

## **Chapter 5 SOLID WASTE MANAGEMENT FACILITY PLAN AND THE COST ESTIMATION**

5.1	Foreword .....	5-1
5.2	Solid Waste Treatment and Disposal Facility Plan .....	5-1
5.3	Solid Waste Management Facilities Construction Plan .....	5-21
5.4	Cost Estimation .....	5-26



## CHAPTER 5 SOLID WASTE MANAGEMENT FACILITY PLAN AND THE COST ESTIMATION

### 5.1 Foreword

With respect to three cases of appropriate Master Plan alternatives (hereinafter referred to as the alternatives) proposed in Chapter 4, facility plans of components for each alternative such as intermediate treatment facilities and final disposal sites were formulated and the approximate costs were estimated. The plan formulation and cost estimation were performed according to a work flow illustrated in Fig. 5.1. In connection with the facility plan, other related components were examined to formulate four subordinate plans which are also introduced in this chapter. They are parking lot construction plan, the existing compost plants repair plan, collection trucks and equipment acquisition plan, and personnel recruitment plan.

### 5.2 Solid Waste Treatment and Disposal Facility Plan

The facility plan is to specify criteria of planning and outline of new facilities of incineration, composting and final disposal involved in the alternatives.

#### 5.2.1 Incineration plant

##### (1) Outline of the facility plan

Outline of incineration plant facility plan is shown in Table 5.1. Continuous firing incinerators will be introduced to all incineration plants. Major conditions of designing and outline of principal components in the design are given in Appendices 5.1 and 5.2. The design aims at establishment of the latest type of incineration plant. Size and number of incinerators were determined as follows based on the result of evaluation:

- . When a capacity of 1,500 t/d is required, 3 units of 500 t/d incinerators
- . When a capacity of 1,200 t/d or 1,100 t/d is required, 3 units of 400 t/d and 370 t/d incinerators respectively.

Fig. 5.1 Facility plan formulation works flow

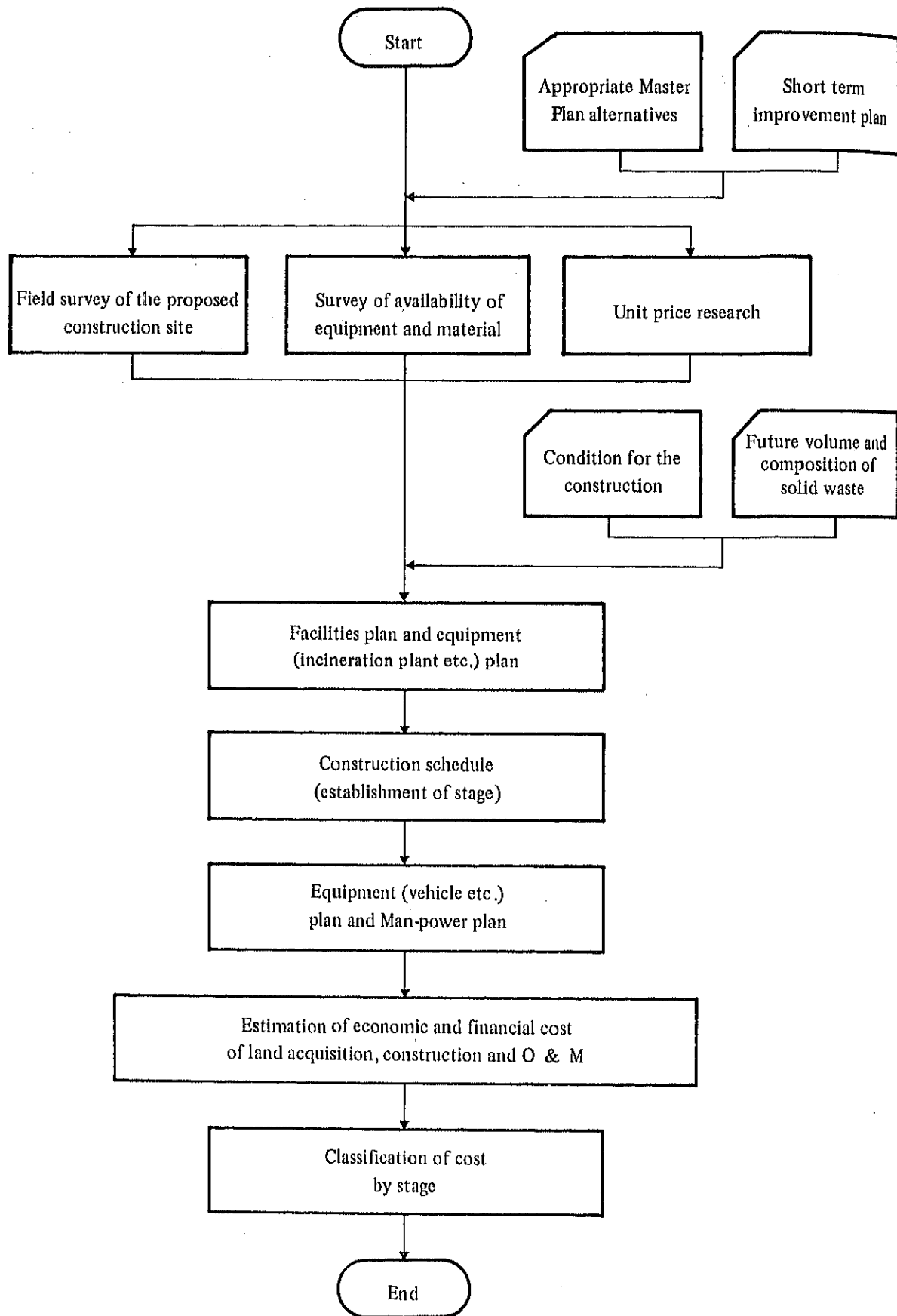


Table 5.1 Outline of incineration plant facility plan

< 1 > Capacity and site area of the plant

Case No.	The plant name	Treatment capacity (t/d)	Number of incinerators (t/d x unit)	Site area (m <sup>2</sup> )	Floor area (Gross floor area) (m <sup>2</sup> )	Electricity generation capacity (kW)
13 or 19-(2)	Yannawa	1,500	500 x 3	79,700	15,000 (37,500)	11,000
13	Bang Kapi	1,200	400 x 3	67,000	12,000 (30,000)	9,000
13	Bangkok Noi	1,100	370 x 3	63,400	11,000 (27,500)	8,000
13	Phasi Charoen	1,100	-do-	58,800	11,000 (27,500)	8,000
19-(2)	Dusit	1,500	500 x 3	77,200	15,000 (37,500)	11,000

< 2 > Main facilities (common to all plants)

Item	Detail
1. Incinerator	Continuous firing mechanical incinerator
2. Exhaust gas cooling	Waste heat boiler type
3. Dust collection	Electric precipitator
4. Waste water treatment	Closed system
5. Waste heat utilization	Steam turbine power generation, air conditioning, and hot water supply
6. Operation and control	Integrated remote control system, data processing system
7. Stack	Steel-made concentration type. Height 60 m
8. Bulk waste pulverizer	50 t/8 h
9. Bldg. and external structure	Plant facilities are accommodated in building
a. Main plant building	One, made of steel reinforced concrete. Height approx. 31 m above ground level with basement (5 m deep). Office building attached
b. Other buildings	One bldg. each for ash weighing, solid waste weighing, vehicle washing, and hazardous material storage
c. External structure	Parking lot, access road, open space, plantation
10. Architectural facilities	Ventilator, fire extinguisher, electrical equipment
11. Plant facilities	An assortment. Ref. Appendix 5.2

(2) The plant layout

Incineration plant layout was formulated based on flow planning taking several important factors into consideration such as economy, ease of operation, impact to the surrounding environment, etc.

a. Flow planning

In designing the flow plan, movement of incoming and outgoing collection trucks to/from the plant was taken as the basis. In the flow plan, importance was attached to the following points.

- . Cross of the path of flow should be avoided as much as possible.
- . Sufficient waiting space of collection trucks should be secured.
- . Coordination of each facility one to others should be considered.

b. Impact to the surrounding areas

The probable media of impact to the surrounding areas will be as follows.

- . Noise and vibration by operation of collection trucks.
- . Rank odour from solid waste reception pits.
- . Dust exhausted from stack.
- . Noise by operation of the facilities.
- . Waste water and leachate.

In the layout, attempts were made to locate each facility in advantageous position to suppress impact caused by the above media by means of, for instance, locating it as remote as possible to the site boundary line and making a green belt on the boundary line. Some examples of the formulated layouts and sectional view of incineration plant are shown in Figures from 5.2 to 5.4. Other layouts and location of incineration plants are shown in Appendices 5.3 and 5.4.

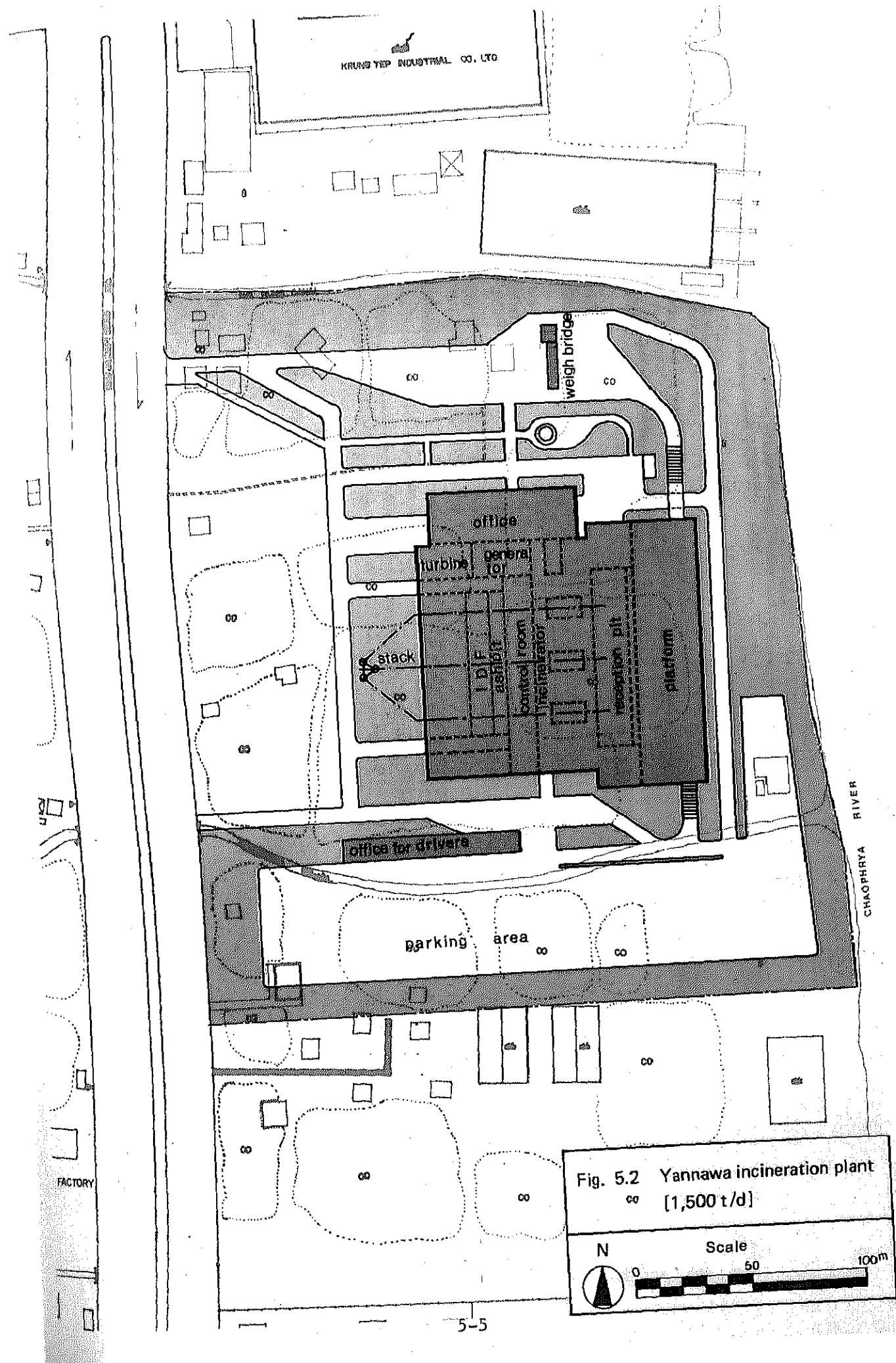


Fig. 5.2 Yannawa incineration plant  
[1,500 t/d]

N

Scale 0 50 100m





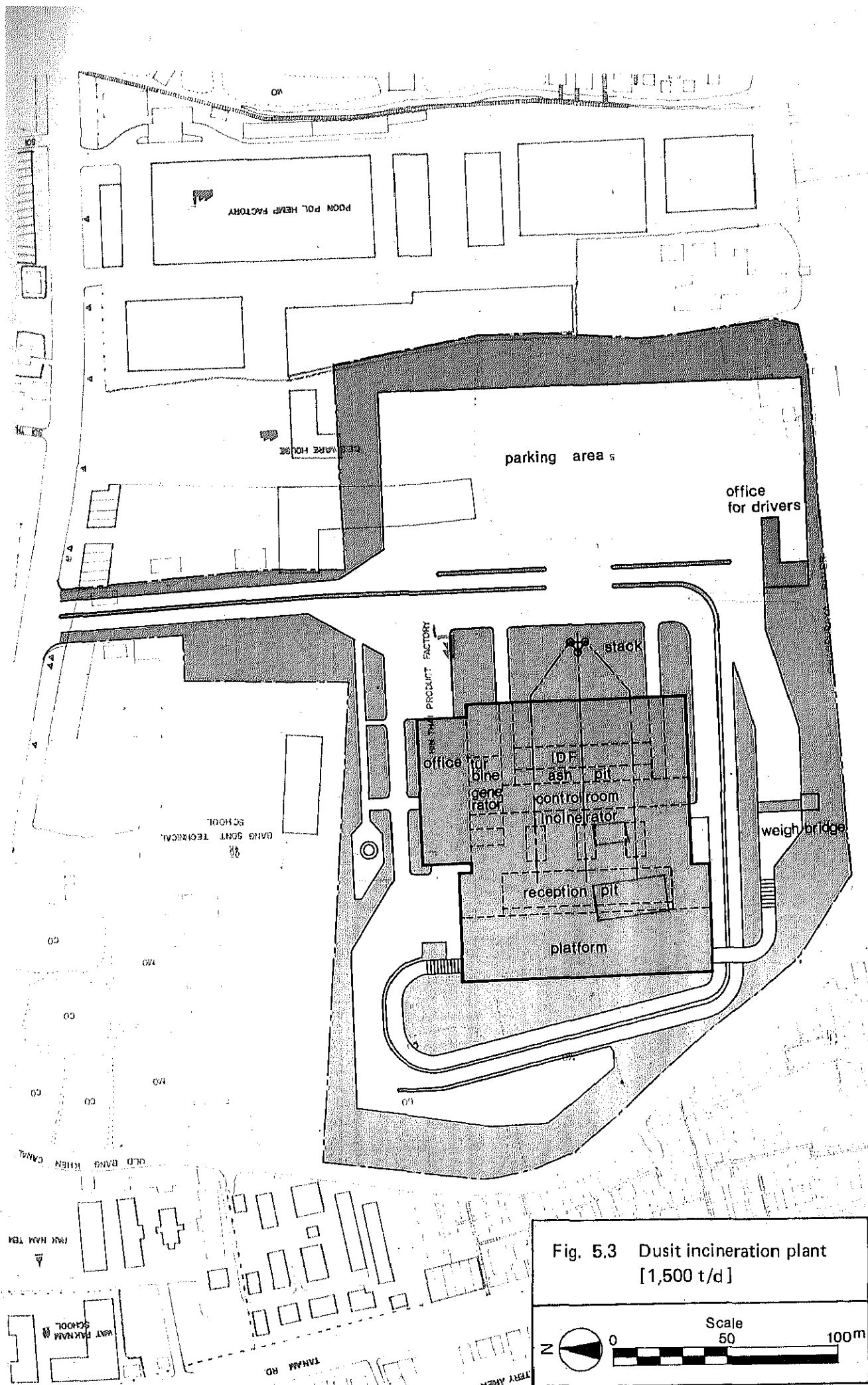


Fig. 5.3 Dust incineration plant [1,500 t/d]

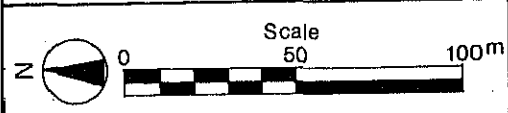
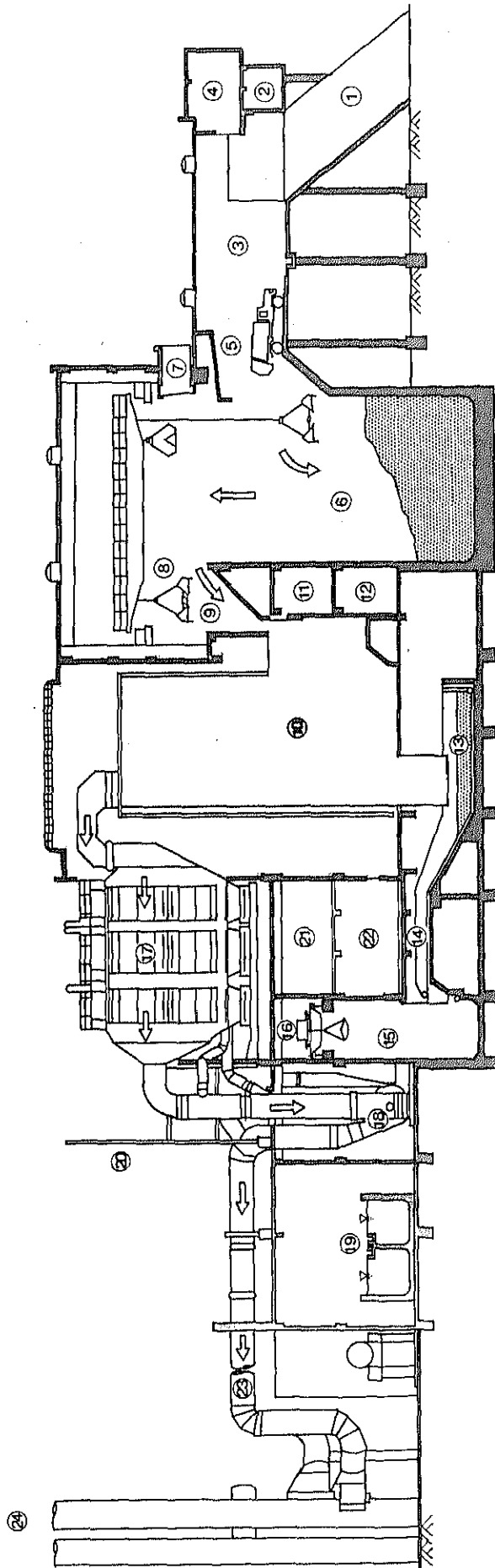




Fig. 5.4 Sectional view of incineration plant



Legend

Symbol	Name of facilities and equipments	Symbol	Name of facilities and equipments	Symbol	Name of facilities and equipments	Symbol	Name of facilities and equipments
①	Ramp	⑦	Crane operation room	⑬	Ash quenching trough	⑲	Sewage treatment equipments
②	Room of air-curtain equipment	⑧	Refuse crane	⑭	Ash conveyor	⑳	Noise shelter
③	Platform	⑨	Refuse charging hopper	⑮	Ash pit	㉑	Room: transformers and breakers
④	Operation center of pit gates	⑩	Incinerator	⑯	Ash removal crane	㉒	Control center
⑤	Pit gate	⑪	Incinerator-cooling fan	⑰	Electric precipitator	㉓	Flue
⑥	Reception pit	⑫	Forced-draft fan	⑱	Induced-draft fan	㉔	Stack

### 5.2.2 New compost plant

#### (1) Outline of the facility plan

Outline of facility plan of compost plants to be newly established is shown in Table 5.2. In this plan, aerobic composting treatment system was introduced. Solid waste is piled up 2.5 meter high in the fermentation trough, both sides of which are enclosed by walls. Air is forcibly fed to solid waste through the bottom of the trough. Fermentation period is designed two months including secondary fermentation; in the meantime, turnover of solid waste is made with minimum necessary frequency.

Incoming solid waste to the compost plant is mounted on belt conveyers, along which workers are positioned who manually collect unsuitable waste for composting such as plastics, metal and glass from flowing solid waste. Bang Khun Tian compost plant with a capacity of 260 t/d, for example, requires five units of this manual selection equipment. Taking this as the basis, the capacity of the reception pit and other facilities were determined.

#### (2) The plant layout

The planned two new compost plants are both located in an agricultural area where, the study result implies, little impact to the surrounding environment is feared. Therefore, the layout was made giving first priority to the ease and efficiency of the plant operation. Layouts of both compost plants are shown in Fig. 5.5 and Fig. 5.6. Location of composting plants and the facilities design of both plants are illustrated in Appendices 5.5 and 5.6.

Table 5.2 Outline of new compost plant facility plan

< 1 > Capacity, method and site area of the plant

Case No.	The plant name	Treatment capacity (t/d)	Treatment method	Site area (m <sup>2</sup> )	Fermentation yard area (m <sup>2</sup> )	Compost production capacity (t/d)
9 13 19-(2)	Bang Khun Tian	260	2 months aerobic fermentation. Treatment on ground surface	173,700 (incl. final disposal site)	16,800	32.6
	Taling Chan	540		291,600 (incl. final disposal site)	33,600	69.5

< 2 > Main facilities

Facility and equipment	Bang Khun Tian	Taling Chan
Reception pit (5m x 7m x 28m) D W L	1 unit	2 units
Handsorting (belt conveyor)	5 units	5 units x 2
Fermentation trough (20m x 13m)	30 units x 2	30 units x 4
Final separation (Trommel, 1 t/h)	14 units	14 units x 2
Weighing scale	1 unit	2 units
Blower 2,200 mmAq 100Nm <sup>3</sup> /min	2 units	4 units
Office building	1 bldg.(400m <sup>2</sup> )	1 bldg.(700m <sup>2</sup> )

< 3 > Outline of landfill site attached to compost plant

The plant name	Bang Khun Tian	Taling Chan
Planned total landfill volume	564,000 m <sup>3</sup>	1,172,000 m <sup>3</sup>
Landfill site area	64,000 m <sup>2</sup>	121,000 m <sup>2</sup>
Landfill life span	20 years	20 years
Landfill height	10 m	10 m
Leachate treatment capacity	200 m <sup>3</sup> /d	260 m <sup>3</sup> /d



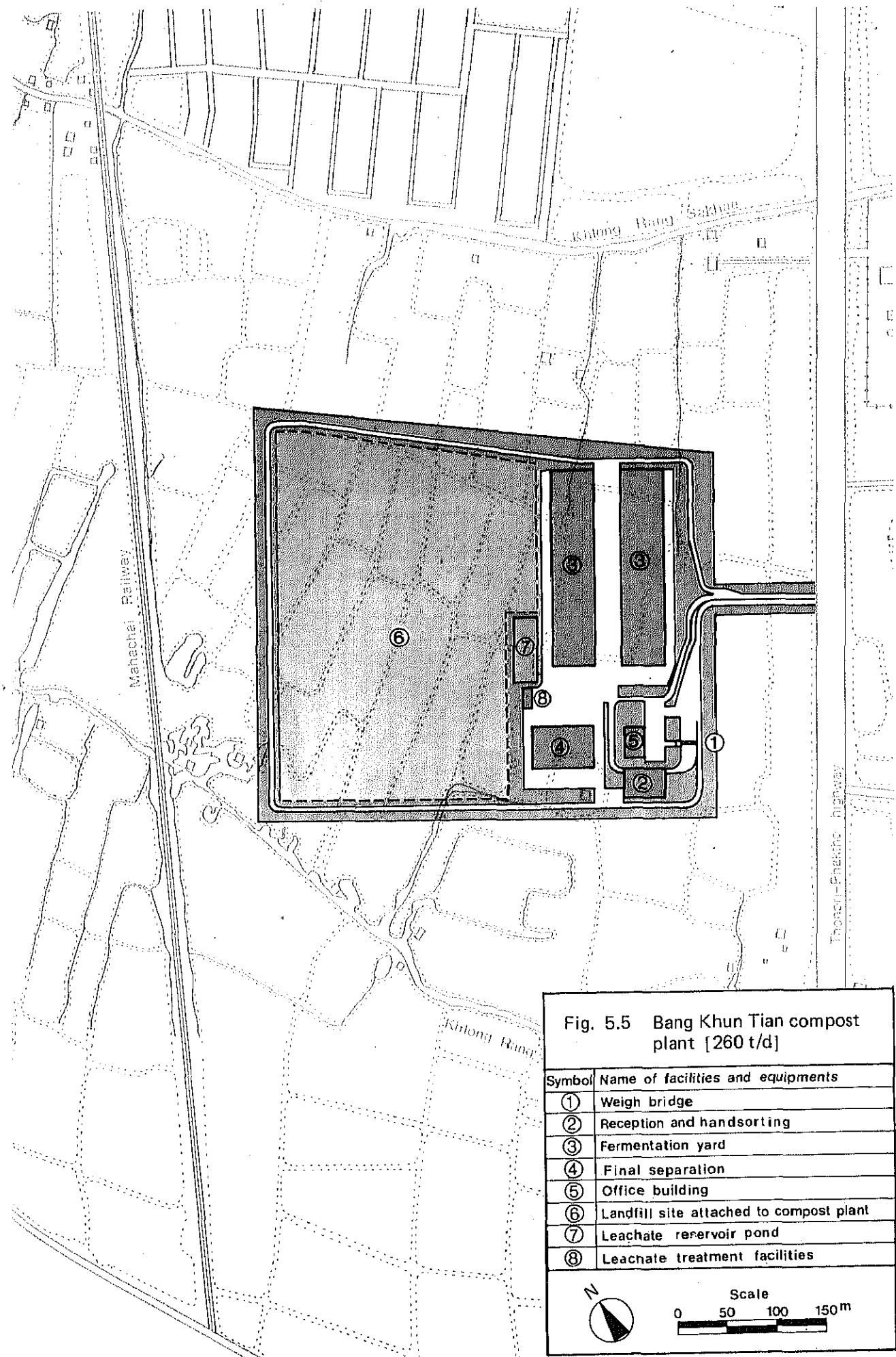
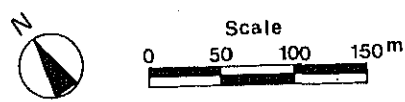


Fig. 5.5 Bang Khun Tian compost plant [260 t/d]

Symbol	Name of facilities and equipments
①	Weigh bridge
②	Reception and handsorting
③	Fermentation yard
④	Final separation
⑤	Office building
⑥	Landfill site attached to compost plant
⑦	Leachate reservoir pond
⑧	Leachate treatment facilities







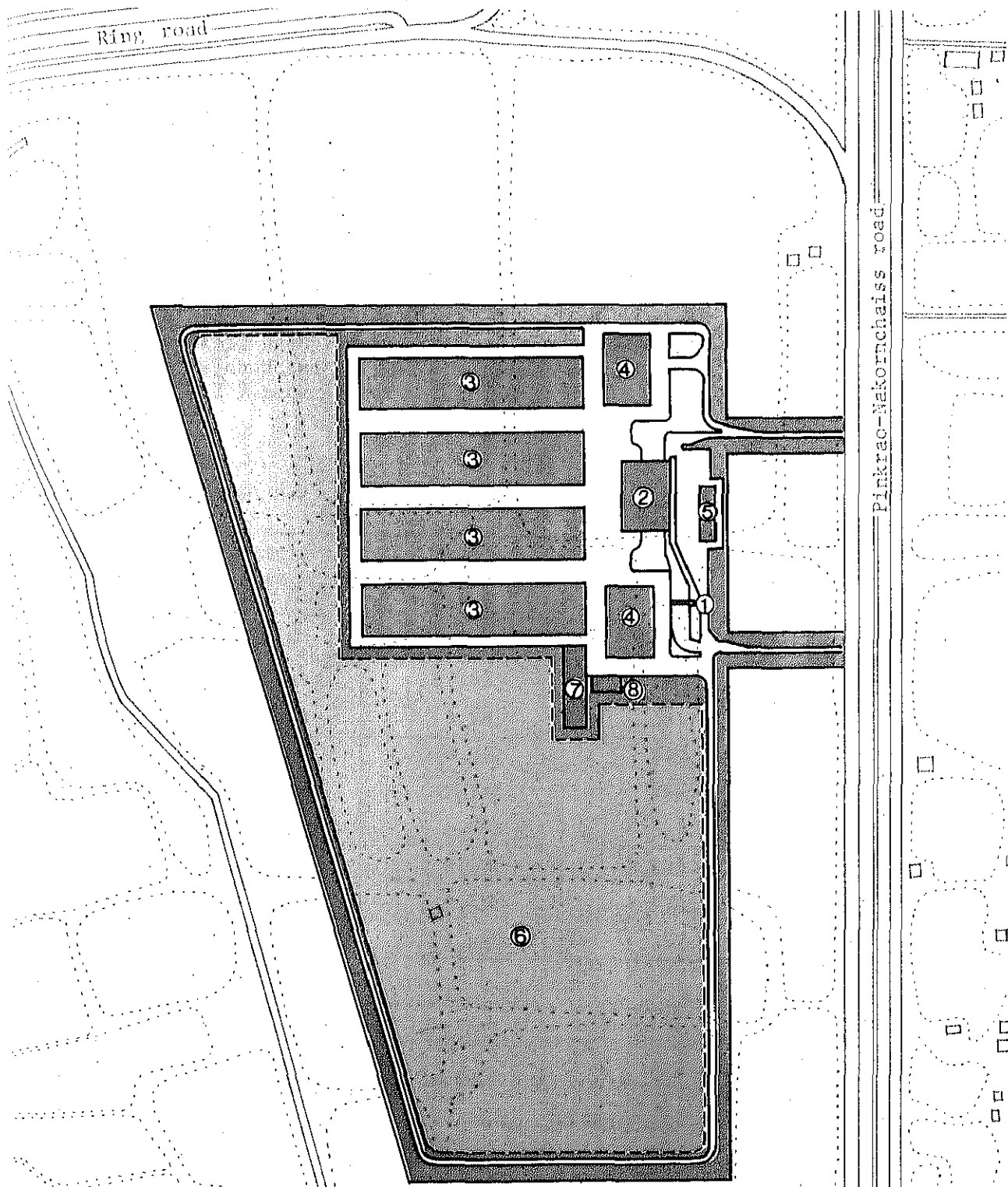
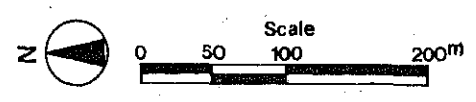


Fig. 5.6 Taling Chan compost plant [540 t/d]

Symbol	Name of facilities and equipments
①	Weigh bridge
②	Reception and handsorting
③	Fermentation yard
④	Final separation equipmen
⑤	Office building
⑥	Landfill site attached to compost plant
⑦	Leachate reservoir pond
⑧	Leachate treatment facilities





### 5.2.3 Final disposal site

#### (1) Outline of the facility plan

##### i) Capacity and area of final disposal site

Table 5.3 below shows capacity (acceptable solid waste volume for landfilling) and area of each final disposal site for each alternative case. The applied landfill method is improved un-aerobic sanitary landfill structure pre-embanked section landfill method (pre-embanked sanitary section landfill). Thickness of landfill was planned at 15 meters (except for particular parts) to be composed of five 3 meter-thick layers. Each layer consists of a 2.7 meter-thick solid waste and a 0.3 meter-thick soil covering.

Table 5.3 Capacity and area of final disposal site

Case No.	Landfill site	Landfill capacity 1,000 m <sup>3</sup>	Landfill site area (1,000 m <sup>2</sup> )	
			Total area	Newly required area
9	On-Nooch	14,672	1,679.8	750.2
	Nong Khaem	13,825	1,296.5	707.7
	Ram Intra	3,991	551.8	462.2
13	On-Nooch	6,222	929.6	0
	Nong Khaem	7,169	756.1	167.3
	Ram Intra	1,993	317.3	227.7
19-(2)	On-Nooch	8,296	1,093.9	164.3
	Nong Khaem	9,478	976.7	387.9
	Ram Intra	2,466	352.9	263.3

Note 1. Landfill capacity satisfies the planned landfill volume until the year 2010. In the case of On-Nooch and Nong Khaem landfill sites, the already landfilled volume is included.

2. Landfill site area includes compost plant site area.

3. Newly required area is the area needed to meet the planned landfill capacity

##### ii) The planned landfill volume

The planned landfill volume is shown in Table 5.4.

This volume was planned based on the following assumptions:

- a. Solid waste to be landfilled is directly transported from the collection site to final disposal site through the nearest route. Ram Intra disposal site will commence reception of solid waste from 1988 with a total landfill volume limitation which is set for suppression of environmental impact to the surroundings.

- b. Bung Phrayasalum and Bung Tanode disposal sites are used in the same manner as at present until 1987, and Tung Kru disposal site until 1991.
- c. Ash from the incineration plant is utilized as covering soil for landfill and the surplus is used for swamp land reclamation. The planned landfill volume by years for each alternative case is shown in Appendix 5.7.

Table 5.4 The planned landfill volume (fiscal 1983 ~ 2010)

(Unit : 1,000 m<sup>3</sup>)

Case No.	Total volume	Landfill volume by material			
		Solid waste	Compost plant waste		Ash from incineration plant
			Compost residue	Incineration ash	
9	28,911	27,116	1,212	583	0
13	12,453	10,470	1,212	583	188
19-(2)	18,003	15,773	1,212	583	435

iii) Main facilities of final disposal site

Main facilities of each final disposal site for each alternative case are listed in the Table 5.5. Other than these, construction of attached facilities are required such as office buildings, repair shops, access roads, and incoming solid waste weighing facilities. The existing facilities should be fully utilized.

Table 5.5 Main facilities of final disposal site

Facility		Case No.								
		9			13			19-(2)		
		On-Nooch	Nong Khaem	Ram Intra	On-Nooch	Nong Khaem	Ram Intra	On-Nooch	Nong Khaem	Ram Intra
Leachate collection facilities	(m)	10,600	9,000	4,500	6,100	5,900	2,740	8,000	7,100	3,000
Pumping facility	(unit)	23	21	14	15	17	9	17	17	11
Block bank (1st layer)	(m)	10,400	8,000	4,300	5,800	5,000	2,600	6,800	6,100	2,900
Block bank (2nd - 5th layer)	(m)	35,200	26,700	14,400	15,000	15,300	8,800	19,100	19,500	10,100
Final soil covering	(ha)	126	109	38	53	51	20	71	73	25
Gas discharge facilities	(unit)	107	92	30	47	55	16	63	70	18
Rainwater drain facilities	(m)	26,200	19,200	8,700	14,800	12,300	4,700	17,000	14,600	5,800
Leachate treatment facilities	(m <sup>3</sup> /d)	1,500	1,300	450	500	800	300	700	900	300

(2) The site layout

i) Selection of the site

Except for the alternative Case No. 13 On-Nooch disposal site, every final disposal site necessitates acquisition of additional landfill areas in order to satisfy the planned landfill volume by 2010. The additional sites were chosen to be located in the adjoining places to the existing site, provided that there are as few houses and other structures to be removed as possible. For the purpose to prevent environmental deterioration of the surroundings, sufficient space was kept between the site boundary line and landfilling area, and in between construction of external structure was planned such as circuit roads, green belt and flood protection banks.

ii) Size of a section

Size of a section was determined on the basis that formation of a section layer with raw waste takes one year; in other words, landfilling of an entire section (five layers) takes five years. In the size determination, condition of the existing facilities and the site topography were also taken into consideration, therefore, some sections were not confined to the above basis.

An outline of landfill capacity and landfilling process for each section are described in Appendix 5.8.

iii) Landfill shape and facilities layout

An example of landfill shape and facilities layout are illustrated in Fig. 5.7 and 5.8. Other landfill facilities layout and location of landfill sites are shown in Appendices 5.9 and 5.10.

iv) Leachate treatment facilities and leachate reservoir pond

- a. Many years after completion of landfill, leachate still oozes out and it is difficult to forecast how long the treatment of oozing leachate should be performed.

For determination of leachate volume to be treated, some conditions were set such that final soil covering should be made immediately after completion of landfill and that leachate oozing from old landfill five years or more after the completion should be excluded from the scope of the treatment.

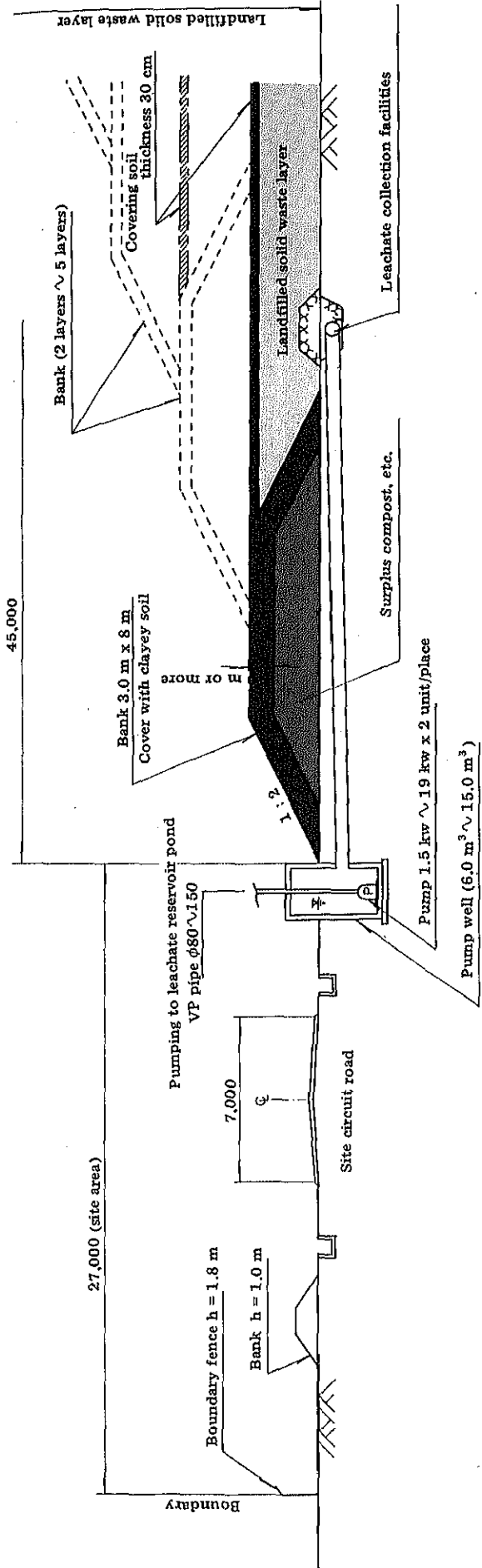
- b. Temporary storage of leachate in the landfill site is thought inevitable from time to time. Accordingly, a leachate reservoir pond was planned in each final disposal site, with capacity to store the leachate volume discharged under probable maximum rainfall of a day through year.

Appendix 5.11 shows outline of leachate treatment facilities and leachate reservoir pond of each final disposal site, planned on the basis of section landfill plan.

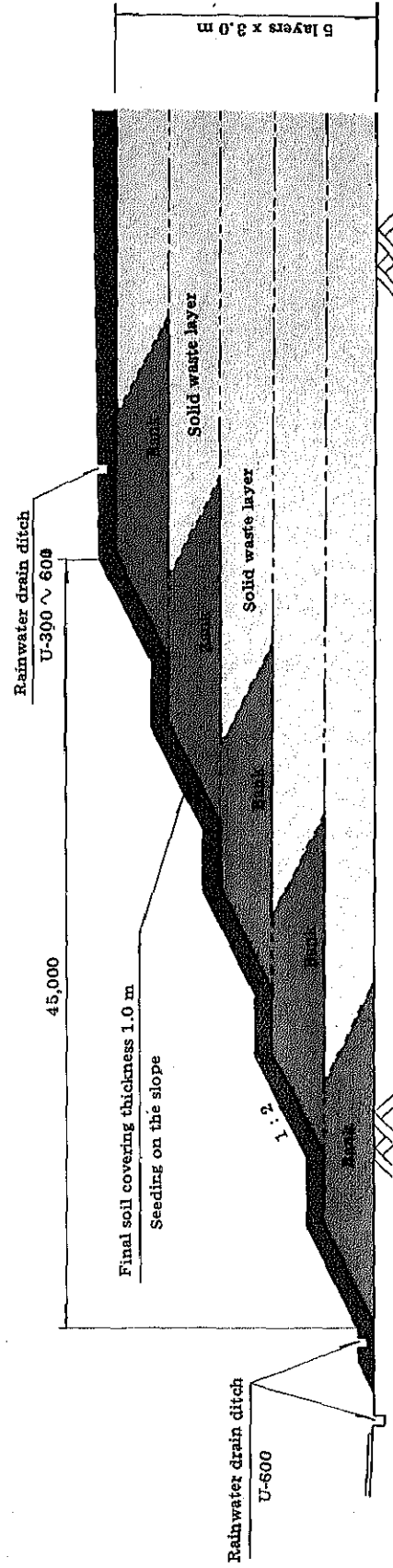


Fig. 5.7 Standard shape of landfill site (section)

(1) At the beginning of landfill



(2) At the completion of landfill



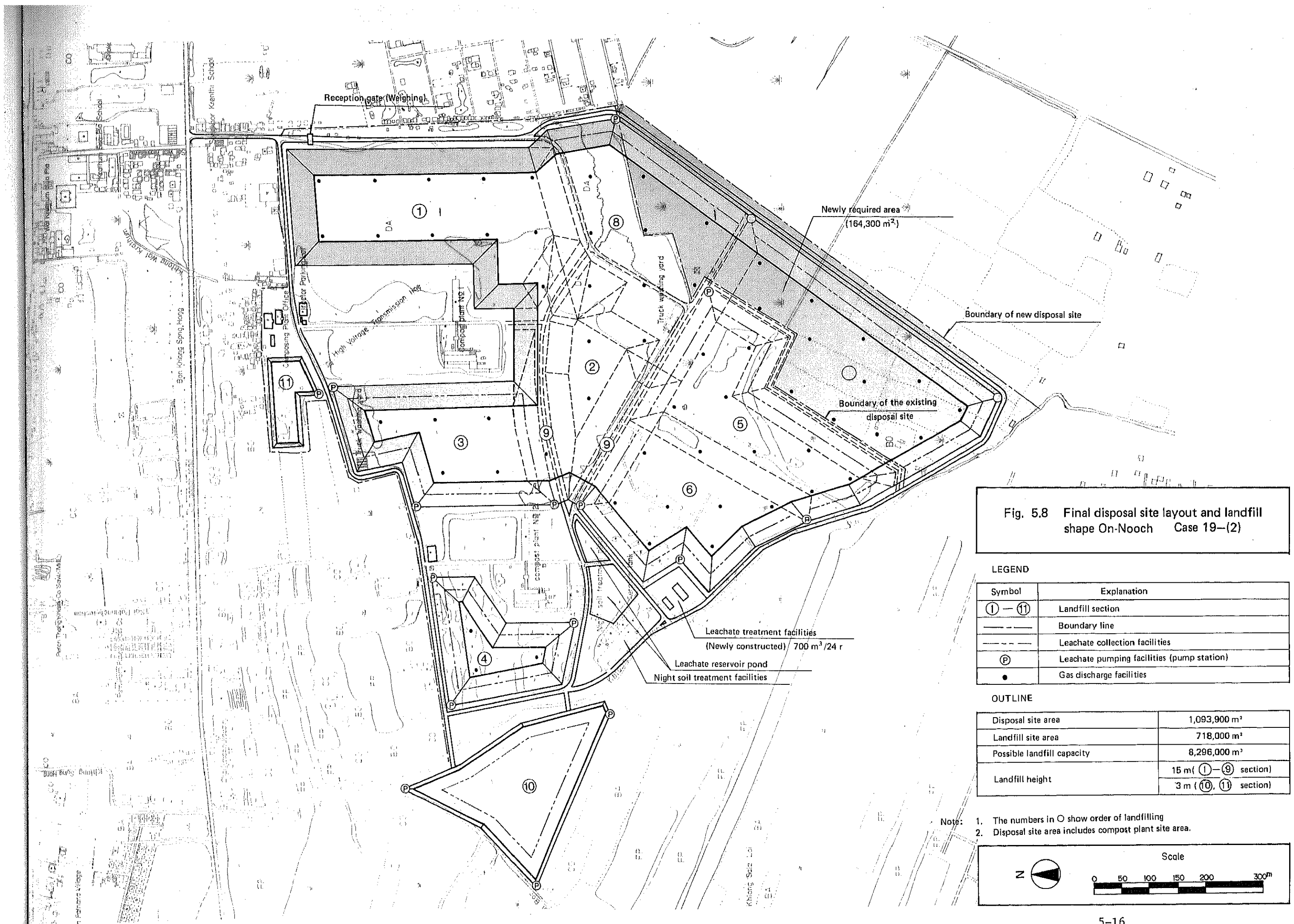


Fig. 5.8 Final disposal site layout and landfill shape On-Nooch Case 19-(2)

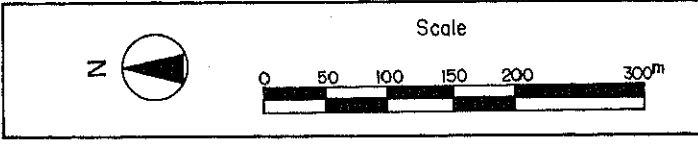
**LEGEND**

Symbol	Explanation
① — ⑪	Landfill section
---	Boundary line
---	Leachate collection facilities
P	Leachate pumping facilities (pump station)
•	Gas discharge facilities

**OUTLINE**

Disposal site area	1,093,900 m <sup>2</sup>
Landfill site area	718,000 m <sup>2</sup>
Possible landfill capacity	8,296,000 m <sup>3</sup>
Landfill height	15 m (①—⑨ section)
	3 m (⑩, ⑪ section)

- Note:
- The numbers in ○ show order of landfilling
  - Disposal site area includes compost plant site area.







#### 5.2.4 Collection trucks parking lot construction plan

In the alternatives Case No. 13 and Case No. 19-(2) which involve establishment of incineration plants, the parking lot will be constructed in each incineration plant utilizing its open space.

In the Case No. 9 which does not involve incineration plant, two proposed incineration plant sites located south and north of the city, at Yannawa and Bangkok Noi, will be converted to construction sites of parking lots for collection trucks. Table 5.6 shows the outline of the parking lot construction plan.

Table 5.6 Outline of parking lot construction plan

Case No.	Site	Parking area (m <sup>2</sup> )	Parking capacity	Building area (m <sup>2</sup> )	Remark
9	Yannawa	14,400	400 trucks	560	Each site has 16,000 m <sup>2</sup> area. Building area is for office and repair shop.
	Bangkok Noi	14,400	400 trucks	560	
13	Yannawa	11,200	300 trucks	-	Parking lot is attached to incineration plant.
	Bangkok Noi	12,350	300 trucks	-	
19-(2)	Yannawa	11,200	300 trucks	-	-do-
	Dusit	9,600	300 trucks	-	

#### 5.2.5 The existing compost plant major repair plan

Major repair of the existing compost plants should be made in 1990 and 2000 so as to maintain their function as it is during the project span. The major repair involves correction, replacement and precautionary treatment of those parts which will deteriorate by wear, corrosion, etc., in the long run. Therefore, the repair will be made on mechanical facilities and equipment mainly, such as crane, hopper, belt conveyor, pulverizer, fermentation trough, insulating fire brick, exhaust gas duct, gas cooling facilities, stack and trommel.

### 5.2.6 Equipment acquisition plan

Acquisition plan of equipment such as collection trucks, mechanical road sweepers, landfilling equipment and river cleaning boats needed in each case of the alternatives is shown in Table 5.7. In the table, the figures show number of equipment to be purchased during each five years. The acquisition is assumed to be made every year. Contents of the equipment by types by work items are shown in Appendix 5.12.

The equipment acquisition during the year 2001 to 2010 was also planned for the use of economic and financial analysis.

### 5.2.7 Man power plan

Manpower plan is divided into two parts: one is number of personnel relating to collection and transportation and the other is that relating to intermediate treatment and final disposal. The details are shown in Tables 5.8 and 5.9. Number of managing staff on collection and transportation work was assumed equivalent to 3.8 - 5.0% of the field workers, and the same on intermediate treatment and final disposal work was estimated by the facilities.

Number of employees by types of work by facilities is shown in Appendices 5.13 and 5.14.

Table 5.8 Man power for collection transportation work

(Unit: person)

Case No.	Type of worker	Fiscal year						Total
		1983	1986	1991	1996	*2001*	*2006*	
		1985	1990	1995	2000	2005	2010	
9	Driver, worker, etc.	463	770	1,349	2,078	1,202	1,093	6,955
	Officer	17	31	57	94	57	55	311
	Total	480	801	1,406	2,172	1,259	1,148	7,266
13	Driver, worker, etc.	463	784	1,031	1,407	783	900	5,368
	Officer	17	31	44	64	37	45	238
	Total	480	815	1,075	1,476	820	945	5,606
19-(2)	Driver, worker, etc.	463	284	1,023	1,377	1,077	941	5,653
	Officer	17	31	44	62	51	47	252
	Total	480	815	1,067	1,439	1,128	988	5,905
Without-project case	Driver worker etc.	463	784	1,384	2,193	1,231	2,353	8,408
	Officer	17	31	59	100	58	118	383
	Total	480	805	1,443	2,293	1,289	2,471	8,791

Note: \* The figures after the year 2001 were calculated as a reference for economic and financial analyses.

Table 5.7 Movable equipment acquisition plan

(Unit: person)

Case No.	Equipment	Fiscal year						Total
		1983 <sup>2)</sup> 1985	1986 <sup>2)</sup> 1990	1991 <sup>2)</sup> 1995	1996 <sup>2)</sup> 2000	2001 <sup>3)</sup> 2005	2006 <sup>3)</sup> 2010	
9	Collection truck	142	255	535	660	607	820	3,019
	Mech. road sweeper	2	17	38	38	28	61	184
	Compost plant equipment	1	32	14	14	29	4	94
	Landfill equipment	2	29	7	26	15	13	92
	Other vehicle <sup>1)</sup>	0	1	17	7	6	117	48
	River cleaning boat	5	11	56	42	11	56	181
	Total	152	345	667	787	696	971	3,618
13	Collection truck	142	223	449	541	465	637	2,457
	Mech. road sweeper	2	17	38	38	28	61	184
	Compost plant equipment	1	21	12	27	10	23	94
	Landfill equipment	2	28	6	22	9	12	79
	Other vehicle <sup>1)</sup>	0	14	36	17	19	36	122
	River cleaning boat	5	11	56	42	11	56	181
	Total	152	314	597	687	542	825	3,117
19-(2)	Collection truck	142	223	449	521	552	684	2,571
	Mech. road sweeper	2	17	38	38	28	61	184
	Compost plant equipment	1	21	12	27	10	23	94
	Landfill equipment	2	29	5	23	13	11	83
	Other vehicle <sup>1)</sup>	0	14	30	7	19	30	100
	River cleaning boat	5	11	56	42	11	56	181
	Total	152	315	590	658	633	865	3,213
without-project <sup>2)</sup>	Collection truck	142	255	536	693	619	841	3,086
	Mech. road sweeper	2	17	38	38	28	61	184
	Compost plant equipment	1	21	2	14	9	1	48
	Landfill equipment	0	8	4	8	7	0	27
	Other vehicle <sup>1)</sup>	0	1	17	7	6	17	48
	River cleaning boat	5	11	56	42	11	56	181
	Total	150	313	653	802	680	976	3,574

Note \* Other vehicles are dump trucks to transport solid waste collected from rivers, khlongs and incineration residue.

\*\* Refer to the definition of "Without project" in Chapter 6.

\*\*\* The figures after the year 2001 were calculated as a reference for economic and financial analyses.

Table 5.9 Man power for intermediate treatment and final disposal

(Unit: person)

Case No.	Facilities	Fiscal year						Total
		1983 1985	1986 1990	1991 1995	1996 2000	2001* 2005	2006* 2010	
9	Incineration plant	-	-	-	-	-	-	-
	New compost plant	0	0	96	171	0	0	267
	Landfill sites	20	42	25	28	35	30	180
	Total	20	42	121	199	35	30	447
13	Incineration plant	0	0	98	168	84	0	350
	New compost plant	0	0	0	96	171	0	267
	Landfill site	20	35	1	118	13	13	48
	Total	20	35	99	246	252	13	665
19-(2)	Incineration plant	0	0	98	98	0	0	196
	New compost plant	0	0	0	96	171	0	267
	Landfill site	20	36	1	19	15	24	87
	Total	20	36	99	185	186	24	550
without-project	Incineration plant	-	-	-	-	-	-	-
	New compost plant	-	-	-	-	-	-	-
	Landfill site	9	10	29	26	23	30	127
	Total	9	10	29	26	23	30	127

Note: \* The figures after the year 2001 were calculated as a reference for economic and financial analyses.

## 5.3 Solid Waste Management Facilities Construction Plan

### 5.3.1 Intermediate treatment facilities construction plan

Figure 5.9 shows a standardized construction process of incineration plant and compost plant. Based on this process, attempts were made to formulate the most practicable construction plan taking the following conditions into account:

- i) Priority of construction of the facilities
  - a. Demand size for solid waste management facilities  
Higher priority of the facility construction should be given to the proposed site which is located near to high density solid waste generation area.
  - b. Economical collection and transportation costs  
Result of simulation made in Phase I Study should be reflected.
  - c. Site considerations  
The present state, urbanization tendency, ease of acquisition, etc. of the proposed site.
  - d. Balance with the existing compost plants
  - e. Reducibility of environmental burden
- ii) Process and period of the construction of the facilities
  - a. Results of similar construction in Japan
  - b. Circumstances in Bangkok city, relating to the construction
- iii) The facilities construction cost
  - a. Minimization and averaging of annual financial burden
  - b. Avoidance of duplication of similar individual project
  - c. Minimization of the total cost
- iv) Facilitation of fund raising
  - a. Division of the project into several construction stages (each stage will be completed within 3 ~ 5 years)
  - b. Adaptability to financial aid system of World Bank, etc.
  - c. Adaptability to fiscal year system
  - d. Possibility of divided fund raising and payment
  - e. Consideration of conditions of finance
- v) Ability of the project implementation organization
  - a. Ability to control preparation of the plan and construction

- b. Ability to secure necessary man power (labourers, engineers, etc.)
- c. Technical competence
- vi) Coordination with the short-term improvement plan
  - a. Balance with the existing compost plants
  - b. Harmony with achievement of short-term improvement

As the result, three cases of intermediate treatment facilities construction plan alternatives were formulated. Among them, the case shown in Fig. 5.10 was selected as the most advantageous plan to construct all facilities required within a limited project time span.

Incidentally, costs of facilities in the project were all calculated based on this case.

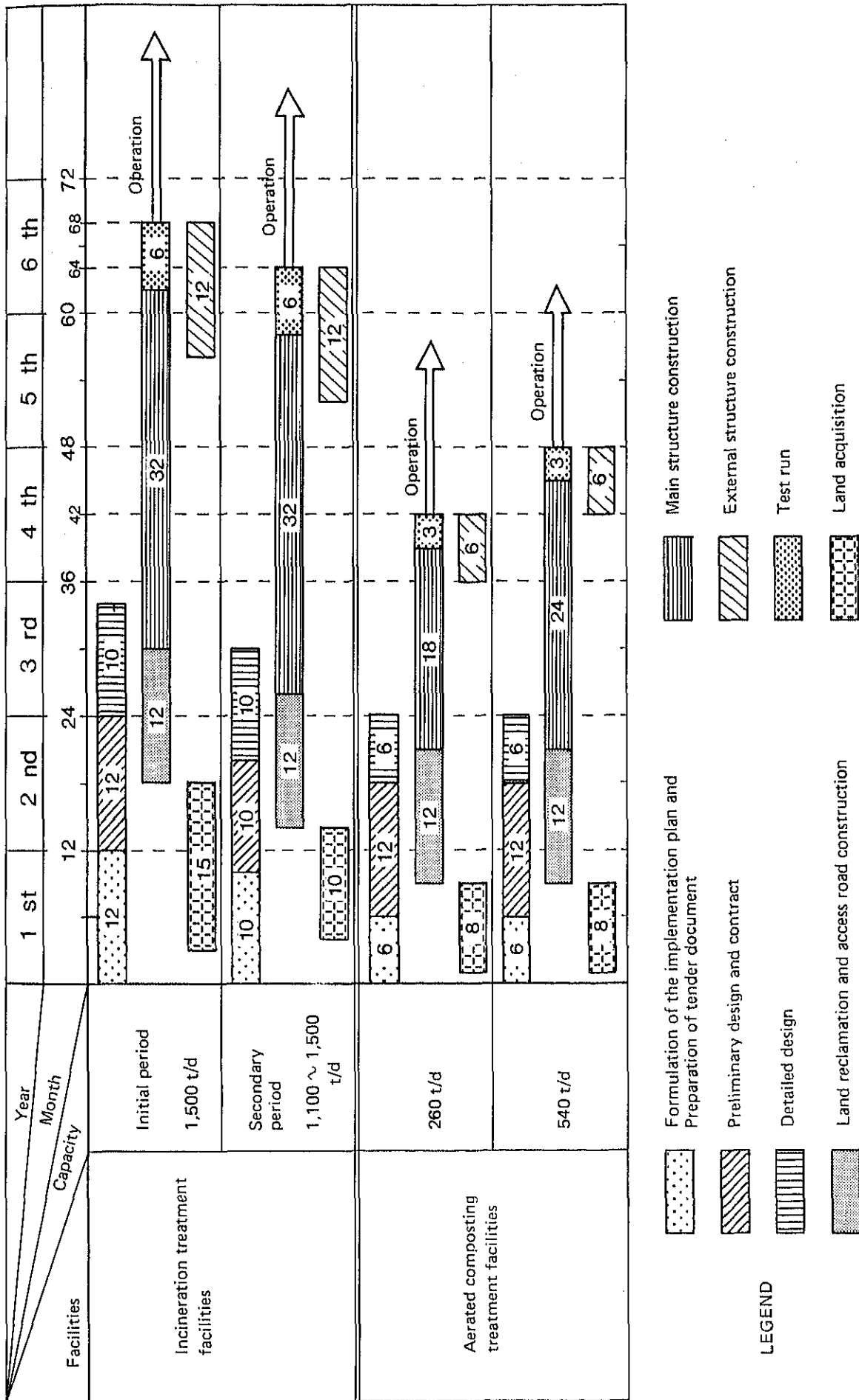
### 5.3.2 Final disposal site construction plan

The period of a landfill plan often extends over tens of years. Therefore, in construction of the final disposal site, it may be advantageous to construct the landfill site section by section according to progress of landfill work.

Facilities of final disposal site are roughly classified into two categories: facilities necessary for landfill work and that for finishing the completed landfill.

A standardized construction process of final disposal site is shown in Fig. 5.11. The construction period was assumed constant regardless of work volume for construction of each section because the period is adjustable by means of increase or decrease of construction machinery. Facilities construction plans of each final disposal site are shown in Appendix 5.15.

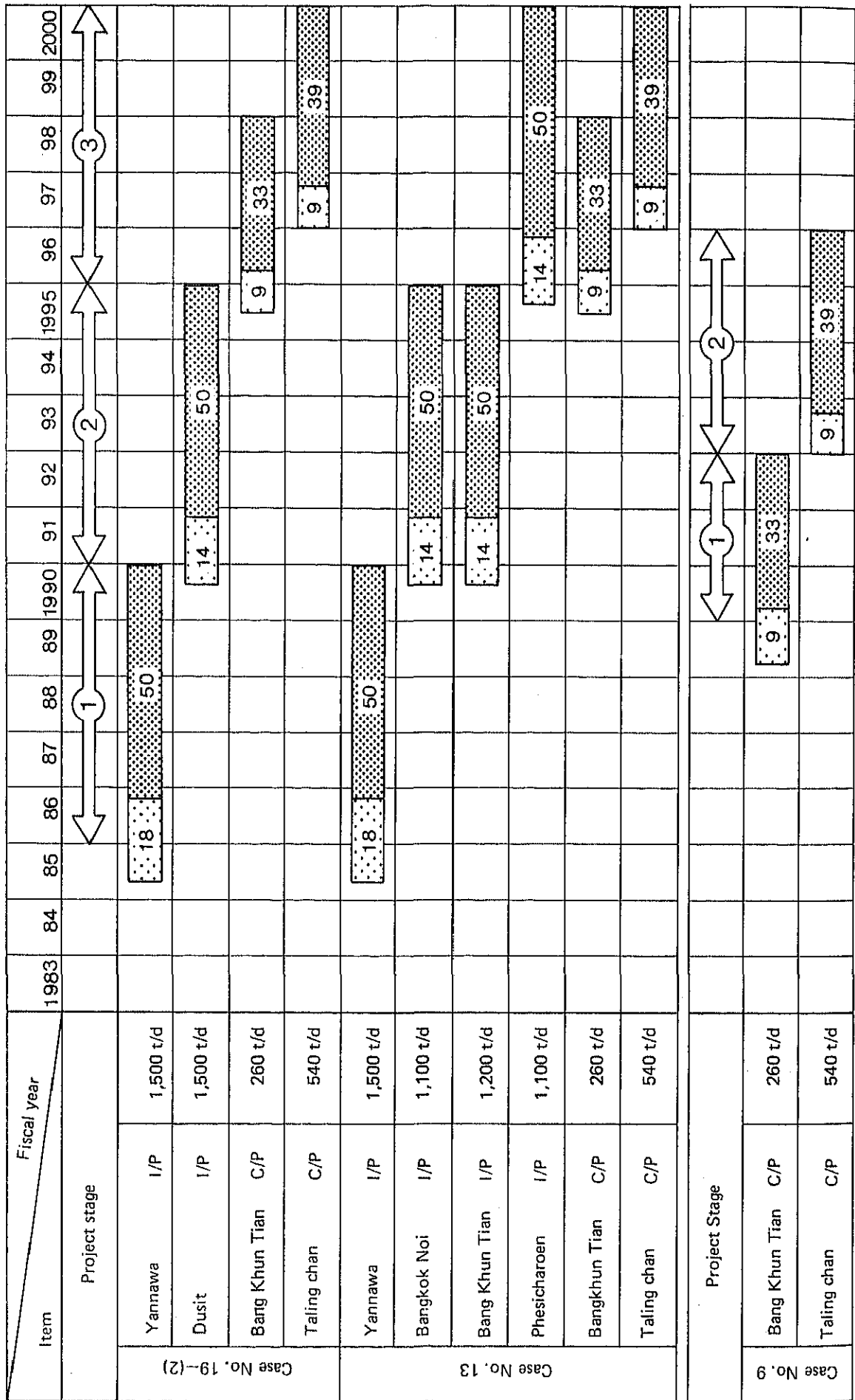
Fig. 5.9 Standardized construction process of intermediate treatment facilities



Note: Numbers in the bars show the required months

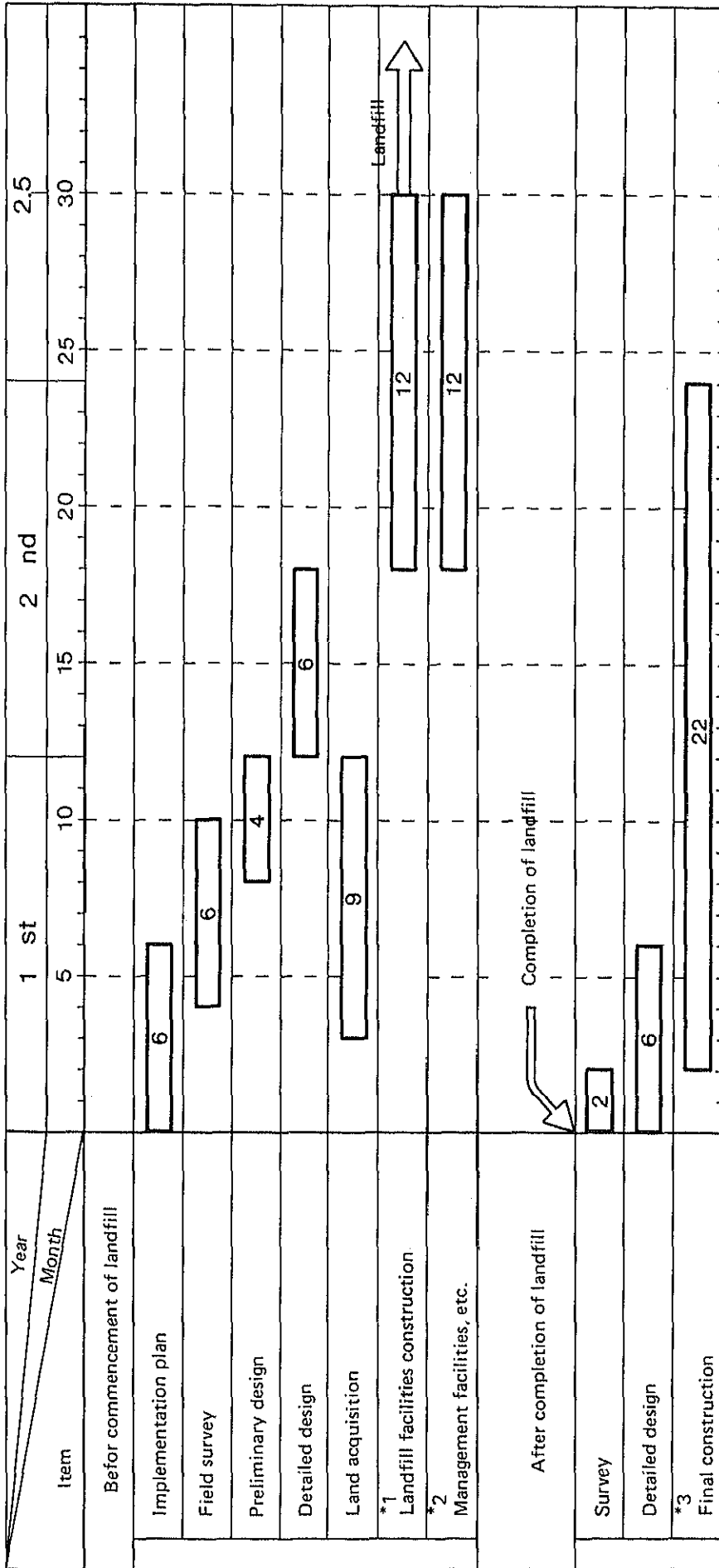


Fig. 5.10 Intermediate treatment facilities construction plan



Note: Numbers in the bars show the required period in months  
 I/P: Incineration plant  
 C/P: Compost plant

Fig. 5.11 A standardized construction plan of final disposal site



- Note:
- \*1 Leachate collection and discharge facilities, embankment, etc.
  - \*2 Leachate treatment facilities, in-site road, repair shop, office, etc.
  - \*3 Final soil covering, Gas discharge and rain water drain facilities, etc.

## 5.4 Cost Estimation

### 5.4.1 Scope and method of the cost estimation

#### (1) Scope of the cost estimation

Scope of the cost estimation was limited to items relating to the facilities plan mentioned in the preceding paragraph.

The total cost by the alternative cases by years, which gives information for comparison of the alternative cases, is introduced in the next chapter.

#### (2) Method of the cost estimation

As many cost elements as possible were summed up to estimate the project cost, upon which economic and financial analyses were made. These cost elements can be classified into three categories: land acquisition cost, construction cost and operation and maintenance cost.

Assumptions applied to the estimation were as follows:

##### a. Currency exchange rate

1980 was taken as a base year and all costs were converted to 1980 base prices. From exchange rates between U.S. dollars, Thai Baht and Japanese Yen (U.S.\$1 = ¥226.75), one Baht was calculated equivalent to eleven Japanese Yen (Baht 1 = ¥11.06).

##### b. Foreign currency part

Among equipment and machinery for incineration plant, new compost plant and final disposal site, those which are not available in Thailand were assumed to be imported from overseas at CIF value. Import tax was calculated on the basis of Customs Tariff and Business Tax of Thailand in 1981. Foreign currency part of equipment and machinery used in the financial cost estimation was calculated by adding import tax, average profit of the importer and the business tax to the CIF price.

##### c. Local currency part

Except for the above-mentioned foreign currency part and costs for oil and steel, construction cost was assumed to be local currency part.

Local currency part was divided into material cost and labour cost, and labour cost was further subdivided to the costs for skilled workers and unskilled workers. As for installation of equipment and machinery in incineration plants, assistance of foreign skilled labourers will be needed, therefore, their duty assignment cost was also included.

#### 5.4.2 The facilities construction cost

##### (1) Incineration plant

As there is no preceding example of construction of a large size incineration plant in Thailand, examples from foreign countries were taken as bases of the construction cost estimation. The estimation was made taking design conditions given in the facilities plan into account. The construction cost was classified into financial cost and economic cost as shown in Tables 5.10 and 5.11.

The main assumptions of the estimation were as follows:

##### a. Design fee

The design fee was assumed to be one percent of the total construction cost. In addition, 4 million Baht per plant was added as the cost for surveys of soil, land and environmental assessment.

##### b. Construction supervision fee

The supervision fee was set at 20% of design cost. Residential fee of staff for the supervision was separately appropriated.

##### c. Temporary structure construction cost, construction site management cost and general management cost

An amount equivalent to 12% of a sum of machinery & equipment purchase cost and labour cost was allocated for the above-mentioned costs.

##### d. Cost for inland transport of equipment and machinery

Tonnage of material including equipment and machinery needed for construction of 1,000 t/d plant was estimated to be 6,400 tons. Considering the scale of plant and traffic condition in Thailand, 3 ~ 4 million Baht was allocated as the inland transport cost.

##### e. Business tax

The sum of machinery and equipment cost, temporary structure construction cost, construction site management cost and general management cost was defined as economic cost. An amount equal to 3.3% of the economic cost was allocated to business tax.

##### f. Classification to local and foreign currency parts

Costs were classified into either local or foreign currency part according to the current availability of machinery and equipment for incineration plant facilities in Thailand.

##### g. Labour cost

Labour cost was also classified to local or foreign currency part according to type of work and the availability of local labour to perform the work.

Table 5.10 Incineration plant construction cost (Financial Cost)

(Unit : million Baht)

Case No.	Plant	Currency	Construction cost	Design fee	Supervision fee	Total
13	Yannawa 1,500 t/d	F/C	1,204.6	17.0	48.2	1,269.8
		L/C	515.9	4.2	7.5	527.6
		Total	1,720.5	21.2	55.7	1,797.4
	Bang Kapi 1,200 t/d	F/C	1,071.5	15.2	47.9	1,134.6
		L/C	425.8	3.8	7.4	437.0
		Total	1,497.3	19.0	55.3	1,571.6
	Bangkok Noi 1,100 t/d	F/C	1,068.7	15.0	47.8	1,131.5
		L/C	403.7	3.7	7.4	414.8
		Total	1,472.4	18.7	55.2	1,546.2
	Phasi Charoen 1,100 t/d	F/C	1,068.7	15.0	47.9	1,131.6
		L/C	414.2	3.8	7.4	425.4
		Total	1,482.9	18.8	55.3	1,557.0
Total 4,900 t/d	F/C	4,413.5	62.2	191.8	4,667.5	
	L/C	1,759.6	15.5	29.7	1,804.8	
	Total	6,173.1	77.7	221.5	6,972.3	
19-(2)	Yannawa 1,500 t/d	F/C	1,204.6	17.0	48.2	1,269.8
		L/C	515.9	4.2	7.5	527.6
		Total	1,720.5	21.2	55.7	1,797.4
	Dusit 1,500 t/d	F/C	1,204.6	17.0	48.2	1,269.8
		L/C	501.1	4.1	7.5	512.7
		Total	1,705.1	21.1	55.7	1,782.5
	Total 3,000 t/d	F/C	2,409.2	34.0	96.4	2,539.6
		L/C	1,017.0	8.1	15.0	1,040.1
		Total	3,425.6	42.3	111.4	3,579.9

Note: F/C: Foreign currency portion  
L/C: Local currency portion

Table 5.11 Incineration plant construction cost (Economic Cost)

(Unit : million Baht)

Case No.	Plant	Currency	Construction cost	Design fee	Supervision fee	Total
13	Yannawa 1,500 t/d	F/C	1,023.8	7.0	48.2	1,089.0
		L/C	460.9	3.5	5.7	470.1
		Total	1,484.7	20.5	53.9	1,559.1
	Bang Kapi 1,200 t/d	F/C	911.6	15.2	47.9	974.7
		L/C	378.0	3.2	5.6	386.8
		Total	1,289.6	18.4	53.5	1,361.5
	Bangkok Noi 1,100 t/d	F/C	909.5	15.0	47.8	972.3
		L/C	356.7	3.1	5.6	365.4
		Total	1,266.2	18.1	53.4	1,337.7
	Phasi Charoen 1,100 t/d	F/C	909.5	15.0	47.9	972.4
		L/C	366.8	3.2	5.6	375.6
		Total	1,276.3	18.2	53.5	1,348.0
Total 4,900 t/d	F/C	3,754.4	62.2	191.8	4,008.4	
	L/C	1,562.4	33.4	22.5	1,597.9	
	Total	5,316.8	95.6	214.3	5,606.3	
19-(2)	Yannawa 1,500 t/d	F/C	1,023.8	17.0	48.2	1,089.0
		L/C	460.9	3.5	5.7	470.1
		Total	1,484.7	20.5	53.9	1,559.1
	Dusit 1,500 t/d	F/C	1,423.9	17.0	48.2	1,089.1
		L/C	446.6	3.4	5.7	455.7
		Total	1,470.5	20.4	53.9	1,544.8
	Total 3,000 t/d	F/C	2,047.7	34.0	96.4	2,178.1
		L/C	907.5	6.9	11.4	925.8
		Total	2,955.2	40.9	107.8	3,103.9

Note: F/C: Foreign currency portion  
L/C: Local currency portion

h. Price of machinery and equipment

All prices were converted to CIF prices for the base year, 1980.

i. CIF price

CIF price was assumed to be 30% higher than average net price in the country of shipment origin.

j. Customs duties, standard profit and business tax

Customs duties were assumed to be equivalent to 10% of the CIF price, and standard profit was set at 16% of a sum of CIF price and customs duties. As for business tax, two rates (7% and 3%) were applied according to type of goods.

Table 5.12 shows contents of incineration plant construction cost by cost item by capacity.

The detailed construction cost by items is shown in Appendix 5.16.

(2) New compost plant

Construction cost of new compost plants was estimated in the same manners as applied to cost estimation of incineration plant.

The total estimated construction cost is shown in Table 5.13 and the breakdown by cost item are shown in Table 5.14.

Table 5.12 Contents of incineration plant construction  
cost by cost item by capacity (Financial cost)

(Unit: million Baht)

Cost item		1500 t/d			1200 t/d		
		Foreign	Local	Total	Foreign	Local	Total
Cost for facilities, equipment and machinery	Solid waste reception and feeding facilities	54.0	-	54.0	47.4	-	47.4
	Incineration facilities	174.9	-	174.9	153.0	-	153.0
	Combustion gas cooling facilities	150.3	-	150.3	131.5	-	131.5
	Condenser	4.0	-	4.0	3.5	-	3.5
	Water purifying apparatus	10.7	-	10.7	8.9	-	8.9
	Combustion gas treatment facilities	165.1	-	165.1	144.4	-	144.4
	Water supply equipment	5.3	-	5.3	25.6	-	25.6
	Waste water treatment facilities	49.5	-	49.5	43.5	-	43.5
	Waste heat utilization facilities	45.6	-	45.6	40.0	-	40.0
	Electricity generator	56.4	-	56.4	49.9	-	49.9
	Ventilator	14.1	-	14.1	12.7	-	12.7
	Exhaust gas duct	26.4	-	26.4	23.1	-	23.1
	Stack	19.5	-	19.5	17.1	-	17.1
	Ash crane	14.0	-	14.0	12.3	-	12.3
	Electrical equipment	123.5	-	123.0	108.5	-	108.5
	Guage and meter	122.3	-	122.3	107.5	-	107.5
	Piping	43.4	-	43.4	36.8	-	36.8
	Subtotal	1,079.0	-	1,079.0	965.7	-	965.7
	Equip. installation fee	*83.6	*12.5	*96.1	*72.1	*10.8	*82.9
	Architectural construction cost	41.7	198.0	239.7	33.3	158.5	191.8
	Foundation construction cost	0.1	29.0	29.1	0.1	22.7	22.8
	Attached construction cost	0.2	42.7	42.9	0.3	30.4	30.7
	Temporary structure construction, site management and general management costs	-	178.4	178.4	-	155.3	155.3
	Inland transport cost	-	0.3	0.3	-	0.3	0.3
	Business tax	-	55.0	55.0	-	47.8	47.8
	Total	1,204.6	515.9	1,720.5	1,071.5	425.8	1,497.3

Note: Figures in \*-marked columns show examples taken from the cases of Yannawa and Bang Kapi.



Table 5.13 New compost plant construction cost  
(Both Financial and Economic Costs)

(Unit : million Baht)

Cost type	Plant	Currency	Construction cost	Design fee	Super- vision fee	Total
Financial Cost (Common to all cases)	Bang Khun Tian 260 t/d	F/C	67.2	4.8	12.4	84.4
		L/C	131.5	1.2	3.9	136.6
		Total	198.7	6.0	16.3	221.0
	Taling Chan 540 t/d	F/C	126.8	7.5	15.0	149.3
		L/C	237.2	2.0	4.4	243.6
		Total	364.0	9.5	19.4	392.9
	Total 800 t/d	F/C	194.0	12.3	27.4	233.7
		L/C	368.7	3.2	8.3	380.2
		Total	562.7	15.5	35.7	613.9
Economic Cost (Common to all cases)	Bang Khun Tian 260 t/d	F/C	56.8	4.8	12.4	74.0
		L/C	125.2	1.0	3.4	129.6
		Total	182.0	5.8	15.8	203.6
	Taling Chan 540 t/d	F/C	107.1	7.5	15.0	129.6
		L/C	225.5	1.7	3.8	231.0
		Total	332.6	9.2	18.8	360.6
	Total 800 t/d	F/C	163.9	12.3	27.4	203.6
		L/C	350.7	2.7	7.2	360.6
		Total	514.6	15.0	34.6	564.2

Note: F/C: Foreign currency portion  
L/C: Local currency portion

Table 5.14 Contents of new compost plant construction cost by cost item (Financial cost)

(Unit : million Baht)

Cost item		Bang Khun Tian (260 t/d)			Taling Chan (540 t/d)		
		Foreign	Local	Total	Foreign	Local	Total
Machine & equip- ment cost	Solid waste reception and manual selection facilities	24.7	-	24.7	49.4	-	49.4
	Fermentation facilities	3.2	-	3.2	6.4	-	6.4
	Secondary selection (Trommel) facilities	18.0	-	18.0	36.0	-	36.0
	Subtotal	45.9	-	45.9	91.8	-	91.8
Equipment installation fee		1.0	0.3	1.3	1.9	0.5	2.4
Architectural construction cost		12.1	37.2	49.3	24.3	73.7	98.0
Foundation construction cost		0.1	27.5	27.6	0.1	54.7	54.8
Attached facilities construction cost		8.1	39.7	47.8	8.7	58.9	67.6
Temporary structure construction, site management and any general management costs		-	20.6	20.6	-	37.8	37.8
Business tax		-	6.3	6.3	-	11.6	11.6
Total		67.2	131.6	198.8	126.8	237.2	364.0

### (3) Final disposal site

Final disposal site construction cost differs with the alternatives; therefore, construction cost of On-Nooch disposal site was estimated first, then, based on it, construction cost per unit solid waste disposal volume was calculated and applied to estimation of construction cost of each final disposal site. This cost contains construction of banks, leachate collection, treatment and discharge facilities, gas discharge facilities, rainwater drain facilities, final soil covering, access roads, reception and weighing facilities, vehicle washing facilities, repair shop, electric facilities, water supply and drain facilities, office building, etc. The results of the cost estimation are shown in the Tables 5.15 and 5.16.

The detailed construction cost by item is described in Appendix 5.17.

Table 5.15 Final disposal site construction cost (Financial Cost)

(Unit : million Baht)

Case No.	Final disposal site	Currency	Construction cost	Design fee	Super- vision fee	Total
9	On-Nooch	F/C	30.4	-	-	30.4
		L/C	483.9	12.9	2.6	499.4
		Total	514.3	12.9	2.6	529.8
	Nong Khaem	F/C	29.8	-	-	29.8
		L/C	471.1	12.5	2.5	486.1
		Total	500.9	12.5	2.5	515.9
	Ram Intra	F/C	13.1	-	-	13.1
		L/C	186.8	5.0	1.0	192.8
		Total	199.9	5.0	1.0	205.9
	Total	F/C	73.3	-	-	73.3
		L/C	1,141.8	30.4	6.1	1,178.3
		Total	1,215.1	30.4	6.1	1,251.6
13	On-Nooch	F/C	17.0	-	-	17.0
		L/C	247.7	6.6	1.3	255.6
		Total	264.7	6.6	1.3	272.6
	Nong Khaem	F/C	20.6	-	-	20.6
		L/C	306.3	8.2	1.6	316.1
		Total	326.9	8.2	1.6	336.7
	Ram Intra	F/C	7.8	-	-	7.8
		L/C	103.2	2.8	0.6	106.6
		Total	111.0	2.8	0.6	114.4
	Total	F/C	45.4	-	-	45.4
		L/C	657.2	17.6	3.5	678.3
		Total	702.6	17.6	3.5	723.7
19-(2)	On-Nooch	F/C	22.6	-	-	22.6
		L/C	340.3	9.1	1.8	351.2
		Total	362.9	9.1	1.8	373.8
	Nong Khaem	F/C	24.8	-	-	24.8
		L/C	377.5	10.1	2.0	389.6
		Total	402.3	10.1	2.0	414.4
	Ram Intra	F/C	9.2	-	-	9.2
		L/C	124.8	3.4	0.7	128.9
		Total	134.0	3.4	0.7	138.1
	Total	F/C	56.6	-	-	56.6
		L/C	842.6	22.6	4.5	869.7
		Total	899.2	22.6	4.5	926.3

Note: F/C: Foreign currency portion  
L/C: Local currency portion

Table 5.16 Final disposal site construction cost (Economic Cost)

(Unit : million Baht)

Case No.	Final disposal site	Currency	Construction cost	Design fee	Super- vision fee	Total
9	On-Nooch	F/C	24.2	-	-	24.2
		L/C	466.7	12.5	2.5	481.7
		Total	490.9	12.5	2.5	505.9
	Nong Khaem	F/C	23.8	-	-	23.8
		L/C	453.7	12.1	2.4	468.2
		Total	477.5	12.1	2.4	492.0
	Ram Intra	F/C	10.6	-	-	10.6
		L/C	178.1	4.8	1.0	183.9
		Total	188.7	4.8	1.0	194.5
	Total	F/C	58.6	-	-	58.6
		L/C	1,098.5	29.4	5.9	1,133.8
		Total	1,157.1	29.4	5.9	1,192.4
13	On-Nooch	F/C	13.7	-	-	13.7
		L/C	236.5	6.4	1.3	244.2
		Total	250.2	6.4	1.3	257.9
	Nong Khaem	F/C	16.7	-	-	16.7
		L/C	292.8	7.9	1.5	302.2
		Total	309.5	7.9	1.5	318.9
	Ram Intra	F/C	6.2	-	-	6.2
		L/C	98.3	2.7	0.6	101.6
		Total	104.5	2.7	0.6	107.8
	Total	F/C	36.6	-	-	36.6
		L/C	627.6	17.0	3.4	648.0
		Total	664.2	17.0	3.4	684.6
19-(2)	On-Nooch	F/C	18.3	-	-	18.3
		L/C	325.6	8.8	1.7	336.1
		Total	343.9	8.8	1.7	354.4
	Nong Khaem	F/C	20.0	-	-	20.0
		L/C	361.7	9.8	1.9	373.4
		Total	381.7	9.8	1.9	393.4
	Ram Intra	F/C	7.3	-	-	7.3
		L/C	118.9	3.3	0.7	122.9
		Total	126.2	3.3	0.7	130.2
	Total	F/C	45.6	-	-	45.6
		L/C	806.2	21.9	4.3	832.4
		Total	851.8	21.9	4.3	878.0

Note: F/C: Foreign currency portion  
L/C: Local currency portion

(4) Parking lot

As explained in the facility plan, a parking lot will be constructed in the Case No. 9 only. Its construction cost was estimated as shown in Table 5.17 below. (Details of the estimation are given in Appendix 5.18)

Table 5.17 Parking lot construction cost

(Unit : million Baht)

Cost Type	Location	Currency	Construction cost	Design fee	Super- vision fee	Total
Financial Cost	Yannawa	F/C	2.7	-	-	2.7
		L/C	53.7	2.3	1.1	57.0
		Total	56.3	2.3	1.1	59.7
	Bangkok Noi	F/C	2.7	-	-	2.7
		L/C	50.6	2.1	1.1	53.8
		Total	53.3	2.1	1.1	56.5
	Total	F/C	5.4	-	-	5.4
		L/C	104.3	4.4	2.2	110.8
		Total	109.6	4.4	2.2	116.2
Economic Cost	Yannawa	F/c	1.9	-	-	1.9
		L/C	51.7	2.2	1.1	55.0
		Total	53.6	2.2	1.1	56.9
	Bangkok Noi	F/c	1.9	-	-	1.9
		L/C	48.8	2.0	1.1	51.9
		Total	50.7	2.0	1.1	53.8
	Total	F/C	3.8	-	-	3.8
		L/C	100.5	4.2	2.2	106.9
		Total	104.3	4.2	2.2	110.7

Note: F/C: Foreign currency portion  
L/C: Local currency portion

(5) The existing compost plant

Continuous use of the existing compost plants is a basic condition for all three cases of the alternatives; therefore, the repair cost which may be needed during the project span was estimated. Each of four existing compost plants (On-Nooch No. 1 and No. 2, Nong Khaem and Ram Intra) is assumed to undergo a six-month long major repair in the years 1990 and 2000. The estimation results are shown in Table 5.18.

Table 5.18 The existing compost plant major repair cost

(Unit: million Baht)

Plant	Item	Financial cost			Economic cost		
		F/C	L/C	Total	F/C	L/C	Total
320 t/d plant (one major repair) (On-Nooch No. 1 & No. 2, Ram Intra)	Weigh house	0.3	2.6	2.9	0.3	2.5	2.8
	Incoming platform	-	-	0	-	-	-
	Pulverization and selection bldg.	-	1.0	1.0	-	1.0	1.0
	Pulverization and selection facilities	25.0	1.6	26.6	21.3	1.5	22.8
	Primary fermentation house	4.1	12.1	16.2	3.5	11.7	15.2
	Incineration house	16.9	7.2	24.1	14.4	7.0	21.4
	Stack	4.0	1.8	5.8	3.4	1.7	5.1
	Water supply facilities	0.7	0.5	1.2	0.6	0.5	1.1
	Others	-	-	0	-	-	0
	Subtotal	51.0	26.8	77.8	43.5	25.9	69.4
3 plants x twice		306.0	160.8	466.8	261.0	155.4	416.4
160 t/d plant (one major repair) (Nong Khaem only)	Weigh house	0.2	1.7	1.9	0.2	1.6	1.8
	Incoming platform	-	-	0	-	-	-
	Pulverization and selection bldg.	-	0.1	0.6	-	0.6	0.6
	Pulverization and selection facilities	16.5	1.0	17.5	14.0	1.0	15.0
	Primary fermentation house	2.7	8.0	10.7	2.3	7.7	10.0
	Incineration house	11.1	4.8	15.9	9.4	4.6	14.0
	Stack	2.7	1.1	3.8	2.3	1.1	3.4
	Water supply facilities	0.5	0.3	0.8	0.4	0.3	0.7
	Others	-	-	0	-	-	-
Subtotal	33.7	17.5	51.2	28.6	16.9	45.5	
1 plant x twice		67.4	35.0	102.4	57.2	33.8	91.0
Total		373.4	195.8	569.2	318.2	189.2	507.4

Note: F/C: Foreign currency portion  
L/C: Local currency portion

### 5.4.3 Land acquisition cost

Land acquisition cost for purchase of the facility sites was estimated on the basis of published prices in Bangkok city in fiscal 1980. The financial cost was estimated at 60% higher than the economic cost. Table 5.19 shows the results of the estimation. Land acquisition cost is finally corrected with compensation (10%) and contingency (15%) as mentioned in paragraph 5.4.6.

### 5.4.4 Operation and maintenance cost

#### (1) Incineration plant

For estimation of operation and maintenance cost of incineration plant, examples of other countries were taken for analysis since parallel example in Thailand do not exist. The results of analysis were applied to the case of Thailand to estimate the cost in question. The operation and maintenance cost fluctuates by years. Above all, the repair cost should be gradually increased each year in order to maintain the equipment as near as its initial condition as possible.

Fig. 5.12 shows operation and maintenance cost of incineration plant by element and Fig. 5.13 shows the relation between operation and maintenance cost and the plant capacity. The costs for five year periods are listed in Table 5.20.

Table 5.20 Incineration plant operation and maintenance cost for five year periods

(Unit : million Baht)

Cost	Plant	Year 1 ~ 5	6 ~ 10	11 ~ 15	16 ~ 20	Total	Average per year
Financial cost	Yannawa	182.6	260.4	295.5	318.6	1,057.1	52.9
	Dusit	181.8	259.8	293.6	316.6	1,051.8	52.6
	Bang Kapi	158.0	225.6	256.6	276.6	916.8	45.8
	Bangkok Noi	154.2	220.9	251.2	270.8	897.1	44.9
	Phasi Charoen	155.0	222.1	252.6	272.7	902.4	45.1
Economic cost	Yannawa	161.8	227.9	258.4	278.3	926.4	46.3
	Dusit	160.9	226.8	256.7	276.6	921.0	46.1
	Bang Kapi	139.9	198.3	224.5	241.9	804.6	40.2
	Bangkok Noi	136.6	193.8	219.7	236.6	786.7	39.3
	Phasi Charoen	137.3	194.8	220.9	238.1	791.1	39.6

Table 5.19 Land acquisition cost of the facilities construction site  
(Economic and Financial Costs)

(Unit : million Baht)

Facility type	Case No.	Location	Required area (m <sup>2</sup> )	Land price * (Baht/m <sup>2</sup> )	Land acquisition	
					Financial cost	Economic cost
Incineration plant	13	Yannawa	79,700	2,200	280.5	175.3
		Bang Kapi	67,000	380	40.7	25.5
		Bangkok Noi	63,400	1,060	107.5	67.2
		Phasi Charoen	58,800	190	17.9	11.2
		Total			446.6	279.2
	19-(2)	Yannawa	79,700	2,200	280.5	175.3
	Dusit	77,200	2,000	247.0	154.4	
	Total			527.5	329.7	
Compost plant	9	Bang Khun Tian	173,700	110	30.6	19.1
	13	Taling Chan	291,600	130	60.7	37.9
	19-(2)	Total			91.3	57.0
Landfill site	9	On-Nooch	722,000	200	231.0	144.4
		Nong Khaem	740,700	55	65.2	40.7
		Ram Intra	375,000	100	60.0	37.5
		Total			356.2	222.6
	13	On-Nooch	-	-	-	-
		Nong Khaem	212,400	55	18.7	11.7
		Ram Intra	218,000	100	34.9	21.8
		Total			53.6	33.5
	19-(2)	On-Nooch	213,000	200	68.2	42.6
		Nong Khaem	407,000	55	35.8	22.4
		Ram Intra	258,000	100	41.3	25.8
		Total			145.3	90.8
	Without project	On-Nooch	704,000	200	225.3	140.8
		Nong Khaem	890,000	55	78.3	49.0
		Ram Intra	376,000	100	60.2	37.6
		Total			363.8	227.4
Parking lot	9	Yannawa	16,000	2,200	56.3	35.2
		Bangkok Noi	16,000	1,060	27.1	17.0
		Total			83.4	52.2

Note : Contingency and compensation costs were excluded.



Fig. 5.12 Incineration plant operation and maintenance cost (Financial cost)

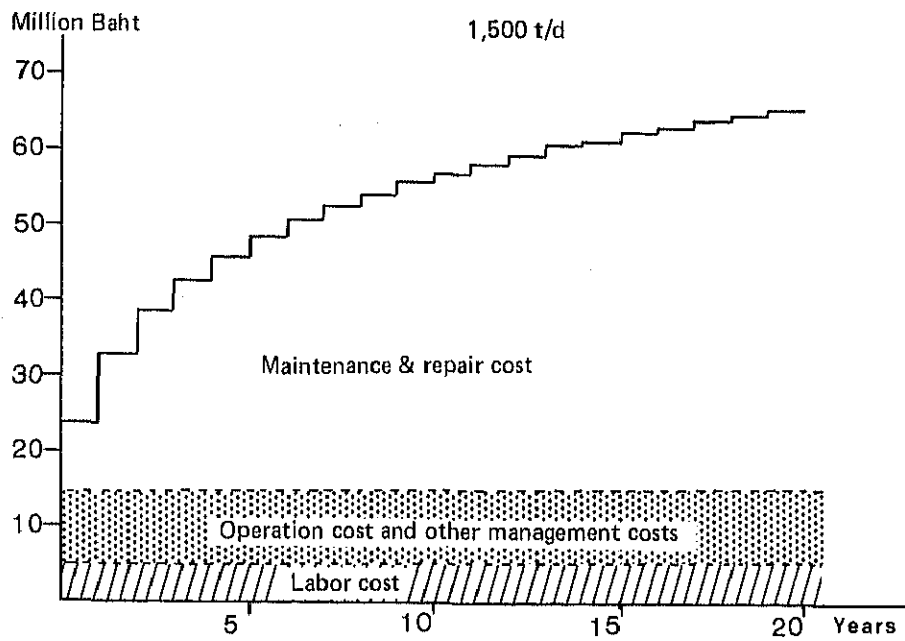
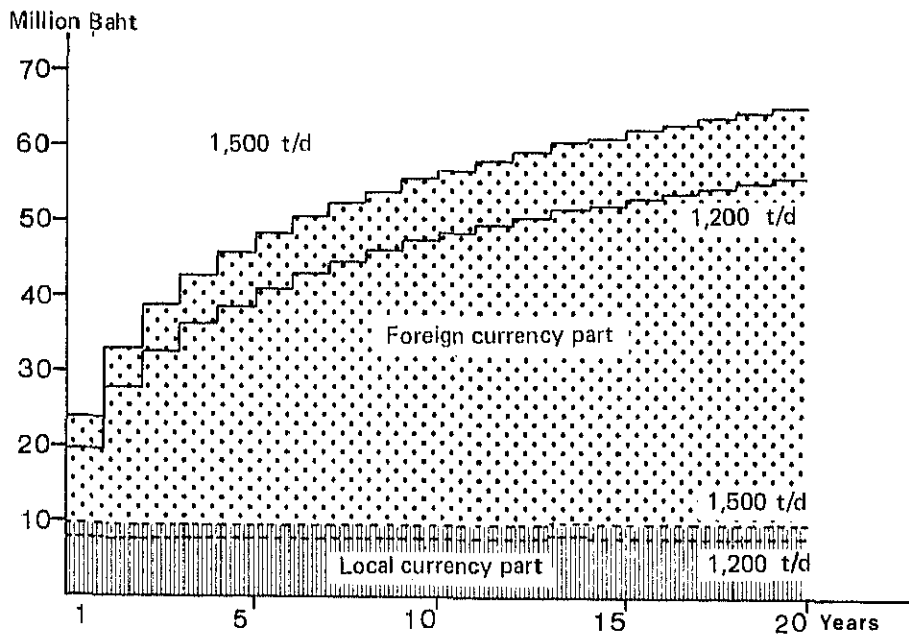


Fig. 5.13 Relation between incineration plant operation & maintenance cost and the plant capacity (Financial Cost)



(2) New compost plant

Moderate operation and maintenance cost was estimated considering capacity and characteristics of new compost plants. An equivalent amount to 3% of the construction cost was assumed as repair cost every year.

In contrast to the case of the incineration plant, operation and maintenance cost of a new compost plant was evenly distributed to each year.

The result of estimation is shown in Table 5.21.

Table 5.21 New compost plant operation and maintenance cost

(Unit : million Baht)

Plant	Financial cost			Economic cost		
	Foreign	Local	Total	Foreign	Local	Total
Bang Khun Tian	2.87	9.22	12.09	2.52	8.65	11.17
Taling Chan	4.67	16.67	21.34	4.02	15.55	19.57

(3) Final disposal site

Operation and maintenance cost of the final disposal site was estimated after subdividing it into the following two parts:

i) Landfill disposal cost

Main cost items included in landfill disposal cost are landfill work cost, environmental protection cost, and the facilities operation, maintenance and repair cost. Landfill work cost is the cost needed for even spreading of solid waste, pressurizing by roller, soil covering, etc., and environmental protection cost is for sterilization, fire prevention, and so forth. The total of these costs was divided by the total landfill volume and unit cost per cubic meter of solid waste was obtained: landfill disposal cost per cubic meter of solid waste will be 30 Baht if compost residue and incineration ash are used as landfill covering material whereas the cost soars to 50 Baht if covering soil is to be purchased.

ii) Leachate treatment cost

Operation and maintenance cost of leachate treatment facilities, which are the major part of the final disposal site, was estimated at 1.4 million Baht/year provided the capacity of the facilities is 500 m<sup>3</sup>/d. Converting the estimated cost into leachate treatment cost per cubic meter of solid waste, 9.0 Baht was obtained.

Operation and maintenance cost of final disposal site was estimated in each alternative based on the above-obtained cost per unit volume of solid waste.

Since the largest part of operation and maintenance cost of the final disposal site consists of local currency to which transfer expenditure is very small, the economic cost and financial cost were regarded as having the same value here.

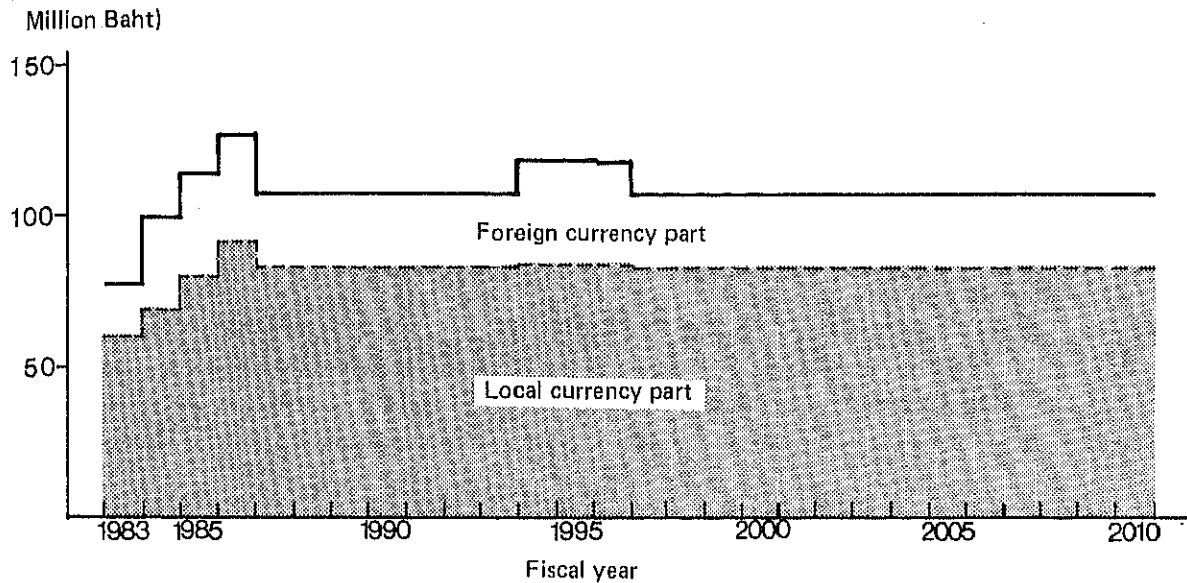
(4) The existing compost plant

In estimation of operation and maintenance cost of the existing compost plants, three cost items proposed in the short-term improvement plan (roofing on fermentation yard, installation of auxiliary burner to incinerator and installation of trommel) were added to the ordinary expenditures. These cost items are also included in cost estimation of short-term improvement plan. The ordinary expenditure contains the cost needed for trommel treatment at On-Nooch and Ram Intra, at which trommel operation is planned to commence in 1985. Summary of the estimated cost is shown in Table 5.22 and Fig. 5.14,

Table 5.22 The existing compost plant operation and maintenance cost

Cost type	Cost item	Fiscal year				Total	Average per year
		1983 1985	1986 1990	1991 1995	1996 2000		
Financial Cost	Ordinary expenditure	238.7	564.8	575.5	575.5	1,954.5	115.0
	Short-term improvement	79.2	33.0	29.0	13.0	154.2	9.0
	Total	317.9	597.8	604.5	588.5	2,108.7	124.0
Economic Cost	Ordinary expenditure	220.8	524.6	534.5	534.5	1,814.4	106.7
	Short-term improvement	70.5	29.4	25.6	11.5	137.0	8.1
	Total	291.3	554.0	560.1	546.0	1,951.4	114.8

Fig. 5.14 The existing compost plant operation and maintenance cost



(5) Summary of operation and maintenance cost

Summary of the operation and maintenance cost for each proposed facility by alternative case is shown in Table 5.23. The cost covers the total operation and maintenance cost required between 1983 and 2010. The calculation was made in accordance with the facilities construction schedule discussed in section 5.3.

5.4.5 Movable equipment acquisition cost

Based on the movable equipment acquisition plan discussed in Section 5.2.6, acquisition cost of the movable equipment was calculated. Among various kinds of equipment, only the solid waste collection trucks purchase cost was taken into consideration. Purchase cost of mechanical road sweepers and river cleaning boats needed in each case of the alternatives were excluded. Landfilling equipment purchase cost was already included in the operation and maintenance cost of the landfill sites; therefore, it was also excluded from this calculation. The movable equipment acquisition cost in Thailand based on 1980 prices is shown in Table 5.24, and the acquisition cost of the solid waste collection trucks summarized in five year intervals during the period from 1983 to 2010 is shown in Table 5.25.

Table 5.24 Acquisition cost of vehicles  
(Unit: Baht/vehicle)

	Financial cost	Economic cost
Compactor	622,900	486,000
Non-compactor	197,000	153,700
Container loader	893,000	697,000
Dump truck	309,000	240,000

Table 5.23 Summary of operation and maintenance cost  
(1983 - 2010)

(Unit: million Baht)

Facilities and the location		Financial Cost			Economic Cost		
		Case 9	Case 13	Case 19-(2)	Case 9	Case 13	Case 19-(2)
Incineration plant	Yannawa	-	936.4	936.4	-	926.4	926.4
	Bang Kapi	-	640.2	-	-	562.7	-
	Bangkok Noi	-	626.3	-	-	550.1	-
	Phasi Charoen	-	377.1	-	-	332.1	-
	Dusit	-	-	734.2	-	-	644.4
	Subtotal	-	2,580.0	1,670.6	-	2,371.3	1,570.8
New compost plant	Bang Khun Tian	217.8	145.2	145.2	201.6	134.4	134.4
	Taling Chan	298.2	213.0	213.0	273.0	195.0	195.0
	Subtotal	516.0	358.2	358.2	474.6	329.4	329.4
Landfill	On-Nooch	37.5	18.2	20.7	37.5	18.2	20.7
	Nong Khaem	142.8	34.9	42.9	142.8	34.9	42.9
	Ram Intra	9.6	9.6	9.6	9.6	9.6	9.6
	Subtotal	189.9	62.7	73.2	189.9	62.7	73.2
* Existing compost plant	On-Nooch	1,862.7	1,862.7	1,862.7	1,725.9	1,725.9	1,725.9
	Nong Khaem	465.7	465.7	465.7	431.5	431.5	431.5
	Ram Intra	931.3	931.3	931.3	863.0	863.0	863.0
	Subtotal	3,259.7	3,259.7	3,259.7	3,020.4	3,020.4	3,020.4
Total		3,965.6	6,260.6	5,361.7	3,544.9	5,683.8	4,893.8

Note: \*Excluding the major repair cost of the existing compost plants.

Table 5.25 Solid waste collection trucks acquisition cost

	Case No.	Fiscal year					
		1983 2 1985	1996 2 1990	1991 2 1995	1996 2 2000	2001 2 2005	2006 2 2010
Finan- cial Cost	9	72.1	133.7	285.4	340.1	326.2	419.4
	13	72.1	133.7	285.4	324.5	287.4	400.8
	19-(2)	72.1	153.5	338.6	395.3	374.5	513.1
	w/o	72.1	153.5	339.5	415.5	382.5	526.4
Economic Cost	9	56.3	104.4	222.7	265.3	254.5	327.1
	13	56.3	104.4	222.7	253.1	224.0	312.5
	19-(2)	56.3	119.9	264.2	308.3	292.4	400.3
	w/o	56.3	119.9	264.9	324.0	298.7	410.7

5.4.6 Recapitulation of the cost relating to the facilities

The total cost relating to the facilities construction and the land acquisition were classified into financial cost and economic cost first, then they were further classified by plants and sites as shown in Table 5.26, and then by the alternative cases adding factors of compensation and contingency as shown in Table 5.27.

Table 5.26 Total investment cost for each treatment/disposal facility\*

(Unit : million Baht)

	Case No.	Location	Financial cost			Economic cost		
			Construction cost	Land acquisition cost	Total	Construction cost	Land acquisition cost	Total
Incineration plant	13	Yannawa	1,797.4	280.5	2,077.9	1,559.1	175.3	1,734.4
		Bang Kapi	1,571.6	40.7	1,612.3	1,361.5	25.5	1,387.0
		Bangkok Noi	1,546.2	107.5	1,653.7	1,337.7	67.2	1,404.9
		Phasi Charoen	1,557.0	17.9	1,574.9	1,348.0	11.2	1,359.2
		Total	6,472.2	446.6	6,918.8	5,606.3	279.2	5,885.5
	19-(2)	Yannawa	1,797.4	280.5	2,077.9	1,559.1	175.3	1,734.4
		Dusit	1,782.5	247.0	2,029.5	1,544.8	154.4	1,699.2
	Total	3,579.9	527.5	4,107.4	3,103.9	329.7	3,433.6	
New compost plant	9	Bang Khun Tian	221.0	30.6	251.6	203.6	19.1	222.7
	13	Taling Chan	392.9	60.7	453.6	360.6	37.9	398.5
	1-(2)	Total	613.9	91.3	705.2	564.2	57.0	621.2
Final disposal site	9	On-Nooch	529.8	231.0	760.8	505.9	144.4	650.3
		Nong Khaem	515.9	65.0	580.9	492.0	40.6	532.6
		Ram Intra	205.9	60.0	265.9	194.5	37.5	232.0
		Total	1,251.6	356.0	1,607.6	1,192.4	222.5	1,414.9
	13	On-Nooch	272.6	—	272.6	257.9	—	257.9
		Nong Khaem	336.7	18.5	355.2	318.9	11.5	330.4
		Ram Intra	114.4	34.9	149.3	107.8	21.8	129.6
		Total	723.7	53.4	777.1	684.6	33.3	171.9
	19-(2)	On-Nooch	373.8	68.2	442.0	354.4	42.6	397.0
		Nong Khaem	414.4	35.6	450.0	393.4	22.3	415.7
		Ram Intra	138.1	41.3	179.4	130.2	25.8	156.0
		Total	926.3	145.1	1,071.4	878.0	90.7	968.7
Parking lot	9	Yannawa	59.7	56.3	116.0	56.9	35.2	92.1
		Bangkok Noi	56.5	27.1	83.6	53.8	17.0	70.8
		Total	116.2	83.4	199.6	110.7	52.2	162.9
The existing compost plant	9	On-Nooch	310.4	—	310.4	277.6	—	277.6
	13	Nong Khaem	155.6	—	155.6	138.8	—	138.8
	19-(2)	Ram Intra	102.4	—	102.4	91.0	—	91.0
	Total	569.2	—	569.2	507.4	—	507.4	

\* Contingency and compensation costs were excluded.

Table 5.27 Total investment cost for each treatment/disposal facility by the alternative cases

(Unit: million Baht)

Case No.	Item	Financial cost			Economic cost		
		Construction cost	Land acquisition cost	Total	Construction cost	Land acquisition cost	Total
9	New compost plant (2)	613.9	91.3	705.2	564.2	57.0	621.2
	Final disposal site (3)	1,251.6	356.0	1,607.6	1,192.4	222.5	1,414.9
	Parking lot (2)	116.2	83.4	199.6	110.7	52.2	162.9
	Existing compost plant (3)	569.2		569.2	507.4		507.4
	Subtotal	2,550.9	530.7	3,081.6	2,374.7	331.7	2,706.4
	Compensation		53.1	53.1		33.2	33.2
	Contingency	297.6	87.4	385.0	280.1	54.8	334.9
	Total	2,848.5	671.2	3,519.7	2,654.8	419.7	3,074.5
13	New compost plant (2)	613.9	91.3	705.2	564.2	57.0	621.2
	Incineration plant (4)	6,472.2	446.6	6,918.8	5,606.3	279.2	5,885.5
	Final disposal site (3)	723.7	53.4	777.1	684.6	33.3	717.9
	Existing compost plant (3)	569.2		569.2	507.4		507.4
	Subtotal	8,379.0	591.3	8,970.3	7,362.5	369.5	7,732.0
	Compensation		59.1	59.1		37.0	37.0
	Contingency	1,172.3	97.5	1,269.8	1,028.3	60.9	1,089.2
	Total	9,551.3	747.9	10,299.2	8,390.8	467.4	8,858.2
19-(2)	New compost plant (2)	613.9	91.3	705.2	564.2	57.0	621.2
	Incineration plant (2)	3,579.9	527.5	4,107.4	3,103.9	329.7	3,433.6
	Final disposal site (3)	926.3	145.1	1,071.4	878.0	90.7	968.7
	Existing compost plant (3)	569.2		569.2	507.4		507.4
	Subtotal	5,689.3	763.9	6,453.2	5,053.5	477.4	5,530.9
	Compensation		76.4	76.4		47.7	47.7
	Contingency	768.3	125.9	894.2	681.9	78.7	760.6
	Total	6,457.6	966.2	7,423.8	5,735.4	603.8	6,339.2

Note:1: Land acquisition compensation was estimated at 10% of subtotal.

2: Land acquisition contingency was estimated at 15% of the sum of the compensation and the subtotal.

3: Construction contingency was estimated at 15% of subtotal of construction costs except compost plant major repair cost.





## **Chapter 6 ECONOMIC AND FINANCIAL ANALYSES**

6.1	Preface .....	6-1
6.2	Economic Analysis .....	6-2
6.3	Financial Analysis .....	6-28
6.4	Comprehensive Evaluation of Economic and Financial Analyses .....	6-52



## CHAPTER 6 ECONOMIC AND FINANCIAL ANALYSES

### 6.1 Preface

It should be noted that the economic and financial analyses in this sanitation project study are only one of the evaluation criteria among three criteria: environmental, technical and economic/financial. Therefore the results of benefit-cost and financing burden are not absolute evaluation indices as in other projects. The topics discussed in the economic and financial analyses in this chapter are outlined below in Fig. 6.1.

For the economic and financial analyses, the project life span was set at 28 years (from 1983 to 2010) because all of the proposed solid waste management facilities will be completed by the year 2000 as a target year, and the facilities will serve the function for at least 10 years thereafter.

After the year 2010, there is a salvage value attached to the facilities. For the analyses, the total solid waste management cost, that is the "project cost", is composed of such as capital investment cost as well as of operating cost, collection and transport cost and collection truck purchase cost; however, the cost for river and canal cleaning and road sweepers were excluded from the evaluation. The prices applied to the calculation are 1980 year price.

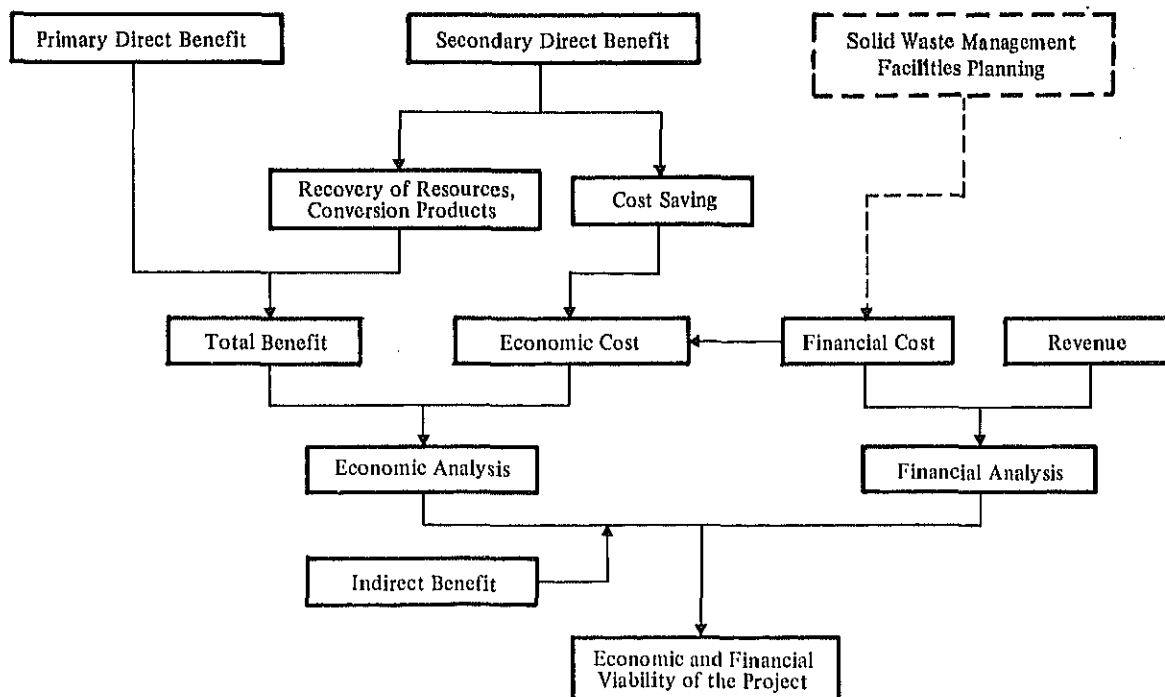


Fig. 6.1 Conceptual study flow of economic and financial analyses

## 6.2 Economic Analysis

### 6.2.1 Methodology

#### (1) Definition of 'with-' and 'without-' project

In this study 'with-' and 'without-' project are defined as follows:

With-project (construct the proposed system)	Solid waste management enterprise will be executed according to one of the proposed appropriate Master Plan alternatives.
Without-project (continue with only the existing system)	<p>Solid waste management enterprise will be executed only by the existing solid waste management system serving the three composting plants and landfill sites at On-Nooch, Nong Khaem and Ram Intra.</p> <p>The number of solid waste collection trucks will be increased to accomplish the design solid waste collection rate. (In the year 2000, this rate will be 97 percent.)</p> <p>In addition, the final disposal site will be executed by the open dump method, the same as the existing landfill.</p>

#### (2) Methodology of the benefit estimation

In a sanitation project it is difficult to separate the benefits of the investment, operation and maintenance costs which are required for execution of the proposed project from the benefits in the existing system after the proposed project is implemented, it is also very management enterprise is a comprehensive enterprise, it is also very difficult to fix the cost needed to maintain the existing solid waste management system (without-project) in the future. In addition, after the completion of the proposed solid waste management system, the proposed system will influence the solid waste treatment volume and system not only for the added system elements but also for the existing system elements. A detailed examination of this subject was made and the result are shown in Appendix 6.1.

Based on the above examination, the benefit was estimated by comparing the benefits which are expected by execution of proposed appropriate solid waste management system (with-project) and the benefit in the base case with no solid waste management work executed (without solid waste management service). From this comparison, the benefit of execution of solid waste management by proposed appropriate Master Plan alternatives was measured. In addition to this comparison, benefit from the existing solid waste management system was also measured for reference.

The outline of the benefit estimation method is shown in Fig. 6.2.