7.6 Environmental Impact Assessment

7.6.1 Outline of assessment items and results

Assessment items and the assessment results are summarized in Table 7.34. The number of environmental items upon which the assessment was based was 24 including 14 items on living environment, 6 on natural environment and 4 on socio-economic environment.

Four elements including incineration plants, new and existing compost plants, final disposal sites, and collection trucks were taken as environmental impact elements. The assessment was made in comparison with the quantitative and qualitative forecast results of the environmental factors related to these elements with the environmental criteria. Countermeasures were taken into account for assessment of the influence of elements which were empirically forecast to affect the environment considerably. (Ref. Table 7.34 for the elements which require countermeasures.) Influence of environmental factors such as air pollution, water pollution, noise, rank odour and traffic were forecast quantitatively and proved not to exceed the criteria.

Other environmental factors were qualitatively forecast and the results indicated that the influence would be slight.

7.6.2 Environmental impact assessment

(1) Living environment

i) Air pollution

a. Incineration plant

Based on a comparison of the forecast results with the criteria made it is clear that the grade of air pollution caused by the plant operation does not exceed the limit set in the criteria for the alternatives Case No. 13 and No. 19-(2). (Ref. Table 7.35)

Table 7.35 Air pollution caused by incineration plant operation

		Pollutant					
		HCl (ppm)	SO_x (ppm)	NO_x (ppm)	CO (ppm)	Dust (mg/m^3)	Total volume of SO_2 (Nm^3/h)
(A)	No. 13	0.029	0.002	0.006	0.002	0.004	61.8
	No. 19-(2)						37.8
(B)	Criteria	0.05	0.04	0.03	8	0.1	(13)188 (19-(2))110
(A)/(B)		1/2	1/20	1/20	1/4,000	1/25	1/3

b. The existing compost plant

Forecast results indicate that air pollution caused by operation of the existing compost plant does not exceed the criteria. (Ref. Table 7.36)

Table 7.34 Assessment items

	Environmental factor	Environmental impact element	Forecast: Quantitative	Forecast: Qualitative	Countermeasure	Assessment	Assessment indicators
Living environment	1. Air pollution	IP	○		*	◎	HCl, SO_X, NO_X, CO, Dust, etc.
		ECP	○		*	◎	– do –
	2. Water pollution	FDS	○		*	◎	BOD, SS, etc.
		IP	○		*	◎	– do –
	3. Noise	IP	○		*	◎	EP, CT
		NCP		○	*	△	Blower
		ECP		○		△	
	4. Vibration	ECP, NCP		○	*	△	
		FDS		○		△	Bulldozer
	5. Rank odour	IP		○	*	△	Reception pit
		ECP, NCP		○		△	Pit, ferm yard
		FDS	○			◎	Ammonia, etc.
	6. Soil contamination	FDS, IP, NCP ECP		○	*	△	Waste water
	7. Subsidence	FDS	○			△	
	8. Low frequency air vibration	IP		○	*	△	
	9. Obstruction against sunshine	IP		○		△	Building
		FDS, NCP, ECP		○		△	Building, landfill site
	10. Wind damage	IP, ECP, NCP		○		△	Building
	11. Elec. wave obstruction	FDS, ECP, NCP		○		△	Building, landfill site
		IP		○	*	△	Building
	12. Residue	IP, ECP, NCP		○		△	Secondary influence
	13. Traffic	Collection truck	○			◎	Air poll., noise
	14. Fire	FDS		○		△	Gas
Natural environment	15. Topology & Geology	FDS, IP, NCP ECP		○		△	Deformation of land
	16. Groundwater	FDS		○		△	Leachate penetration
	17. Aesthetics	FDS, IP		○	*	△	
	18. Flora	FDS, IP, ECP, NCP		○	*	△	Loss of plants
	19. Fauna	FDS, IP, ECP, NCP		○		△	Loss of animals
	20. Aquatic life	FDS, IP, ECP, NCP		○		△	Loss of aquatic life
Socio-economic environment	21. Historical place, cultural assets	FDS, IP, ECP, NCP		○		△	Loss of historical assets
	22. Land use	FDS, IP, ECP, NCP		○		△	Land value
	23. Industry	Whole system		○		△	
	24. Employment	Whole system		○		△	

Legend

* Requring countermeasures

◎ There is influence, but does not exceed the criteria

△ There is only a little influence

○ To be forecast

IP Incineration plant
ECP Existing compost plant
NCP New compost plant
FDS Final disposal site
EP Electric precipitator
CT Cooling tower
FY Fermentation yard

Table 7.36 Air pollution caused by the existing compost plant operation

	Pollutant					
	HCl (ppm)	SO_x (ppm)	NO_x (ppm)	CO (ppm)	Dust (mg/m^3)	Total volume of SO_2 (Nm^3/h)
(A)No. 9, 13 and 19-(2)	0.037	0.013	0.022	0.006	0.015	1.5
(B) Criteria	0.05	0.04	0.03	8	0.1	7.8
(A)/(B)	1/1.3	1/3	1/1.4	1/1,330	1/7	1/5

ii) Water pollution

For each alternative, pollutants volume in waste water from the incineration plants was estimated as well as that of landfill sites.

The results showed that the alternatives except without-project case do not exceed the criteria. (Ref. Table 7.37) .

Table 7·37 Water pollution of landfill sites and plants

(Unit: kg/d)

		Case No.							
		9		13		19-(2)		without-project	
		BOD	SS	BOD	SS	BOD	SS	BOD	SS
Landfill site	On-Nooch	15.0(1/1.2)	22.5(1/1.3)	5.6(1/3.4)	8.4(1/3.4)	6.6(1/2.9)	9.9(1/2.9)	256(13.5)	256(9.0)
	Nong Khaem	17.4(1/1.1)	26.1(1/1.1)	10.0(1/1.9)	15.0(1/1.9)	11.0(1/1.7)	16.5(1/1.7)	300(15.8)	300(10.5)
	Ram Intra	7.0(1/2.7)	10.5(1/2.7)	3.6(1/5.3)	5.4(1/5.3)	4.4(1/4.3)	6.6(1/4.3)	120(6.3)	120(4.2)
	Taling Chan*	5.2(1/3.6)	7.8(1/3.7)	5.2(1/3.6)	7.8(1/3.7)	5.2(1/3.6)	7.8(1/3.6)	–	–
	Bang Khun Tian*	4.0(1/4.8)	6.0(1/4.7)	4.0(1/4.8)	6.0(1/4.7)	4.0(1/4.8)	6.0(1/4.7)	–	–
Incineration plant	Yannawa	–	–	6.0(1/3.2)	9.0(1/3.2)	6.0(1/3.2)	9.0(1/3.2)	–	–
	Dusit	–	–	–	–	6.0(1/3.2)	9.0(1/3.2)	–	–
	Bang Kapi	–	–	4.8(1/3.9)	7.2(1/3.9)	–	–	–	–
	Bangkok Noi	–	–	4.4(1/4.3)	6.6(1/4.3)	–	–	–	–
	Phasi Charoen	–	–	4.4(1/4.3)	6.6(1/4.3)	–	–	–	–
Criteria		19.0	28.5	19.0	28.5	19.0	28.5	19.0	28.5

Note 1. Numbers in parentheses indicate (Total discharged volume of pollutants/criteria).

2. Coefficient of leachate discharge C = 1.0 was taken for Taling Chan and Bang Khun Tian.

iii) Noise

a. Incineration plant

Noise from the electric precipitaters and cooling tower, typical noise sources of incineration plant, attenuated by

the effect of building wall and decreases by distance. Then the influence of noise becomes insignificant on the boundary line.

b. New compost plant

Blower, main noise source of the new compost plant, should be installed in the specially designed room for noise mitigation. This will allow the noise level measured on the boundary line to be reduced to an extent to meet the criteria.

c. The existing compost plant

The existing compost plant is located in the landfill site remote to its boundary. Therefore, it was forecast that the noise from the plant would not affect the adjacent area very much.

iv) Vibration

Measures to suppress vibration should be applied to the vibration sources in the incineration plant, new compost plant and existing compost plant. Vibration problems will probably occur in the landfill site caused by operation of bulldozers, though limited in daytime.

v) Rank odour

a. Incineration plant

Offensive gas generated in the reception pit should be fed to incinerator where the gas is resolved and deodorized at a temperature more than 750°C.

b. Compost plant

Gas generated in the reception pit and fermentation yard is mostly diffused and deconcentrated. Therefore, the rank odour will not have much affect outside the site.

c. Landfill site

The forecast results indicate that rank odour generated in the landfill site is very much weakened before reaching the boundary. (Ref. Table 7.38)

Table 7.38 Rank odour of landfill site

	Substance			
	Ammonia	Methyl-mercaptan	Hydrogen sulfide	Methyl sulfide
(A) Concentration (ppm)	0.29	2.57×10^{-4}	6.85×10^{-4}	5.14×10^{-4}
(B) Criteria (ppm)	1	0.002	0.02	0.01
(A)/(B)	1/3.5	1/7.8	1/29.2	1/19.5

vi) Soil contamination

To minimize soil contamination, the leachate generated in landfill site, incineration and compost plants, which is probable source of the contamination, should be treated in the waste water treatment facilities.

vii) Land subsidence

The amount of subsidence of landfill site was forecast to be 4 cm in 60 years at the boundary. Therefore, influence of the subsidence to the adjacent area is negligible.

viii) Low frequency air vibration

The incineration plant is a possible source of low frequency air vibration. Therefore, it should be so designed as not to cause any vibration problems.

ix) Obstruction against sunshine

20-meter high buildings of the existing and new compost plants were forecast to cast their shade inside the site and not outside. The 15 meters-high landfill will also not cast its shadow outside of the site. The 30 meters-high incineration plant of Bang Kapi may cast it shadow outside of the site in winter when the sun is low.

x) Wind damage

The tall buildings, which often cause wind damage, do not exist now around the proposed sites. They were also not expected to be built in the future. Therefore, wind damage was not forecast.

xi) Electric wave obstruction

The low buildings such as the existing and new compost plants, and the landfill site will not cause remarkable electric wave obstruction. The incineration plant should be equipped with the anti-obstruction apparatus if the influence is intollerable.

xii) Treatment residue

Compost residue and ash from incineration plant are the main residue from the treatment facilities.

Secondary influence such as decomposition, fermentation, rank odour and breeding of vector from the compost residue was forecast not to be serious.

The ratio of combustibles in ash (ignition loss) is estimated as low as 5%. Therefore, secondary influence is expected to be insignificant.

xiii) Traffic

a. Air pollution

Main pollutants contained in exhaust gas of collection trucks are CO and NO_x; with the former being dominant. Diffusion forecast showed that the degree of CO concentration at the roadside would be less than that limited by the criteria, accordingly it would not be harmful to human health.

b. Noise (on the roads)

300 collection trucks will be added to ordinary traffic volume of 1,000 vehicles per hour. Owing to this, traffic noise was forecasted to be raised by 3 [dB(A)]. However, this will occur at the peak hour only, therefore the influence will not be so serious.

c. Noise (on the site)

To suppress the influence of noise on the surroundings, operation of the collection trucks should be made at 20 km/h or slower.

xiv) Fire

Occurrence of fire caused by either human activity or natural phenomena can be mostly avoided by sanitary landfill (Sandwich method).

Fire hazard owing to generation of methane gas can also be avoided by installation of gas release equipment.

Occasional fire will not spread beyond the landfill area since sectional landfill method is used and the banks provide a barrier for the area.

(2) Natural environment

i) Topography and geology

Features of topography and geology in solid waste treatment facility sites will change to a certain extent. Change of the feature in the Case No. 9 will be larger than that in other cases, because it requires a wider landfill site owing to lack of incineration which contributes to volume reduction. No serious influence was forecast since any land or building to be preserved was not found in the site. Influence to the adjacent areas from the change of land feature was neither forecast as space will be kept between the facilities and the boundary line, which functions as a buffer zone.

ii) Groundwater

Bangkok city lies on a flat alluvium deposit which is composed of clay and sand. Groundwater from four aquifers within 300 meters deep have been pumped and used by industries. Groundwater pollution by landfill leachate is probable accidental. According to our investigation, however, the coefficient of permeability of the top soil (Bangkok clay, 30 meters thick) is 3×10^{-7} (cm/s). This means that the leachate may take more than 300 years to reach the first aquifer, so that it scarcely causes any groundwater pollution.

iii) Aesthetics

Existing landscape around the site will be changed when the solid waste treatment facilities are built in the low housing areas. The grade of change depends on the viewer. In order to mitigate an oppressive impression given to viewer near the site,

space should be kept between the facilities and the boundary line. Trees and grass should be planted so as to make the conspicuous appearance of facility softened. Side slopes of the landfill should be formed on a gentle slope in order to widen the view. When landfilling is completed, the landfill should be finally covered with soil, then planting should be made on its surface considering harmony with scenery of the surroundings.

iv) Flora

No important species of plant has been found around the site. Grass and trees should be planted after construction so that the surroundings would provide improved landscape.

v) Fauna

No important species or scientifically valuable species of fauna have been found around the sites. The birds and animals living on the proposed sites can move outside. Therefore, no influence was forecast regarding fauna.

vi) Aquatic life

Water from the facilities should be treated before discharge so that it does not affect aquatic life.

Therefore, no remarkable damage was forecast.

(3) Socio-economic environment

i) Historic site and cultural assets

The proposed sites are not designated as historic sites, and no cultural assets have been found on the sites.

ii) Land use

a. Restriction on land use

Forecasts were made about future land use and probable restrictions on land use around the proposed sites as shown in Table 7.39. (For the details, please refer to Appendix 7.5 General influence on land use by the solid waste treatment facilities)

b. Land value

Land value around the facilities will be influenced as described below by development of the surrounding areas. (Ref. Appendix 7.6)

- Land value around the incineration plant

Rise of land value was forecast small at Yannawa, Dusit, and Bangkok Noi.

Rise of land value at Bang Kapi was forecast to be restrained as the plant was considered a nuisance facility. The value would rise if the adjacent roads are widened and access from the main road to the area is improved. In case of Phasi Charoen, the land value was forecast to rise if the adjacent roads are widened and access from the main road becomes more convenient.

Table 7.39 Restriction on land use

Location and facilities	Future land use and restrictions on land use
1. Yannawa Incineration plant	1) Construction of tall buildings (apartment houses, office buildings and hotels) will be restricted near the plant. 2) High density housing area for commercial and industrial land use.
2. Dusit Incineration plant	1) The same as item 1) of Yannawa above. 2) The school next to the plant is facing a street which is so wide that the collection trucks will not obstruct the pedestrians or pupils.
3. Bangkok Noi Incineration plant	1) The same as item 1) of Yannawa above.
4. Bang Kapi Incineration plant	1) The areas around the site are growing to medium density housing areas, but construction of tall buildings in the areas may be restricted in the future. 2) Route of the collection trucks should be made carefully so as not to obstruct a school standing on the opposite side of a street from the plant. The roads in the area are all narrow. Widening of the adjacent roads with pedestrian footpath are desirable.
5. Phasi Charoen Incineration plant	1) The same as item 1) of Bang Kapi above. 2) No ill effect on the plant is not forecast even if the present land use as an orchard is continued in the future.
6. Bang Khun Tian New compost plant	1) Construction of new town is under progress in the green area at several hundred meters away from the site, but no restriction will be enforced.
7. Taling Chan New compost plant	1) No restriction will be enforced as the surroundings are green areas.
8. On-Nooch The existing compost plant and landfill site	1) Low density mixed use. Restriction of housing development in a few hundred meters from the site is desirable. 2) Junk dealers are expected to line up along the road. The area are not expected to become the high class residencial areas.
9. Nong Khaem The existing compost plant and landfill site	1) Green area. Restriction of housing development in a few hundred meters from the site is desirable. 2) The same as item 2) of 8 above.
10. Ram Intra The existing compost plant and landfill site	1) The same as the 8 above.

- Land value around the compost plant

  Rise of land value of adjacent residential areas to Bang Khun Tian plant was forecast restrained. No influence on land value was forecast for Taling Chan.

- Land value around the landfill site and the existing compost plant

  Rate of land value increase around the sites were forecast not particularly different from that of the surrounding areas.

iii) Industry

a. Promotion of industry

This project requires purchase of collection trucks and equipment for the incineration and compost plants.

The number of trucks to be purchased annually was estimated to be 100 - 150, which shares a small part in the total number of vehicles (46,000) sold in a year in Bangkok city; therefore, its contribution to vehicle industry cannot be much.

The main equipment of incineration and compost plants will be imported from overseas, therefore, local plant makers cannot benefit much from the project. Construction of incineration plant may promote development of plant construction industries.

b. Influence of compost on the chemical fertilizer industries

The area of farmland where the compost could be used was estimated 55,250 km^2 in an entire Thailand, or 16,136 km^2 in central plain (Ref. Table 7.40). Chemical fertilizer would be used for these entire areas if compost is not supplied. Compost production volume was estimated to be 89,300 t/year. This volume of compost will be supplied to 89.3 km^2 of farmland provided 1,000 m^2 of land is fertilized annually by 1 ton of compost. Assuming that a half volume of chemical fertilizer can be saved if it is used together with compost, the decrease of expected consumption of chemical fertilizer was forecast 0.08% in an entire Thailand from calculation by ratio of fertilization areas. The chemical fertilizer industries or its importers are expected to grow in the future, though currently use of chemical fertilizer is not so popular. Compost production would affect their latent share of market. However, the influence was forecast not so serious because the percent of compost is small.

Table 7.40 Compost usable area

(Unit: km^2)

	Field crops area	Fruit tree & tree crops area	Vegetables & flowers area	Total area
Thailand	38,015	16,679	556	55,250
Central Plain	12,481	3,401	253	16,136

iv) Employment

a. Opportunity of employment

Number of workers engaged in solid waste collection and transport and road cleaning was estimated to increase from 5,500 in 1981 to a range from 10,400 to 11,100 in the year 2000, whereas the population of Bangkok city will increase from 5,150,000 in 1980 to 8,030,000 in the year 2000. The percentage of workers was estimated to increase from 0.107% to a range from 0.129 to 0.138% because of increase of solid waste generation and collection volume.

Their work does not require special skill, therefore they promote improvement of employment opportunity of unskilled workers.

b. Employment of the engineers

Regarding the solid waste management facilities, the incineration plant requires the greatest number of engineers. 85 engineers will be required for the alternative Case No. 13 which is composed of four the incineration plants. Although this number shares only a small part in the total number of employees of engineering field, its share of the number of university graduate engineers would be considerable. University graduate engineers are likely to work for other fields than solid waste disposal, therefore, the difficulty of employing enough number for solid waste disposal occur. (Ref.• Appendix 7.7)

7.6.3 Results of environmental impact assessment

Table 7.41 shows the assessment results of three appropriate Master Plan alternatives. From the results of environmental impact assessment, it was made clear that all of the environmental factors of each case do not exceed the criteria. Therefore, any case can be selected as the optimum Master Plan from the environmental viewpoint.

However, the results of assessment indicate that the without-project case would have serious influence on the environment.

Table 7.41 Environmental impact assessment matrix

Case No.	Environmental element		Living environment														Natural environment						Socio-economic environment				Assessment result
			Air pollution	Water pollution	Noise	Vibration	Rank odour	Soil contamination	Land subsidence	Low frequency air vibration	Obstruction against sunshine	Wind damage	Electric wave obstruction	Treatment residue	Transportation	Fire	Topology & geology	Groundwater	Aesthetics	Flora	Fauna	Aquatic life	Historical site & cultural assets	Land use	Industry	Employment	
9	New compost plant	Plant			Δ		Δ					Δ	Δ	Δ					o	Δ	Δ	Δ		Δ	Δ		Influence does not contravene the criteria.
		Landfill site		o	Δ		Δ	Δ						Δ		Δ	Δ	Δ	o	Δ	Δ	Δ					
	Final disposal site & existing compost plant	Landfill site		o	Δ	Δ	Δ	Δ	Δ			Δ		o		o	o	o	o	Δ	Δ	Δ					
		Exist. comp. plant	o		Δ		Δ					Δ	Δ	Δ					Δ					o			
	Collect. trucks	Transportation	Δ		o	o	o								o												
13	New compost plant	Plant			Δ		Δ					Δ	Δ	Δ					o	Δ	Δ	Δ		Δ	Δ		-do-
		Landfill site		o	Δ		Δ	Δ						Δ		Δ	Δ	Δ	o	Δ	Δ	Δ					
	Incineration plant	Plant	Δ	o	Δ						Δ	Δ		Δ					Δ	Δ	Δ	Δ		Δ			
		Attached facilities			Δ														Δ								
	Final disposal site & existing compost plant	Landfill site		o	Δ	Δ	Δ	Δ	Δ			Δ		o		Δ	Δ	o	o	Δ	Δ	Δ		o			
		Exist. comp. plant	o		Δ		Δ					Δ	Δ	Δ					Δ								
	Collect. trucks	Transportation	Δ		Δ	Δ	o								o												
19-(2)	New compost plant	Plant			Δ		Δ					Δ	Δ	Δ					o	Δ	Δ	Δ		Δ	Δ		-do-
		Landfill site		o	Δ		Δ	Δ						Δ		Δ	Δ	Δ	o	Δ	Δ	Δ					
	Incineration plant	Plant	Δ	o	Δ						Δ	Δ		Δ					Δ	Δ	Δ	Δ		Δ			
		Attached facilities			Δ														Δ								
	Final disposal site & existing compost plant	Landfill site		o	Δ	Δ	Δ	Δ	Δ			Δ		o		o	o	o	o	Δ	Δ	Δ		o			
		Exist. comp. plant	o		Δ		Δ					Δ	Δ	Δ					Δ								
	Collect. trucks	Transportation	Δ		o	o	o								o												

Legend : o : Do not contravene the criteria, Δ : Influence was forecast a little, Blanck : No influence was forecast.

7.7 Comparison of the Appropriate Master Plan Alternatives

The results of the environmental impact assessment cleanly indicate that each alternative does not give a negative impact on the environment.

In order to ascertain the ranking of the alternatives from the environmental viewpoint, their comparison was made by scoring method as described hereinafter.

7.7.1 Method of comparison

Table 7.42 shows a comparison form of the alternatives.

The comparison is made as follows.

(1) Evaluation of environmental indicators

The same kinds of environmental indicators as applied to environmental impact assessment were used. (Ref. Table 7.17) Grade of indicator evaluation (E1) was determined as follows.

"0" There is no influence on environment.

"1" There is a little influence which is far below the criteria. (Ref. Table 7.33)

"2" There is influence, but it does not exceed the criteria.

"3" There is influence which exceeds the criteria.

The weight factor (W1) was determined considering importance of each indicator. Total of W1 in each environmental factor was set to be 1.0. In the case there was only one indicator, W1 was set to be 1.0.

The indicator evaluation point (E2) was calculated by multiplying E1 by W1.

(2) Evaluation of environmental factor

Grade of environmental factor (E3) expresses the total of the indicator evaluation point (E2) in each environmental factor. The weight factor (W2) was determined considering importance of each factor. Total of W2 in each environmental phenomenon was set 1.0. Factor evaluation point (E4) was calculated by multiplying E3 by W2.

(3) Evaluation of environmental phenomenon

Grade of environmental phenomenon (E5) expresses the total of factor evaluation point (E4) in each phenomenon. The weight factor was distributed considering its influence on health as follows: 0.6 to living environment, 0.3 to natural environment, and 0.1 to socio-economic environment. (Total is 1.0)

The environmental phenomena evaluation point (E6) was calculated by multiplying E5 by W3.

Table 7.42 Form of alternatives comparison

Environmental indicator	Indicator E1 Grade	Indicator W1 Weight	Indicator E2 Point	Environmental factor	Factor E3 Grade	Factor W2 Weight	Factor E4 Point	Environmental phenomena	Phenomena E5 Grade	Phenomena E3 Weight	Phenomena E6 Point	Element E7 Grade	Element W4 Weight	Element E8 Point	Facility E9 Grade	Facility W5 Weight	Facility E10 Point	E11 Evaluated grade of the case
NOx		0.1		Air Pollution		0.2		Living environment		0.6			(In case of Incineration plant, W4=0.8 for plant and W4=0.2 for the attached facilities, others were weighted in proportion to solid waste treatment volume.)			(W5=0.1 for the collection trucks, others were weighted in proportion to solid waste treatment volume.)		
SOx		0.1																
HCl		0.1																
CO		0.2																
Dust		0.2																
SO_2 Total volume		0.3																
PH		0.1		Water Pollution		0.2												
BOD		0.1																
SS		0.1																
Zn		0.05																
Cr		0.05																
Hg		0.05																
Cd		0.05																
BOD Total volume		0.3																
SS Total volume		0.2																
Sound level		1.0		Noise		0.1												
Vibration level		1.0		Vibration		0.05												
Odour concentration		1.0		Rank odour		0.1												
Contaminater concentration		1.0		Soil contamination		0.05												
Land subsidence		1.0		Land subsidence		0.05												
Sound pressure level		1.0		Low frequency air vibration		0.03												
Shadow duration		1.0		Obstruction against sunshine		0.03												
Wind damage		1.0		Wind damage		0.03												
Electric wave obstruction		1.0		Electric wave obstruction		0.03												
Secondary influence		1.0		Treatment residue		0.03												
Transportation		1.0		Traffic		0.05												
Fire		1.0		Fire		0.05												
Topography & geology		1.0		Topography & geology		0.2		Natural environment		0.3								
Groundwater		1.0		Groundwater		0.1												
Aesthetics		1.0		Landscape		0.1												
Loss of plants		1.0		Flora		0.2												
Loss of wild animal		1.0		Fauna		0.2												
Loss of aquatic life		1.0		Aquatic life		0.2												
Historical Place & cultural assets		1.0		Historical place & cultural assets		0.2		Socio-economic environment		0.1								
Restriction on land use		0.7		Land use		0.4												
Land value		0.3																
Industry		1.0		Industry		0.2												
Employment		1.0		Employment														

(4) Evaluation of environmental impact element

Grade of environmental impact element (E7) expresses the total of living, natural and socio-economic environmental point (E6). The weight factor was determined considering solid waste treatment volume for each element. In the case of incineration plant, however, owing to difficulty of separation by its treatment volume, the factors of 0.8 and 0.2 were given to the plant and the attached facilities respectively. Total of W4 was set to be 1.0 in each facility.

The element evaluation point (E8) was calculated by multiplying E7 by W4.

(5) Evaluation of facility

Evaluated grade of facility (E9) expresses the total of element evaluation point (E8). The facilities are new compost plant, incineration plant, Final disposal site and the existing compost plant, and collection trucks.

The weight factor (W5) was determined considering solid waste treatment volume of each facility. The factor of the collection trucks, however, was set at 0.1 from its lesser importance.

(6) Evaluation of the alternative cases

Evaluated grade of the alternative case (E11) expresses the total of facility evaluation point (E10). It is the grade estimated to determine the relative superiority of the alternatives.

7.7.2 Results of Comparison

Table 7.43 shows the environmental factor evaluation points (E4) of environmental impact elements of each alternative, evaluation of their phenomena (K5, W3, E6), and evaluation of their element (E7). Among them, factor evaluation of socio-economic environment was made in groups because of difficulty with separation of it. Evaluation of historic place and cultural assets was made for each facility, and evaluation of industry and employment was made for each alternative. (Ref. Appendix 7.8(1) - (4) Environmental factor evaluation (E3, W2, E4) of each alternative)

Table 7.44 shows results of evaluation made on environmental impact element (E7, W4, E8), facilities (E9, W5, E10), and appropriate Master Plan alternatives (E11).

The results indicate that the evaluation grade (E11) of the alternative Case No. 13 is the least; in other words, it has the least influence on environment.

Environmental influence of Case No. 19-(2) is larger than that of Case No. 13, and Case No. 9 has the largest influence.

Influence of without-project case was also forecast and the result implied that its influence would be serious.

This order indicates that the influence decreases as the number of incineration plant increases.

Conversion of evaluation grade (E11) of the alternatives to scores to facilitate comprehension of their comparison.

Case No.	Environmental element		Living environment																Natural environment									Socio-economic environment								Element evaluation
			Factor (E4)													Phenomena			Factor (E4)						Phenomena			Factor (E4)				Phenomena			
			Air pollution	Water pollution	Noise	Vibration	Rank odour	Soil contamination	Land subsidence	Low frequency air vibration	Obstruction against sunshine	Wind damage	Electric wave obstruction	Treatment residue	Traffic	Fire	Grade	Weight	Point	Topology & Geology	Groundwater	Aesthetics	Flora	Fauna	Aquatic life	Grade	Weight	Point	Historical place & cultural assets	Land use	Industry	Employment	Grade	Weight	Point	
																E5	W3	E6							E5	W3	E6					E5	W3	E6	E7
9	New compost plant	Plant	0	0	0.1	0	0.1	0	0	0	0	0.03	0.03	0.03	0	0	0.29	0.6	0.174	0	0	0.2	0.2	0.2	0.2	0.8	0.3	0.24	0	0.4	0.2	0	0.6	0.1	0.06	0.474
		Landfill site	0	0.3	0.1	0	0.1	0.05	0	0	0	0	0	0.03	0	0.05	0.63	0.6	0.378	0.2	0.1	0.2	0.2	0.2	0.2	1.1	0.3	0.33					0.6	0.1	0.06	0.768
	Final disposal site and existing compost plant	Landfill site	0	0.4	0.1	0.05	0.1	0.05	0.05	0	0	0.03	0	0.06	0	0.1	0.94	0.6	0.564	0.4	0.2	0.2	0.2	0.2	0.2	1.4	0.3	0.42	0	0.8			1.0	0.1	0.10	1.084
		Existing compost plant	0.36	0	0.1	0	0.1	0	0	0	0	0.03	0.03	0.03	0	0	0.65	0.6	0.39	0	0	0.1	0	0	0	0.1	0.3	0.03					1.0	0.1	0.10	0.520
	Collection trucks	Transportation	0.2	0	0.2	0.1	0.2	0	0	0	0	0	0	0	0.1	0	0.80	0.6	0.480	0	0	0	0	0	0	0	0.3	0	0	0			0.2	0.1	0.02	0.500
13	New compost plant	Plant	0	0	0.1	0	0.1	0	0	0	0	0.03	0.03	0.03	0	0	0.29	0.6	0.174	0	0	0.2	0.2	0.2	0.2	0.8	0.3	0.24	0	0.4	0.2	0	0.6	0.1	0.06	0.474
		Landfill site	0	0.3	0.1	0	0.1	0.05	0	0	0	0	0	0.03	0	0.05	0.63	0.6	0.378	0.2	0.1	0.2	0.2	0.2	0.2	1.1	0.3	0.33					0.6	0.1	0.06	0.768
	Incineration plant	Plant	0.2	0.3	0.1	0	0	0	0	0	0.03	0.03	0	0.03	0	0	0.69	0.6	0.414	0	0	0.1	0.2	0.2	0.2	0.7	0.3	0.21	0	0.4			0.6	0.1	0.06	0.684
		Attached facilities	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0.1	0.6	0.06	0	0	0.1	0	0	0	0.1	0.3	0.03					0.6	0.1	0.06	0.150
	Final disposal site & existing compost plant	Landfill site	0	0.4	0.1	0.05	0.1	0.05	0.05	0	0	0.03	0	0.06	0	0.05	0.89	0.6	0.534	0.2	0.2	0.2	0.2	0.2	0.2	1.2	0.3	0.36	0	0.8			1.0	0.1	0.10	0.994
		Existing compost plant	0.36	0	0.1	0	0.1	0	0	0	0	0.03	0.03	0.03	0	0	0.65	0.6	0.39	0	0	0.1	0	0	0	0.1	0.3	0.03					1.0	0.1	0.10	0.520
	Collection trucks	Transportation	0.2	0	0.1	0.05	0.2	0	0	0	0	0	0	0	0.1	0	0.65	0.6	0.390	0	0	0	0	0	0	0	0.3	0	0	0			0.2	0.1	0.02	0.410
19-(2)	New compost plant	Plant	0	0	0.1	0	0.1	0	0	0	0	0.03	0.03	0.03	0	0	0.29	0.6	0.174	0	0	0.2	0.2	0.2	0.2	0.8	0.3	0.24	0	0.4	0.2	0	0.6	0.1	0.06	0.474
		Landfill site	0	0.3	0.1	0	0.1	0.05	0	0	0	0	0	0.03	0	0.05	0.63	0.6	0.378	0.2	0.1	0.2	0.2	0.2	0.2	1.1	0.3	0.33					0.6	0.1	0.06	0.768
	Incineration plant	Plant	0.2	0.3	0.1	0	0	0	0	0	0.03	0.03	0	0.03	0	0	0.69	0.6	0.414	0	0	0.1	0.2	0.2	0.2	0.7	0.3	0.21	0	0.4			0.6	0.1	0.06	0.684
		Attached facilities	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0.1	0.6	0.06	0	0	0.1	0	0	0	0.1	0.3	0.03					0.6	0.1	0.06	0.150
	Final disposal site & existing compost plant	Landfill site	0	0.4	0.1	0.05	0.1	0.05	0.05	0	0	0.03	0	0.06	0	0.10	0.94	0.6	0.564	0.4	0.2	0.2	0.2	0.2	0.2	1.4	0.3	0.42	0	0.8			1.0	0.1	0.10	1.084
		Existing compost plant	0.36	0	0.1	0	0.1	0	0	0	0	0.03	0.03	0.03	0	0	0.65	0.6	0.39	0	0	0.1	0	0	0	0.1	0.3	0.03					1.0	0.1	0.10	0.520
	Collection trucks	Transportation	0.2	0	0.2	0.1	0.2	0	0	0	0	0	0	0	0.1	0	0.8	0.6	0.48	0	0	0	0	0	0	0	0.3	0	0	0			0.2	0.1	0.02	0.500
Without Project	Final disposal site and existing compost plant	Landfill site	0	0.6	0.1	0.05	0.1	0.05	0.05	0	0	0.03	0	0.09	0	0.15	1.22	0.6	0.732	0.4	0.3	0.3	0.2	0.2	0.2	1.6	0.3	0.48	0	0.8	0.2	0	1.0	0.1	0.10	1.312
		Existing compost plant	0.36	0.6	0.1	0	0.1	0.05	0	0	0	0.03	0.03	0.09	0	0	1.36	0.6	0.816	0	0	0.1	0	0	0	0.1	0.3	0.03					1.0	0.1	0.10	0.946
	Collection trucks	Transportation	0.2	0	0.2	0.1	0.2	0	0	0	0	0	0	0	0.1	0	0.8	0.6	0.480	0	0	0	0	0	0	0	0.3	0	0	0			0.2	0.1	0.02	0.500

Note: Calculation E5 = Total of E4, E6 = (E5) x (W3), E7 = Total of E6

Table 7.44 Evaluation of alternatives

Alternative Case No.	Alternative evaluation	Facility	Facility			Environmental impact element	Element		
			Point	Weight	Grade		Point	Weight	Grade
	E11		E10	W5	E9		E8	W4	E7
9	0.873	New compost plant	0.061	0.12	0.506	Plant	0.422	0.89	0.474
						Landfill site	0.084	0.11	0.768
		Final disposal site & existing compost plant	0.762	0.78	0.977	Landfill site	0.878	0.81	1.084
						Existing compost Plant	0.099	0.19	0.520
		Collection trucks	0.050	0.10	0.500	Transportation	0.500	1.00	0.500
13	0.551	New compost plant	0.061	0.12	0.506	Plant	0.422	0.89	0.474
						Landfill site	0.084	0.11	0.768
		Incineration plant	0.352	0.61	0.577	Plant	0.547	0.80	0.684
						Attached facility	0.030	0.20	0.150
		Final disposal site & existing compost plant	0.097	0.17	0.572	Landfill site	0.109	0.11	0.994
						Existing compost plant	0.463	0.89	0.520
		Collection trucks	0.041	0.10	0.410	Transportation	0.410	1.00	0.410
19-(2)	0.680	New compost plant	0.061	0.12	0.506	Plant	0.422	0.89	0.474
						Landfill site	0.084	0.11	0.768
		Incineration plant	0.219	0.38	0.577	Plant	0.547	0.80	0.684
						Attached facility	0.030	0.20	0.150
		Final disposal site & existing compost plant	0.350	0.40	0.875	Landfill site	0.683	0.63	1.084
						Existing compost plant	0.192	0.37	0.520
		Collection trucks	0.050	0.10	0.500	Transportation	0.500	1.00	0.500
Without-project	1.175	Final disposal site & existing compost plant	1.125	0.90	1.250	Landfill site	1.089	0.83	1.312
						Existing compost plant	0.161	0.17	0.946
		Collection trucks	0.050	0.10	0.500	Transportation	0.500	1.00	0.500

The score of the alternative Case No. 13 was set 100, and the evaluation grades of the other alternatives were ranked respectively. (Ref. Table 7.45)

Their ranks are 81 and 63 for Case No. 19-(2) and Case No. 9 respectively. Without-project case was ranked 47.

Table 7.45 Comparison of the alternatives

Ranking	1	2	3	Reference Case
Case No.	13	19-(2)	9	Without-project
Index (Relative to Case No. 13)	100	81	63	47

Chapter 8 OPTIMUM MASTER PLAN AND ITS IMPLEMENTATION SCHEDULE

CHAPTER 8 OPTIMUM MASTER PLAN AND ITS IMPLEMENTATION SCHEDULE

The purpose of this chapter is to make an evaluation of three appropriate Master Plan alternatives from technological viewpoint and an overall evaluation based on the results of four considerations (namely, economic and financial analyses, environmental impact assessment and the above mentioned evaluation from technological viewpoint) in order to select an optimum Master Plan. In addition, the implementation schedule for the selected optimim Master Plan will be formulated in order to clarify the scope of the plan and its implementation procedure.

8.1 The Evaluation Procedure

(1) Selection of evaluation items

Based on the results of the economic and financial analyses, the appropriate Master Plan alternative (referred to as the Cases) were ranked in the following order: Case No. 9, Case No. 19-(2) and Case No. 13. On the other hand, the order of ranking as a result of environmental impact assessment was just the reverse: namely, Case No. 13, Case No. 19-(2) and Case No. 9. The results of economic and financial analyses indicated that if the level of solid waste management service is increased, the benefit-cost ratio (B/C) will be reduced. This results for the following two reasons: 1) Because it was not possible to evaluate all the types of benefits derived from invested costs. In the benefit evaluation, as many of the benefits as possible were converted into quantitative values, but many of the qualitative benefits which could not be quantified were not considered. Some typical examples of these are the benefits brought about by the contribution to maintenance of public health and protection of pollution from the viewpoint of protection of the living environment, benefit brought about by the advantage of incineration treatment for raw waste, landfilling from viewpoint of solid waste treatment efficiency, and so forth. 2) Because benefit-cost evaluation was based on solid waste management enterprise which produces negative added value from the economic point of view. Thus, more solid waste management service necessarily reduces the B/C ratio.

For these two reasons, the common method of evaluation normally applied to a productive enterprise, which directly determines the optimum plan from among the alternatives according to the value of B/C ratio only, cannot be immediately applied to a service enterprises such as solid waste management. For selection of an optimum plan of such a service enterprise, it is considered reasonable to make an overall evaluation based upon other evaluation factors in addition to the B/C evaluation.

The overall evaluation includes environmental and technical factors and social and administrative requirements (referred to as 'environment and technology') besides the economic factors. The 'environment and technology' items concerning environment protection have already been evaluated in the preceding 'Environmental impact assessment'. The other items that have not yet been evaluated are summarized and formulated into the evaluation element called 'evaluation from technological viewpoint', which includes technical, social and administrative

viewpoints and reinforces the results of the economic and financial analyses and environment impact assessment. From among many miscellaneous evaluation items derived from technical, social and administrative requirements, the significant evaluation items will be evaluated in the 'evaluation from technological viewpoint'.

The optimum Master Plan of the year 2000 is a plan not only to determine the solid waste management system in Bangkok city in 20 years, but also to indicate the way of solid waste management in Bangkok which will proceed after 50 years, or even after a hundred years. Therefore, if the decision-maker wants to select the Master Plan based on wider and longer viewpoints, he might evaluate the alternatives from the technological viewpoint as well as economic and environmental protection viewpoints.

A summary of the evaluation items is shown in Table 8.1.

Table 8.1 List of evaluation items

Evaluation item			Explanation
Evaluation factor	Evaluation element	Second-order evaluation element	
Economy (X)	Benefit-cost ratio (X1)		Benefit/cost
	Financial share rate (X2)		The project cost/BMA budget
Environment and technology (Y)	Environmental protection (Y1)		Comparison of evaluation marks given in environmental impact assessment
	Technological viewpoint (Y2)	Administrative viewpoint ($Y2_1$)	Compatibility with the existing solid waste management system. Facility for alteration of the plan. Organizational adaptability. Conformity to administrative vision. Others.
		Technical viewpoint ($Y2_2$)	Grade of technical advancement of the applied system. Reliability of the applied system. Solid waste treatment effect. Others.

Note: Letters in parentheses designate symbols of evaluation items.

(2) Overall evaluation process flow

The overall evaluation was performed based on the process shown in Fig. 8.1.

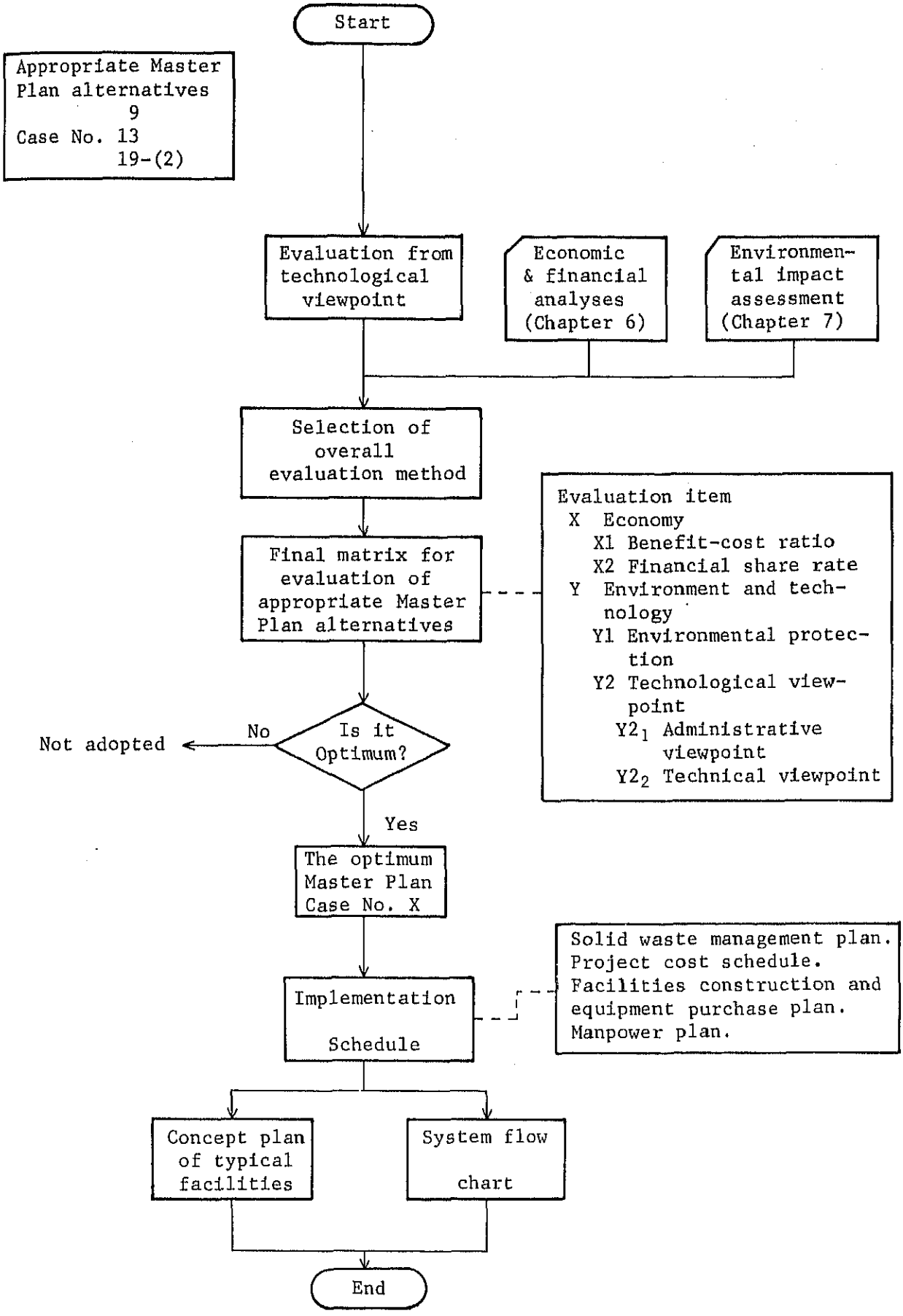


Fig. 8.1 Work flow of overall evaluation

The most appropriate overall evaluation method was selected because it was able to involve miscellaneous factors as objects of the evaluation, such as contents of three appropriate Master Plan alternatives equipment and facilities plans, the project costs, and results of economic and financial analyses, environmental impact assessment and evaluation from technological viewpoint for the three alternatives.

A final matrix for evaluation of the appropriate Master Plan alternatives was formulated. The outline of features of appropriate Master Plan alternatives and results of economic analysis, financial analysis, environmental impact assessment and evaluation from technological viewpoint are shown in tables attached to the matrix. The overall evaluation was made based on the final matrix, and the appropriate Master Plan alternative with the highest evaluation result was selected as the optimum Master Plan.

The implementation process for the selected optimum Master Plan is clarified in the implementation schedule which describes the steps to be taken in each year concerning the solid waste management, project cost, facilities construction, equipment purchase, manpower, and so on.

For reference, the system flow chart of the optimum Master Plan is attached to the implementation schedule.

8.2 Evaluation from Technological Viewpoint

8.2.1 Evaluation method

Economic analysis, financial analysis and environmental impact assessment were not able to cope with some matters relating mostly to either administrative or technical affairs. Therefore, these matters will be summed up and evaluated under the name of 'technological viewpoint'. In evaluation from technological viewpoint (referred to as the evaluation in this paragraph), a scoring method is adopted by which the level of fulfillment of the evaluation criteria is qualitatively evaluated and the results illustrated in a table with scores. From among the miscellaneous items, the most significant 12 items were selected as the evaluation items and the results are shown in Table 8.2.

In the evaluation, scores were given by relative comparison to the without-project case: (1) when an item was evaluated as equivalent to the without-project case, 3 mark were given to it. (2) in the case of better than without-project case, 4 or 5 mark were given according to its superiority. (3) 2 or 1 mark was given to items evaluated to be worse than the without-project case according to its inferiority (5-rank evaluation from 1 to 5). Details of evaluation items and evaluation criteria are shown in Table 8.3. Scores of administrative and technical viewpoints are represented by weighted averages of scores of evaluation items contained based on the respective viewpoints, weighted with relative importance among the evaluation items.

Evaluation items belonging to the administrative viewpoint have similar importance to each other, therefore, no difference in weight was given for them.

Among the three evaluation items related to the technical viewpoint, part of 'treatment effect' has already been evaluated in the economic and financial analyses and environmental impact assessment. Therefore, despite the high importance of 'treatment effect', less weight is given to it than the other two evaluation items.

8.2.2 Result of the evaluation

The results of the evaluation from the technological viewpoint are shown in Table 8.4, and the background of the scoring procedure in Appendix 8.1.

Outline of results of the evaluation are as follows:

(1) Compatibility with the existing solid waste management system

All appropriate Master Plan alternatives are compatible with the existing solid waste management system since the new system planned for each case can be composed by adding new functional elements without major alteration of the existing system.

Table 8.2 List of evaluation items for evaluation from technological viewpoint

Second-order evaluation item			Third-order evaluation item [j]				Fourth-order evaluation item [i]			
Symbol		Score S_3	weight W_{2j}	Symbol		Score S_{2j}	weight W_{1i}	Symbol		Score S_{1i}
$Y2_1$	Administrative viewpoint		0.2	$Y2_{11}$	Compatibility with the existing solid waste management system		1	$Y2_{111}$	Compatibility with the existing solid waste management system	
			0.2	$Y2_{12}$	Ease of alteration of the plan		1	$Y2_{121}$	Ease of alteration of the plan	
			0.2	$Y2_{13}$	Organizational adaptability		0.5	$Y2_{131}$	Composition of organization	
							0.5	$Y2_{132}$	Management of organization	
			0.2	$Y2_{14}$	Balance with progress of organization of other urban systems than solid waste management system		1	$Y2_{141}$	Balance with progress of organization of other urban systems than solid waste management	
			0.2	$Y2_{15}$	Conformity to administrative vision		1	$Y2_{151}$	Conformity to other administrative vision	
$Y2_2$	Technical viewpoint		0.4	$Y2_{21}$	Grade of technical advancement		1	$Y2_{221}$	Grade of technical advancement	
			0.4	$Y2_{22}$	Reliability		0.5	$Y2_{211}$	Reliability of treatment method	
							0.5	$Y2_{222}$	Variety of treatment method	
			0.2	$Y2_{23}$	Treatment effect		1/3	$Y2_{231}$	To make solid waste nontoxic, harmless and not decomposable	
							1/3	$Y2_{232}$	To make solid waste reduced in volume	
							1/3	$Y2_{233}$	To utilize solid waste as resources	

[Composition of score]

Score S_1 : 5 ranks (1, 2, 3, 4, 5)

Score $S_2 = \sum_i W_{1i} S_{1i}$ $\left(0 \leq W_{1i} \leq 1, \quad \sum_i W_{1i} = 1 \right)$

(A range of S_2 score : $1 \leq S_2 \leq 5$)

Score $S_3 = \sum_j W_{2j} S_{2j}$ $\left(0 \leq W_{2j} \leq 1, \quad \sum_j W_{2j} = 1 \right)$

(A range of S_3 score : $1 \leq S_3 \leq 5$)

(2) Ease of alteration of the plan

Case No. 13 is restricted by severe conditions that it should bear total volume intermediate treatment facilities. That makes alteration of the plan difficult; so, a lower score was assigned to this case.

(3) Composition of organization

Lower score was assigned to Case No. 13 based on the consideration that Case No. 13 would require full effort for recruitment of a good number of engineers in several fields.

(4) Management of organization

Higher scores were given to both Cases No. 13 and No. 19-(2) since they require about 20% less personnel than the without-project case which may facilitate management of the organization.

(5) Balance with progress of organization of other urban systems

The case which involves more intermediate treatment facilities gets a higher score because more facilities raise the standard of solid waste management system above that of the without-project case. (Compared with the standards of other urban systems, the standards of the existing solid waste management system are much inferior. Therefore in all appropriate Master Plan alternatives, there will be no possibility of too progressive an alteration of the solid waste management system.)

(6) Conformity to administrative vision

When evaluating conformity to administrative vision, the most important thing is to assume BMA's administrative vision in the future. Present observed and probable vision will introduce diversified intermediate treatment methods in order to increase the treatment effect, in addition to collection of as much solid waste as possible. The vision should involve establishment of an advanced solid waste management system which can be favorably compared with the systems in capitals or major cities of the neighbouring countries. From this point of view, introduction of a incineration system is thought indispensable. Adaptability of the incineration technology to Bangkok city, however, must be evaluated and confirmed before and after introduction of the incineration system. The construction of large capacity incineration plants, which causes large financing burdens, one after another without evaluation and confirmation of the adaptability of the preceding one should normally be avoided. Therefore, in this evaluation item, higher score was given to Case No. 19-(2) which has an appropriate size (not more and not less) of incineration.

(7) Grade of technical advancement

Higher score was given to the cases which involve various intermediate treatment methods.

(8) Reliability of disposal method

No remarkable difference in reliability of disposal method was seen among the cases, therefore, even scores were given to all alternatives.

(9) Variety of disposal methods

Case No. 19-(2), which has the most variety of disposal methods, got the highest score.

(10) Treatment effect (inactivation, volume reduction and resource recovery)

Incineration treatment has the most excellent effect in these functions; accordingly, higher scores were given to Cases No. 13 and No. 19-(2) which involve incineration treatment.

Table 8.3 Evaluation items and evaluation criteria

(1/5)

Evaluation item		Evaluation criteria		
$Y2_1$	Administrative evaluation			
	When introducing a new solid waste management system, evaluation should be made on the system from the viewpoint of administrative management (flexibility of the management and compatibility with administrative activities) and from the viewpoint of whether or not the administrative vision is reflected on the system, other than consideration of the financing burden. For this reason, the following evaluation items are set up.			
	$Y2_{11}$	Compatibility with the existing solid waste management system		
		Ease of conversion from the existing solid waste management system to new system is evaluated.		
		score	5	Not applicable
			4	- do -
			3	New solid waste management system can be organized by adding new functional elements to the existing system without its particular alteration. No difficulties are expected in conversion from the existing system to new system.
			2	New solid waste management system can be organized by adding new functional elements to the existing system with its partial alteration. Conversion from the existing to new system may incur slight difficulty.
			1	New solid waste management system can be organized by adding new functional elements to the existing system provided most of the existing system should be altered. Conversion from the existing to new system is a drastic change.
	$Y2_{12}$	Ease of alteration of the plan		
		Ease of alteration or correction of the plan is judged based on the case that new solid waste management system has become inadequate for some reasons after commencement of its function so that alteration or correction of the system is required.		
		score		Compared with the without-project case, the alteration or correction is:
			5	easy
			4	rather easy
			3	equivalent to the without-project case
			2	rather difficult
			1	difficult

Evaluation item	Evaluation criteria		
$Y2_{13}$	Organizational adaptability For implementation of a new solid waste management system, competent personnel in various fields should be recruited and a new organizations should be established. The new organizations should be effectively managed with regard to personnel affairs and labour control. Ease of such organizational arrangement and management is evaluated.		
	score		Compared with the without-project case, the organizational arrangement and management are:
		5	easy
		4	rather easy
		3	equivalent to the without-project case
		2	rather difficult
		1	difficult
$Y2_{14}$	Balance with progress of organization of other urban systems Judgement is made whether or not new solid waste management system is well-organized in balance with organization of other urban systems such as urban traffic, road network, water supply, drainage and sewerage, medical facilities, housing, cultural facilities, city parks, etc.		
	score		Compared with the without-project case, the relative level of organization of solid waste management system compared with that of other urban systems is:
		5	very high
		4	high
		3	equivalent to the without-project case
		2	low
		1	very low
$Y2_{15}$	Conformity to administrative vision Conformity of the new solid waste management system to the presumed administrative vision is judged. The administrative vision may determine the maintainance of the attractiveness of Bangkok city as the capital of Thailand, as well as in comparison with other capitals of the neighbouring southeast Asian countries.		
	score		Compared with the without-project case, conformity to administrative vision is:
		5	excellent
		4	better
		3	as good as the without-project case
		2	inferior
		1	much inferior

(Cont'd) (3/5)

Evaluation item	Evaluation criteria
$Y2_2$ Technical viewpoint	Among the technical matters which could not be evaluated in environmental impact assessment and economic and financial analyses, three important items, (namely, grade of technical advancement, reliability and treatment effect) are evaluated.
$Y2_{21}$ Grade of technical advancement	When considering how to cope with the huge volume of solid waste generated in the large city in the limited land area, introduction of an intermediate treatment method into conventional solid waste management system (collection - transport - landfill) is thought to be an essential requirement to be brought up sooner or later for solution of environmental problems and for achievement of the objectives of solid waste management. Positive introduction of moderate intermediate treatment technology is one way to solve problems before they occur, or to retard occurence of environmental problems and to lighten their impact. For solution of environmental problems, it is desirable to continuously endeavor to introduce new technology as much as it can be useful, and to convert the existing system to the more effective new system. Technical innovation of solid waste management, which aims at improvement of public health and increase of work efficiency, is required not only in the field of intermediate treatment, but also in other fields such as storage, collection, transport and disposal.
score	Compared with the without-project case, grade of technical advancement is:
5	very high
4	high
3	equivalent to the without-project case
2	low
1	very low
$Y2_{22}$ Reliability	The word reliability used here means reliability of solid waste disposal method (technique) including range in variety of disposal methods.
$Y2_{221}$ Reliability of solid waste disposal method	The conditions of desirable solid waste disposal method (technique) are: less difficulty with equipment breakdown, higher operational rate, durablity for long-term use and less deterioration. Reliability of solid waste disposal method is evaluated based on a general examination of the results of the use of the method in the past, operating rate, ease of operation and maintenance, and the number of facilities.
score	Compared with the without-project case, reliability of solid waste disposal method is:

Evaluation item	Evaluation criteria			
			5	very high
			4	high
			3	equivalent to the without-project case
			2	low
			1	very low
	$Y2_{222}$	Variety of disposal methods		
		The alternative which contains different types of disposal methods can produce the miscellaneous desposal effects and satisfy the varied request for the disposal technology. Application of several methods which can compensate the weak points of any one, will make the system as a whole stronger. Therefore, it is desirable to select several disposal methods and not be confined in a single type.		
		score		Compared with the without-project case, extent of variety of disposal method is:
			5	very large
			4	large
			3	equivalent to the without-project case
			2	small
			1	very small
	$Y2_{23}$	Disposal effect		
		In addition to collection and transportation, an important question for solution of solid waste management problems is how to cope with the collected solid waste. Although solid waste disposal is principally based on landfilling, economic development and expansion of the urban area will not always make it possible in the future to acquire land for landfill sites even in the places where land for sites is presently abundantly available. Considering the future of the city, introduction of the proper treatment technology for solid waste volume reduction is an essential requirement for the city. Faster inactivation (physical, chemical and biological) of disposed-of materials (solid waste or treatment residue) contributes not only to shorten the influence time on the environment, but also to realize utilization of the reclaimed land at an earlier date and to increase the value of the land. Highly inactivated treatment residue such as slag and incineration residue, the characteristics of which are far from the concept of solid waste, can be utilized as good land reclamation material. Even if the residue is not utilized in such an economical way, there are other advantages; namely, that the residue cannot cause environmental problems even though the landfill areas are nearby the urbanized area. Some retrieval of value resources from solid waste before the disposal will facilitate resource saving, which is important as a progressive		

Evaluation item	Evaluation criteria
	technique taking into consideration the future benefit as well as the present economical advantages.
	$Y2_{231}$ Inactivation Giving higher marks to incineration residue and lower marks to solid waste, weighted average by disposal volume rate was calculated for each case. Comparing each weighted average with that of the without-project case, the score was fixed as follows.
	score / Compared with the without-project case, grade of inactivation is: 5 very high 4 high 3 equivalent to the without-project case 2 low 1 very low
	$Y2_{232}$ Evaluation is made according to grade of volume reduction.
	score / Compared with the without-project case, grade of volume reduction is: 5 very high 4 high 3 equivalent to the without-project case 2 low 1 very low
	$Y2_{233}$ Resource recovery Giving higher marks to incineration technology with which energy is recovered in a form of much demanded electricity, middle marks to material recovery technology such as composting considering problems about storage and the limits of demand, and lower marks to solid waste landfilling, marks to represent grade of resource recovery in each case are calculated and applied to the evaluation.
	score / Compared with the without-project case, grade of resource recovery is: 5 very high 4 high 3 equivalent to the without-project case 2 low 1 very low

Table 8.4 Summary of results of evaluation from technological viewpoint

(Score table)

Fourth-order evaluation item [i]	Score by case S_{1i}				Weight W_{1i}	Third-order evaluation item [j]	Score by case S_{2j}				Weight W_{2j}	Second-order evaluation item	Score by case S_3			
	9	13	19-(2)	Without-project case			9	13	19-(2)	Without-project case			9	13	19-(2)	Without-project case
Compatibility with the existing solid waste management system	3	3	3	3	1	Compatibility with the existing solid waste management system	3	3	3	3	0.2	Administrative viewpoint	3.2	3.2	3.9	3
Ease of alteration of the plan	3	2	3	3	1	Ease of alteration of the plan	3	2	3	3	0.2					
Composition of organization	3	2	3	3	0.5	Organizational adaptability	3	3	3.5	3	0.2					
Management of organization	3	4	4	3	0.5											
Balance with progress of organization of other urban systems	4	5	4	3	1	Balance with progress of roganization of other urban systems	4	5	5	3	0.2					
Conformity to administrative vision	3	3	5	3	1	Conformity to administrative vision	4	5	5	3	0.2					
Grade of technical advancement	4	5	5	3	1	Grade of technical advancement	4	5	5	3	0.4	Technical viewpoint	3.4	4.2	4.33	3
Reliability of treatment method	3	3	4	3	0.5	Reliability	3	3	3.5	3	0.4					
Variety of treatment method	3	3	4	3	0.5											
To make solid waste non-toxic, harmless and not decomposable	3	5	4	3	1/3	Treatment effect	3	5	4.67	3	0.2					
To make solid waste reduced in volume	3	5	5	3	1/3											
To utilize solid waste as resources	3	5	5	3	1/3											

[Composition of the score]

Score of minor items S_{1i} : 1, 2, 3, 4, 5 (5 ranks)

Score of major items $S_{2j} = \sum_i W_{1i} S_{1i}$

Score of evaluation element $S_3 = \sum_j W_{2j} S_{2j}$

8.3 Selection of the Optimum Master Plan

8.3.1 Method of overall evaluation

(1) Selection of the evaluation method

There are several evaluation methods applicable to the evaluation in question. Considering the evaluation items, however, it seems proper to adopt the deterministic evaluation method because the evaluation items contain diversified evaluation items from various fields and since the evaluation items involve the matters which can be evaluated by only qualitative means in addition to the quantitative matters. Therefore, the deterministic evaluation method was applied to the overall evaluation. In the rating, the scoring method was used to facilitate ease of comparison. The scores for the evaluation results for both quantitative and qualitative evaluation items were determined and are summed up (in this study, by weighted average) to the final score of the case, upon which the merit of the case is judged.

(2) Evaluation items

As already mentioned in section 8.1, evaluation items involve two evaluation factors and four evaluation elements.

(3) Formulation of evaluation criteria

The value of each evaluation item is not expressed in a unified manner: economy is expressed by a real number whereas environmental protection and technological viewpoint by indices. For overall evaluation of these values all together, they are standardized in order to make them stand on a common evaluation basis utilizing the same rating method. Although several methods of the standardization are available, considering the fact that the value of each evaluation item was determined referring to the evaluated value of the without-project case, this evaluated value will be taken as common basis for overall evaluation and scores will be given according to superiority or inferiority in comparison with this base.

Therefore, giving the score of 100 to the without-project case, 0 is the lowest possible score to be given to each evaluation (or the analysis value) while 200 is the highest possible score for the same. These adjusted scores are used for relative evaluation. Equations to convert evaluation scores into adjusted scores are shown in Table 8.5, and adjusted scores of evaluation items in Table 8.6.

Table 8.5 Equations for scoring and adjustment of original score of evaluation items

Evaluation items	Range of original value or mark				Range of adjusted mark				Equation *2
	Variable	Min.	W/O*3	Max.	Variable	Min.	W/O*3	Max.	
Benefit/Cost ratio (B/C)	X1	0	1.48	-	Sx_1	0	100	-	$Sx_1 = 67.57X1(J)$
Financing burden (million Baht)	X2	*1 28,932	10,752	-	Sx_2	*1 50	100	-	$Sx_2 = 129.6 - 0.00275X2(J)$
Environmental protection (score)	Y1	3	1,175	0	Sy_1	-	100	200	$Sy_1 = 200 - 85.106\ Y(J)$
Administrative viewpoint (score)	$Y2_1$	1	3	5	$Sy2_1$	0	100	200	$Sy2_1 = -50 + 50Y2_1(J)$
Technical viewpoint (score)	$Y2_2$	1	3	5	$Sy2_2$	0	100	200	$Sy2_2 = -50 + 50Y2_2(J)$

Note *1 An assumption was made that BMA's financing burden for solid waste management during the period from fiscal 1983 to 2010 can be allowed up to 10% of a sum of estimated BMA budget of the same period, that is, 28,932 million Baht. On this assumption, a maximum of 50 points were given to this amount.

*2 J in the parentheses shows the alternatives case number.

*3 W/O means the without-project case.

Table 8.6 Adjusted scores of evaluation items

Case No.	Economy (X)				Environment and technology (Y)					
	Benefit/cost ratio (B/C)		Financing burden (million Baht) 1)		Environmental protection (Y1)		Technological viewpoint (Y2)			
							Administrative viewpoint		Technical viewpoint	
	Sx_1	X1	Sx_2	X2	Sy_1	Y1	$Sy2_1$	$Y2_1$	$Sy2_2$	$Y2_2$
9	94	1.39	93	13,540	126	0.873	110	3.2	120	3.4
13	66	0.98	74	20,195	153	0.551	110	3.2	160	4.2
19-(2)	70	1.04	84	17,104	142	0.680	145	3.9	167	4.33

Note: 1) Financing burden means here the net project cost after subtracting revenue (collection fee, electric power sales, etc.) in the period 1983 through 2010.

(4) Weighting of evaluation items

The overall evaluation score is calculated as a sum of individual evaluation scores. Before summing them up, weighting of each evaluation item was made according to relative importance of the item to others.

In this evaluation, weighting was made as described below.

i) Overall evaluation score S

In the case of an enterprise like solid waste management for which accurate measurement of benefit or performance is almost impossible, conventionally popular criteria applied to evaluation cannot be adopted because they attach importance to the cost so that the plan which requires lower investment cost is given higher superiority as far as it satisfies the required performance. Because of such difficulty in the solid waste management evaluation, an evaluation factor 'environment and technology' is necessary in addition to the conventional evaluation factor 'economy'. It can in fact be said that the factor concerning environmental protection and technological adequacy is as important as economic factors. No particular reason was found to give heavier weight to either 'economy' or 'environment and technology'. Therefore, the weight of these two evaluation factors ('economy' and 'environment and technology') are determined to be 0.5.

ii) Evaluation factor 'economy' Sx

Score (Sx) of the evaluation factor 'economy' is obtained as a weighted mean value of scores of two evaluation elements 'benefit/cost ratio B/C' (Sx_1) and 'rate of financial burden' (Sx_2).

Both of these two evaluation elements have the same importance because no particular reason was found to emphasize one over the other. The weights of the two evaluation elements are, thus, determined to be the same 0.5.

iii) Evaluation factor 'environment and technology' (Sy)

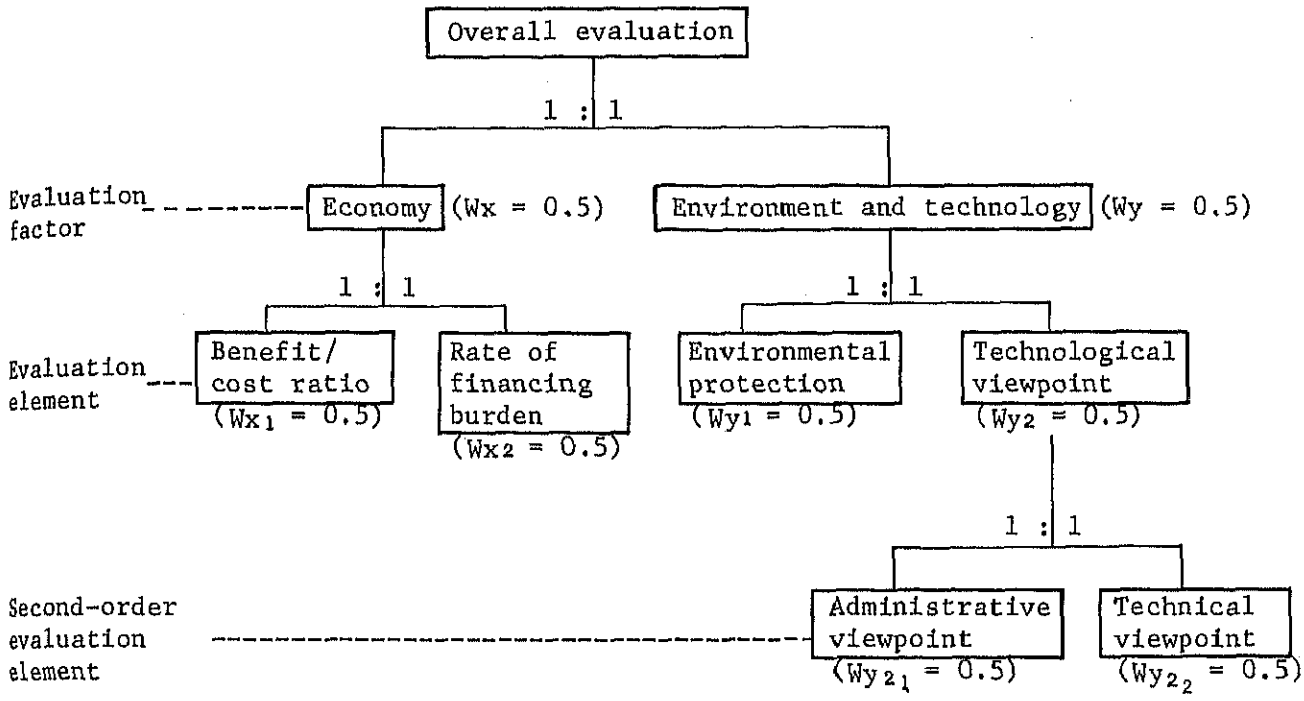
Evaluation factor 'environment and technology' is divided into two evaluation elements: 'environmental protection' (Sy_1) and 'technological viewpoint' (Sx_2). Its score (Sy) is obtained as the weighted mean value of scores of these elements. Neither element was found to be more important than the other, therefore, each of these two evaluation elements has the same weight, 0.5.

iv) Evaluation element 'technological viewpoint' (Sy_2)

Evaluation element 'technological viewpoint' is composed of two second-order evaluation elements: 'administrative viewpoint' (Sy_{2_1}) and 'technical viewpoint' (Sy_{2_2}). Since there is no reason to attach more importance to either of these second-order evaluation elements, their weights are the same 0.5.

v) Summary

The relations of weighting to evaluation items mentioned in above articles i) to iv) is summarized below.



Note: Wx, Wy, ····, and Wy_{2_2} are weights applied to calculation of the weighted mean value or score. For the details of calculation, refer to the next paragraph (5).

(5) Score of overall evaluation

Score of overall evaluation will be calculated from the following equation (weight addition method is applied).

$$S = Wx(Wx_1Sx_1 + Wx_2Sx_2) + Wy[Wy_1Sy_1 + Wy_2(Wy_{2_1}.Sy_{2_1} + Wy_{2_2}Sy_{2_2})]$$

where, S : Score of overall evaluation (range; [0, 200])

Sx : Score of evaluation factor 'economy' (range; [0, 200])

Sy : Score of evaluation factor 'environment and technology' (range; [0, 200])

Wx : Weight of 'economy'

Sx_1 : Score of evaluation element 'benefit/cost ratio' (range; [0, 200])

Sx_2 : Score of evaluation element 'financing burden' (range; [0, 200])

Wx_1 . Weight of 'benefit/cost ratio'

Wx_2 : Weight of 'financial burden'

Wy : Weight of 'environment and technology'

Sy_1 : Score of 'environmental protection' (range [0, 200])

Wy_1 : Weight of 'environmental protection'

Wy_2 : Weight of 'Technical viewpoint'

Sy_{2_1}: Score of evaluation element 'administrative viewpoint' (range; [0, 200])

Sy_{2_2}: Score of evaluation element 'technical viewpoint' (range; [0, 200])

$Wy2_1$: Weight of 'administrative viewpoint'

$Wy2_2$: Weight of 'technical viewpoint'

The appropriate Master Plan alternative which gets the highest score of overall evaluation is selected as the optimum Master Plan.

8.3.2 The optimum master plan

(1) Overall evaluation of appropriate Master Plan alternatives

Overall evaluation matrix and project outline are shown as PART II of Table 8.7. Rows show the appropriate Master Plan alternatives and columns show the evaluation factors and elements. Scores resulting from overall evaluation are displayed in the cells together with the scores of the individual evaluation items in Table 8.6.

PART I summarizes output of the previously performed evaluation of economic and financial analyses, environmental impact assessment, and evaluation from technological viewpoint.

In PART III, an outline of the facilities, equipment and manpower required for implementation of each appropriate Master Plan alternative is listed.

As a result of the overall evaluation, the highest score was given to Case No. 19-(2) and the second highest to Case No. 9. Case No. 13 ranked the lowest. In order to prove the adequacy of the evaluation results, the evaluation was repeated by changing the weight of the evaluation factors in a range of ±15%, but no change in the above order appeared. Therefore, the Study team determined that appropriate Master Plan alternative Case No. 19-(2) would be the optimum Master Plan.

(2) Optimum Master Plan

Table 8.8 outlines the solid waste management system contained in the optimum Master Plan. Figures in this table indicate the values for the year 2000 which is the target year for this project. Solid waste disposal plan in the top of the table is on the basis of a 365-day collection a year; therefore, in the case of 6 days collection per week, the incoming volume to the treatment/disposal facilities per day is calculated by multiplying the figures in the disposal plan by 7/6.

Additional notes regarding the facility plan are as follows: One parking lot is attached to two incineration plants respectively. The location of the incineration plants was determined considering the attached parking lot to be used in common by the neighbouring districts. The buffer zone surrounding an incineration plant building will provide a suitable site for a parking lot.

On-Nooch landfill site will not be completely filled before the year 2000; however, the landfill site should be acquired in advance preparing for about ten years in the future. Acquisition of an additional 164,000 m^2 land adjoining the existing site by the year 2000 was scheduled in the plan. Use of Ram Intra landfill site will be started from fiscal 1988, where additional 263,000 m^2 land should be

Table 8.7 Overall evaluation and project outline

PART I

Individual evaluations

Economic and Financial analyses (1983 – 2010) (million Baht)			
Item	Case No. 9	13	19–(2)
Economic analysis			
Economic benefit	22,532.8	24,714.6	24,032.4
Direct benefit	21,980.0	21,980.0	21,980.0
Indirect benefit	552.8	2,734.6	2,052.4
Economic cost	15,906.3	21,165.1	19,207.0
Construction cost	3,074.5	8,858.2	6,339.2
Operation and maintenance cost	11,690.7	12,612.0	12,154.8
General management cost	1,753.5	1,891.7	1,823.3
Salvage value	−612.4	−2,196.8	−1,110.3
B/C	1.39	0.98	1.04
Order	1	3	2
Financial analysis			
Revenue (Solid waste collection fee and resource recovery)	4,467.8	5,719.9	5,318.4
Financial project cost	18,007.6	25,915.2	22,422.4
Construction cost	3,519.7	10,299.2	7,423.8
Operation and maintenance cost	12,598.1	13,579.0	13,042.3
General management cost	1,889.8	2,037.0	1,956.3
Order	1	3	2

Environment and technology

Environmental impact assessment (Year 2000)

Objective environmental phenomena

- Living environment → air pollution, water pollution, noise, rank odour, traffic congestion, etc.
- Natural environment → topography groundwater, flora, fauna, etc.
- Socio-economic environment → historic spot, cultural assets, land use, industry, etc.

Environmental impact elements

New compost plant, existing compost plant, incineration plant, landfill site, collection truck

Assessment score

Environment impact element	Case No. 9	13	19–(2)
New compost plant	0.061	0.061	0.061
Existing compost plant	0.077	0.077	0.077
Incineration plant	0	0.352	0.219
Landfill site	0.685	0.020	0.273
Collection truck	0.050	0.041	0.050
Overall	0.873	0.551	0.680
Order	3	1	2

Evaluation from technological viewpoint

Item	Case No. 9	13	19–(2)	Weight w_i
Score of evaluation from technical viewpoint				
Grade of technical advancement a_1	4	5	5	0.4
Reliability a_2	3	3	3.5	0.4
Treatment effect a_3	3	5	4.67	0.2
Overall ($\Sigma a_i w_i$)	3.4	4.2	4.33	
Order	3	2	1	
Score of evaluation from administrative viewpoint				
Compatibility with the existing solid waste management system a_4	3	3	3	0.2
Ease of alteration of the plan a_5	3	2	3	0.2
Organizational adaptability a_6	3	3	3.5	0.2
Balance with other urban systems a_7	4	5	5	0.2
Conformity to administrative vision a_8	3	3	5	0.2
Overall ($\Sigma a_i w_i$)	3.2	3.2	3.9	
Order	2	2	1	

PART II

Overall evaluation matrix

Conversion of evaluation standard level

Case No.	Order	Score: Overall evaluation	Economy			Environment and technology				
				B/C	Rate of financing burden		Environmental protection	Technological viewpoint		
									Administrative viewpoint	Technical viewpoint
		S	Sx	Sx_1	Sx_2	S_Y	S_{Y_1}	S_{Y_2}	$S_{Y_{21}}$	$S_{Y_{22}}$
9	2	108	94	94	93	121	126	115	110	120
13	3	107	70	66	74	144	153	135	110	160
19–(2)	1	114	77	70	84	150	144	156	145	167
			Wx	Wx_1	Wx_2	W_Y	W_{Y_1}	W_{Y_2}	$W_{Y_{21}}$	$W_{Y_{22}}$
			0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
			Weight of evaluation items							

$S = W_X S_X + W_Y S_Y$

$S_X = W_{X_1} S_{X_1} + W_{X_2} S_{X_2}$

$S_Y = W_{Y_1} S_{Y_1} + W_{Y_2} S_{Y_2}$, $S_{Y_2} = W_{Y_{21}} S_{Y_{21}} + W_{Y_{22}} S_{Y_{22}}$

PART III

Outline of solid waste management system for the year 2000

Item			Case No. 9	13	19–(2)
Solid waste disposal plan (ton per day on a solid waste basis) (percent in parentheses)	Compost plant	Existing	950	950	950
		New	680	680	680
		Subtotal	1,630 (29)	1,630(29)	1,630(29)
	Incineration plant		0 (0)	3,910(71)	2,400(43)
	Landfill site		3,910 (71)	0(0)	1,510(28)
	Total		5,540 (100)	5,540(100)	5,540(100)
Facilities	Compost plant	Number	6	6	6
		Capacity (t/d)	1,920	1,920	1,920
	Incineration plant	Number	0	4	2
		Capacity (t/d)	0	4,900	3,000
	Landfill site	Number	3	3	3
		Incoming volume (t/d)	4,081	953	2,161
	Parking lot	Number	2	2	2
		Size (trucks)	800	600	600
Equipment (unit)	Collection and transport	Collection trucks	1,374	1,139	1,164
		Incineration residue transport truck	0	42	26
	Compost plant and landfill work	Bulldozer	22	17	18
		Front-end loader	14	14	14
		Dump truck	19	18	18
		Others	29	29	29
	Road cleaning	Mech. road sweeper	21	21	21
		Water sprinkler truck	21	21	21
		Dump truck	21	21	21
		Crane-attached compactor	25	25	25
	River and canal cleaning	Mech. cleaning boat	5	5	5
		Boat	110	110	110
		Dump truck	25	25	25
Man power (person)	Collection and transport	Driver	1,499	1,254	1,274
		Driver (residue transp.)	0	46	28
		Worker	4,438	3,671	3,758
	Plant	Worker, operator	426	707	586
	Landfill site	Worker	133	65	75
	Road cleaning	Driver, assistant	167	167	167
		Sweeper	3,740	3,740	3,740
	River and canal cleaning	Boat worker	389	389	389
		Driver, worker	550	550	550
	Engineer (head office and branches)		43	85	63
	Office (head office and branches)		502	493	482
	Worker (head office)		170	182	177
	Total		12,057	11,340	11,289

Table 8.8 Outline of solid waste management system of optimum Master Plan (the year 2000)

Solid waste disposal plan (incoming solid waste basis) (t/d)

			Remark
Compost plant	1,630	(29%)	Compost products 245 t/d
Incineration plant	2,400	(43%)	Electricity generation 401,280 kWh/d
Final disposal site	1,510	(28%)	
Total	5,540	(100%)	

Facilities Plan

Facilities	Treatment/disposal volume (t/d)	Capacity (t/d)	Location	
Compost plant (1)	540	640	On-Nooch (1)(2)	The existing
Compost plant (2)	270	320	Ram Intra	The existing
Compost plant (3)	217	260	Bang Khun Tian	Operation from fiscal 1998
Compost plant (4)	463	540	Taling Chan	Operation from fiscal 2000
Compost plant (5)	140	160	Nong Khaem	The existing
Incineration plant (1)	1,200	1,500	Yannawa	Operation from fiscal 1990 Residue is transported to On-Nooch
Incineration plant (2)	1,200	1,500	Dusit	Operation from fiscal 1995 Residue is transported to Nong Khaem
Final disposal site (1)	520	857	On-Nooch	The existing. 164,000 m^2 extension by 2010.
Final disposal site (2)	740	1,005	Nong Khaem	The existing. 263,000 m^2 extension by 2010.
Final disposal site (3)	250	299	Ram Intra	Operation from fiscal 1988. 388,000 m^2 extension by 2010
Parking lot (1)	–	300 trucks	Yannawa	Constructed in incineration plant site.
Parking lot (2)	–	300 trucks	Dusit	Constructed in incineration plant site.

Equipment plan

Collection transport	Collection trucks	1,164 units	Reserved trucks 5%
	Incineration residue transport trucks	26	Reserved trucks 5%
Road sweeping	Mech. road sweepers	21	
	Other vehicles	67	Water sprinkler, dump truck, etc.
River and canal cleaning	Mech. cleaning boats	5	Owned by BSD
	Boats	110	
	Dump trucks	25	
Composting & Landfill work	Bulldozer	18	
	Front-end loader	14	
	Dump truck	18	
	Other vehicles	29	Jeep, sterilization truck, etc.

Manpower plan

BOS. ; District

Officer	482 person		Head office 344
Engineer	63		Plants, final disposal sites 753
Worker	9,805	Driver 1,397 Collector 3,830 Sweeper 3,740 Others 838	Collection and transport 9,253
Subtotal	10,350		Total 10,350

BSD

Boat Worker	389	Mech. boat 29
Driver & Worker	550	Boat 360
Subtotal	939	Land work 550
		Total 939
Total	11,289	

acquired by 2010. Nong Khaem landfill site was estimated to be completely filled by 1995, accordingly, acquisition of the neighbouring 388,000 m^2 land is necessessary to satisfy the requirements until 2010.

Construction of two incineration plants each with a capacity of 1,500 t/d was planned: one at Yannawa and the other at Dusit. The Yannawa plant was scheduled to be constructed before Dusit because it contributes to an increase in the collection and transport efficiency so it has economic advantages. Nevertheless, it may be practicable to give priority for construction to whichever site can successfully acquire its land earlier than the other because this is the most important factor in implementing the plant construction.

Construction of new compost plants should be established after resolving miscellaneous existing problems such as improvement of the existing compost plant facilities, upgrading of compost quality, popularization of compost use, and promotion of compost sales activities.

In the equipment plan, an adequate number of pieces of equipment should be provided.

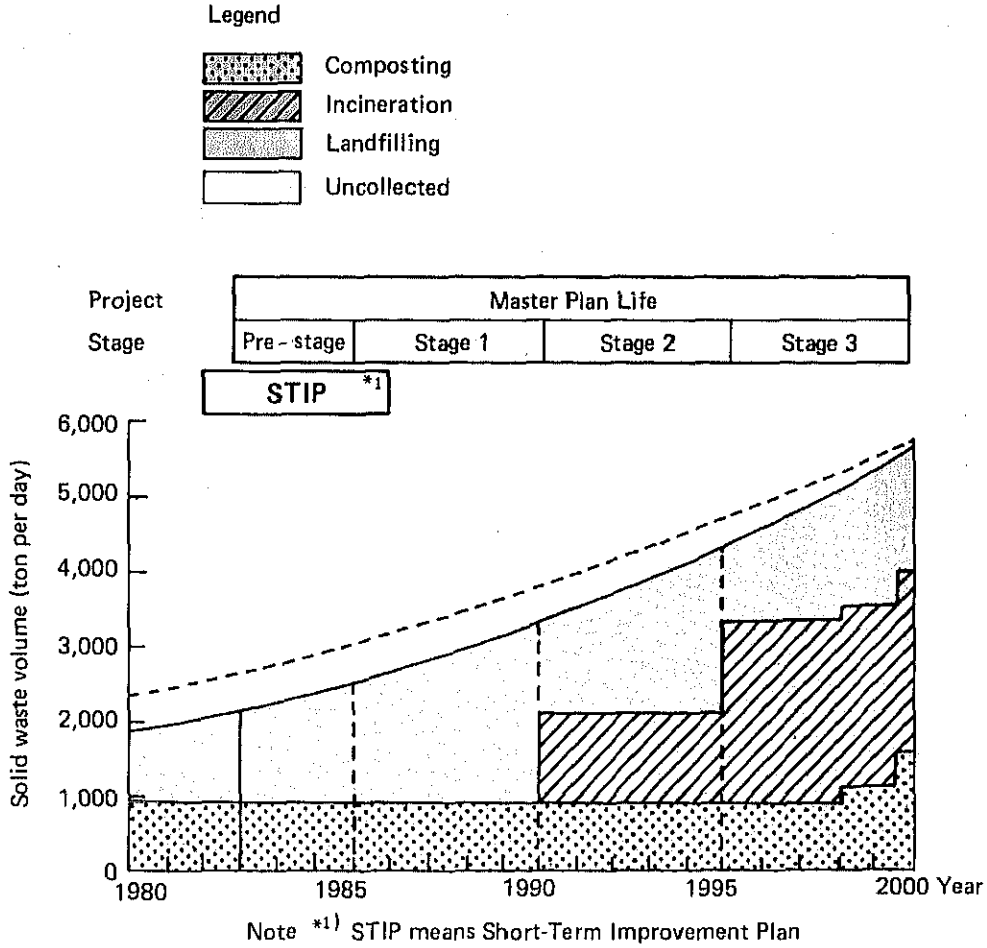
The manpower plan is one of the most indispensable plans. Success of this project all depends upon whether or not competent and active officers can be recruited or trained, who are able to actually organize and manage the new solid waste management system. Considering the difficulties with recruitment of educated people in Thailand, the number of officers and engineers was decreased to the minimum desirable number. Therefore, the number listed in the manpower plan should be taken as an indispensable number for the implementation of this project.

8.4 The Master Plan Implementation Schedule

The implementation schedule for the optimum Master Plan was formulated. The solid waste disposal plan (1983 - 2000) according to the optimum Master Plan is outlined in Fig. 8.2 and solid waste disposal flow of the year 2000 is shown in Fig. 8.3.

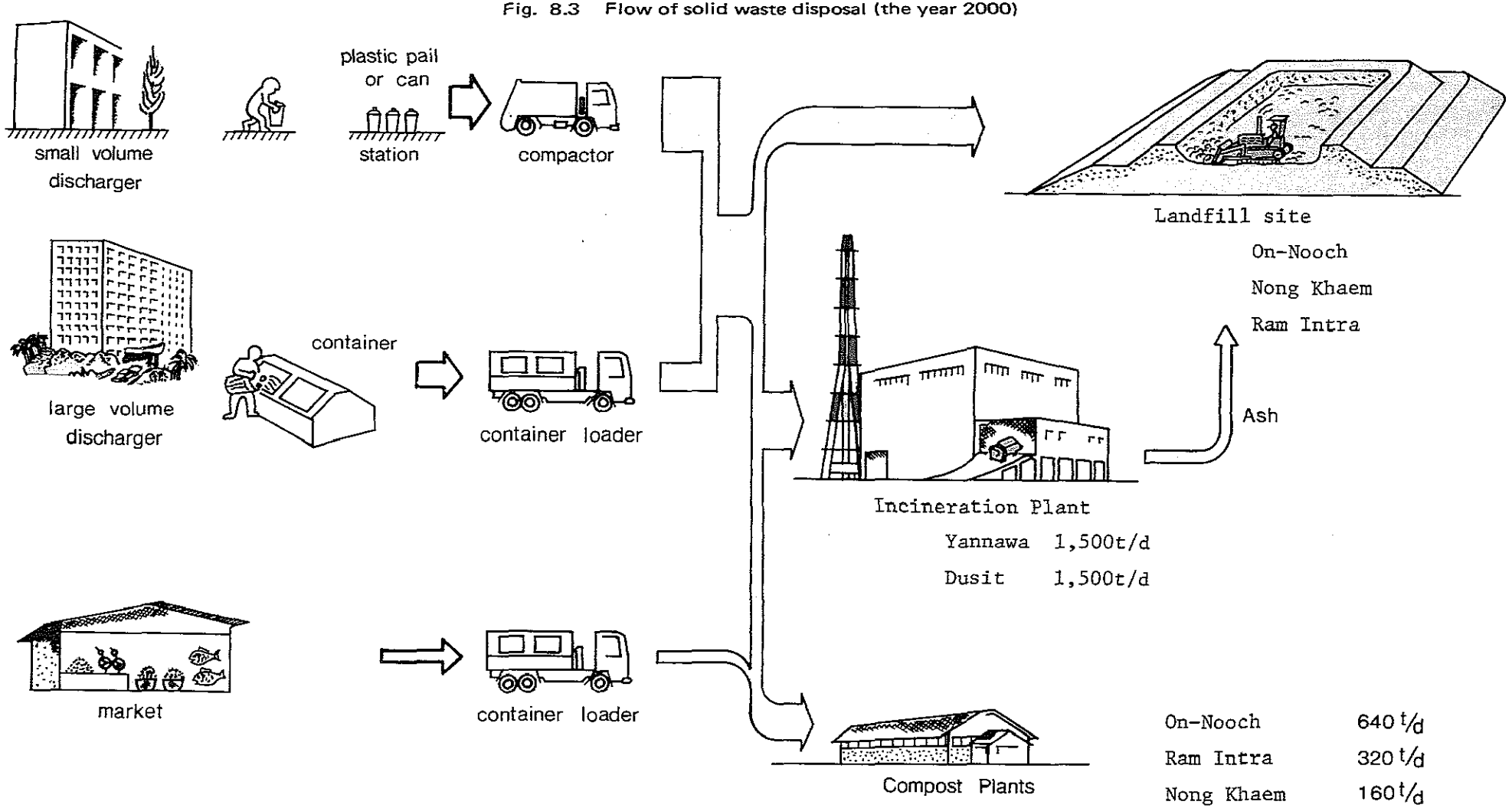
The construction and manpower schedule is shown in Table 8.9, in which the construction process up to the year 2000 was divided into four stages considering construction steps, financial plans and other factors.

Fig. 8.2 Disposal plan of solid waste



Note *1) STIP means Short-Term Improvement Plan

Fig. 8.3 Flow of solid waste disposal (the year 2000)



Note: .Collection volume in the year 2000 is 5,540 tons per day the basis of 365 days in a year.
.The figures attached to the names of the facilities show the capacity.

Table 8.9 Construction and manpower schedule

	Year																					
	Pre-Stage				Stage 1						Stage 2						Stage 3					
	1983	1984	1985	Total	1986	1987	1988	1989	1990	Total	1991	1992	1993	1994	1995	Total	1996	1997	1998	1999	2000	Total
Incineration Plant																						
Yannawa (1,500 t/d)																						
Dusit (1,500 t/d)																						
Compost Plant																						
Barg Khun Tian (260 t/d)																						
Taling Chan (540 t/d)																						
Landfill site																						
On-Nooch																						
Nong Khaem																						
Ram Intra																						
Number of trucks																						
to be purchased	63	40	39	142	40	45	46	46	46	223	39	82	102	123	103	449	103	111	121	116	115	566
in possession	585	618	650	–	683	721	745	769	793	–	780	810	855	892	939	–	969	1,005	1,051	1,108	1,164	–
Number of officers	308	311	318	–	326	339	350	360	373	–	380	385	393	408	423	–	428	437	454	465	482	–
(net increase)	0	3	7	10	8	13	11	10	13	55	7	5	8	5	15	50	5	9	7	11	17	59
Number of engineers	13	17	21	–	27	31	36	41	41	–	43	46	46	51	58	–	58	58	60	60	63	–
(net increase)	1	4	4	9	6	4	5	5	0	20	2	3	0	5	7	17	0	0	2	0	3	5
Number of workers																						
Drivers	579	628	664	–	704	760	784	810	850	–	856	866	933	1,006	1,093	–	1,106	1,176	1,251	1,327	1,397	–
(net increase)	33	49	36	118	40	56	24	26	40	186	6	10	67	73	87	243	13	70	75	76	70	304
Collectors	2,306	2,388	2,486	–	2,604	2,752	2,786	2,820	2,856	–	2,861	2,865	2,895	3,068	3,215	–	3,300	3,441	3,580	3,715	3,830	–
(net increase)	45	82	98	225	118	148	34	34	36	370	5	4	30	173	147	359	85	141	139	135	115	615
Sweepers	2,760	2,770	2,780	–	2,790	2,800	2,850	2,900	2,950	–	3,000	3,070	3,140	3,210	3,280	–	3,350	3,440	3,540	3,640	3,740	–
(net increase)	0	10	10	20	10	10	50	50	50	170	50	70	70	70	70	330	70	90	100	100	100	460
Others	348	356	372	–	374	403	409	424	500	–	500	501	507	585	595	–	595	595	674	674	838	–
(net increase)	55	8	16	79	2	29	6	15	76	128	0	1	6	78	10	95	0	0	79	0	164	243

Legend

- Preparation of tender document
- Preliminary design & contract
- Detailed design
- Land acquisition
- Land reclamation & access road construction
- External structure construction
- Main structure construction
- Test run

Note: The number in bar show the section number to be used for landfilling. Section facilities such as the piping for leachate collection will be continuously constructed.

Note: The trucks include collection trucks such as compactor, non-compactor and container-loader, and spare trucks.

The 3-year period from 1983 until 1985 was assigned as the preparation period (Pre-Stage) for implementation of the optimum Master Plan (for fund raising, establishment of the administrative organization, etc.).

The period from 1986 to 2000 was evenly divided into three, 5 year-long stages (Stage 1, Stage 2 and Stage 3) and the construction schedule in each stage was fixed as indicated below:

Stage 1: Construction of Yannawa incineration plant

Stage 2: Construction of Dusit incineration plant

Stage 3: Construction of Bang Khun Tian and Taling Chan compost plants.

Facilities construction plan for each stage was designed in order to facilitate its implementation as an independent project.

The project cost was classified according to facilities construction cost, land acquisition cost and management cost (general management cost, collection and transport cost, collection trucks and other equipment purchase cost, and operation and maintenance cost) and is shown in Table 8.10. In the table additional system portion means increased portion of the total cost compared with without-project case portion. Without-project case portion is an equivalent cost to what is needed for disposal of the same volume of solid waste as planned in the optimum Master Plan without additional construction of incineration plants and other treatment/disposal facilities. The detailed costs by item are shown in Appendix 8.2.

Destinations for collected solid waste are listed in Appendix 8.3.

The costs shown in Table 8.10 are based on 1980 prices. If increase of prices in the future is taken into consideration, the construction costs (the total of incineration plants construction costs, new compost plants construction costs, large-scale repair costs for the existing compost plants and land acquisition costs) is estimated as shown in Table 8.11.

Table 8.10 Summary of project costs

(Unit: million Baht)

		Year																						Total
		Pre-Stage				Stage 1						Stage 2						Stage 3						
		1983	1984	1985	Total	1986	1987	1988	1989	1990	Total	1991	1992	1993	1994	1995	Total	1996	1997	1998	1999	2000	Total	
Facilities construction cost	T	155.1		4.6	159.7	13.7	288.3	922.8	797.4	494.0	2,516.2	5.2	240.3	959.9	796.5	206.8	2,208.7	37.7	142.1	300.7	145.4	947.1	1,573.0	6,457.6
	F/C	8.7		3.7	11.9		162.5	584.0	576.3	334.4	1,657.2		160.1	586.6	576.3	144.0	1,467.0	6.6	52.5	78.6	61.2	293.3	492.2	3,628.3
	L/C	146.9		0.9	147.8	13.7	125.8	338.8	221.1	159.6	859.6	5.2	80.2	373.3	220.2	62.8	741.7	31.1	89.6	222.1	84.2	653.8	1,080.8	2,829.3
Plant	T			4.6	4.6	9.8	253.0	797.4	797.4	209.4	2,067.0	5.2	240.3	796.5	796.5	206.8	2,045.3	37.7	142.1	197.4	145.4	183.6	706.2	4,823.1
	F/C			3.7	3.7		160.1	576.3	576.3	147.7	1,460.4		160.1	576.3	576.3	144.0	1,456.7	6.6	52.5	72.0	61.2	76.6	268.9	3,189.7
	L/C			0.9	0.9	9.8	92.9	221.1	221.1	61.7	606.6	5.2	80.2	220.2	220.2	62.8	588.6	31.1	89.6	125.4	84.2	107.0	437.3	1,633.4
Final disposal site	T	155.1			155.1	3.9	35.3	125.4			164.6			163.4			163.4			103.3		478.9	582.2	1,065.3
	F/C	8.2			8.2		2.4	7.7			10.1			10.3			10.3			6.6		30.0	36.6	65.2
	L/C	146.9			146.9	3.9	32.9	117.7			154.5			153.1			153.1			96.7		448.9	545.6	1,000.1
Major repair of the existing compost plant	T									284.6	284.6											284.6	284.6	569.2
	F/C									186.7	186.7											186.7	186.7	373.4
	L/C									97.9	97.9											97.9	97.9	195.8
Land acquisition cost	L/C			71.0	71.0	336.0					336.0	312.5		45.0		23.2	380.7	15.4	76.8			86.3	178.5	966.2
Plant	L/C			71.0	71.0	283.8					283.8	312.5				23.2	335.7	15.4	76.8				92.2	782.7
Final disposal site	L/C					52.2					52.2			45.0			45.0					86.3	86.3	183.5
Management cost	T	273.8	301.3	324.5	899.6	349.5	335.6	343.4	350.2	365.7	1,744.4	377.2	424.9	456.2	510.6	513.0	2,281.9	522.3	537.5	568.0	594.1	619.6	2,841.5	7,767.4
	F/C	66.6	77.1	80.6	224.3	84.0	75.0	79.0	79.8	81.9	399.7	91.3	125.1	144.0	176.8	168.7	705.9	180.3	183.4	198.7	205.1	210.0	977.5	2,307.4
	L/C	207.2	224.2	243.9	675.3	265.5	260.6	264.4	270.4	283.8	1,344.7	285.9	299.8	312.2	333.8	344.3	1,576.0	342.0	354.1	369.3	389.0	409.6	1,864.0	5,460.0
Total project cost	T	428.9	301.3	400.1	1,130.3	699.2	623.9	1,266.2	1,147.6	859.7	4,596.6	694.9	665.2	1,461.1	1,307.1	743.0	4,871.3	575.4	756.4	868.7	739.5	1,653.0	4,593.0	15,191.2
	F/C	74.8	77.1	84.3	236.2	84.0	237.5	663.0	656.1	416.3	2,056.9	91.3	285.2	730.6	753.1	312.7	2,172.9	186.9	235.9	277.3	266.3	503.3	1,469.7	5,935.7
	L/C	354.1	224.2	315.8	894.1	615.7	386.4	603.2	491.5	443.4	2,539.7	603.6	380.0	730.5	554.0	430.3	2,698.4	388.5	520.5	591.4	437.2	1,149.7	3,123.3	9,255.5
Without-project case portion	T	270.7	298.2	321.4	890.3	423.1	332.5	343.0	357.1	657.2	2,112.9	396.2	423.1	517.3	488.8	502.1	2,327.5	820.0	521.0	531.8	543.4	849.4	3,265.6	8,596.3
Additional system portion	T	158.2	3.1	78.7	240.0	276.1	291.4	923.2	770.5	202.5	2,483.7	298.7	242.1	943.8	818.3	240.9	2,543.8	△244.6	235.4	336.9	196.1	803.6	1 327.4	6,594.9

Note: T: Total
F/C: Foreign currency
L/C: Local currency

Table 8.11 Facilities construction cost and land acquisition cost on the basis of the forecast future prices

(Unit : million Baht)

Year	at 1980 prices			escalation factor		at estimated future prices		
	local currency	foreign currency	Total	local currency	foreign currency	local currency	foreign currency	total
1983	146.9	8.2	155.1	1,405	1,158	206.4	9.5	215.9
84	0	0	0	1,574	1,216	0	0	0
85	71.9	3.7	75.6	1,762	1,276	126.7	4.7	131.4
86	349.7	0	349.7	1,974	1,340	690.3	0	690.3
87	125.8	162.5	288.3	2,211	1,407	278.1	228.6	506.7
88	338.8	584.0	922.8	2,476	1,477	838.9	862.6	1,701.5
89	221.1	576.3	297.4	2,773	1,551	613.1	909.4	1,522.5
1990	159.6	344.4	494.0	3,106	1,629	495.7	544.7	1,040.4
91	317.7	0	317.7	3,479	1,710	1,105.2	0	1,105.2
92	80.2	160.1	240.3	3,896	1,796	312.5	287.5	600.0
93	418.3	586.6	1,004.9	4,363	1,886	1,825.0	1,106.3	2,931.3
94	220.2	576.3	796.5	4,887	1,980	1,076.1	1,141.1	2,217.2
1995	86.0	144.0	230.0	5,474	2,079	470.8	299.4	770.2
96	46.5	6.6	53.1	6.130	2,183	285.0	14.4	299.4
97	166.4	52.5	218.9	6,866	2,292	1,142.5	120.3	1,262.8
98	222.1	78.6	200.7	7,690	2,407	1,707.9	189.2	1,897.1
99	84.2	61.2	145.4	8,613	2,527	725.2	154.7	879.9
2000	740.1	293.3	1,033.4	9,646	2,653	7,139.0	778.1	7,917.1
Total	3,795.5	3,628.3	7,423.8	—	—	19,038.4	6,650.5	25,688.9

Note : The rate of increase in local price is estimated to be 12 percent per annum and that of foreign prices, 5 percent per annum.

The facilities construction cost includes cost for major repair of the existing composat plants.

8.5 Conclusion

The appropriate Master Plan alternative Case No. 19-(2) was finally selected as the optimum Master Plan.

Features of the optimum Master Plan are described below in comparison to the without-project case.

a. Solid waste disposal

- Landfill volume of solid waste will be reduced to one third.
- Two incineration plants with respective capacity of 1,500 tons per day will be constructed; one at the northern part of the city and the other at southern part within 10 km from the city center. Parking lots will be annexed to each incineration plant to meet the increase in the number of collection trucks.
- In addition to the existing four compost plants at three locations, two more new compost plants with respective capacity of 260 t/d and 540 t/d will be constructed, utilizing the aerated composting method. The compost plants will be constructed in Stage 3. Implementation plan for the construction should be formulated taking into consideration the sales results for compost produced in the existing plants.
- The number of collection trucks can be reduced by 17%.

b. Effect of solid waste volume reduction

- Provision of sufficient intermediate treatment facilities enables a reduction in the ultimate disposal volume (by weight) of solid waste by 50% (ultimate disposal volume: 86% of collection volume in the without-project case and 43% in the Master Plan).

c. Resource recovery

- About 150 kg of compost will be produced from one ton of solid waste.
- Owing to construction of new aerated compost plants, the average compost production volume per day will be increased by 72%, that is, from 142 of the present to 244 tons/day. Volume of recovered ferrous metal is also estimated to increase by 72%.
- From one ton of solid waste, about 170 kW·h of electric power is generated in the incineration plant, 60 kW·h of which will be consumed in the plant. The remaining 110 kW·h will be supplied to external consumers.
- Material recovery is possible by handsorting before aerobic fermentation in the compost plants to be constructed.

d. Economy

- The project benefit/cost ratio (B/C) is 1.04; hence, benefit slightly exceed the costs.

- From financial point of view, this project is considered feasible provided that 20% of the facilities construction cost is borne by BMA or subsidized by the Government and the balance (80%) is financed by banks, or the interest is borne by the Government in case 100% of the cost is financed by banks.

e. Environmental protection

- The quality of living environment will be considerably improved as a result of project implementation.

f. Technical and administrative viewpoints

- Advanced and sophisticated technology will be introduced into the solid waste management system.
- Introduction of various solid waste disposal methods assures the maintenance of a highly reliable solid waste management system.
- The optimum Master Plan is quite compatible with the existing solid waste management system. The plan can easily be altered according to changes in the situation.
- Bangkok's solid waste management system, which used to be regarded as underdeveloped technology, can be upgraded to the high standard maintained by other urban systems. This may influence other urban systems as a motive for their further development.
- The contents of the optimum Master Plan conforms to the present vision of BMA concerning improvement of solid waste management system.

Chapter 9 RECOMMENDATIONS FOR IMPLEMENTATION OF ADMINISTRATIVE ORGANIZATION AND SERVICES

CHAPTER 9 RECOMMENDATIONS FOR IMPLEMENTATION OF ADMINISTRATIVE ORGANIZATION AND SERVICES

9.1 Foreword

This chapter is intended to summarize recommendations to BMA with respect to the various plans of solid waste management administration and matters to be noted for implementation of this Project. Whehter this Project had been set up or not, time will require BMA to expand solid waste management administration by means of establishing miscellaneous appropriate plans. These plans vary from macro-projects involving the entire BMA and Government such as systematization of laws and governmental organizations to micro-projects which may be coped with by BOS alone such as review of the Bureau Regulations, alteration of Division jurisdiction within the Bureau, employment and training of competent staff, and so forth.

Based on experience of solid waste management administration managed by Tokyo Metropolitan Government, the Study team has selcted six main subjects of recommendation which are essential for implementation of this Project or are necessary for development of solid waste management administration.

9.2 Systematization of Laws and Regulations

9.2.1 The existing laws and regulations relating to solid waste management

Laws, regulations and ordinances enforced in Thailand or in Bangkok city with respect to solid waste management are listed in Appendix 9.1.

After reviewing the provisions and enforcement of these laws, regulations and ordinances for solid waste management, the following questions arise:

i) Although laws are promulgated, the behavior of citizens is not always according to the law due to relaxation of enforcement.

ii) Contradictions occur between individual laws which makes it difficult to coordinate a comprehensive system of justice.

iii) The concept and content of the law are not sufficiently systematized; hence, the spirit and sense of the law are not commonly understood.

iv) Contents of the laws often fail to stipulate fundamental matters while at the same time excessively describing minute details which can be stipulated in notices or in ordinances.

v) Despite the fact that officials and official organizations are requested to respect and submit themselves to the law and to set good examples for the public and private sectors, they are often excluded or exempted from application of the law. This interferes with the dignity and fairness of the law.

vi) Enactment and repeal of the law are not very difficult in Thailand. This allows for flexible enforcement of the law; however, on the other hand, this also affects the perpetuation of the law.

9.2.2. Systematization of the juristic system

The following recommendations are thought to be useful for the establishment of a juristic system in Thailand:

i) The laws and regulations relating to solid waste management which are enforced in Thailand and Bangkok should be reviewed and systematized so as to enable both Government and local authorities to coordinate with each other for their execution.

ii) Matters which are fundamental and common all over the country should be enacted into National Law whereas the matters relating to regional characteristics or concerning minute details of judgement and execution should be stipulated in the Local Government Regulations to be enforced by the administrative authorities of each region.

iii) Solid waste presents an environmental problem which expands in accordance with socio-economic development for which the solution becomes more difficult each year. In order to develop countermeasures against the future expansion of such problems, establishment of a well-organized solid waste management law should be sought.

iv) Regulations and the relative status of basic laws for solid waste management to other laws in this field such as pollution control law, environmental protection law, city planning law, etc., should be clarified and contradiction between them removed. The cases in Japan are exampled in Appendix 9.2-(1).

v) The framework of the basic laws for solid waste management mentioned above in paragraphs iii) and iv) should include laws to be issued in the following order.

- "General Provisions" which describe the aim of legislation and define fundamental matters.

- "Management System" which sets forth solid waste management standards, specific management methods, etc. Conditions to be attached to the standards are explained in Appendix 9.2-(2).

- "Miscellaneous regulations and punitive provisions" to ensure adherence to the law.

vi) Particularities of the administrative system in Bangkok should be respected and taken into consideration when an attempt is made to clarify the relationship between national and local Governments.

9.2.3 Constitution of the general provisions

(1) Aim of the law

The law aims at the improvement of public health, protection of the living environment (including social and natural), and preservation and effective use of resources. To attain this aim, maintenance of sanitary living environment and proper management of solid waste is necessary.

(2) Definition and category of solid waste

i) Solid waste properties change and vary in accordance with socio-economic development. The properties to be regulated by law should be clearly specified based on the present and forecast volume of solid waste generation.

ii) Disposal methods for solid waste to be regulated by law and the parties responsible for the disposal should be specified.

iii) There are many methods used to categorize and classify solid waste which is legally regulated as shown in Appendix 9.3. The categorization and classification should be made by considering the actual state of solid waste discharge and the discharge control policy. Appendix 9.4(1) outlines the legal classification in Japan.

(3) Powers and duties of the state and local authorities

For smooth performance of solid waste management administration, the powers and duties of the state and local authorities should be clearly specified. (For details, ref. Appendix 9.4(2))

i) Powers and duties of the state should include the following:

a. To establish the policy and master plan for solid waste management administration

b. To formulate practical standards for solid waste management

c. To give technical and financial assitance for the management of solid waste maintained by local authorities

d. To legislate restrictions against particular or hazardous waste after coordination with the concerned ministries and bureaus

e. To systematically organize a judicial system concerned with solid waste management and to examine local ordinances and regulations for approval

f. Others

ii) Powers and duties of local authorities should include the following:

a. To make citizens and businesses understand the importance of sanitation

b. To maintain the management of solid waste in a sanitary and effective manner

c. To train, instruct and supervise solid waste disposers (licensed private disposers)

d. To survey the actual state of solid waste discharge, treatment and disposal

e. To supervise and control businesses and licensed private disposal companies who discharge or handle peculiar or hazardous waste such as industrial waste

f. Others

(4) Essential duties of citizens and businesses

i) Common duties of citizens and businesses are as follows:

a. To clean living places and working places by themselves

b. To cooperate with local authorities and licensed private disposers who manage solid waste

c. To lighten the burden of solid waste management by means of reduction of solid waste generation volume such as by reutilization of waste material (Also to reduce solid waste volume by suppression of the generation volume)

d. To bear expenses for solid waste management according to the ability and size of benefit received

e. To keep public places clean

ii) Other duties of businesses are as follows:

a. Businesses are obliged to treat and dispose of solid waste generated in their own business activities. When businesses are unable to manage their solid waste by themselves, they should entrust the treatment and disposal work to a licensed private disposer or the local authority and pay the appropriate expenses for such management.

b. Manufacturers should attempt to produce products which will not cause treatment and disposal difficulties when they are abandoned as waste.

(5) Application of the law

i) As a rule, the law should be applied to the entire country except for the areas which are sparsely populated, where entrance is restricted like a military base, or where the local authority judges that solid waste management is not necessary. In order to exclude these areas, standards should be set up so that the areas are legally excluded from the necessity for solid waste activity.

ii) In application of the law, the principle of territorial jurisdiction should be adopted so that the law covers the nation, businesses, foreigners staying in Thailand permanently or temporarily, and foreign enterprises established in Thailand.

9.2.4 Systematization of regulations relating to a solid waste management system

(1) Formulation of a solid waste management plan by local authorities

The local authorities should set up a solid waste management plan for each district and make the concerned citizen and businesses aware of their duties as specified in the plan.

(2) Basis of solid waste management by local authorities

In principle, local authorities are responsible for the collection, transportation and disposal of solid waste according to the established management plan, before the waste affects the living environment. Business waste may be managed by local authorites if the management plan permits it and it does not obstruct household waste management.

(3) Conditions for entrusting private disposers with solid waste management

A regulation should be established which, under specified

conditions, permits local authorities to entrust private disposers with some or all solid waste management activities in a part or the entire service area. However, the fundamental obligation of solid waste management should remain with local authorities. Therefore, basic work such as formulation of the management plan should not be entrusted to the private sector.

(4) Management of excessive volume or peculiar kinds of solid waste

Local authorities should be given power to exercise control over businesses to allow them to manage their own business waste in a specified manner when their discharging waste is excessive in volume or peculiar in nature so that it is beyond the local authority's ability to control.

When business waste is able to be disposed of at the local treatment/disposal facilities, the local authority should be entitled to impose a disposal fee on the dischargers or a representative disposers and allows them to bring their own waste to the facilities.

(5) Levy of solid waste collection and disposal fees

Expenses needed for solid waste management will increase year after year and become a large burden to the authorities. To compensate for the solid waste management cost, the fee levy system should be regulated by national legislation, based on which local authorities are entitled to levy fees based on their local conditions.

Even in the case when licensed private disposers manage solid waste on behalf of a local authority, the fees should be levied on citizens by the local authority lest the private disposers should charge fees unfair. The commission fees should be paid directly by the local authority to the private disposers.

Commission contracts between businesses and the licensed disposers should be made on a competitive contract basis.

(6) Permission by local authorities

Those who intend to conduct local solid waste management should be subject to permission of the concerned authorities. Basic conditions for the permission should be specified in national legislation but their execution should be entrusted to local authorities.

(7) Solid waste disposal standards

For proper treatment and disposal of solid waste, solid waste disposal standards should be specified in national legislation. In formulation of the standards, miscellaneous factors should be taken into consideration such as environmental protection, economic activities, actual state of solid waste disposal in each district, technical expertise availability, and so forth.

Examples of solid waste disposal standards in Japan are shown in Appendix 9.5.

(8) Notification of solid waste management facilities

In the case of promoting self disposal by businesses or disposal by the entrusted disposers, it is necessary to license their disposal facilities to ensure sufficient capacity and satisfactory environmental protection. For this purpose, those who plan to use more than a certain size and capacity of the facilities should be required to report the local authority in advance of the utilization of such facilities.

(9) Control and maintenance standards of solid waste management facilities and administrative orders for their improvement

Control and maintenance of solid waste management facilities should be made according to standards which may be specified in ordinances based on the national legislation. When control and maintenance of the facilities are found improper, the local authority should be empowered to issue warnings or orders for the improvement, and, if the warning or order is ignored or the facilities seem to have no room for improvement, to issue an order to close down the facilities.

9.2.5 Systematization of regulations covering miscellaneous rules and punitive provisions

(1) Trainig of engineers specialized in solid waste management

For training of engineers specialized in solid waste management, the national Government and local authorities should endeavor to establish and legally regulate systems of the training, qualification and certification.

(2) Collection of reports and on-the-spot inspection

The local authorities should be empowered to request the concerned people to submit reports within a time period which is necessary for execution of laws, regulations and ordinances. They should also be empowered by national legislation to dispatch officials in charge of environmental sanitation for on-the-spot

inspection wherever they consider necessary.

(3) Countermeasures against contravention

If any contravention of the law or illegal act is found by the officers in charge of environmental sanitation, warnings or improvement orders should be issued under the name of the local authority. In case such improvement cannot be expected or urgent measures should be taken for a purpose of environmental protection, the case should be prosecuted in the courts.

(4) Punishment against illegal disposal

In assessment of the case, extenuating circumstances with regard to the offense such as seriousness of the offense, impact to environment, etc. should be taken into consideration in order to ensure the fair execution of the law.

9.2.6 Systematization of BMA ordinances and regulations

Priority should be given to systematization of national laws. BMA ordinances and regulations should be organized in accordance with national laws.

Considering the characteristics of Bangkok city as the capital to which special status and power ought to be given, enforcement of particular ordinances and regulations different from those other local authorities may be permitted. If enactment of the basic laws about solid waste management are not immediately realizable, it is suggested that BMA choose from among miscellaneous articles mentioned in paragraphs 9.2.4 to 9.2.6 and organizes them into BMA ordinances or regulations.

9.3 Characteristics of Solid Waste Management Enterprises

9.3.1 Patterns of solid waste management

Solid waste management enterprises can be classified into the following patterns:

a. Direct management system by local authorities

b. Semi-governmental management system

c. Commission basis management system maintained by the private disposers

d. Private management system by private sectors (based on free contract with the licensed disposers)

e. Combined management system (Combination of systems shown above a ∿ d.)

The most popular pattern is the direct management system; however, there are cases utilizing private sectors in solid waste management in the manner described in itmes b ∿ e above.

Characteristics and drawbacks of each management system are described below.

The Study team recommends that, although the management should be based on a direct management system in principle, BMA should attempt to utilize the private sector to the maximum extent possible in order to establish a better solid waste management system.

9.3.2 Direct management system

(1) Characteristics of the direct management system

In this system, local authorities collect and dispose of solid waste by themselves. In the case of Bangkok city, solid waste management is under the control of BMA, and BOS and 24 districts handle the work on the basis of a direct management system.

(2) Advantages and disadvantages of a direct management system

The following two points are considered to be major advantages of this system:

a. Since local authorities conduct all processes from collection to disposal by themselves, the local authorities can administer their activities responsibly.

b. The results of the activities can be reviewed by the administration for further improvement.

At the same time, this system has several disadvantages which might cause administrative troubles:

a. A direct management system is a kind of monopoly system. Expenses for the management are paid from taxes, therefore there will be little motivation to increase the efficienty of the operations.

b. Since the field workers are all official employees or the equivalent, they are apt to neglect to give adequate services to the citizens.

c. Generally speaking, a direct management system provides less efficiency and a higher cost.

d. Because of budget constraints, the administrative needs for a solid waste management are not always fully satisfied. This system tends to lack activity and flexibility in the work.

9.3.3 Semi-governmental management system

(1) Features of a semi-governmental management system

Independent semi-governmental organization (public corporation) established by cooperation between the local authority and the private sector, shares responsibility with solid waste management under control of the local authority.

(2) Advantages and disadvantages of a semi-governmental management system

This can be said to be a "medium control system by local authority". Certain advantage is expected if this system is applied to either the case where solid waste management by a third party is thought to produce higher efficiency than that by local authority or the case where sound management by the corporation is expected provided that the local authority maintains the interest and subsidizes the operations.

On the other hand, if the management is poor, only the drawbacks of both public and private sectors will appear and, as a result, it will be difficult for the local authority to control the corporation or, in case of managemental default, the cause and debt will most often be attributed to the local authority.

9.3.4 Commission basis management system

(1) Features of commission basis management system

Private disposers who satisfy the required conditions have responsibility for the solid waste management on behalf of local authority on a commission basis. The private disposers perform the work according to a work plan and directions given by the local authority. The local authority pays adequate commission fees to the disposer.

(2) Advantages and disadvantages of a commission basis management system

The major advantages of this system are as follows:

a. As the entrusted disposers prepare necessary workers and equipment, the burden of labour control by the local authority is very much reduced.

b. In general, this system produces higher efficiency with lower cost.

c. Necessary information for the further improvement of solid waste management system can be obtained by means of a comparison between the commission basis management system and the direct management system.

The major disadvantages are as follows:

a. The entrusted disposers may attach importance to making a profit which might result in services to the citizens often becoming inadequate.

b. When the expected profit is not obtained, the loss is easily shifted on to the employees.

c. Local authorities are responsible to the citizens for solid waste management, therefore they should always supervise and control the work performance of the entrusted disposers.

Incidentally, some useful information about commission basis management system are given in Chapter 3.3.R(6) and Chapter 9.2.4.

(3) Cost of commission basis management system

At the present time the commission basis management system has not been adopted in Bangkok city.

In the case of Japan, as shown in Appendix 9.6, 65.6% of solid waste is disposed using a direct management system, 25.4% using a

commission basis and 9.0% by permission basis. As for night soil management, 87.1% is entrusted to the private disposers in Japan.

Appendix 9.7 shows a comparison of cost between direct and commission basis management systems: the data were obtained from results of cities, towns and villages in metropolitan Tokyo. Although an accurate comparison between them is not possible because the method of management and the work conditions are different in each city, an attempt was made to compare collection and transportation cost which is common to all these cities. Collection and transportation cost in the case of the direct management system was 1,807 Baht/t whereas that in the case of commission basis management was 838 Baht/t; the latter being only 53.6% of the former. The result was converted to a collection and transportation efficiency as shown in Appendix 9.8; 127 Baht/t.km with direct management system and 63 Baht/t.km with commission basis.

Results of Appendix 9.7 and 9.8 were applied to the case of BMA and, assuming that one quarter of the collection and transportation work in fiscal 1980 was shifted from a direct management to a commission basis, the cost saving was estimated to be as shown in Appendix 9.9.

The estimate shows that 11 Baht per ton, or 7,893,000 Baht per year, of the cost could be saved, which is equivalent to 3.5% of the total solid waste management cost.

(4) Application of commission basis management system

If BMA intends to adopt a commission basis management, it may be advantageous to apply it to the following work.

i) Collection and transportation at places where;

a. BOS or the district has difficulties with solid waste collection, like slums.

b. Work efficiency is low in spite of the existence of a large number of workers, tools and machines, and a large budget being expended, such as for areas with narrow lanes and areas which are sparsely populated.

c. Working hours and solid waste depots are constrained so that collection service during normal working hours can not be achieved, for example, in amusement centers.

d. Application of particular means of collection are required, such as collection by boats and transporation through a transfer station.

ii) Work at intermediate treatment or final disposal facilities such as;

a. Selection of reutilizable material at compost plant

b. Soil covering at landfill site

c. Operation and maintenance of the facilities

9.3.5 Permission basis management system

(1) Features of permission basis management system

Upon permission of the local authority, the private disposers cope with solid waste which is excluded from the local authority's disposal plan. The diposers contract with the dischargers based on a principle of open competition, therefore, although the local authority is able to control the diposers with the right of permission, it cannot be involved in the practical work.

(2) Advantages and disadvantages of permission basis management system

The advantages are as follows:

a. Open competition reduces the cost.

b. The disposers perform the work with their own funds so that the local authority does not have to bear the financial burden.

c. The contract is directly concluded between the discharger and the disposer. The local authority therefore is released from responsibility for fees and payments.

The disadvantages are as follows:

a. Since the local authority is not immediately involved in the work, the disposers are apt to carry on the work perfunctorily.

b. The management fees and grade of the service may be influenced by the amount of profit which the disposers receive.

c. The local authority is not responsible for complete supervision and control of the disposers.

(3) Adaptability of permission basis management system

Whether a local authority acknowledges the permission basis management system or not depends upon the local authority's policy about the extent it should cope with miscellaneous solid waste

discharged in its jurisdiction. Some local authorities are reluctant to acknowledge permission basis disposers because of lack of control over them; however in practice, there are various types of solid waste, some of which the local authority is neighter required nor able to cope with. Therefore, limiting to such sort of waste, disposal by private disposers on a permission basis should be acknowledged. In this case, the following types of solid waste are considered suitable to be disposed of by the permitted disposers.

a. Particular solid waste or filth which the local authority does not accept.

b. Solid waste containing hazardous substances or contagious pathogenic bacteria, which requires specialized treatment and disposal techiniques.

c. Solid waste which the local authority is not responsible to cope with, such as difficult-to-treat waste and industrial waste.

d. Reutilizable waste.

The states of permitted disposal in Japan is described in Appendix 9.6.

9.3.6 Combined management system

This system is composed of several appropriate systems selected from among the above-mentioned systems considering the local characteristics of each region.

In the case of Bangkok city, the following combinations will be applicable.

a. Direct management system + commission basis management system

b. Direct management system + commission basis management system + permission basis management system (or management by the extra-governmental organization)

The commission basis management system can be regarded as a variation of the direct management system. Accordingly the former case a. is intended for the management of total volume of solid waste discharged from the city, whereas the latter (case b.) leaves some part of solid waste management activities out of the local authority's plan. Selection of either system a. or b. should be left to BMA for its further examination.

9.4 Improvement of Administrative Organization and Execution System

9.4.1 Administrative organizations relating to solid waste management in Thailand

Among various administrative organizations in Thailand, the following ministries, bureaus and committees have a close relation to solid waste management:

(Administrative organization of Thailand is illustrated in Appendices 9.10-(1) and 9.10-(2).)

(1) Ministry of Interior (MOInt)

MOInt, a key organization to control general domestic administration in Thailand, is deeply involved in not only national administration such as the public peace and order but also the local administrations in general.

MOInt is composed of Office of Policy and Planning, Departments of Land, Local Administration and some other Departments. Its organization is large and its authority is wide.

In the national administrative organization, BMA is positioned under direct control of MOInt. This is probably because Bangkok is a capital and the only huge city in Thailand. Within Bangkok, the BMA plays a more important role than normal local governments do. The role is said to be equivalent to that of a Ministry.

The National Government has rights to appoint Bangkok's Governor and key officials of BMA; most of the administrative work of BMA is, in a sense, entrusted work by the National Government. The National Government controls BMA through MOInt and legally reserves the right to cope with some important affairs arising in BMA including solid waste management.

(2) Ministry of Public Health (MOPH)

MOPH consists of the Department of Health and four other departments. It copes with medicine, infectious diseases prevention, and general public health administration. The Department of Health of MOPH supervises solid waste management enterprise and the administration of local authorities excluding BMA. Sanitation Division of the Department does the document work concerning solid waste management. Organization of the Sanitation Division is given in Appendix 9.10-(3).

(3) Office of the National Environment Board (NEB)

NEB, one of the external bureaus of Ministry of Science, Technology and Energy, was established as a special organization for environmental administration.

NEB takes charge of planning, survey and supervision concerning environmental standards, environmental improvement, environmental impact assessment, etc.

In the Environmental Quality Standard Division of NEB, the Solid Waste Section was established to supervise projects relating to solid waste management from an environmental viewpoint. NEB also functions as a Secretariat of the National Environment Committee.

Organization of NEB is shown in Appendix 9.10-(4).

(4) Office of the National Economic and Social Development Board (NESDB)

NESDB is one of the external bureau of Office of the Prime Minister. Together with Ministry of Finance, NESDB holds a key of administration and finance of the Thai Government; it is also in charge of the Fifth National Economic and Social Development Plan in Thailand.

(5) National Environment Committee

National Environment Committee is organized based on National Environment Promotion and Preservation Act. The Committee, headed by Vice Prime Minister as the chairman and compsoed of Under Secretaries and the equivalents of Ministries and Bureaus and men of learning and experience, examines projects and plans relating to the environment and reports its opinion or recommendations to the Cabinet or the Ministries concerned as necessary.

If any discord occurs between MOInt (which controls BMA) and MOPH (which supervise provinces (Changwats) excluding Bangkok city, districts (Amphur) and City (Nakorn)), the matter is reported to a Committee of the Cabinet for arbitration.

(6) Other administrative organizations

The administration of the Thai Government covers one prefecture, twelve ministries and one bureau, and its power is highly centralized. Therefore, when improvement or extension of solid waste management administration is intended, negotiation and coordination with ministries other than mentioned above will be required such as Ministries of Finance, Foreign Affairs, Communications, Commerce, Industry, etc. Ten universities belonging to Office of University Affairs and National Institute of Development Administration promote study concerning solid waste management.

9.4.2 BMA's organization and its solid waste management administration

BMA's organization as of Jan. 1982 is shown in Appendix 9.10-(5). Work and its execution by offices relating to solid waste management are as follows: (Ref. Appendix 9.10-(6))

(1) District (24 districts)

24-Districts in Bangkok city are subordinate administrative districts to BMA and not local autonomous entities.

Each District has a Sanitation Section and Revenue Section, whose work tasks are summarized as below:

i) Sanitation Section

a. Collection and transport of household waste and solid waste which is not collected by the Garbage Collection Division, BOS

b. Cleaning of public areas such as roads, parks, sidewalks, pedestrian bridges, temples and markets

c. Collection of carcasses abondoned on roads

d. Collection of solid waste from rivers and khlongs

e. Control of collection trucks

f. Control and operation of final disposal sites (Rat Burana and Minburi) belonging to the Districts

ii) Revenue Section

a. Levy of solid waste collection fee

b. Others

The above work tasks had been performed by BOS till transferred to the Districts in 1979. Reasons for the transfer were inferred to be as follows:

a. To avoid insufficiency of staff which may be caused by excessive expansion of BOS organization

b. To raise work efficiency by transferring local work to Districts such as collection fee levy

c. To obey the national policy which demands transfer of local administrative work to the local authorities

At present, some Districts seem unable to cope with the transferred administrative work whereas others seem to cope easily; also within BMA, no separate function has been established yet to control the Districts. These drawbacks may cause some trouble in performance of solid waste management.

(2) Bureau of Sanitation (BOS)

Although a large part of administrative responsibility of BOS was transferred to Districts and BSD, BOS still plays important roles in solid waste management administration.

Activities of each Division in BOS are as follows: (Ref. Appendix Fig. AP3.1)

i) Office of Secretary

a. General affairs

b. Personnel affairs

c. Matters relating to the Ordinance and Acts

d. Financial management

ii) Technical Division

a. Planning of sanitation work

b. Investigation and data compilation on solid waste management

iii) Garbage Collection Division

a. Collection and transportation of solid waste from major markets and hospitals

b. Inspection, delivery and control of collection trucks

c. Cleaning of roads (trunk roads and roads in the business section)

iv) Compost Plant Division

a. Control and operation of compost plants, contact and coordination with compsot plant sites

b. Selection and sale of ferrous metal

c. Control and operation of final disposal sites, contact and coordination with final disposal sites

d. Disposal of carcasses

v) Night Soil Collection and Disposal Division

a. Night soil treatment

(3) Bureau of Sewage and Drainage (BSD)

BSD is composed of five Divisions, among which Canal and Maintenance Division has close relation with solid waste management and flood control. Its functions are:

a. Collection of solid waste from rivers and Khlongs

b. Procurement and control of boats for river and Khlong waste collection

c. Planning, construction and maintenance of waste water treatment facilities at final disposal sites

(4) Bureau of Finance (BOF)

BOF handles finance, budget, accounting, treasury, revenue and expenditure, etc. of BMA. BOF has seven Divisions. Of these, three offices (Mechanical Division, Revenue Division and Office of Fertilizers) have closest relation with solid waste management.

i) Mechanical Division

a. Purchase of collection trucks

b. Repair and periodical inspection of collection trucks

c. Purchase and control of reserved collection trucks

d. Purchase and repair of the registered BMA vehicles

ii) Revenue Division

a. Manufacture and sales control of compost

b. Revenue control from solid waste collection fee

iii) Office of Fertilizers (2 Locations)

a. Business Division ..... Compost sales development
Compost quality control

b. Finance Division ..... Compost sales revenue control
Compost price control

c. Factory Division ..... Compost secondary treatment
Compost plant operation

d. Marketing Management ... Compost sales policy

e. Special Activities Division ... Marketing research
Utility, etc.

(5) Office of Under Secretary of State for BMA

This office manages general affairs of BMA.

The Divisions of City Planning, Budget, Law and Legal Procedure, and Administration and Registration have indirect relation with solid waste management for its smooth execution.

(6) Department of Policy and Planning (DPP)

DPP takes charge of establishment of basic policy and master plan of BMA and formulation of the future plans as a key section of BMA organization.

Solid waste management in Bangkok city in the future will be very influenced by the policy of DPP. Therefore, solid waste management activities should progress under organizational cooperation between DPP and practical work sections such as BOS and Districts.

(7) Internal committees

To compensate for deficiency caused by longitudinal structure of administrative organization, miscellaneous committees are set up as cross-sectional organization. The character of such committees varies according to the chairman's qualification and position. Some committees offer contact opportunity and coordination between the sections, some achieve staff functions by means of examination and approval of cases, and others decide on basic policy and other basic matters.

The following committees are related to solid waste management.

i) Committee of administrative organization relating to solid waste management

The committee, headed by Director of BOS and composed of Chiefs of Sanitation Section of each District, Chiefs of each Division and Section of BOS and staff of Office of Secretary, is held once a month periodically to exchange information and opinions concerning complaints, improvement plan, policy, etc. about solid waste management.

ii) Special committee for new projects

The committee is composed of the Governor as the chairman, Directors of the concerned Bureaus and Chiefs of Districts.

The agenda is limited to matters relating to new projects. Modification and manner of introduction of the project are discussed.

iii) Assembly Subcommittee

Sanitation and Environment Subcommittee is attached to BMA assembly. The Subcommittee is composed of Chairman and five members of BMA assembly and representatives of MOPH, Universities, MOA and Districts.

9.4.3 The present state and the existing problems

24 Districts and three Bureaus (BOS, BOF and BSD) take partial charge of solid waste management in Bangkok city; however, under the existing administrative system, BOS who ought to govern solid waste management activities is not empowered with proper authority to control Districts and other Bureaus. As the result, miscellaneous problems as described below have arisen.

(1) Relation between BOS and Districts

According to a policy of decentralization of administrative power, a large part of authority concerning solid waste collection and transportation work was transferred from BOS to Districts. This caused the following problems:

i) Insufficient management capacity of each District could not fully satisfy various requirements with respect to solid waste collection and transport.

ii) Since each District is administratively independent under the existing system and empowered to decide treatment of its personnel such as salary scale and work volume individually, it is difficult to correct inequity of the treatment of personnel engaged in sanitation activities in Bangkok city.

iii) Solid waste disposal from collection and transport to intermediate treatment and final disposal should be conducted in a series process. In fact, however, authority concerning collection and transport has been transferred to Districts so that BOS has no power to directly order or control the Districts for maintenance of unity of solid waste disposal.

iv) Since division of collection service of both BOS and Districts is not clear, solid waste in some areas is often left uncollected.

v) Under the existing administrative system, BOS and each District individually perform public utility enterprises including solid waste disposal. Therefore, BOS is unable to correct inequality with manpower and equipment which arises among Districts. This makes results of services such as

grade of collection service, percentage of levied collection fee, and grade of administrative guidance to citizen and businesses different by Districts.

(2) Relation between BOS and BOF

i) Control of collection trucks

Control of collection trucks involves purchase, distribution, inspection and maintenance, repair (including acquisition of spare parts) of collection trucks, and reserve and delivery of spare trucks. In BMA, control of collection trucks is made by BOF (Mech. Div.), BOS and each District saparately. The separated control has caused unclearness of responsibility, occurrence of sectionalism and, as the result, obstruction to effective use of collection trucks.

ii) Operation of compost plant

Presently, BOS takes charge of a process from reception of solid waste to completion of the secondary fermentation of compost, and Office of Fertilizer Section of BOF does fine classification of secondary fermented compost by trommel, packing of refined compost, and marketing of compost. Since BOF, which is in charge of compost sales, is involved in compost production despite sales function ought to be separated from production function, it is difficult for BOS to establish policy upon agreement with BOF concerning operation, maintenance, management, and evaluation of composting facilities, or to decide closedown of obsolete or superannuated facilities. The difficulty for BOS to agree with BOF makes smooth operation of compost plant harder.

(3) Relation between BOS and BSD

i) Cleaning of rivers and Khlongs

BSD takes charge of cleaning of Chao Phraya river and main parts of large rivers and Khlongs whereas each District does cleaning of medium and small rivers and Khlongs. Nevertheless, as rivers and Khlongs normally run across several Districts, duty and collection service areas of each District cannot be clearly specified. Because of this unclearness, some parts of rivers and Khlongs are left uncollected or unprotected from illegal discharge of solid waste or filth into them. BOS is in position to coordinate BSD with the Districts in order to avoid such deficiency but unable since no power to control them is empowered.

ii) Leachate treatment in the final disposal site

An anomalous system that solid waste is to be landfilled by BOS and leachate generated from the landfill is to be treated by BSD makes it difficult to take prompt and proper countermeasures against increase of leachate or superannuation of the treatment facilities.