6.2.5 Medical Waste

For the forecast of future medical waste generation, it is assumed that the total number of beds in AMSS increases in proportion to the increase rate of the urban population in AMSS, and that the medical waste generation as well increases in proportion to the number of beds. The urban population in 2010 will be 1.245 times of that in 1999. Therefore, it is forecast that the medical waste generation amount in 2010 will also be 1.245 times of that generated in 1999, whose amount was estimated after examining and comparing the Study's field investigation results carried out in 1999/2000 and MSPAS's data and information.

The medical waste generation amount in 1999 was estimated to be 3.2 ton/day as shown in the section of "Current Situation of Solid Waste Management".

Accordingly, medical waste generation amount from 2001 to 2010 is forecast based on the assumptions above (see the table below).

Table 6-15: Forecast of Future Medical Waste Generation Amount

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Increase Rate	1.000	1.027	1.053	1.078	1.103	1.126	1.148	1.170	1.189	1.208	1.227	1.245
Amount (ton/day)	3.20	3.29	3.37	3.45	3.53	3.60	3.67	3.74	3.80	3.87	3.93	3.98

6.3 Other Pre-Conditions

6.3.1 Financial Conditions

6.3.1.1 Economic Growth Rate

Economic growth rate until year 2004 is forecast by FUSADES(Fundacion Salvadorena para el Desarrollo Economico y Sociales) for 3 scenario cases of for low, base and high growth (see the table below).

Table 6-16: Forecast of Economic Growth Rate until 2004

Case	Model without Human Capital	Model with Human Capital
Low	4.2%	4.1%
Base	5.1%	5.0%
High	6.1 – 6.2%	6.0 – 6.1%

In paying attention to the above forecast, past 5 years national economic growth records (about 5.0%) and the recent global lower growth rate on average, the economic growth rate in this country is assumed to be 5.0% until year 2005 and 4.0% after that time for the analyses and examinations given by this study. Meanwhile, the growth rates of GRDP, municipal budget and household income in AMSS are estimated to be 0.5% above the GDP growth rate considering that the AMSS continues to receive localization of more weighted central functions of most production and consumption activities than other areas.

Table 6-17: GRDP in San Salvador Metropolitan Area

	Unit	1999	2000	2001 to 2005	2006 to 2010
GDP growth rate	%	2.1%	3.5%	5.0%	4.0%
GRDP growth rate	%	2.6%	4.0%	5.5%	4.5%

Table 6-18: GRDP in San Salvador Metropolitan Area

	Unit	1999	2000	2005	2010
GRDP	million colon in 1998 price	42,057	43,739	57,166	71,239
GRDP/capita *	US$	2,466	2,500	2,927	3,369

Note: * divided by total population of 14 municipalities

6.3.1.2 Financial Conditions

a. Financial Scale of Municipalities

Estimations on 14 municipal budgets are shown in the table below assuming that will be increased proportion to the GRDP growth rates estimated.

Table 6-19: Financial Scale of Municipalities

Unit: 1000 colones in 1999 price

City \ Year	1999	2005	2010
San Salvador	322,537	438,409	546,335
Mejicanos	15,227	20,697	25,793
Delgado	18,175	24,704	30,786
Cuscatancingo	13,016	17,692	22,047
Ayutuxtepeque	8,652	11,760	14,655
San Marcos	10,662	14,492	18,060
Nueva San Salvador	56,785	77,185	96,186
Antiguo Cuscatlan	21,265	28,904	36,020
Soyapango	40,332	54,821	68,317
Ilopango	12,970	17,629	21,969
San Martin	6,743	9,165	11,422
Apopa	13,994	19,021	23,704
Nejapa	8,554	11,627	14,489
Tonacatepeque	5,986	8,136	10,139

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 6-20: Prediction of Average Household Income

Unit: colones/year in 1999 price

City \ Year	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 6-21: 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 6-22: 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 6-23: Balance of OPAMSS

Unit: 1,000 colones

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

6.3.2 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

6.4 Comparative Examination of Technical Alternatives

6.4.1 Storage and Discharge System

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.

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.

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.

6.4.2 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 6-24.

Table 6-24: 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.

6.4.2.1 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. 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 6-25: 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

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.

In this section, technical alternatives listed in Table 6-26 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 6-26: 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 6-27: Institutional Consideration of Primary Collection

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

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.

a. 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 6-28: 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

b. 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 6-29: 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

c. 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 6-30: 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

d. 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 6-31: 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)

6.4.2.2 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.

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.

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.

6.4.2.3 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 6-32 shows flows of direct transport and transfer transport.

Table 6-32: 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 6-33 are discussed.

Table 6-33: 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 6-1.

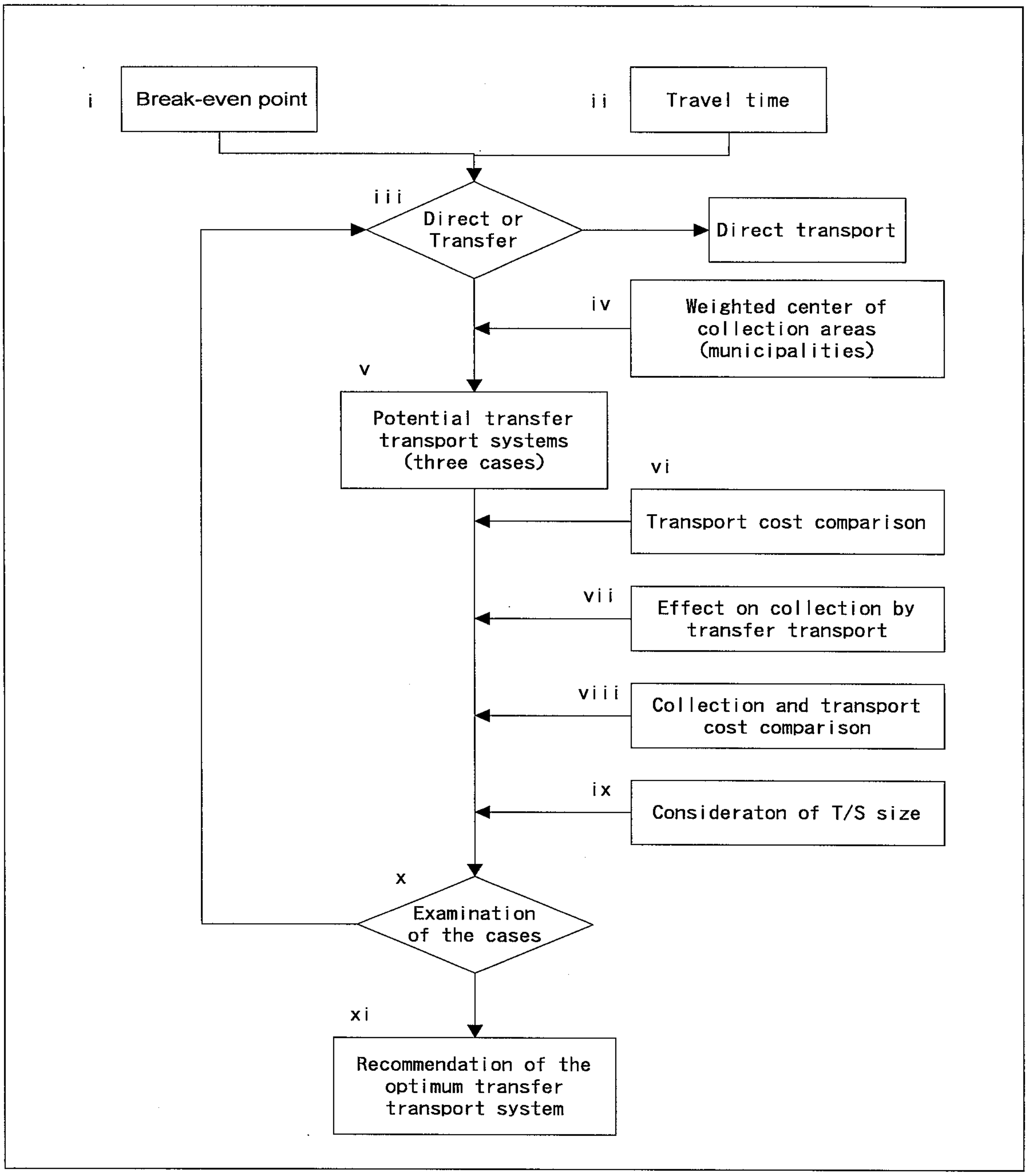


Figure 6-1: Flow of Examination on Transport Method

i. Break-even Point

Table 6-34 and Table 6-35, cost estimates that are used for obtaining break-even points are shown. Table 6-36 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 6-34: Cost Estimates of Transport (Summary)

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

Table 6-35: 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 6-36 summarizes breakeven travel time, distance and the unit transport cost in respective cases.

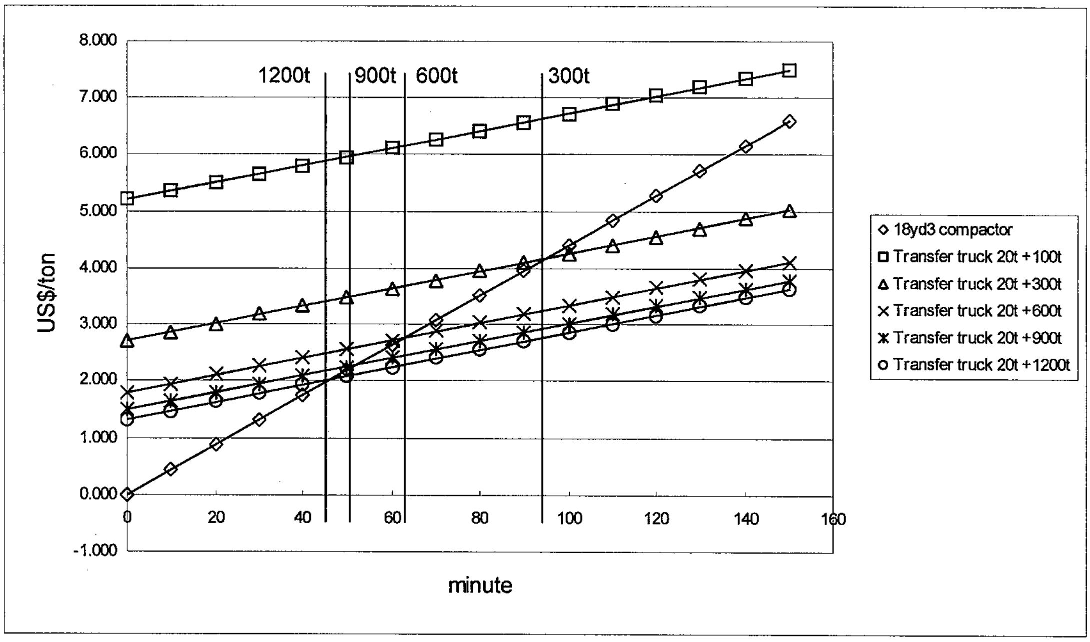


Figure 6-2: Break-even Distance/Time between Direct and Transfer Transport and its Unit Cost

Table 6-36: 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 6-3 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 6-37: 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

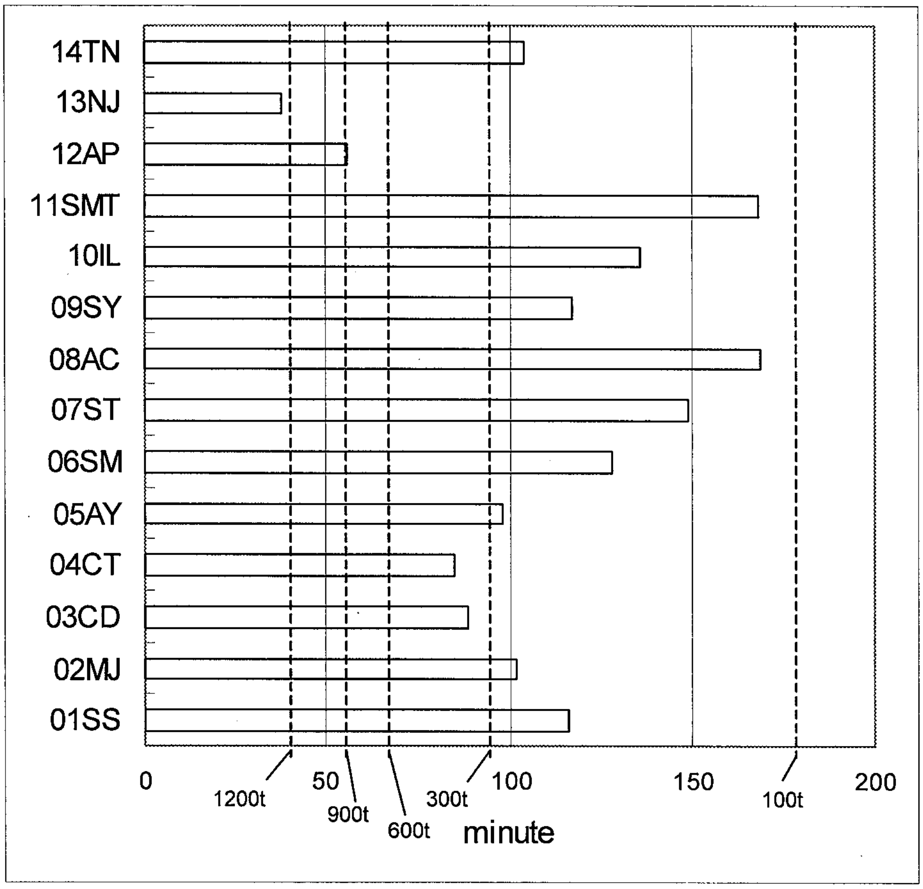


Figure 6-3: Travel Time to Nejapa Disposal Site (round trip)

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 Figure 6-4. 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.

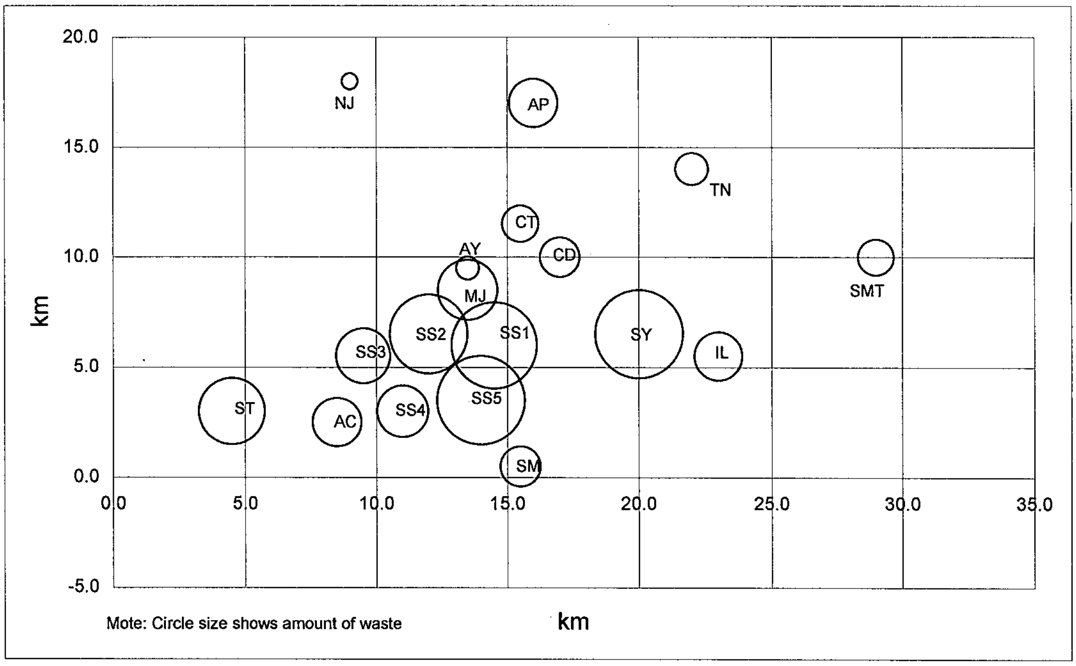


Figure 6-4: Waste Amount and Weighted Center of Municipalities

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.

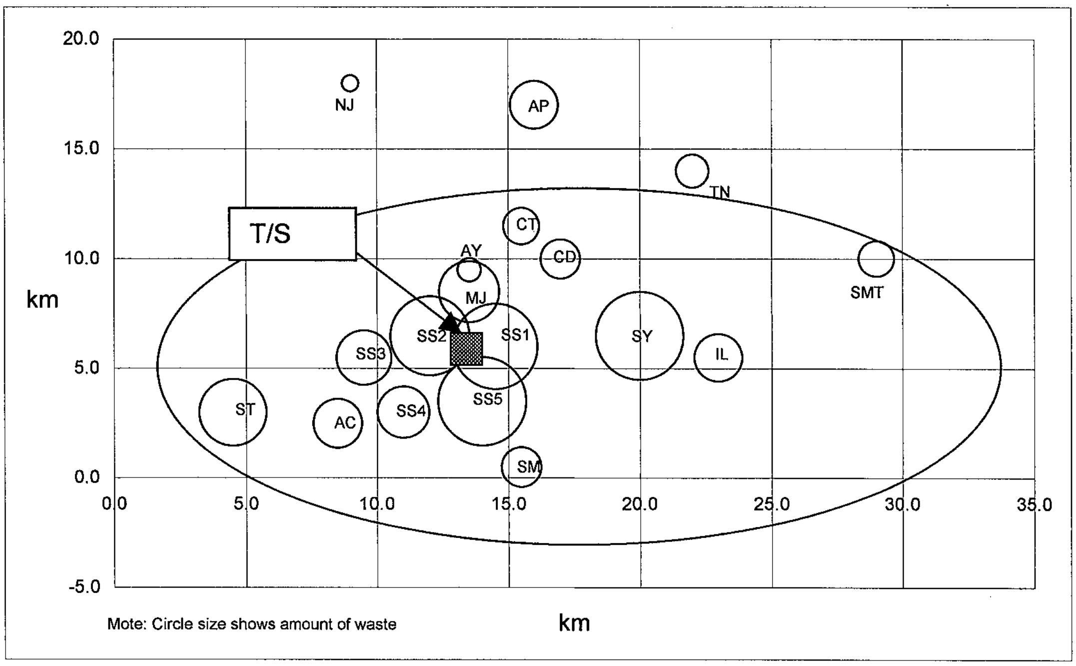


Figure 6-5: Transfer Station and its Covering Area (Case 1)

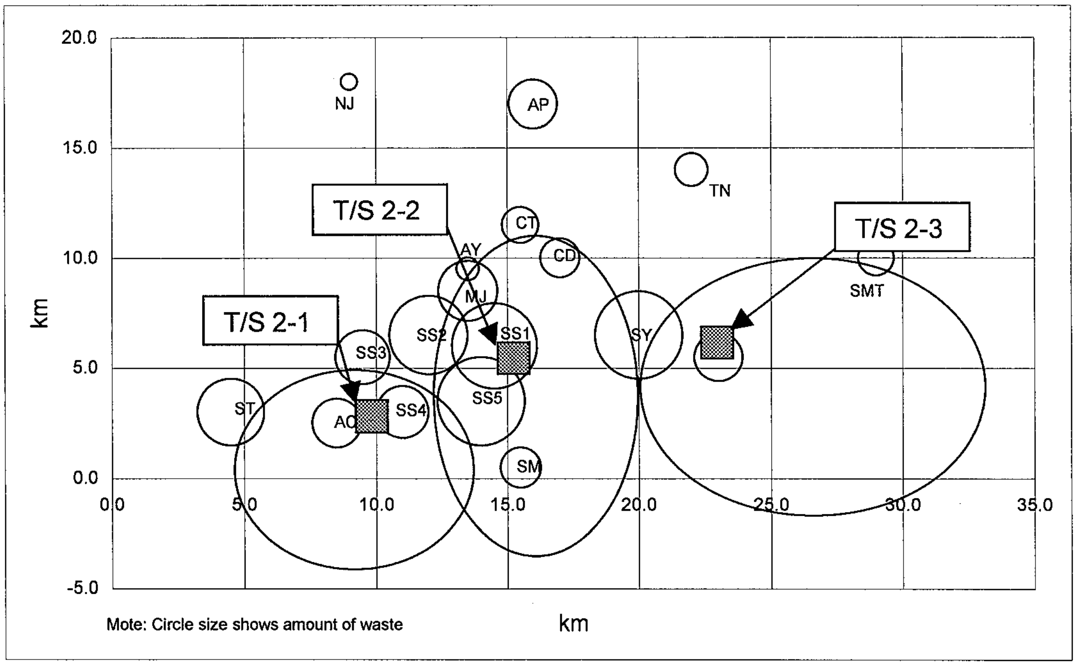


Figure 6-6: Transfer Station and its Covering Area (Case 2)

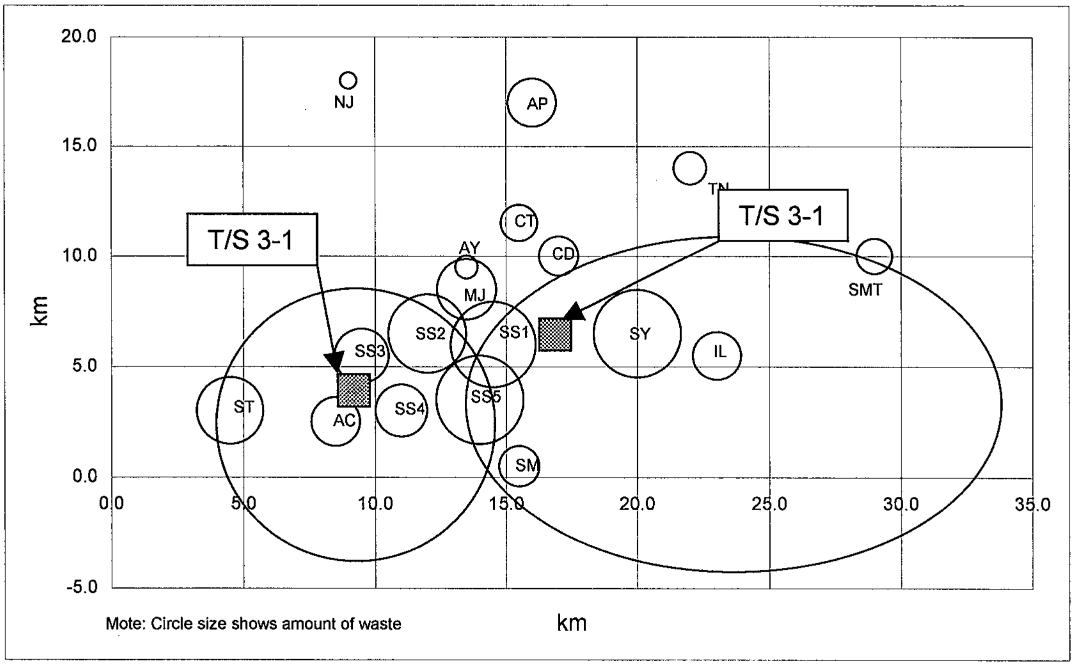


Figure 6-7: Transfer Station and its Covering Area (Case 3)

vi. Transport Cost Comparison

Costs of direct transport and transfer transport were examined in each case. In this examination, the direct transport costs consider:

- transport costs from the weighted center of each municipality/district to Nejapa Disposal Site (D/S) by 18yd^3 compactor truck.

The transfer transport costs consist of:

- transport costs from the weighted center of each municipality/district to the transfer station by 18yd^3 compactor truck,
- costs for the transfer station, and
- transport costs from the transfer station to Nejapa Landfill.

From a viewpoint of costs, whether the employment of transfer transport is beneficial or not (i.e., whether the transfer transport in total can be cheaper than the direct transport or not) is examined. The results show that Case 1 leads to the largest cost reduction, the second place is Case 2 and the third one is Case 3, but Case 2 and Case 3 are almost the same.

Case 1

Table 6-38: Cost Reduction by Transfer Transport (Case 1; T/S 1-1, 1200t)

Municipality	Direct	Transfer	Direct – Transfer	
	US$/ton	US$/ton	US$/ton	%
T/S 1-1 (1200t)				
011SS	5.20	3.35	1.85	35.6
012SS	4.94	3.88	1.06	21.5
013SS	5.29	4.54	0.75	14.2
014SS	6.00	4.36	1.64	27.3
015SS	5.91	3.79	2.12	35.9
02MJ	4.41	4.05	0.36	8.2
03CD	4.28	4.76	-0.48	-11.2
04CT	3.70	5.02	-1.32	-35.7
05AY	4.10	4.32	-0.22	-5.4
06SM	6.88	4.76	2.12	30.8
07ST	6.31	6.12	0.19	3.0
08AC	6.22	5.11	1.11	17.8
09SY	5.64	4.98	0.66	11.7
10IL	6.35	5.82	0.53	8.3
11SMT	6.66	7.84	-1.18	-17.7
Average	5.46	4.85	0.61	9.6

Case 2

Table 6-39: Cost Reduction by Transfer Transport (Case 2; T/S 2-1, 300t; T/S 2-2, 600t; T/S 2-3, 300t)

Municipality	Direct	Transfer	Direct – Transfer	
	US$/ton	US$/ton	US$/ton	%
T/S 2-1 (300t)				
013SS	5.29	5.56	-0.27	-5.1
014SS	6.00	5.70	0.30	5.0
07ST	6.31	5.78	0.53	8.4
08AC	6.22	5.12	1.10	17.7
average	5.96	5.54	0.42	6.5
T/S 2-2 (600t)				
011SS	5.20	3.78	1.42	27.3
012SS	4.94	4.22	0.72	14.6
015SS	5.91	4.35	1.56	26.4
02MJ	4.41	4.35	0.06	1.4
03CD	4.28	5.14	-0.86	-20.1
04CT	3.70	5.32	-1.62	-43.8
05AY	4.10	4.66	-0.56	-13.7
06SM	6.88	5.32	1.56	22.7
average	4.93	4.64	0.29	1.9
T/S 2-3 (300t)				
09SY	5.64	5.23	0.41	7.3
10IL	6.35	5.27	1.08	17.0
11SMT	6.66	7.17	-0.51	-7.7
average	6.22	5.89	0.33	5.5
Average	5.70	5.36	0.35	4.6

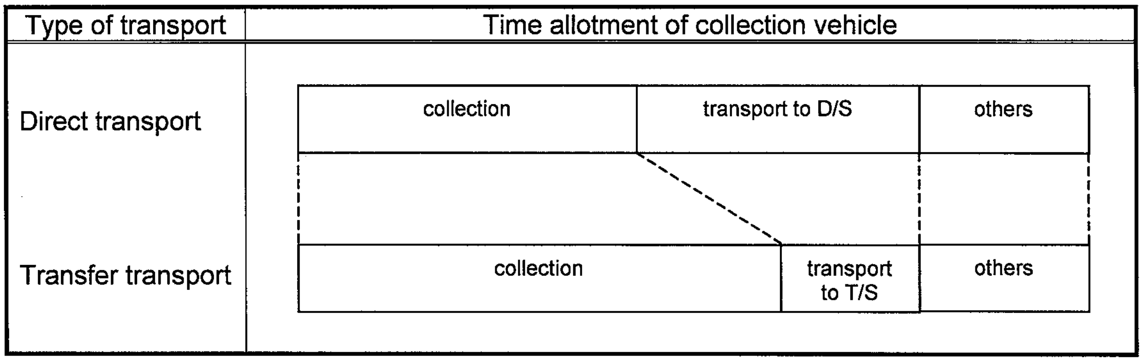
Case 3

Table 6-40: Transport Cost Reduction of Transfer Transport (Case 3; T/S 3-1, 300t; T/S 3-2 900T)

Municipality	Direct	Transfer	Direct – Transfer	
	US$/ton	US$/ton	US$/ton	%
T/S 3-1 (300t)				
012SS	4.94	5.66	-0.72	-14.6
013SS	5.29	4.96	0.33	6.2
014SS	6.00	5.36	0.64	10.7
07ST	6.31	6.11	0.20	3.2
08AC	6.22	5.27	0.95	15.3
average	5.75	5.47	0.28	4.2
T/S 3-2 (900)				
011SS	5.20	4.00	1.20	23.1
015SS	5.91	4.44	1.47	24.9
02MJ	4.41	4.53	-0.12	-2.7
03CD	4.28	4.49	-0.21	-4.9
04CT	3.70	5.02	-1.32	-35.7
05AY	4.10	4.75	-0.65	-15.9
06SM	6.88	5.06	1.82	26.5
09SY	5.64	4.31	1.33	23.6
10IL	6.35	5.24	1.11	17.5
11SMT	6.66	7.22	-0.56	-8.4
average	5.31	4.91	0.41	4.8
Average	5.53	5.19	0.35	4.5

vii. Effect on Collection

In case that the transfer transport is adopted, collection vehicles can gain more time for waste collection activity, as the time required for transport is reduced. The following figure schematically shows the difference of time spared for collection vehicle between the direct transport and the transfer one.



As more time is spared for the collection activity, a collection vehicle can collect more waste in a day. Table 6-41 shows the increase of collection amount by the employment of the transfer transport in case of the 18yd^3 compactor. Case 1 shows 41% of increase of collection amount, Case 2 and Case 3 are 53% and 48% respectively.

Table 6-41: Comparison of Collection Amount by Direct or Transfer Transport

Case	Direct ton/day/vehicle	Transfer ton/day/vehicle	Increase
Case 1	9.0	12.7	41%
Case 2	8.8	13.5	53%
Case 3	9.0	13.3	48%

viii. Collection and Transport Cost Comparison

Transport cost comparison concentrated on the costs of transport, it did not take into account the effect on collection, i.e., more time is spared for the collection activity and a collection vehicle can collect more waste in a day. In this section, taking it into consideration, “collection costs plus transport costs” are compared for the cases of direct transport and transfer transport, i.e., how much in collection and transport cost in total can be reduced if the transfer transport is adopted (see Table 6-42 to Table 6-44).

In Case 1, 3 municipalities of CD, CT and AY do not get benefit by employing the transfer transport. In Case 2, the same 3 municipalities (CD, CT and AY) do not become beneficial. In Case 3, District 2 of SS is added to them as non-beneficial members.

The results of “collection costs plus transport costs” comparison were almost same as the transport cost comparison carried out in the previous section. 8 municipalities, SS, MJ, SM, ST, AC, SY, IL, SMT, obtain benefit from the transfer transport. However, the justifiable reasons for employing the transfer transport for CD, CT and

AY municipalities, which are relatively close to Nejapa Disposal Site, could not be found in this examination.

Table 6-42: Collection and Transport Cost Reduction by Transfer Transport (Case 1; T/S 1-1, 1200t)

Municipality	Direct	Transfer	Direct - Transfer	
	US$/ton	US$/ton	US$/ton	%
T/S 1-1				
011SS	13.53	11.50	2.03	15.0
012SS	13.20	11.86	1.34	10.2
013SS	13.69	12.33	1.36	9.9
014SS	14.95	12.24	2.71	18.1
015SS	14.76	11.79	2.97	20.1
02MJ	12.46	12.01	0.45	3.6
03CD	12.20	12.57	-0.37	-3.0
04CT	11.55	12.75	-1.20	-10.4
05AY	11.94	12.17	-0.23	-1.9
06SM	16.89	12.57	4.32	25.6
07ST	15.55	13.82	1.73	11.1
08AC	15.35	12.84	2.51	16.4
09SY	14.38	12.75	1.63	11.3
10IL	15.75	13.51	2.24	14.2
11SMT	16.42	15.93	0.49	3.0
Average	14.17	12.71	1.47	9.5

Table 6-43: Collection and Transport Cost Reduction by Transfer Transport (Case 2; T/S 2-1, 300t; T/S 2-2 600t; T/S 2-3, 300t)

Municipality	Direct	Transfer	Direct - Transfer	
	US$/ton	US$/ton	US$/ton	%
T/S 2-1				
013SS	13.69	13.53	0.16	1.2
014SS	14.95	13.61	1.34	9.0
07ST	15.55	13.69	1.86	12.0
08AC	15.35	13.17	2.18	14.2
average	14.89	13.50	1.39	9.1
T/S 2-2				
011SS	13.53	11.93	1.60	11.8
012SS	13.20	12.22	0.98	7.4
015SS	14.76	12.29	2.47	16.7
02MJ	12.46	12.29	0.17	1.4
03CD	12.20	12.92	-0.72	-5.9
04CT	11.55	13.09	-1.54	-13.3
05AY	11.94	12.52	-0.58	-4.9
06SM	16.89	13.09	3.80	22.5
average	13.32	12.54	0.77	4.5
T/S 2-3				
09SY	14.38	13.28	1.10	7.6
10IL	15.75	13.28	2.47	15.7
11SMT	16.42	14.88	1.54	9.4
average	15.52	13.81	1.70	10.9
Average	14.58	13.28	1.29	8.2

Table 6-44: Collection and Transport Cost Reduction by Transfer Transport (Case 3; T/S 3-1, 300t; T/S 3-2 900t)

Municipality	Direct	Transfer	Direct - Transfer	
	US$/ton	US$/ton	US$/ton	%
T/S 3-1				
012SS	13.20	13.57	-0.37	-2.8
013SS	13.69	13.05	0.64	4.7
014SS	14.95	13.34	1.61	10.8
07ST	15.55	13.89	1.66	10.7
08AC	15.35	13.27	2.08	13.6
average	14.55	13.42	1.12	7.4
T/S 3-2				
011SS	13.53	11.96	1.57	11.6
015SS	14.76	12.33	2.43	16.5
02MJ	12.46	12.41	0.05	0.4
03CD	12.20	12.34	-0.14	-1.1
04CT	11.55	12.75	-1.20	-10.4
05AY	11.94	12.58	-0.64	-5.4
06SM	16.89	12.83	4.06	24.0
09SY	14.38	12.19	2.19	15.2
10IL	15.75	13.01	2.74	17.4
11SMT	16.42	15.02	1.40	8.5
average	13.99	12.74	1.25	7.7
Average	14.27	13.08	1.19	7.6

ix. Consideration Transfer Station Size

The lager size of transfer stations lead to the fewer cost. However, construction of large facility has large impact on traffic, environment, etc. Consideration of such impacts is summarized in Table 6-45.

Table 6-45: Comparative Evaluation of Transfer Stations by Size

Comparative Evaluation Item	Small T/S (e.g., up to 300 ton/day)	Medium T/S (e.g., 300 to 900 ton/day)	Large T/S (e.g., more than 900 ton/day)
1. Land Acquisition	Easy	← →	Difficult
2. Neighborhood Consensus	Easy	← →	Difficult Consensus with residents along the access road is also necessary.
3. Compatibility with Development Plan, and Construction Permit	Easy Possibly acceptable in many candidate sites	← →	Difficult Numbers and locations of candidate sites will be largely limited.
4. Environmental Impact (Acceptability)			
• impacts of noise, offensive odor	Small	← →	Large Prevention measures e.g., buffer zone is inevitable.
• traffic congestion	Very small	← →	Large Prevention measures will be necessary, or appropriate localization is indispensable (sufficient access to trunk road).
• aesthetic view impact	small mitigation measures	← →	Large mitigation measures
• other impacts	Small	← →	Large
5. Economic Feasibility			
• Land Area Necessary • and • Acquisition Cost	Small, Small	← →	Large (including buffer zone), Large
• Access Road Improvement Cost	Small	← →	Large
• Transport distance by collection vehicles, and its benefit	Shorter, Large	← →	Longer, Small
• Benefit of "Economy of Scale"	Small	← →	Large

x. Examination of the Cases and Recommendation of the Optimum Transfer Transport System

As the cost comparison of the three cases shows, Case 1 is the most beneficial in viewpoint of costs. However, construction and operation of the 1200t T/S must be absolutely difficult in the densely populated city center of SS. Acquiring such large scale of land and getting neighborhood consensus must face severe opposition from the citizens. Moreover, a thorough investigation on its impact on traffic is necessary, as the city is being annoyed about heavy traffic congestion even at present.

Case 2 is the secondly beneficial at the cost comparison, but almost the same as Case 3. Construction and operation of 300ton/day T/Ss in the west and in the east of the Study Area would not give serious adverse impacts on and around the sites due to their small sizes. The weighted center of the west is on AC, and one of the east is on SY. A 600ton/day T/S in the city center of SS would face problems, however, those would not be so serious as ones of 1200ton/day T/S.

Case 3 is with the least benefit. Construction and operation of 300t T/S in the west would not face serious problems as mentioned in the previous paragraph. The 900ton/day T/S in the east has more serious adverse impacts than 300 or 600ton/day

T/Ss due to its large size. However, these impacts must be less than those of 1200ton/day T/S in the central part of SS.

As for each municipality, CD, CT and AY would never get benefit from the employment of transfer transport in any 3 cases above, if the final destination were Nejapa Disposal Site. As for CT, its present destination is the ESPIGA Disposal Site. If the final destination were ESPIGA, CT would gain benefit from the transfer transport, as the proposed T/Ss are located on the way south to ESPIGA. However in the assumptive case of Nejapa destination, collection vehicles of CT should go south to a T/S and a transfer vehicle will travel north from such T/S to Nejapa site maybe on the same road again.

Consequently, the Case 3 is recommendable as the optimum transfer transport system for AMSS.

The examination carried out here is based on the several assumptions. Ideally, locations and sizes of T/Ss are determined by weighted centers of waste generation areas and waste amount dealt with. However, the reality is different from the ideal. The locations and sizes of T/Ss depend on actually available lands and their circumstances. Therefore, it would be necessary and recommended that, after selecting candidate sites from several possibly available lands, a more concrete investigation (such as a feasibility study) on them should be executed.

c.2 Type of Transfer Station

Generally, transfer stations are classified into two types; direct-load and storage-load. The direct-load transfer stations means that waste brought by collection vehicles such as compactor trucks is directly discharged into transport vehicles such as tractor-trailers. On the other hand, storage-load transfer stations have a certain capacity to store waste, e.g., one to three days.

Table 6-46: Comparative Evaluation of Transfer Stations by Type

Item	Direct-load	Storage-load
Required land size	**Small** space for storing waste is not necessary.	**Larger** large space for storing waste is necessary.
Required equipment	**Few** not necessary for loading waste into transport vehicles.	**Many** wheel loader or equivalent equipment is necessary for loading waste into transport vehicles.
Required prevention measures to environment	**Few** negative impact on environment, such as odor, waste litter, would be small, as waste is directly transshipped to transport vehicles.	**Many** negative environmental impact would be large as waste is placed on storage pits before transferred into transport vehicles. prevention measures to odor, waste litter, etc. and wastewater (leachate from waste) treatment would be necessary.
Reliability. flexibility	**Small** if transport system stops, collection system immediately halts too.	**Large** even though transport system stops, collection system can work until capacity of the storage pit fills.

Applicability

Construction and operation of direct-load would be less costly than that of storage-load, but less reliable to collection system. In the Study Area, round trip travel times of all the present collection routes never exceed three hours on the assumption that the final destination is Nejapa Disposal Site. This means that when the transfer transport system halts, at least one or two collection trips can be carried out in one working shift, which is 6 hours to 8hours, by returning to the direct transport. Therefore, even if the transfer transport system halts one day or two days, the negative impact on the collection system would not be serious. Consequently, direct-load is recommendable to the Study Area.

However, if the transfer station is used in conjunction with MRF, waste needs to be placed on the storage pit to be carried to material recovery process, where sufficient environmental prevention measures will be inevitable.

c.3 Type of Transfer Vehicle

Basically, type of transfer vehicle is determined from an economic point of view. Waste must be transported at minimum cost. The larger capacity of vehicle, generally, results in the fewer unit costs. However, gross vehicle weight (GVW), maximum payload, dimensions of body, etc. should meet with regulations which control vehicles and traffic.

Decree No.86 "Reglamento para el Control de Pesos, Carga y Medidas de Vehiculos Automotores que Circulan por las Carreteras de la Republica" by Ministry of Public Works (Ministerio de Obras Pubulicas) prescribes that:

- Maximum width is 2.50m,

- Maximum height is 3.80m,
- Maximum length is 18.30m, and
- Vehicle weight plus load do not exceed 33,800kg. If a total weight exceeds 33,800kg, it is necessary to obtain a certificate from Dirección General de Caminos.

Proposed Vehicle

The proposed transport vehicle is tractor-trailer that has capacity to load 20 ton of waste and over. The container (trailer) should be open top type as the direct-load transfer station is recommended.

d. Conclusion

Whether the transfer transport should be employed or not is depending on the size of T/Ss that are used. Small T/Ss' unit costs tend to be expensive, contrarily large T/Ss' ones are likely to be inexpensive due to economy of scale. In the examination of breakeven distance and travel time to Nejapa Disposal Site, 100ton/day transfer transport system never became beneficial to the Study Area, 300ton/day or over transfer transport system were advantageous compared with the direct transport.

In order to seek optimum location of T/Ss and their sizes, three cases were set.

- Case 1 is to use one large size of T/S, 1200 ton/day, in the central part of SS,
- Case 2 is to use two small size of T/Ss, 300 ton/day, in the west and in the east of the Study Area and one medium size of T/S, 600 ton/day, in the central part of SS, and
- Case 3 is to use one small size of T/S, 300 ton/day in the west and one large T/S, 900 ton/day in the east.

Case 1 leaded to maximum cost reduction, 9.6% in transport cost and 9.5% in collection and transport cost. Case 2 (4.6%, 8.2%) and Case 3 (4.5%, 7.6%) were the almost same, but Case 2 reduced the cost a little more than Case 3 did. It was thought, however, that Case 1 would be the least realistic as due to its size and the location. Case 2 would be more feasible than Case 1, but it would still be difficult to construct and operate the 600t transfer transport system in the central part of SS. Case 3 would be the most practical as the both T/Ss are out of the densely populated area of the Study Area.

The examination included 11 municipalities except AP, NJ and TN. Any case could not find the justifiable reasons for employing transfer transport for CD, CT and AY.

As for type of T/S, direct-load type is recommendable due to its fewer cost and smaller environmental impacts on and around the site. Although the direct-load type is less reliable than the storage-load type for maintaining the collection system, this would not be a serious problem because waste collection works can temporarily return to the direct transport system that is presently practiced.

20 ton or over tractor-trailers are recommendable as transport vehicles. Smaller capacity vehicles than those are not recommendable because use of a small vehicle for transfer transport raises transport cost.

The examination carried out here were based on several assumptions. More concrete investigation such as feasibility study must be necessary to decide the employment of an optimum transfer transport for AMSS.

6.4.3 Intermediate Processing System

6.4.3.1 Concept of Intermediate Processing Introduction

Objectives and methods of the intermediate processing system in municipal SWM are summarized in the table below. As it could be judged from the table below, the primary objective in the intermediate processing is the volume reduction in general. Subsequent objectives could be in the order of: improvement of waste handling; waste stabilization (e.g., prevention of waste decay); resource recovery; and energy recovery.

Table 6-47: Objectives and Methods of Intermediate Processing System

	Improvement of waste handling	Volume reduction	Waste stabilization	Resources recovery	Energy recovery
Separation		X		X	
Baling	X	X			
Composting	X	X	X	X	(X)
Incineration	X	X	X		X

What method of intermediate processing to be selected in municipal SWM will largely depend on the intrinsic local conditions (e.g., geographical, social, economical conditions).

In Japan, as the incineration in municipal SWM is the common and major intermediate processing, the intermediate processing is almost perceived as a synonym of incineration. The reasons are as follows.

- The Japanese summer is humid and hot, therefore organic waste decay and vectors proliferation takes place in a short time. To cope with these problems, municipal wastes (especially perishables) should be frequently collected and be subject to a "stabilization" process before long.
- Although the national economical standard is high, 130 million people live on the narrow territory. Consequently land prices are extremely high, therefore it is required to limit as much as possible the land destined for sanitary landfills.

Therefore, the principal objectives of the incineration process in Japanese municipal SWM are: "waste stabilization" in a sanitary manner and "volume reduction" to economize the use of landfill sites.

For example in the United States of America, as the climate is comparatively dry, risks of vectors proliferation on rotten waste are lesser. Meanwhile extensive territory usable for landfills is generally available. Hence, the incineration process for the municipal SW there normally have a principal objective of energy recovery such as power generation, rather than the objectives of waste stabilization or volume reduction.

Small countries in Europe such as Denmark and Switzerland employ incineration processes widely. The climate there is relatively dry and the winter being freezing. Therefore, incineration objectives are mainly volume reduction and heat energy recovery rather than a Japanese objective of waste stabilization.

Meanwhile, intermediate processing facilities for "resource recovery" from municipal waste are being constructed and operated many recently in many industrialized countries, with an objective of "resource conservation".

As explained above, in introducing an intermediate processing facility, examination for the below aspect is indispensable:

- local conditions (e.g., geographical, social, economical conditions).

Modernity and newness of a facility, its performance and functioning in foreign industrialized countries and such commercial propaganda will not help to examine appropriate solutions in search. On the contrary, they may place confusion in the examination of what intermediate process answers to objectives raised.

Special attentions should be paid to that intermediate processing facilities normally require considerable investment costs for construction as well as significant O&M costs that will be a continuous financial burden.

Therefore, it is essential to introduce an optimum intermediate processing at an optimum time, i.e., the introduction should be when it is really needed.

6.4.3.2 Evaluation of Intermediate Processing System

a. Separation

Objectives of selection plant (S/P) are summarized in the table below. List of target recovery materials will vary a little depending on the S/P objectives. However, the plant structure basically does not change even the list of target recovery materials changes. Meanwhile, list of target recovery materials might be changed due to market price fluctuation of such materials. Therefore, the facility plans for S/P should be such that the plant can cope with changes in target recovery materials.

Table 6-48: Objectives and Activities of Selection Plant (S/P)

<table>
<tr><th colspan="2">Objectives</th><th>Target recovery materials</th><th>Activities</th></tr>
<tr><td>Case1</td><td>Recovery of recyclable material from commingled waste</td><td>• Bulky items, cardboard, paper, plastics(PET, HDPE, etc.), glass, aluminum cans, tin cans, other ferrous materials</td><td rowspan="3">• Manual separation of bulky item, cardboard, plastics, glass by color, aluminum cans, and large ferrous items.
• Magnetic separation of magnetism item (tin can, etc.)
• Baling of separated materials for shipping. Storage of baled materials</td></tr>
<tr><td>Case 2</td><td>Recovery of recyclable material from commingled waste and source-separated materials</td><td>• Bulky items, cardboard, paper, plastics(PET, HDPE, etc.), glass, aluminum cans, tin cans, other ferrous materials
• Source-separated materials</td></tr>
<tr><td>Case 3</td><td>Preparation of MSW for use as a feedstock for composting</td><td>• Bulky items, cardboard, plastics, glass, aluminum cans, tin cans, other ferrous materials.</td></tr>
</table>

If a S/P is introduced for AMSS, it should initially be the Case 1 for the time being and will be converted to that for Case 2 in the course of increase in the separate collection for source separated materials.

b. Baling

The baling process is normally employed as a part of process in S/P. There are a few exceptional cases that a baling process without pre-treatment is implemented at the upstream municipal SW flow so that final disposal volume reduction and transport cost cut would be attained. However in such cases, if examination on such as: treatment of residual liquid of waste squeezed by baling; and specification of binding wire; etc is forgotten, original objectives will not be complied with.

Direct baling of municipal SW was attempted in Japan in 1970s. Baled waste was asphalt coated to shape a block, which was intended to be used as construction materials. However, leachate leaked out from the block and baling wire was eroded and broken down. Consequently those blocks did not work as construction materials and polluted the environment. This technique of asphalt coated baled waste was abandoned. Current baling techniques in Japan are mostly used for baling the recovered materials in S/P with an objective of "handling improvement".

As the case above explains, direct baling of municipal SW has the problem. It is suggested that baling should be employed as a part of S/P functions in AMSS.

c. Composting

There are basically two types of composting process for organic fraction of municipal solid waste: "aerobic process" and "anaerobic process". The comparison of the two processes is shown in the table below.

Table 6-49: Comparison of Aerobic and Anaerobic Composting for Organic Fraction of Municipal SW

Characteristic	Aerobic process	Anaerobic process
Energy use	Net energy consumer	Net energy producer
End products	Humus, CO_2, H_2O	Sludge, CO_2, CH_4
Volume reduction	Up to 50%	Up to 50%
Processing time	20 to 30 days	20 to 40 days
Curing time	30 to 90 days	30 to 90 days
Primary goal	Volume reduction	Energy production
Secondary goal	Compost production	Volume reduction, waste stabilization

Source : Integrated Solid Waste Management, McGraw-Hill

The table explains that the aerobic process has a primary goal of volume reduction and the anaerobic process requires higher cost of pressure vessel and several instruments in order to recover biogas. Therefore, when an examination on compost introduction takes place, it will be recommended to adopt and/or maintain aerobic process for AMSS so that the volume reduction can be targeted at relatively low cost.

d. Incineration

Incineration treatment can reduce the amount to 15% in weight, however its construction costs and O&M costs are enormous.

Generally speaking, incineration facilities of municipal SW requires the following that are considerably high:

- Construction investment costs that have a range of from US$ 100,000 to 150,000/ton[1] depending upon the plant capacity; and
- O&M cost ranges from US$ 25 to 38/ton.

Incineration plants further require substantial technical abilities of operators. Therefore, it is suggested that introduction of an incineration process for municipal waste in AMSS is still too early, in view of the absence of real necessity for incineration and economical capability that municipalities have at the present situation.

6.4.4 Final Disposal System

6.4.4.1 Landfill Structure

In view of groundwater and soil pollution prevention, it is required for final disposal sites to equip impermeable liner and/or to be localized at places whose ground is impermeable. In such cases, it becomes necessary to drain and treat leachate generated in the final disposal sites. Leachate treatment could be inside or outside of the landfill.

To equip impermeable liner and to treat leachate necessitates a considerable amount of financial resources and adequate technical assets for its operation and maintenance.

[1] daily treatment capacity (e.g., cost of 100ton/day capacity incinerator is US$ 15,000,000)

It generally turns out a crucial burden on municipal SWM in low and middle income countries and cities.

Accordingly, there are few cases in the past and to date in developing countries that municipal final disposal sites have impermeable liners. Majority of them allows leachate to infiltrate into the ground.

To infiltrate the leachate into the ground is undesirable from the viewpoints of groundwater and soil pollution prevention, however, in places where whose groundwater has no use due to it has already polluted long before or is saline, localizing a final disposal site without impermeable liner has little problems.

Anyhow, from the environmental viewpoints, it is desirable to equip an impermeable liner for final disposal sites. Meanwhile, as for the environmental legislation, the "Transitory Decree of Solid Waste" was issued on October 6th, 1999 and was turned into the "Special Regulation on Integral Solid Waste Management" on June 1st, 2000. The table below summarizes the technical requirements for the final disposal sites.

Table 6-50: Outline of Technical Standard for MSW Landfill

			Transitory Decree (October/06/1999)	Special Regulation (June/01/2000)
Level from grand water table			More than 10 m	must ensure the conservation of the existing aquifers in the zone.
Distance from flood area			More than 500m	at a distance that prevents damages towards flooding zones, swamps, salt marshes, water bodies and natural drainage zones.
Distance from water source area			More than 1km	at a distance that ensures that the zones for recharging of aquifer or supply sources of drinkable water is free of pollution. Such distance will be set within national technical norms.
Soil characteristic and permeability			Loamy, 10^{-5} to 10^{-7} cm/sec	10^{-7} cm/sec
Land use			Without agricultural use	-
Distance from fault line			-	more than 60 meters away from faults with recent shifts.
Landfill area/ total site area			Less than 30 %	-
Location	Distance form urban area		More than 1km	More than 500 meter
	Prohibit area		natural protection area, airport influence area, pipelines area, gas-ducts, aqueducts, hydrocarbon storage area, winds area	natural protected areas or fragile ecosystems, buffer zones devoted for the passage of aquaducts, irrigation canals, sewerage and electricity wire lines.
Operation	daily disposal amount	less than 20ton/day	Manual filling	-ditto-
		20 to 40ton/day	combined filling (manual and heavy equipment)	-ditto-
		more than 40ton/day	heavy equipment filling	-ditto-

The present legislation (Special Regulation) requires soil characteristics of a maximum permeability coefficient of 10^{-7}cm/sec, and that the depth to groundwater level should guarantee the existing aquifer conservation.

Although the transitory decree stipulated the minimum depth to groundwater as 10 meter, the superceding legislation does not stipulate the depth to guarantee the existing aquifer conservation. Hence as an example calculation, where the leachate travel time to aquifer is calculated under the conditions of permeability 10^{-7}cm/sec and 10 meter thickness, the travel time becomes 320 years.

If it is assumed that the legislative requirements of "to guarantee aquifer conservation" refers a leachate travel time in the order of 320 years, it will be very difficult in El Salvador to find geological sites suitable for localizing a landfill without an artificial impermeable liner. Because, the geological requirements for such will be the impermeable soil layer thicker than 10 meter with the coefficient less than 10^{-7}cm/sec, sites intermittently wide enough with such soil characteristics and depth are hardly found in a volcanic geology.

Hence, in order to comply with this environmental requirement, it is necessary to artificially create the impermeability to satisfy these technical requirements. The following alternatives can be considered:

- To create impermeability by laying and compacting impermeable clay materials; or
- To create impermeability with synthetic liner (e.g., high density polyethylene sheet).

The former alternative has an important geological restriction that the landfill candidate site should be near to the abundant and high quality (impermeable) clay deposits. Meanwhile, since the latter does not depend on geological features, the landfill site can be selected from multiple choices without such geographical restrictions.

It is recommended in this M/P to select the latter alternative (synthetic liner) in final disposal system due to that accurate locations of final disposal candidate sites in the M/P are not determined and whose hydro-geological information are not sufficient.

When in the future an accurate location of final disposal site is determined along with the M/P implementation, detail investigation on hydro-geological conditions etc. should be carried out and specification of impermeable lining should be reviewed accordingly.