactor, they mentioned difficulty of drive due to its large size, although it has high efficiency. To the contrary, they pointed out the easy drive of 11yd^3 compactor due to its small size.

ii. Dump Truck

Some municipalities use the dump truck due to convenience of its multipurpose use. The dump truck is not efficient, as it is not designed for waste collection. However, the dump truck may be suitable for high density of waste such as market waste and construction debris, that are not suitable or can not be dealt with by the compactor truck.

iii. Detachable Container Truck

Employment of the detachable container truck to the Study Area is doubtful. In 1989, 8 detachable container trucks and 94 containers of 7yd^3 (5m^3) were donated along with compactor trucks but those had disappeared, although considerable number of the compactor trucks are still working (34/55, 62%). The reason of disappearance of the detachable trucks might be; difficulty to find spaces to place the large containers, citizens' repugnance to unsanitary conditions made by inappropriate use of the container, large capital cost for purchasing additional containers and inflexible availability of the truck (it can only work with container). Therefore, the detachable container truck would not suitable for the Study Area.

Cost Comparison

Collection costs of the 18yd^3 compactor, the 11yd^3 compactor and the dump truck are calculated below. The costs are exclusively to collection activity not including transportation, preparation such as daily inspection, and other unproductive activities.

Table K-43 shows, the compactors' collection costs per ton of waste are much cheaper than the dump truck's, the 18yd^3 is 6.07 US$/ton, the 11yd^3 is 7.14 US$/ton and the dump truck is 10.28 US$/ton.

Table K-43: Collection Costs according to Vehicle Type (Summary)

Type of vehicle	Collection costs	
18yd^3 compactor	6.07	US$/ton
11yd^3 compactor	7.14	US$/ton
Dump truck	10.28	US$/ton

Applicability

Use of compactor truck is recommendable for the Study Area. If the road conditions and town structure allow, larger compactor trucks achieve high efficiency. With taking into account the experience of use of collection vehicles and the efficiency, the 18yd^3-compactor truck should be majority of collection vehicles. The 11yd^3-

compactor truck and the dump truck should be deployed according to particular condition of each municipality.

c.5 Working Shift

In the 14 municipalities, only 4 municipalities adopt plural shifts. Other municipalities employ single shift. If it were impossible to increase number of trips in a shift, employment of plural shifts would be effective in order to raise collection coverage.

Cost Comparison

Collection costs of the 18yd^3-compactor truck according to number of shifts are examined below. It is supposed that service life is 7 years when one shift is applied, 6 years for two shifts and 5 years for three shifts.

Table K-44: Collection Costs according to Number of Shift (Summary)

Nos. of shift/day	Collection costs
once	6.07 US$/ton
twice	4.81 US$/ton
three times	4.44 US$/ton

Applicability

At present, most of municipalities do not consider depreciation costs of vehicles as the majority of collection vehicles they own were acquired through donation. Therefore, their attention is only paid on the operation and maintenance costs, especially personnel cost. Then, they hesitate to apply plural shifts, as it results in increase of total personnel cost.

It is clear, however, that the plural shifts lead to efficient use of vehicles when the depreciation cost is taken into account. If expansion of collection service is required, application of plural shifts is recommendable rather than purchasing other vehicles. Also it would be an idea to rent vehicles to the private sector for the second shift or the third shift in order not to increase expenditure for the personnel cost.

d. Conclusion

In order to achieve the essential objective of waste collection, i.e., to eliminate waste from living environment before the waste becomes hindrance to keep the sanitary environment, twice or three times a week of collection frequency should be applied. On the other hand, every day waste collection is not recommendable as it results in considerably high collection cost.

Almost of the municipalities in the Study Area still need to raise collection coverage. Therefore, mixed collection is recommendable over the Study Area in principal. There are, however, some municipalities that have achieved high collection coverage such as San Salvador, Nueva San Salvador and Antiguo Cuscatlan. In high-income areas of such municipalities, introduction of separate collection in the near future is recommendable.

In the Study Area many communities that is inaccessible for the collection vehicle exist. For such communities, point collection (container collection or station collection) or house to house collection by community-based collection or micro-enterprises depending on conditions of a target community would be applicable. For the accessible area to collection vehicle, continuation of the present collection method, i.e., curbside collection with ringing bell, is recommendable.

The 18 yd^3 compactor truck would be the best suitable for the Study Area especially in view of its efficiency, i.e., fewer collection cost per ton of waste. The 11 yd^3 compactor truck and the dump truck would also be used depending on town structure, road condition, type of waste, etc. It should be kept in mind, however, the collection costs of those vehicles are high. Especially, one of the dump truck is enormous.

When expansion of collection service is required, making plural shifts is recommendable rather than purchasing other vehicles. This results in fewer collection cost per ton of waste. Also it would be a way to rent collection vehicles to the private sector for the second or third shift.

K.4.2.3 Haulage (Transport)

Transport means carrying waste from collection areas to certain destinations such as material recovery facilities (MRFs) or disposal sites (D/S). Collection vehicles are often used for the transport, where the destination exists close to the collection area. This is called as Direct Transfer. If the destination is far from the collection area, it will be cheaper to transship the waste from the collection vehicles to larger vehicles (transport vehicles) that are used to transport the waste to the destination. This is called as Transfer Transport. The transport system requires transfer stations (T/S) to transship the waste.

Table K-45 shows flows of direct transport and transfer transport.

Table K-45: With/Without Transfer Transport

Transport	Flow
Direct transport	collection area → collection vehicles → MRF, D/S
Transfer transport	collection area → collection vehicles → T/S → transport vehicles → MRF, D/S

a. Problem Recognition

10 out of 14 municipalities, excluding Apopa and Nejapa that are close to Nejapa Landfill, and San Martin and Tonacatepeque that dispose of waste in their jurisdictions, have problem of the long haul distances. Average one-way haul distance of 10 municipalities is about 30km.

Such long haul distances not only make the municipalities spend large expenditure for transporting waste, but also shorten the time which could be used for collection. This is clear from the results of Time and Motion Survey. The transport takes more than one hour and counts for 15 to 30% of a trip. Then, number of trips is limited, and the collection is considerably made inefficient. Consequently, the long haul distance raises not only transport cost but also collection cost.

b. Potential Technical Alternatives

In this section, the technical alternatives shown in Table K-46 are discussed.

Table K-46: Potential Technical Alternatives of Transport

Technical system	Subsystem	Subsystem components
Transport	• transport method	• direct transport • transfer transport • examination by setting potential cases
	• type of transfer station	• direct-load • storage-load
	• transfer vehicle	• tractor-trailer

c. Screening of the Alternatives

c.1 Transport Method

Decision on whether direct transport or transfer transport to be selected should basically depend on which cost is cheaper. In case of short haul distance the direct transport is less costly than the transfer transport, the former is more expensive than the later in long haul distance.

It is generally said that employment of the transfer transport is beneficial in case of:

- haul distance is more than about 30km, and/or
- when using small capacity collection vehicles.

In this section, the need for transfer transport is examined. Flow of the examination is presented in Figure K-1.

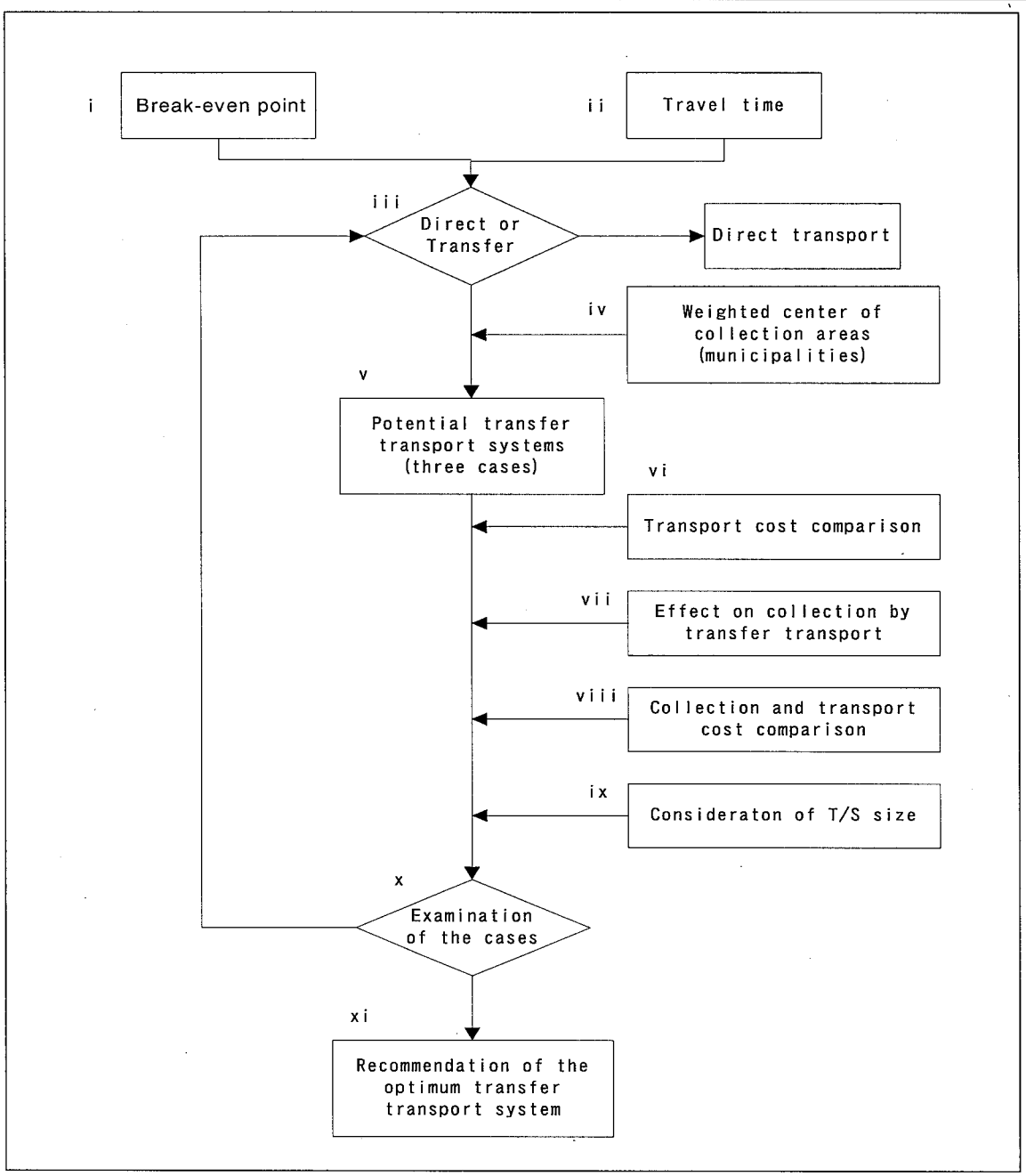

Figure K-1: Flow of Examination on Transport Method

i. Break-even Point

Table K-47 and Table K-48, cost estimates that are used for obtaining break-even points are shown. Table K-49 shows the break-even points between the direct transport by 18yd^3-compactor and the transfer transport by 20ton tractor-trailer with cases of 100ton/day, 300ton/day, 600ton/day, 900ton/day and 1200ton/day capacities of transfer stations.

It should be noted that costs are estimated at several assumptions. Attention should be paid to that the costs have some ranges, and that especially costs of the transfer stations may have large ranges depending on locations where the transfer stations are

constructed because the T/S location decide both distances to which a collection vehicle travel and from which a transport vehicle travel.

Table K-47: Cost Estimates of Transport (Summary)

Vehicles	US$/ton-minute
18yd^3-collection truck	0.0441
20ton tractor-trailer	0.0154

Table K-48: Cost Estimates of Transfer Station (Summary)

T/S	Cost (US$/ton)
100t	5.19
300t	2.71
600t	1.80
900t	1.48
1200t	1.32

The below figure shows breakeven distance and time for respective cases of T/S sizes such as follows:

- In case of 100ton/day capacity T/S, the breakeven travel time is 181 minutes (i.e., breakeven distance is 90.5km). If the distance from T/S to a destination is shorter than 90.5km, direct transport is cheaper. And the breakeven transport unit cost per ton in this case becomes US$7.9774/ton.
- Likewise, in case of 300ton/day capacity T/S, the breakeven travel time is 94 minutes (i.e., breakeven distance is 47.0km). And the breakeven transport unit cost per ton in this case becomes US$4.1576/ton.

Table K-49 summarizes breakeven travel time, distance and the unit transport cost in respective cases.

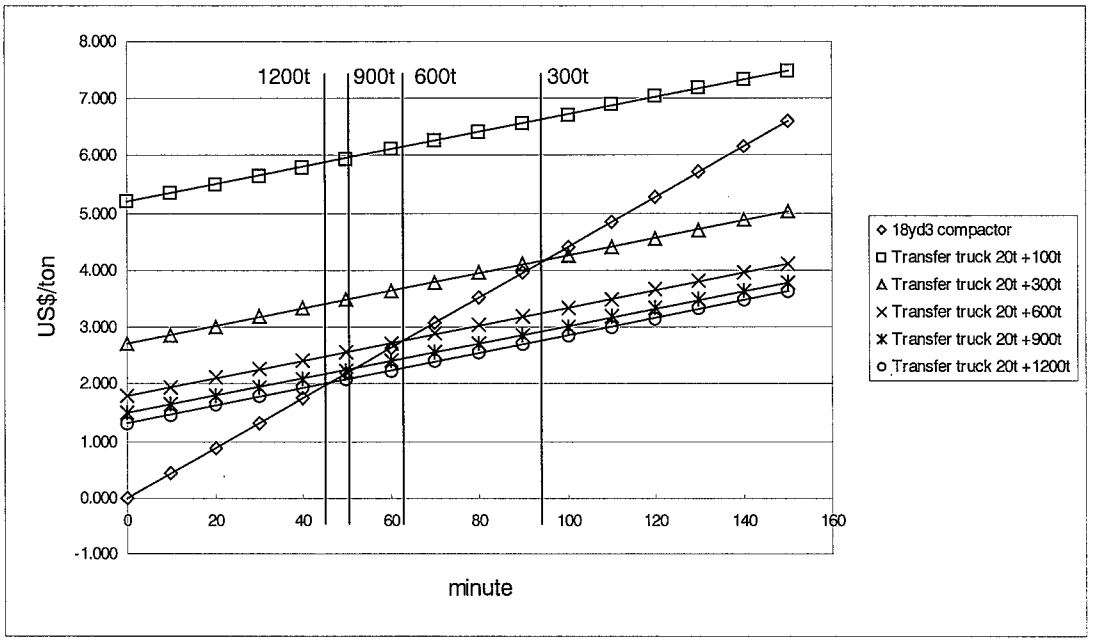

Figure K-2: Break-even Distance/Time between Direct and Transfer Transport and its Unit Cost

Table K-49: Breakeven Distance/Time between Direct and Transfer Transport and its Unit Cost

Combination	Breakeven transport time (minutes)	Breakeven distance (km)		Transport unit cost at breakeven point (US$/ton)
		round trip	one way	
Transport with 100t of T/S	181	90.5	45.3	7.9774
Transport with 300t of T/S	94	47.0	23.5	4.1576
Transport with 600t of T/S	63	31.5	15.8	2.7702
Transport with 900t of T/S	52	26.0	13.0	2.2808
Transport with 1200t of T/S	46	23.0	11.5	2.0284

ii. Travel Time

In order to examine whether employment of the transfer transport is beneficial or not for each municipality, The collection vehicle travel time from municipalities to the disposal site is compared with the breakeven travel time indicated above. Figure K-3 shows this comparison schematically. It is supposed that the destination were Nejapa disposal site just in order to simplify the comparison, although ESPIGA, SMT and TN disposal sites are used at present.

Table K-50: Travel Time to Nejapa Disposal Site

Municipality	velocity one way (km)	30 km/hr	
		round trip (km)	round trip (min)
01SS	28.9	57.8	116
02MJ	25.5	51.0	102
03CD	22.2	44.4	89
04CT	21.2	42.4	85
05AY	24.5	49.0	98
06SM	32.1	64.2	128
07ST	37.3	74.6	149
08AC	42.2	84.4	169
09SY	29.3	58.6	117
10IL	33.9	67.8	136
11SMT	42.0	84.0	168
12AP	14.0	28.0	56
13NJ	9.6	19.2	38
14TN	26.0	52.0	104

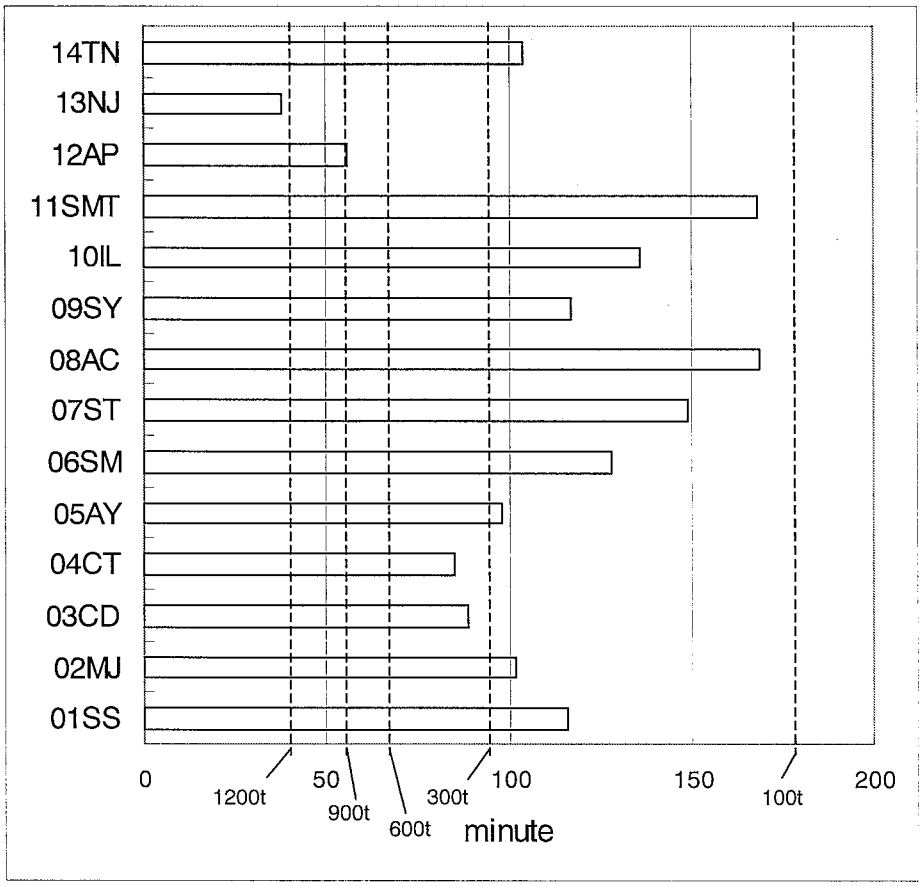

Figure K-3: Travel Time to Nejapa Disposal Site (round trip)

iii. Direct Transport or Transfer Transport

A transfer transport with 100ton/day T/S never becomes beneficial as any municipality's travel time does not exceed one of the break point, 181minutes. 300ton/day T/S would be advantageous to SS, MJ, AY, SM, ST, AC, SY, IL, SMT and TN rather than the direct transport. In case of 600ton/day T/S, CD and CT would receive benefit from the transfer transport, besides the mentioned municipalities. AP would be added to them in case of 900ton/day T/S. NJ would not receive benefit even in case of transfer transport with a 1200ton/day T/S. Therefore, it can be said that employment of the transfer transport would be beneficial for many municipalities in the Study Area.

The discussion above is based on an assumption that transfer stations are located on the center of each municipality. This is, however, impossible, as most municipalities do not generate so large quantity of waste as to require a transfer station of 300 ton/day, 600 ton/day or 900ton/day. Therefore, it is necessary to examine optimum location(s) of transfer station(s) and transport cost from each municipality to a transfer station. This is carried out in the following sections.

iv. Weighted Center of Municipalities

In order to find optimum location(s) of transfer station(s), it is necessary to know the weighted center and waste collection amount of each municipality. Those are shown in Table K-51 and Figure K-4. SS is divided into 5 districts. Coordinate shows relative location of the weighted center of each municipality/district. x shows east-west location coordinate, y shows north-south coordinate, and unit is length in km. The waste amount here means the forecast generation amount in 2010.

Table K-51: Waste Amount and Weighted Center of Municipalities

Municipality	Coordinate		waste amount
	x	y	ton/day
011SS	14.5	6.0	195
012SS	12.0	6.5	166
013SS	9.5	5.5	79
014SS	11.0	3.0	72
015SS	14.0	3.5	209
02MJ	13.5	8.5	98
03CD	17.0	10.0	42
04CT	15.5	11.5	36
05AY	13.5	9.5	14
06SM	15.5	0.5	43
07ST	4.5	3.0	119
08AC	8.5	2.5	64
09SY	20.0	6.5	205
10IL	23.0	5.5	61
11SMT	29.0	10.0	34
12AP	16.0	17.0	64
13NJ	9.0	18.0	7
14TN	22.0	14.0	29

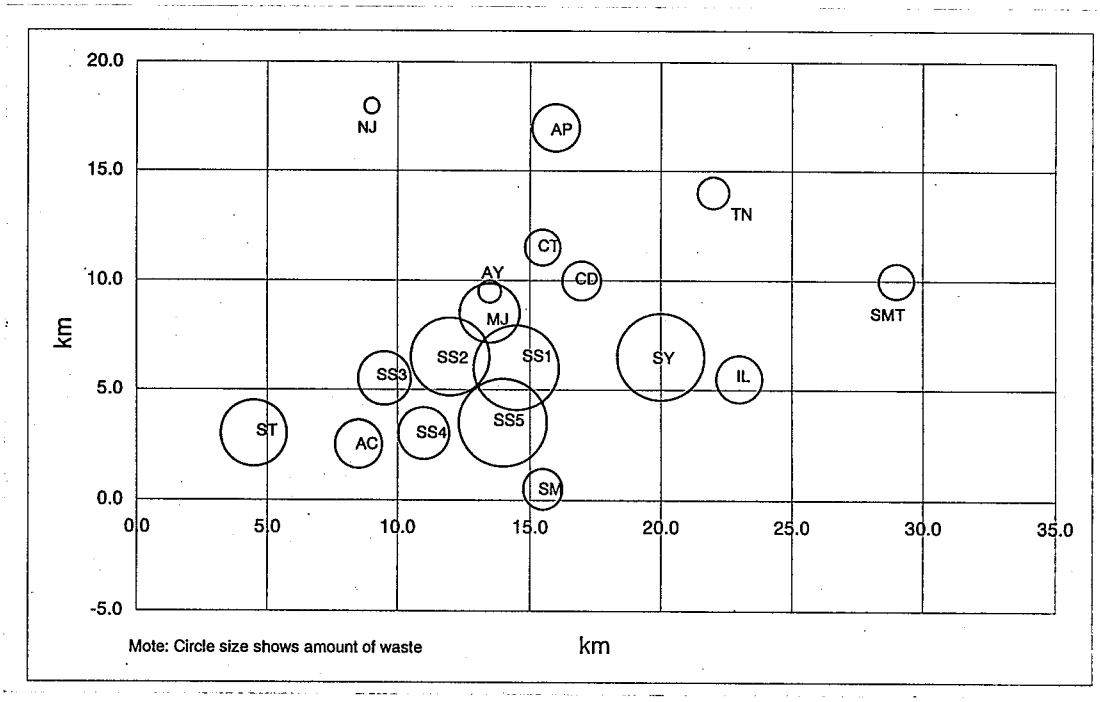

Figure K-4: Waste Amount and Weighted Center of Municipalities

v. Potential Transfer Transport Systems

On the basis of waste amount, weighted center of each municipality and profitable size of transfer station (i.e., more than about 300 ton/day as discussed in the previous section), three cases of deployment of transfer stations were given consideration as potentially appropriate alternatives.

Case 1

One large size of transfer station covers 11 municipalities, SS, MJ, CD, CT, AY, SM, ST, AC, SY, IL, SMT. The weighted center of the area covered by this transfer station has the coordinate (x, y) of (14.1, 5.6), which is almost the city center of SS. The total forecast waste generation amount in 2010 from the 11 municipalities is 1,437 ton/day. A 1200ton/day transfer station is applied for this examination.

Case 2

Three transfer stations are deployed. The first transfer station, T/S 2-1, covers District 3 and 4 of SS, ST and AC. The coordinate (x, y) of weighted center of the area is (7.9, 3.5). The total forecast waste generation amount is 334 ton/day. A 300ton/day transfer station is applied to the area for examination.

The second transfer station, T/S 2-2, covers District 1, 2 and 5 of SS, MJ, CD, CT, AY and SM. The coordinate of weighted center of the area is (13.9, 6.0). The total forecast waste generation amount is 803 ton/day. A 600ton/day transfer station is applied to the area for examination.

The last transfer station, T/S 2-3, covers SY, IL and SMT. The coordinate of weighted center of the area is (21.6, 6.7). The total forecast generation amount is 300 ton/day. A 300ton/day transfer station is applied for this examination.

Case 3

Two transfer stations are deployed. The first one, T/S 3-1, covers District 2, 3 and 4 of SS, ST and AC. The coordinate (x, y) of weighted center is (9.2, 4.5). The total forecast generation amount is 500 ton/day. A 300ton/day transfer station is applied.

The second transfer station covers District 1 and 5 of SS, MJ, CD, CT, AY, SM, SY, IL and SMT. The coordinate (x, y) of weighted center is (16.7, 6.1). The total forecast generation amount is 937 ton/day. A 900ton/day transfer station is applied for this examination.

Table K-52: Calculation of Weighted Center (Case 1)

T/S 1-1

Municipality	x	y	w (t/d)	w,x	w,y
011SS	14.5	6.0	195	2827.5	1170.0
012SS	12.0	6.5	166	1992.0	1079.0
013SS	9.5	5.5	79	750.5	434.5
014SS	11.0	3.0	72	792.0	216.0
015SS	14.0	3.5	209	2926.0	731.5
02MJ	13.5	8.5	98	1323.0	833.0
03CD	17.0	10.0	42	714.0	420.0
04CT	15.5	11.5	36	558.0	414.0
05AY	13.5	9.5	14	189.0	133.0
06SM	15.5	0.5	43	666.5	21.5
07ST	4.5	3.0	119	535.5	357.0
08AC	8.5	2.5	64	544.0	160.0
09SY	20.0	6.5	205	4100.0	1332.5
10IL	23.0	5.5	61	1403.0	335.5
11SMT	29.0	10.0	34	986.0	340.0
Total	221.0	92.0	1437	20307.0	7977.5

Weighted center	
x	y
14.1	5.6

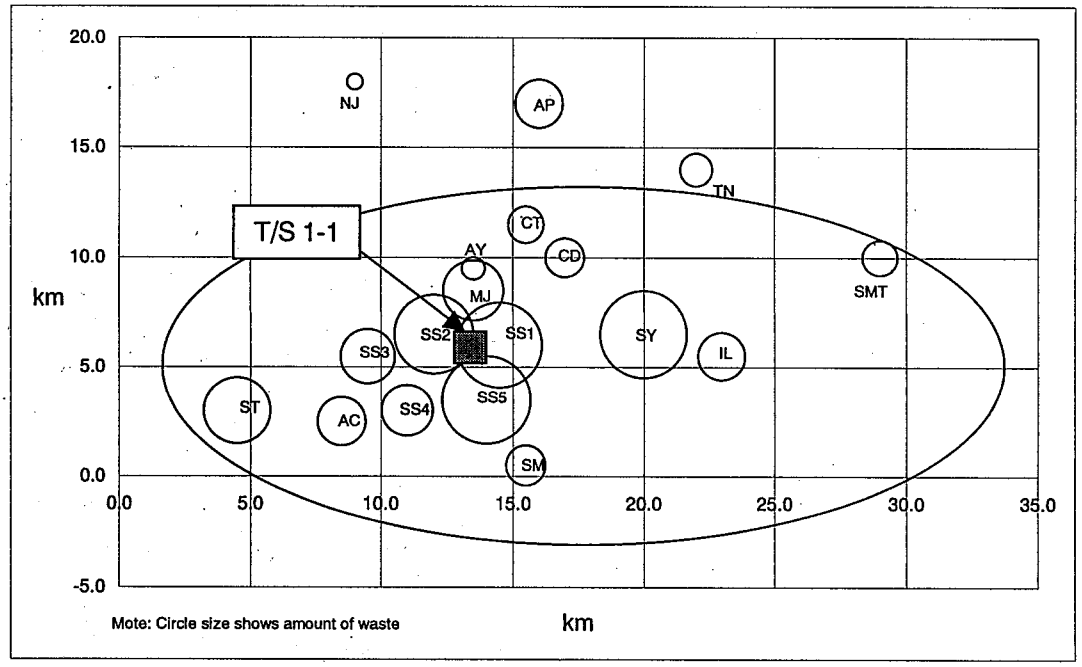

Figure K-5: Transfer Station and its Covering Area (Case 1)

Table K-53: Calculation of Weighted Center (Case 2)

T/S 2-1

Municipality	x	y	w (t/d)	w,x	w,y	Weighted center	
013SS	9.5	5.5	79	750.5	434.5		
014SS	11.0	3.0	72	792.0	216.0		
07ST	4.5	3.0	119	535.5	357.0	x	y
08AC	8.5	2.5	64	544.0	160.0		
Total	33.5	14.0	334	2622.0	1167.5	7.9	3.5

T/S 2-2

Municipality	x	y	w (t/d)	w,x	w,y	Weighted center	
011SS	14.5	6.0	195	2827.5	1170.0		
012SS	12.0	6.5	166	1992.0	1079.0		
015SS	14.0	3.5	209	2926.0	731.5		
02MJ	13.5	8.5	98	1323.0	833.0		
03CD	17.0	10.0	42	714.0	420.0		
04CT	15.5	11.5	36	558.0	414.0		
05AY	13.5	9.5	14	189.0	133.0	Weighted center	
06SM	15.5	0.5	43	666.5	21.5	x	y
Total	115.5	56.0	803	11196.0	4802.0	13.9	6.0

T/S 2-3

Municipality	x	y	w (t/d)	w,x	w,y	Weighted center	
09SY	20.0	6.5	205	4100.0	1332.5		
10IL	23.0	5.5	61	1403.0	335.5	Weighted center	
11SMT	29.0	10.0	34	986.0	340.0	x	y
Total	72.0	22.0	300	6489.0	2008.0	21.6	6.7

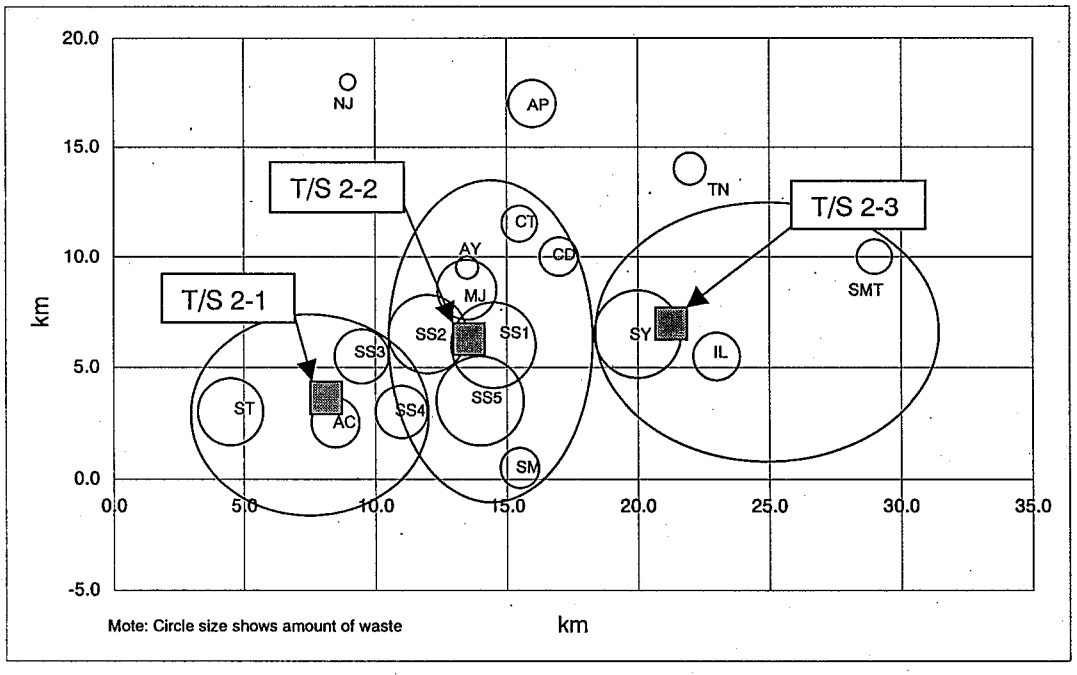

Figure K-6: Transfer Station and its Covering Area (Case 2)

Table K-54: Calculation of Weighted Center (Case 3)

T/S 3-1

Municipality	x	y	w (t/d)	w,x	w,y		
012SS	12.0	6.5	166	1992.0	1079.0		
013SS	9.5	5.5	79	750.5	434.5		
014SS	11.0	3.0	72	792.0	216.0		
07ST	4.5	3.0	119	535.5	357.0	Weighted center	
08AC	8.5	2.5	64	544.0	160.0	x	y
Total	45.5	20.5	500.0	4614.0	2246.5	9.2	4.5

T/S 3-2

Municipality	x	y	w (t/d)	w,x	w,y		
011SS	14.5	6.0	195	2827.5	1170.0		
015SS	14.0	3.5	209	2926.0	731.5		
02MJ	13.5	8.5	98	1323.0	833.0		
03CD	17.0	10.0	42	714.0	420.0		
04CT	15.5	11.5	36	558.0	414.0		
05AY	13.5	9.5	14	189.0	133.0		
06SM	15.5	0.5	43	666.5	21.5		
09SY	20.0	6.5	205	4100.0	1332.5		
10IL	23.0	5.5	61	1403.0	335.5	Weighted center	
11SMT	29.0	10.0	34	986.0	340.0	x	y
Total	175.5	71.5	937.0	15693.0	5731.0	16.7	6.1

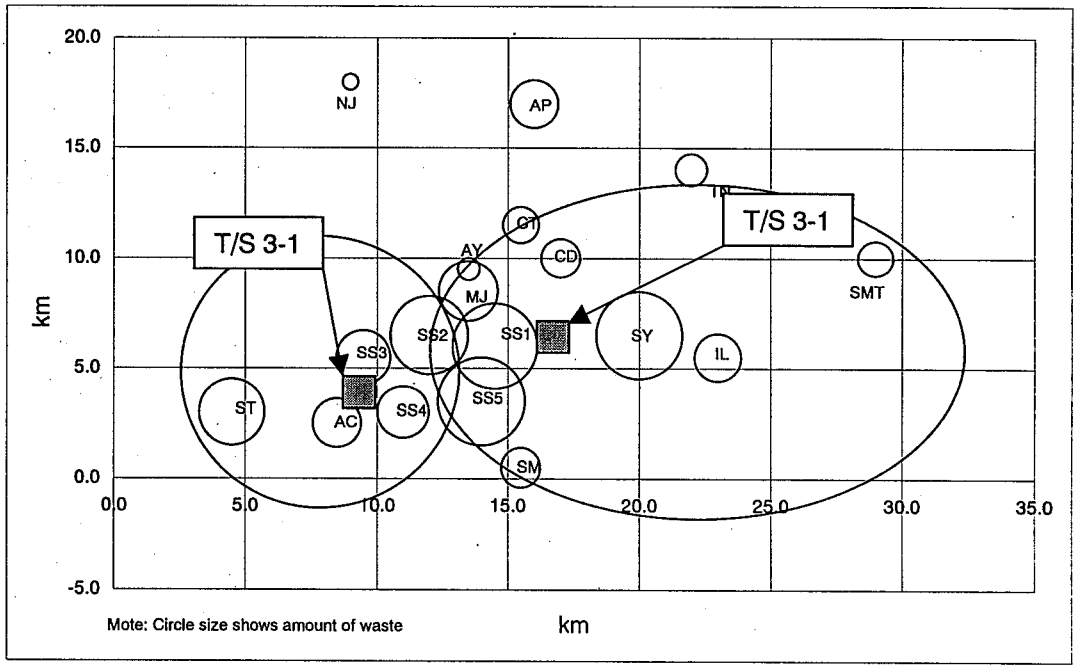

Figure K-7: Transfer Station and its Covering Area (Case 3)