社会開発協力部報告書

THE REPUBLIC OF KOREA

MASTER PLAN AND FEASIBILITY STUDY
ON
SEOUL MUNICIPAL SOLID WASTE MANAGEMENT SYSTEM
IN
THE REPUBLIC OF KOREA

FINAL REPORT

SUMMARY

OCTOBER, 1985

JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO, JAPAN

THE REPUBLIC OF KOREA

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PREFACE

In response to the request of the Government of the Republic of Korea, the Government of Japan decided to conduct a Master Plan and Feasibility Study on Seoul Municipal Solid Waste Management System Project and entrusted the Study to the Japan International Cooperation Agency (JICA).

JICA sent to Korea a preliminary survey team headed by Dr. Masao SAGO, Professor of Science University of Tokyo, from October to November, 1983.

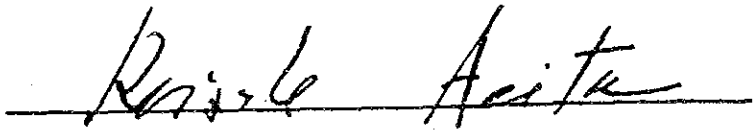
The team had a series of discussions on the Project with the officials concerned of the Government of Korea, in particular with those of the Ministry of Science and Technology (MOST), and the Korea Advanced Institute of Science and Technology (KAIST), and has agreed on the Scope of Work for the Study.

After a preliminary survey was conducted, JICA dispatched to Korea a Study team led by Mr. Fusao NODE, Nippon Jogesuido Sekkei Co., Ltd., and made full-scaled survey based upon the Scope of Work, from June 1984 to October 1985, and the present report has been prepared.

I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of the Government of Korea for their close cooperation extended to the team.

October, 1985



Keisuke ARITA
President
Japan International Cooperation Agency

LOCATION MAP
S=1：200,000
0
5
10KM
SEOUL
서울特別市
仁川直轄市
富川市
光明市
安養市
城南市
高陽郡
九里邑
渼金邑
元堂邑
神道邑
一山邑
碧蹄邑
蘇萊邑
松浦面
知道面
桂陽面
高村面
長興面
別內面
西部面
恩平區
西大門區
城北區
東大門區
鍾路區
中區
麻浦區
龍山區
江西區
永登浦區
九老區
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冠岳區
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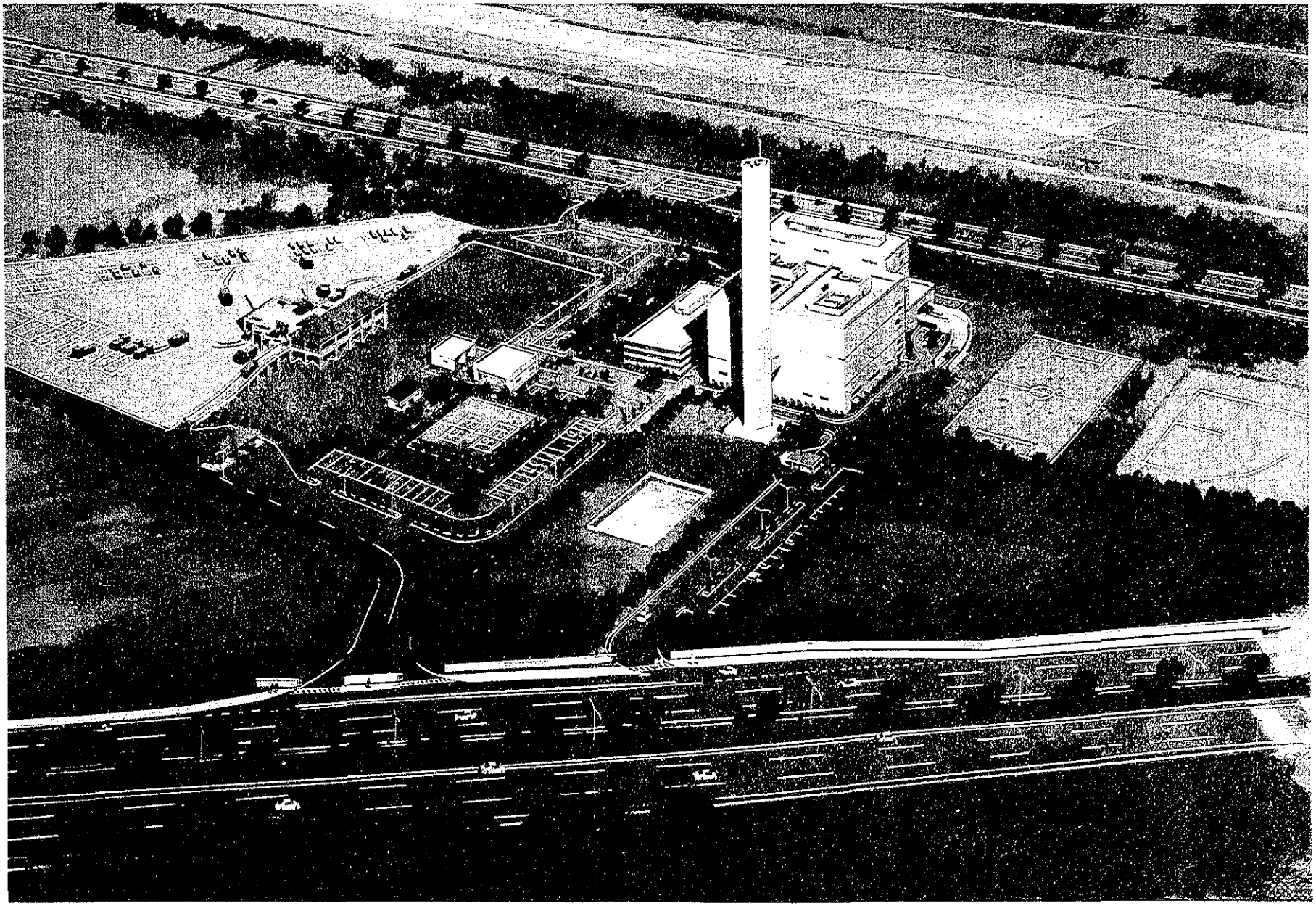
道峰區



PERSPECTIVE VIEW OF INTERMEDIATE PROCESSING CENTER

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Incinerator construction plan in Hok-Dong area
Nanjido mounding plan
Feasibility study on large scale waste landfill siting in metropolitan area (Incheon)

↓

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↓

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↓

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↓

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→ -1 GNP of 65.5 trillion W in 1988 by 1980 value is expected by R.O.K.
-2 GNP of 147.1 trillion W in 2000 by 1980 value is expected by R.O.K.
-3 GNP is projected to be 65.6 and 185.4 trillion W by 1980 value in 1988 and in 2005 with the annual growth rate of 6.6%, respectively in this study
-4 Seoul GRP is projected to be 9.1 and 28.0 trillion W by 1984 value in 1988 and 2005 with the annual growth rate of 7.6%, respectively

↓

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PART I GENERAL

I-1 Background of Study

In response to the request from the Government of the Republic of Korea, the Government of Japan has decided to carry out a Master Plan and Feasibility Study on Seoul Municipal Solid Waste Management System in the Republic of Korea (hereafter referred to as "the Study"), in accordance with the laws and regulations in force in Japan. The Japan International Cooperation Agency (hereafter referred to as "JICA"), the official agency responsible for the implementation of technical cooperation programs of the Government of Japan, performed the Study in close cooperation with the authorites concerned of the Government of the Republic of Korea, in particular with the Ministry of Science and Technology (hereafter referred to as "MOST") and the Korea Advanced Institute of Science and Technology (hereinafter referred to as "KAIST").

With the rapid increase of urban population and variation in socio-economical conditions, the establishment of an appropriate management system for the increasing output of solid waste has become an urgent need for the City of Seoul. The background to the Study is described as;

1) From the environmental and energy-saving point of view, Seoul municipality is anxious to establish an appropriate management system for solid waste which is characterized by certain properties.

2) The prevailing solid waste management system in Seoul is represented by a mixed collection system using hand carts, the transfer of collected waste and simplified landfill. This system brings inevitable problems of pollution, labor efficiency and limitation of landfill sites and, as a result, the urgent establishment of an appropriate alternative system involving the flow from waste generation to disposal is needed.

3) Under the 5th Five Year Plan for Economic and Social Development Plan (1982-1986), balanced development and utilization of national land and environmental preservation are raised as a principal policy of the Government. Under this situation, the appropriate management of the municipal solid waste in the capital city of the Republic of Korea is considered of great importance.

4) The Asian Games will be held in Seoul in 1986 and the Olympic Games in 1988. With this incentive, the establishment of the rational waste management system has become an urgent and important issue for improving the living environment and to promote the modern city planning of Seoul.

5) In Korea, various surveys and studies have been made regarding the municipal solid waste management system by governmental organizations and universities and some projects are being implemented. In the course of the Study, documents on these existing projects are consulted for planning the comprehensive solid waste management system for the future.

6) The Government of Korea desires that the execution of this project will become the model case for improvements in solid waste management systems in other municipalities.

Preliminary survey was carried out in October-November, 1983 and again in February-March, 1984 when agreement on the Scope of Works were made and confirmed between the Japanese Mission and the Steering Committee.

I-2 Objectives

The objectives of the Study are: i) to analyze and evaluate the technical and economic feasibilities of an effective and rational solid waste management system for the future, based upon the local conditions of Seoul City, and ii) to ensure a "clean" municipality that is acceptable socially, economically and environmentally.

I-3 Scope of Study

This document contains two studies. A Phase I Study establishes a Master Plan for the year 2005, and a Phase II Study carries out a Feasibility Study on a Short Term Improvement Project.

The Master Plan phase has been performed to promote the establishment of an effective municipal solid waste management system for improved public sanitation and also resource conservation, environmental preservation and the socio-economical aspects of a total system from generation to final disposal.

Basic field surveys to supplement existing data and identify the problems of the existing system are used as basic material for the Master Plan and the Short Term Improvement Project.

The Feasibility Study is conducted on a Short Term Improvement Project targeted for the year 1988. This includes the basic design of transfer and processing facilities, and final disposal facilities, as well as economic/financial evaluation and environmental assessment.

The Study area covers, in principle, the entire Seoul municipality. However, further extensive area was considered for the transportation, disposal and landfill studies. Since this Study area is extremely wide, it has been divided into five zones according to Gu's as illustrated in Fig. S-1.

The Study covers municipal solid waste of Seoul City which consists of domestic and commercial waste including sludge from public waste treatment facilities (night soil and sewage treatment facilities). The components of this waste are combustibles such as paper, plastics, textiles and wood, and non-combustibles such as metal, glass, ceramics and briquet ash.

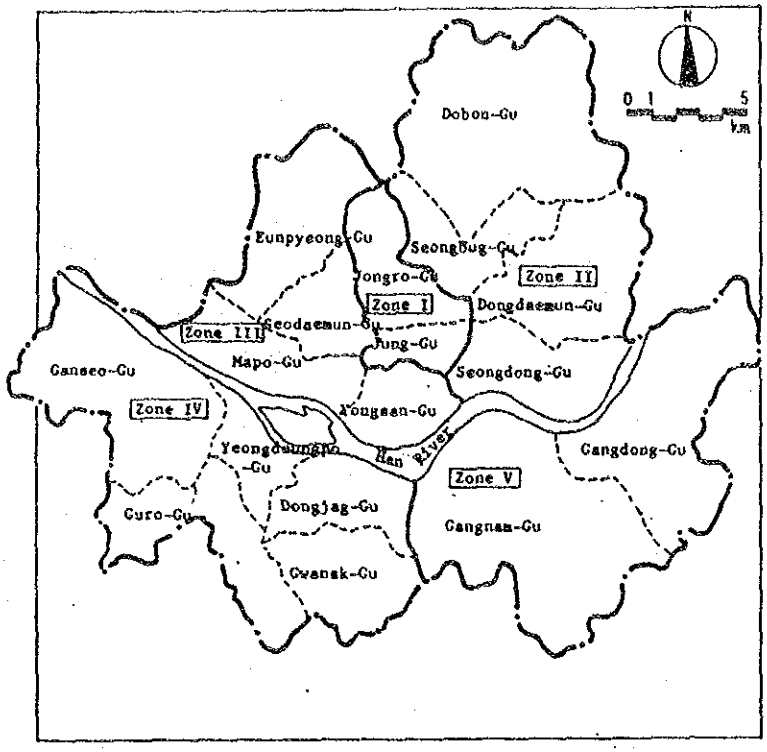


Fig. S-1 Five Zones of Study Area

I-4 Study Framework

The problems of the existing solid waste management system in Seoul and their countermeasures are identified in Table S-1. These will be used as bases for forming the Master Plan. Those requiring immediate improvement will be analyzed and considered in the decision alternatives for proposal of the short term improvement project.

From studies on existing population forecasts, and based upon the assumption that the government's population control policy will be promoted continuously, a conclusion is made that the future population in Seoul City will be 10.3 million in 1988 and 12.5 million in 2005. These projections into Gu's and zones are indicated in Table S-2.

A peculiar characteristic of solid waste in Seoul is the exceedingly large amount of briquet ash. This is also reflected in the forecast of waste components as shown in Table S-3. The per capita waste generation rate is predicted to be about 2 kg/cap/day in 1988 and about 2.1 kg/cap/day in 2005. The generation rate forecasts are listed in Table S-4.

Table S-1 Problems of Existing System

Subsystem	Problem		Remedy
	Element	Description	
On-Site Storage	dustchute	unsanitary, inefficient for collection	. plastic bucket with lid, paper and plastic bag
	fixed dust box	inefficient for collection	. same as above
	high moisture content in garbage	unsanitary, inefficient for collection and processing	. dewater garbage, plastic bag
Collection	hand cart	unaesthetic, labor intensive	. compactor collection vehicle, curbside collection
	narrow and/or steep road	inefficient for collection	. road improvement, station collection, city planning
	tip	unequal level of service	. discontinue, labor incentive
Transfer and Transport	long haul distance	inefficient for transport	. mechanized transfer station, processing facility
	manual transfer	unaesthetic, unsanitary, labor intensive	. discontinue and/or direct haul, mechanized transfer station, processing facility
	leachate dripping from vehicle	unaesthetic, oderous, unsanitary	. water tight vehicle
Intermediate Processing	consciousness on processing	inexperienced, misunderstood	. definition (i.e. distinction between disposal and intermediate processing), education of engineer, propaganda
	waste characteristics and quantity	inefficient for processing, marketability of recoverable materials and energy	. separate collection, market development, promotion, institutional arrangement
Resource Recovery	self-support work corps	unsanitary, unaesthetic, unstable income, unsafe	. discontinuation, systematic resource recovery (e.g. intermediate processing, on-site recycling), employment counseling
	scavenging at disposal sites	same as above	. same as above
Final Disposal	dumping at Nanjido	unaesthetic, unsanitary, pollution of environment	. daily soil covering, environmental control (e.g. leachate treatment)
	present landfill site	saturation of Nanjido	. acquisition of new landfill sites, Nanjido mounding, reduction of disposed refuse (e.g. intermediate processing, recycling)
	candidate landfill sites	scarcity	. Nanjido mounding, reduction of disposed refuse(same as above), long distence haul
	incoming truck management	inaccurate information	. truck scale
Financial Aspects	collection fee	insufficient for operation cost, difficulty in securing residents' cooperation	. administrative reform, education, propaganda

Table S-2 Estimated Future Populations by Gu and Zone

(Unit: thousand person)

Gu \ Year	1983	1988	1991	1996	2001	2005
Jongro	277	280	290	290	300	300
Jung	225	230	230	240	240	240
Zone I Total	502	510	520	530	540	540
Seongdong	737	790	810	850	870	880
Dongdaemun	914	960	990	1,020	1,050	1,060
Seongbug	589	610	620	630	640	650
Dobong	813	980	1,070	1,180	1,270	1,320
Zone II Total	3,053	3,340	3,490	3,680	3,830	3,910
Yongsan	335	340	350	350	360	360
Eunpyeong	422	440	450	460	460	470
Seodaemun	423	440	440	450	460	460
Mapo	439	470	490	510	530	540
Zone III Total	1,619	1,690	1,730	1,770	1,810	1,830
Ganseo	635	820	920	1,040	1,140	1,190
Guro	630	660	680	700	720	730
Yeongdeungpo	446	470	470	490	490	500
Dongjag	400	410	420	420	430	430
Gwanak	540	550	560	570	580	580
Zone IV Total	2,651	2,910	3,050	3,220	3,360	3,430
Gangnam	652	900	1,030	1,190	1,320	1,390
Gangdong	727	950	1,080	1,210	1,340	1,400
Zone V Total	1,379	1,850	2,110	2,400	2,660	2,790
Total	9,204	10,300	10,900	11,600	12,200	12,500

Estimated by the study team

Table S-3 Forecast on Physical Components

(Wet Basis)

Component	(With Briquet ash) Observed Data in 1981 %	(With Briquet ash) Forecast for 1988 %	(With Briquet ash) Forecast for 2005 %	(Without Briquet ash) Observed Data in 1981 %	(Without Briquet ash) Forecast for 1988 %	(Without Briquet ash) Forecast for 2005 %
(Combustibles)						
Paper	7.20	11.17	20.46	16.40	21.37	28.53
Wood	1.77	1.76	1.71	4.03	3.37	2.38
Textiles	1.44	2.06	3.61	3.28	3.94	5.08
Garbage	17.67	17.83	18.13	40.26	34.12	25.28
Plastics	2.93	5.00	9.92	6.68	9.61	13.82
Rubber	0.42	0.39	0.38	0.96	0.75	0.53
Others	5.77	5.68	5.50	13.14	10.87	7.68
Subtotal	37.20	43.89	59.71	84.75	84.03	83.25
(Non Combustibles)						
Briquet ash	56.11	47.74	28.29	0	0	0
Metals	0.87	1.42	2.56	1.99	2.72	3.58
Glass/Ceramics	2.01	3.18	5.79	4.58	6.07	8.08
Others	3.81	3.77	3.65	8.68	7.18	5.09
Subtotal	62.80	56.11	40.29	15.25	15.97	16.75

Table S-4 Waste Generation Forecast by Zone

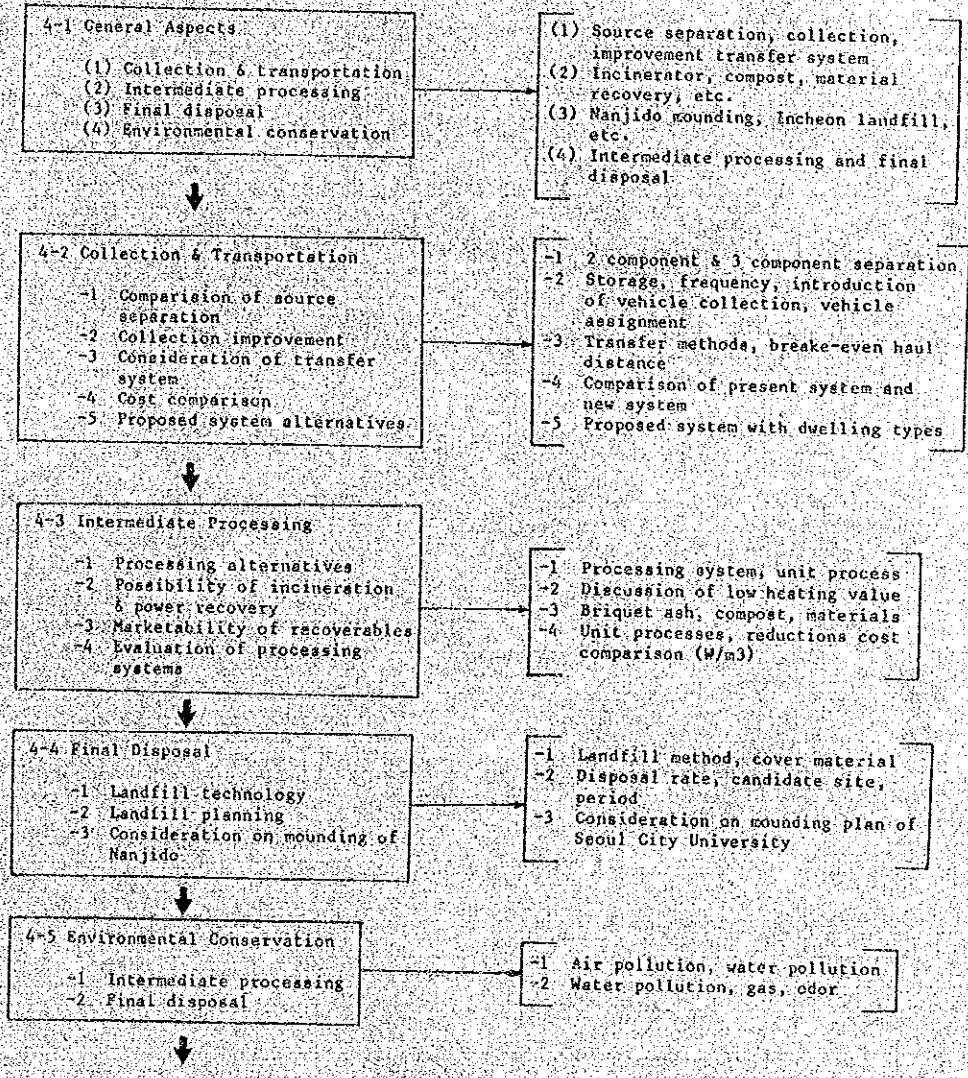
	Per capita Rate for Whole City (kg/cap/d)	Per Capita Rate* Index	Per capita Rate for Each Zone (kg/cap/d)	Population (persons)	Combustibles (ton/day)	Non Combustible Ash (ton/day)	Sub-Total (ton/day)	Briquet Ash (ton/day)	Total Generation Rate (ton/day)
(In 1988)									
I		2.561	5.229	510,000	1,170	220	1,390	1,280	2,670
II		0.819	1.672	3,340,000	2,450	470	2,920	2,660	5,580
III		1.042	2.128	1,690,000	1,580	300	1,880	1,710	3,590
IV		0.901	1.839	2,910,000	2,350	450	2,800	2,550	5,350
V		1.016	2.075	1,850,000	1,680	320	2,000	1,840	3,840
Total	2.042	1.000	2.042	10,300,000	9,230	1,760	10,990	10,040	21,030
(In 2005)									
I		2.575	5.425	540,000	1,750	350	2,100	830	2,930
II		0.823	1.735	3,910,000	4,050	810	4,860	1,920	6,780
III		1.054	2.221	1,830,000	2,430	490	2,920	1,150	4,070
IV		0.906	1.909	3,430,000	3,910	790	4,700	1,850	6,550
V		1.022	2.153	2,790,000	3,590	720	4,310	1,700	6,010
Total	2.107	1.000	2.107	12,500,000	15,730	3,160	18,890	7,450	26,340

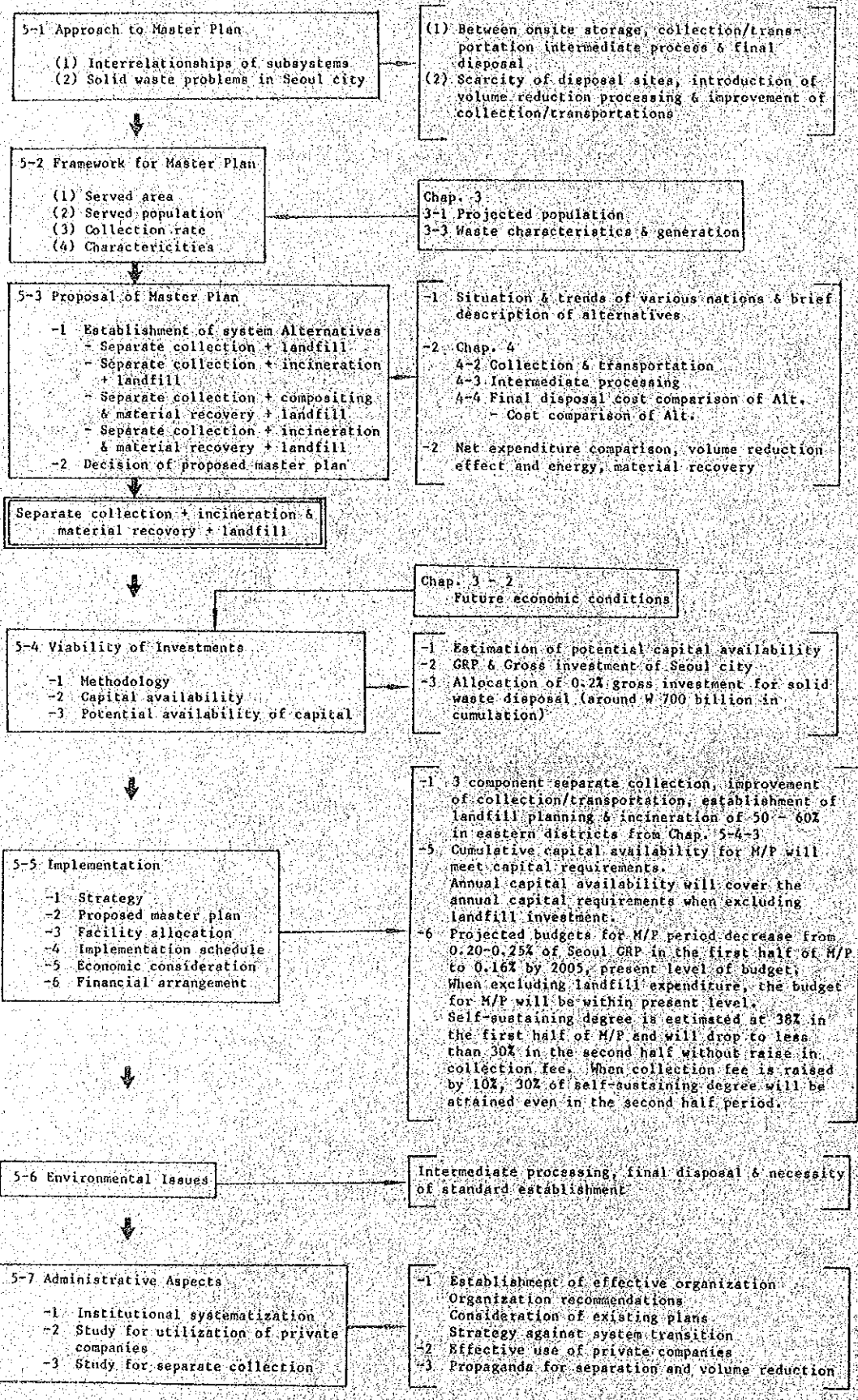
* Per capita rate index for each zone was adjusted to make the sum of generation rate of each zone and the generation rate of whole city.

PART II

MASTER PLAN

PART II M/P: (1) Chap. 4 TECHNICAL CONSIDERATIONS




5-1 Approach to Master Plan
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- Separate collection + incineration + landfill
- Separate collection + compositing & material recovery + landfill
- Separate collection + incineration & material recovery + landfill
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-1 Situation & trends of various nations & brief description of alternatives
-2 Chap. 4
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4-3 Intermediate processing
4-4 Final disposal cost comparison of Alt.
- Cost comparison of Alt.
-2 Net expenditure comparison, volume reduction effect and energy, material recovery
Separate collection + incineration & material recovery + landfill
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-2 Capital availability
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-1 Estimation of potential capital availability
-2 GRP & Gross investment of Seoul city
-3 Allocation of 0.2% gross investment for solid waste disposal (around W 700 billion in cumulation)
5-5 Implementation
-1 Strategy
-2 Proposed master plan
-3 Facility allocation
-4 Implementation schedule
-5 Economic consideration
-6 Financial arrangement
-1 3 component separate collection, improvement of collection/transportation, establishment of landfill planning & incineration of 50 - 60% in eastern districts from Chap. 5-4-3
-5 Cumulative capital availability for M/P will meet capital requirements.
Annual capital availability will cover the annual capital requirements when excluding landfill investment.
-6 Projected budgets for M/P period decrease from 0.20-0.25% of Seoul GRP in the first half of M/P to 0.16% by 2005, present level of budget.
When excluding landfill expenditure, the budget for M/P will be within present level.
Self-sustaining degree is estimated at 38% in the first half of M/P and will drop to less than 30% in the second half without raise in collection fee. When collection fee is raised by 10%, 30% of self-sustaining degree will be attained even in the second half period.
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-3 Study for separate collection
-1 Establishment of effective organization
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Consideration of existing plans
Strategy against system transition
-2 Effective use of private companies
-3 Propaganda for separation and volume reduction

PART II MASTER PLAN

II-1 Concept for Master Plan

Having an effective waste stream from generation point to final disposal is a basic concept for solid waste management. In this respect, acquisition of landfill sites as the final destination of the waste stream is considered to be a major point of solid waste management, where the waste stream is established by traditional ways.

Taking into account the existing situation in Seoul, opening of the Incheon coastal landfill site, which the Office of Environment (OOE) has studied, is an important matter for Seoul City. However, since Incheon landfill planning is within a comprehensive project spanning across several administrative districts, the actual construction must be delayed due to institutional hindrances. Therefore, Nanjido mounding is indispensable for Seoul.

However, although the waste stream may be established by the above landfill projects, the basic problem is not solved. It is always difficult to acquire sufficient landfill sites for the future and this problem is faced by Seoul City. Therefore, the master plan must have effective solutions for this situation.

As a consequence, the master plan proposes incineration, because a reasonable landfill planning can be established as a result of the large volume reduction and the production of a stable and harmless output. Furthermore, separate collection is also proposed to complement the adoption of incineration and the need to improve the collection and transportation system. However, since the proposed system requires a large investment for complete implementation, an incineration ratio of about 50-60% is established for the target year of 2005 in respect to the potential availability of capital. The basic policies for the master plan are:

- Improvement of collection and transportation
- Adoption of intermediate processing
- Establishment of landfill planning

II-2 Technical Consideration

2-1 Consideration of Collection and Transportation

The collection and transportation system should be improved by a stepped program considering the local conditions, such as road conditions, type of household, working conditions and the present collection and transportation system. The recommended modifications of the present system are:

- For improvement of the existing collection method (hand cart collection), new vehicles need to be purchased and exchanged for the existing ones. For combustibles, 2 t and 4 t compactor trucks and for non-combustibles and briquet ash, 2 t and 4 t dump trucks are recommended.

- The break-even distance for direct haulage is about 11 km and 16 km for 2 t trucks and 4 t trucks, respectively. Therefore, large scale transfer stations become necessary, and new 10 t container trucks ($20m^3$) are recommended for transportation to the disposal site.

The comparison in costs for operation and maintenance between the present system and the proposed system is given in Table S-5.

There is not much difference between both systems under the same condition such as working hours, working days per year, etc, however, personnel expenses, as part of the total cost is very big with hand cart system. Vehicle collection system will be more advantageous in the future as personnel expenses escalate.

Table S-5

Operation and Maintenance Cost Comparison for Collection/Transportation

(including Depreciation) (Unit : ₩/ton)

Item	Hand Cart System	Improved System	Remarks
(1) Collection	* 5,708	4,962	* Including cost for unloading from hand cart onto dump truck
(2) Transfer Station	* -	700	* Small scale transfer station
(3) Transportation (to Nanjido)	2,190	2,122	Hauling distance is assumed to be 15 km
(4) Transportation (to Incheon)	4,865	4,947	Hauling distance is assumed to be 40 km
Total (1)+(2)	5,708	5,662	
Total (1)+(2)+(3)	7,898	7,784	
Total (1)+(2)+(4)	10,573	10,609	

2-2 Consideration of Intermediate Processing

As a consequence of the difficulties in securing suitable final disposal sites, the effectiveness of intermediate processing to reduce the waste volume must be substantiated. Various processes are currently available, but the waste characteristics, output marketability and other factors are required to select the correct process. Table S-6 is an evaluation of eight processes, with special emphasis on technical experience on a world-wide basis. As a result, the alternative processing systems for intermediate processing in Seoul City are proposed as listed below and these should be adopted singly or in combination according to generated waste characteristics, marketability of processing products and other local conditions.

1. Non-intermediate processing system : Collected waste is directly hauled to the final disposal site.

2. Incineration system : Collected waste is brought to the processing plant where the waste is incinerated and residues are hauled to the final disposal site. In this case, the waste to be processed should have sufficient calorific value for incineration. Therefore, three component source separation *-1 of combustibles may be necessary.

3. Incineration with heat and/or power recovery system *-2 : Same as 2. above except waste heat from incineration is recovered as energy. In this case, stabilization of output heat must be considered.

*-1 The results of calculations on component and lower heating values is shown in the following Table. In 1988, the lower heating values are 720 kcal/kg and 840 kcal/kg on the conditions of two component separation and three component separation, respectively. The critical point of self burning is estimated from experience to be between 700 - 750 kcal/kg. Thus waste separated into two components is not reliable to sustain burning without supplemental fuel. On the other hand, waste separated into three components has enough heating value to support combustion.

Separation Type	Component	1988		2005	
		Medium Quality Waste	Low Quality Waste	Medium Quality Waste	Low Quality Waste
2 Components	Volatile (%)	28.9	23.4	34.1	27.8
	Ash (%)	26.1	21.9	25.9	23.0
	Moisture Content (%)	45.0	54.7	40.0	49.2
	Lower Heating Value (kcal/kg) (H_l)	1,030	720	1,290	950
3 Components	Volatile (%)	32.9	26.9	39.7	32.4
	Ash (%)	16.8	11.5	15.1	11.5
	Moisture Content (%)	50.2	61.6	45.2	56.1
	Lower Heating Value (kcal/kg) (H_l)	1,180	840	1,520	1,120

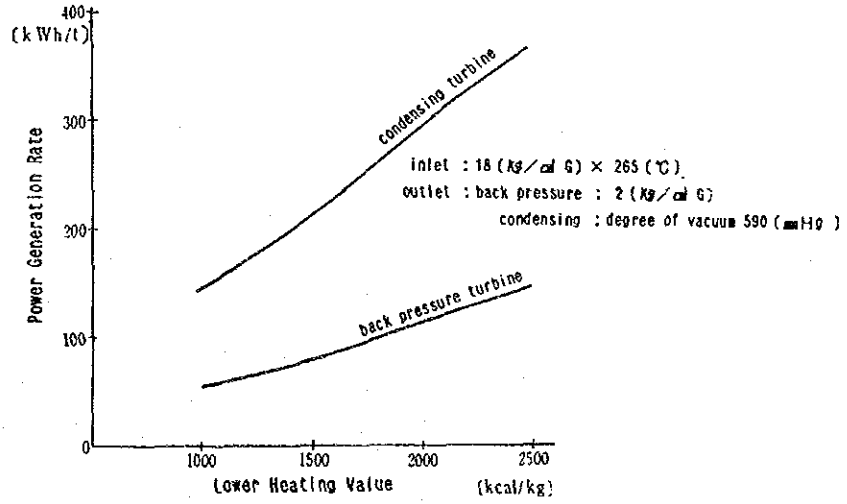
Note: Lower heating value (H_l) was calculated by

$H_l = 45V - 6M$

where, V: Volatile matter (%), M : Moisture content (%)

*-2 Lower Heating Value and Power Recovery

Power generation rate is determined by the lower heating value of waste, type of turbines and scale of the power generation unit. Relationship between lower heating values and generation rates are examined from experience and depicted in the following Figure. As the power consumption for an incineration facility is between 40-70 kWh/t, the lower heating value should be about 1,200 kcal/kg to be self-sufficient if a back pressure turbine is used.



Source : Japan Environmental Sanitation Center

4. Materials recovery system : Collected waste is transported to the processing plant where recoverable materials are sorted manually and/or mechanically, and the residues are brought to the final disposal site. In this case, marketability of materials must be carefully studied, and source separation of non-combustibles may be desirable.

5. Composting system : Organic portion of collected waste brought to the processing plant is fermented and matured to yield a product useful as a soil conditioner or a stabilized and volume-reduced fill material. If the compost is to be used as a soil conditioner, a thorough marketing survey is essential, and upgrading facilities may be required.

Table S-6 Preliminary Evaluation of Intermediate Processing

Process	Initial Cost	O/M* Cost	Experience *	Volume Reduction	Score	Comment
Incineration	X	X	O	O	6	Proven on a wide-scale,World-wide. Most effective process for waste volume reduction.
RDF	Δ	Δ	X	Δ	3	Has been researched extensively in the U.S.A., but actual demonstrations were unsuccessful.
Material Recovery	Δ	Δ	Δ	Δ	5	Recovery of non-combustibles is successfully proven. Other materials have yet to be proven.
Composting	Δ	Δ	O	Δ	7	Marketability of end-product is insufficient for feasibility. Proven in some European cities.
Methane Recovery	X	Δ	X	Δ	2	Digestion is proven as a technology, but is yet unproven on municipal solid waste. Landfill methane recovery is presently on-going demonstration in U.S.A. and Europe.
Feed Production	Δ	Δ	X	Δ	3	Uncomplicated process, but yet to be proven on mixed municipal solid waste.
Pyrolysis	X	X	X	O	2	High volume reduction, but actual demonstration yet to be proven.
Landfill	O	O	O	X	8	Traditionnally favored if acquisition of suitable sites is possible.

Note : X: 0 point, Δ: 1 point , O: 2 points,* points for experience receive double.
*O/M: Operation and maintenance

The pros and cons of the alternatives in Table S-6 are compared in Table S-7. Then, an evaluation based on technical points, waste characteristics, marketability of by-products and other significant local conditions is listed in Table S-8.

2-3 Consideration of Final Disposal

Seoul City University has projected that the mounded system at Nanjido is to be used up to 1994. If incineration plants are introduced the required landfill capacity will decrease, then the surplus volume can be reserved for unexpected occasions such as disasters. After 1994, the Incheon coastal area is needed as a major landfill site. In addition, sanitary landfilling of subsidiary sites is recommended to be carried out in parallel from 1995.

- Nanjido Mounds

  The existing plan studied by Seoul City University seems to need further detail study regarding:

  1) Slope Structure of the Mound
     Briquet ash should be used as a retaining slope structure and the other disposal refuse placed inside landfill to protect the mound from failure by rotational slipping.

  2) Leachate Treatment process
     The treatment process proposed by Seoul City University consists of an aerated lagoon and a high rate chemical sedimentation tank. Considering environmental preservation and investment effects, it is recommended to install a rapid sand filter and an activated carbon absorption column in addition to the proposed process.

  3) Environmental Protection
     Environmental impacts of landfill are studied by Seoul City University, and measures are recommended. These measures should be implemented and the monitoring devices should be provided to obtain the accurate information.

Table S-7 Comparison of Alternative Systems

System	Advantages	Disadvantages
Non-intermediate Processing	-Low costs -Easy management -High technology not required	-Siting of Landfills difficult -Can involve high transportation cost -Environmental disruption possible -Unaesthetic
Incineration	-Waste volume reduction -Yields stable and harmless output	-High initial cost -High operation and maintenance cost - Requires high technology -Consideration of combustibility needed -Requires air pollution control measures
Incineration With heat and/or power recovery	-Waste volume reduction -Yields stable and harmless output -Waste heat can be recovered as energy	-High initial cost -Required high technology -Consideration of combustibility needed -Requires air pollution control measures -Stabilization of waste heat required
Materials Recovery	-Waste volume reduction -Yields valuable resources -Can increase employment	-Marketability of recovered materials uncertain -Requires high technology and high costs
Composting	-Yields stable and harmless output -Can be operated in combination with sewage and nightsoil treatment	-Marketability of compost is uncertain -High operation and maintenance cost -Requires seasonal storage area

Table S-8 System Evaluation

System	Source Separation Recommendation	Volume Reduction* (m^3/t)	Evaluation
Non-intermediate processing	None	0 %	Since Nanjido is almost saturated and acquisition of other sites is difficult, and moreover, does assist resource preservation, this system is not suitable for Seoul City.
Incineration with or without energy recovery	Combustibles	80 % (Comb. only) 74 % (With noncomb.)	This is a well proven system on a world-wide scale and greatly reduces waste volume. If energy is recovered, further benefits are obtained.
Materials Recovery	Non-combustibles	12 % (Noncomb. only) 3 % (With comb.)	Though recovered materials are marketable, instead of sophisticated recovery at the intermediate processing stage of solid waste management, recovery at the source of generation is more beneficial for refuse of Seoul City.
Composting	Compostable (Garbage,paper)	59 % (Comp. only) 57 % (With others)	Marketability of compost product as soil conditioner or fertilizer is rather low in and around Seoul to make this system economically feasible.

* Reduced landfill volume (m^3)/input amount (t)

- Incheon Coastal Landfill

The expected landfill site after Nanjido is Incheon coastal area which was studied by O.O.E. However, judging from Japanese experience it is expected to take a long time to implement the plan due to such tasks as legal procedures, comprehensive organization, standards of refuse and, other technical and administrative matters. Therefore, efforts for early project promotion to avoid delays mentioned above are required.

2-4 Consideration of Environment

Studies on the environmental impact which accompanies operation of an incineration plant indicates that solutions are needed to mitigate air pollution from discharged gases from the stack. Measures against water pollution are also required, because the leachate from the refuse pit and gas washing water are highly polluted. For securing safe and smooth traffic at the front gate of plant, provision of turning lane is recommended.

Environmental impact assessment must be made during the detail design of the incineration plant.

II-3 Proposal and Evaluation of Master Plan

The alternatives for the Master Plan are established on the basis of source separation and intermediate processing. The alternatives are described below and are schematically illustrated in Fig. S-2.

Option I : Complete landfill type is the most economic system in the case where the acquisition of sufficient landfill sites is easily accomplished. Briquet ash is separately collected for use as cover material.

Option II : Two component wastes (briquet ash and others) separation option in which intermediate processing for the waste without briquet ash is adopted. Selection of an intermediate processing system is difficult due to factors such as, if composting is chosen, the quality of compost products is poor due to impurities, and if incineration is selected, the amount of residue is large because of non-combustibles.

Option III : Three component wastes (briquet ash, combustibles and non-combustibles) separation option where efficiency and reliability of intermediate processing is obtained by the separation.

Option IV : Four component wastes (briquet ash, combustibles non-combustibles and recoverables) separation option which applies a large task on residents because of the separation task required of them.

Among the alternatives considered in Subsection 4-2-1 of the main report, a three component waste separation is appropriate for maintaining the efficiency of intermediate processing due to merits on such matters as up-grading the compost products, raising heating value and minimizing plant capacity. The costs for collection of 2 and 3 components separation are almost equal as is shown in Table 4-2-6 of the main report. The appropriateness of the following alternatives are studied:

1. Option I : (Transfer station) + Landfill
2. Option III-a : Incineration + Transfer station + Landfill
3. Option III-b : Composting + Material Recovery + Transfer station + Landfill
4. Option III-c : Incineration + Material Recovery + Transfer station + Landfill

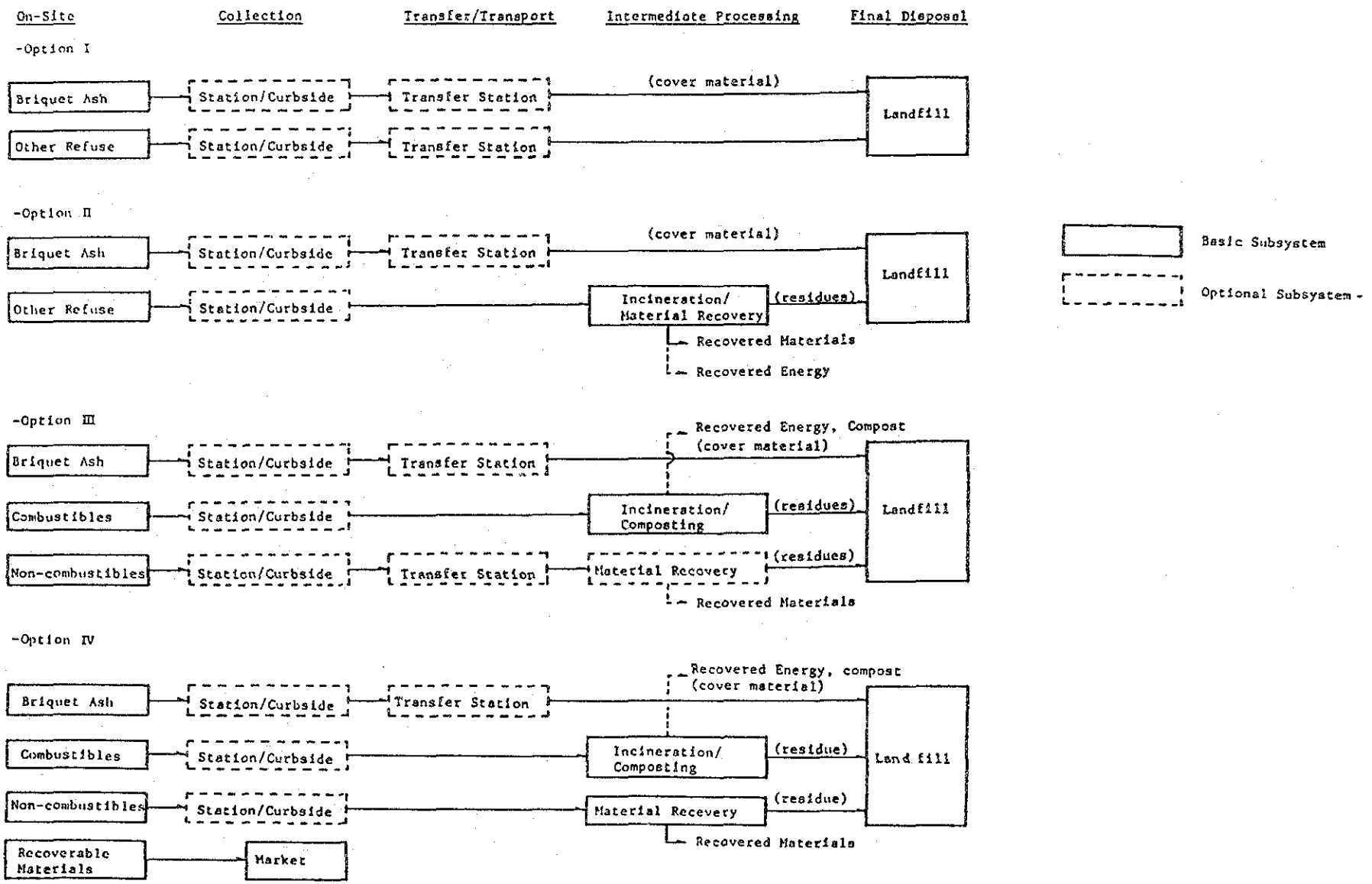


Fig. S-2 Schematic Alternatives for Master Plan

The cost comparison of the above options is indicated in Table S-9. From the cost view point:

- Option I, with transfer station, is the least expensive, while Option I, without transfer station, is the most expensive. This fact means that a transfer station has a large impact to improve collection and transportation efficiency in contrast to the costly vehicle collection system, because the distance to Incheon landfill site is long and the transportation cost is high.

- If compost is marketable and is not use as fill, Option III-b has merits in economics and volume reduction. However, demand for the compost product at present and in future is expected to be low even if it is distributed free of charge.

- On the other hand, Option III-a and III-c have potential for revenue from selling the steam for district heating and power generation when the heating value of refuse becomes sufficient for burning in the future. Shown in Table 4-3-1 of the main report.

  Therefore, in consideration of the following factors, Option III-c is recommended as the most appropriate option, and is proposed as the optimum master plan for Seoul City.

1. Most effective process for waste volume reduction (Refer to Table S-9)

2. Improved collection and transportation system to promote collection efficiency

3. Technology is proven world-wide

4. Appropriate waste process method in metropolitan areas (from view-points of environmental aspects, processing rate, etc.)

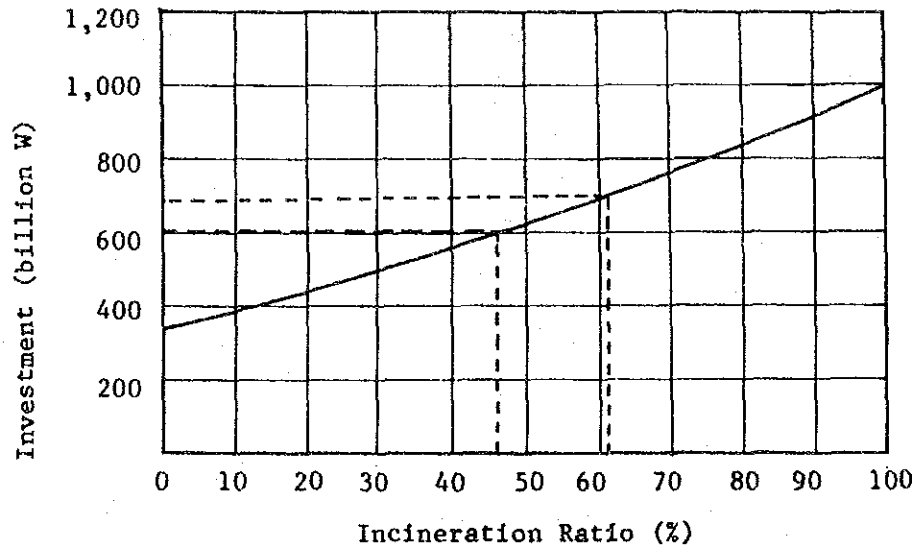
5. Potential energy and material recovery

Table S-9 Cost Comparison of Alternatives

Item		Option I (L/F)		Option III-a (I/C)	Option III-b (C)		Option III-c (I/C+M/R)
		Without T/S	With T/S		Marketable	Non-Marketable	
Investment (billion W)	Compost	-	-	-	470	456	-
	Incineration	-	-	644	-	-	644
	Material Recovery	-	-	-	68	68	68
	Transfer Station	-	17	8	8	8	8
	Operation Vehicles	261	177	186	195	243	182
	Total	261	294	838	741	775	902
O/M + Depreciation (million W/day)	Collection/Transport	430	258	181	194	249	172
	Intermediate Processing	-	-	162	138	134	186
	Landfill	35	35	15	19	27	14
	Total	465	293	358	351	410	372
Revenue	(million W/day)	-	-	-	1	1	1
Net Expenditure	(million W/day)	465	293	358	350	409	371
Filling Rate (t/day)	Incineration Ash	-	-	2,190	-	-	2,190
	Combustibles	14,580	14,580	-	5,100	10,210	-
	Non-combustibles	3,070	3,070	3,070	2,610	2,160	2,160(-RETURN-)
	Briquet Ash	7,330	7,330	7,330	7,330	7,330	7,330
Landfill Volume (m3/day)	Incineration Ash	-	-	1,530	-	-	1,530
	Combustibles	13,120	13,120	-	4,590	9,190	-
	Non-Combustibles	2,460	2,460	2,460	2,090	2,090	2,090
	Briquet Ash	4,400	4,400	4,400	4,400	4,400	4,400
	Total	19,980	19,980	8,390	11,080	15,680	8,020
Reduction Effect	(₩/M3) $\left\{\frac{\text{Net Expenditure}}{\text{Reduced Volume}}\right\}$	-	-	30,900	39,400	95,100	31,000

Note; (L/F): Landfilling, (I/C): Incinerating, (C): Composting, (M/R): Material Recovery
Reduced Volume = [Landfill Volume of Option I] - [Landfill Volume of each Option]
Mass Balance of each alternative is shown in Fig. 4-3-1

Nevertheless, Option III-c needs a large investment for implementation. Since total processing of waste is the target for the master plan, the available amount of investment should be evaluated. The optimum master plan is established on the processing ratio of the projected waste generation rate, which comes from the results of the economic evaluation in the following section (II-5). The relationship between incineration ratio and investment is shown in Fig. S-3.



Note : Investment for landfill includes Incheon landfill and Nanjido Mounding.

Fig. S-3 Correlation between Investment and Incineration Ratio

II-4 Implementation

4-1 Strategy

The basic strategy for implementation of the Master Plan is listed below.

- Introduction of separate collection at source
- Improvement of collection and transportation

- Adoption of intermediate processing
- Establishment of landfill planning
- Cooperation of residents
- Personnel and institutional reinforcement

Each subsystem of the proposed Master Plan is described:

On-site Storage	:	Three component separation of waste into briquet ash, combustibles and non-combustibles
Collection	:	Mainly adoption of mechanical collection, container box collection for briquet ash and station or curbside collection for the other waste
Transfer/Transportation	:	Mechanical transfer stations and large size transportation vehicles
Intermediate Processing	:	Incineration for combustibles and material recovery for non-combustibles
Final Disposal	:	Nanjido mounds, Incheon coastal landfill and subsidiary landfills in Seoul

The flow diagram for the proposed system is depicted in Fig. S-4 for the three separated wastes. The schedule recommended for implementation of the Master Plan is shown in Table S-10. The investment program to attain the Master Plan is indicated in Table S-11.

4-2 Proposed Facility Allocation

Derived from the least cost method in principle location for the incinerating facilities and mechanical transfer stations is proposed as shown in Fig.S-5.

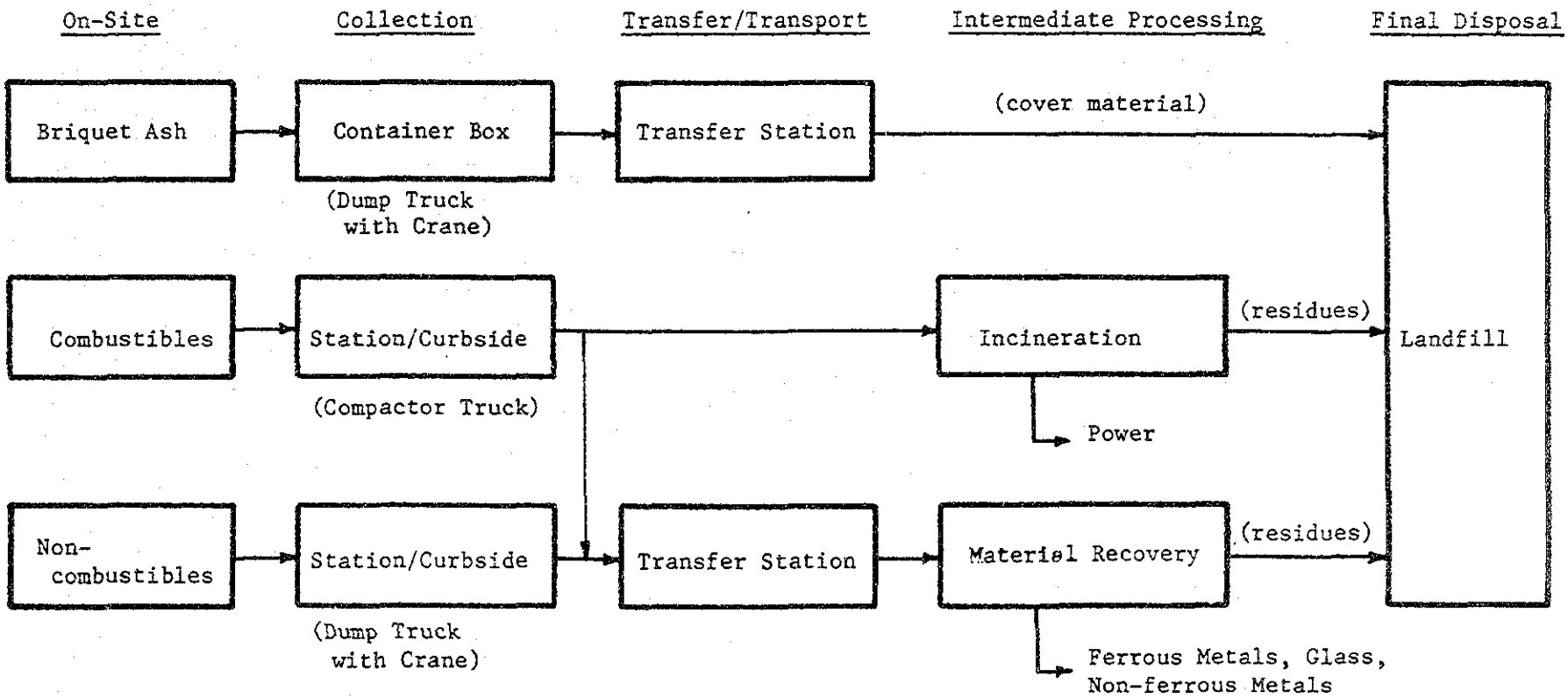


Fig. S-4 Flow Diagram of Proposed System

Table S-10 Implementation Schedule for Proposed Master Plan

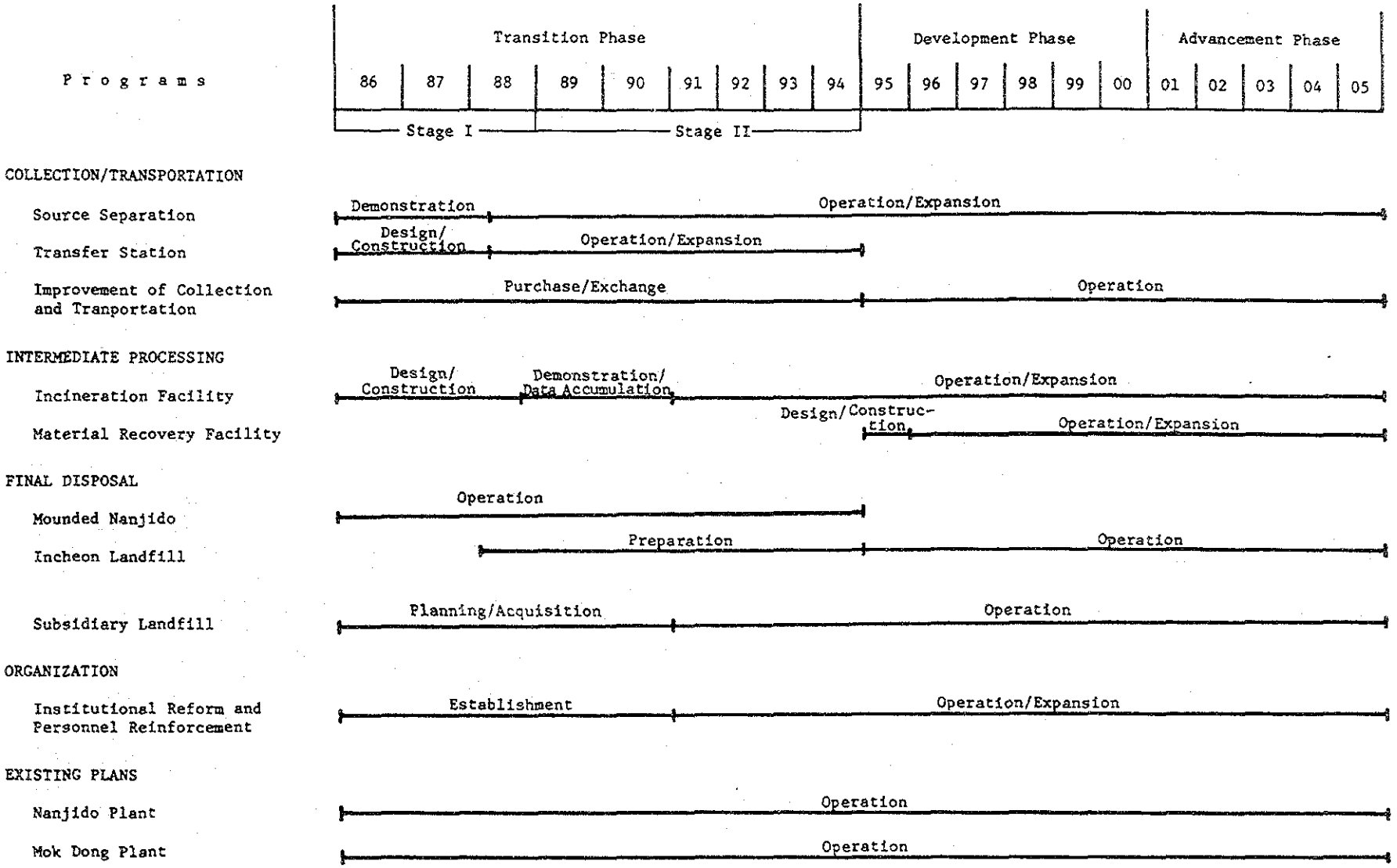


Table S-11 Investment Schedule for Proposed Master Plan

(Unit: million Won)

Year	Facility					Vehicle			Landfill			Total
	Incinerator	Transfer Station	Material Recovery	Land Acquisition	Subtotal	Collection	Transfer/ Transport	Subtotal	Nanjido	Incheon	Subtotal	
1986				1,845	1,845				3,350		3,350	5,195
1987	7,694	483			8,177				1,267		1,267	9,444
1988	15,356	371			15,727	2,893	2,495	5,388	1,267		1,267	22,382
1989		1,555		449	2,004				1,266		1,266	3,270
1990	4,796	1,845		3,780	10,421	4,694	3,535	8,229	850		850	19,500
1991	19,184	1,849		780	21,813	4,646	3,581	8,227	850		850	30,890
1992	23,980	1,849		780	26,609	4,909	3,719	8,628	400		400	35,637
1993	4,796	1,897		3,780	10,473	6,867	4,071	10,938	400	4,499	4,899	26,310
1994	19,184	1,972		780	21,936	7,679	6,091	13,770	400	15,935	16,335	52,041
1995	23,980	242	660		24,882	4,862	13,330	18,192		39,855	39,855	82,929
1996	4,796	290	660		5,746	6,658	3,895	10,553		900	900	17,199
1997	19,184	242	660		20,086	4,646	3,581	8,227		899	899	29,212
1998	23,980	242	660		24,882	4,909	3,719	8,628		2,335	2,335	35,845
1999	7,194	290	660	4,500	12,644	8,854	4,438	13,292		899	899	26,835
2000	28,776	338	660		29,774	7,679	6,091	13,770		899	899	44,443
2001	35,970	242	660		36,872	4,862	13,330	18,192		10,174	10,174	65,238
2002	7,194	290	660	4,500	12,644	9,629	4,438	14,067		899	899	27,610
2003	28,776	242	660		29,678	4,646	3,581	8,227		899	899	38,804
2004	35,970	242	660		36,872	4,909	3,719	8,628		1,126	1,126	46,626
2005		290	-		290	11,802	4,982	16,784		899	899	17,973
Total	310,810	14,771	6,600	21,194	353,375	105,144	88,596	193,740	10,050	80,218	90,268	637,383

Collection Waste Amount

Site for Facility		Collection Waste Amount [t/d]			
		I/C	T/S		
		C	B	N.C	Total
I/C + T/S	No.1	1,800	853	362	1,215
	No.2	2,040	966	411	1,377
	No.3	1,789	847	359	1,206
	No.4	2,009	951	403	1,354
T/S	No.5	-	1,209	3,068	4,277
	No.6	-	643	1,500	2,143
	No.7	-	1,861	3,909	5,770

Note; C : Combustibles for incineration
B : Briquet ash
N.C: Non-combustibles and non-processed combustibles
I/C: Incinerator
T/S: Transfer station

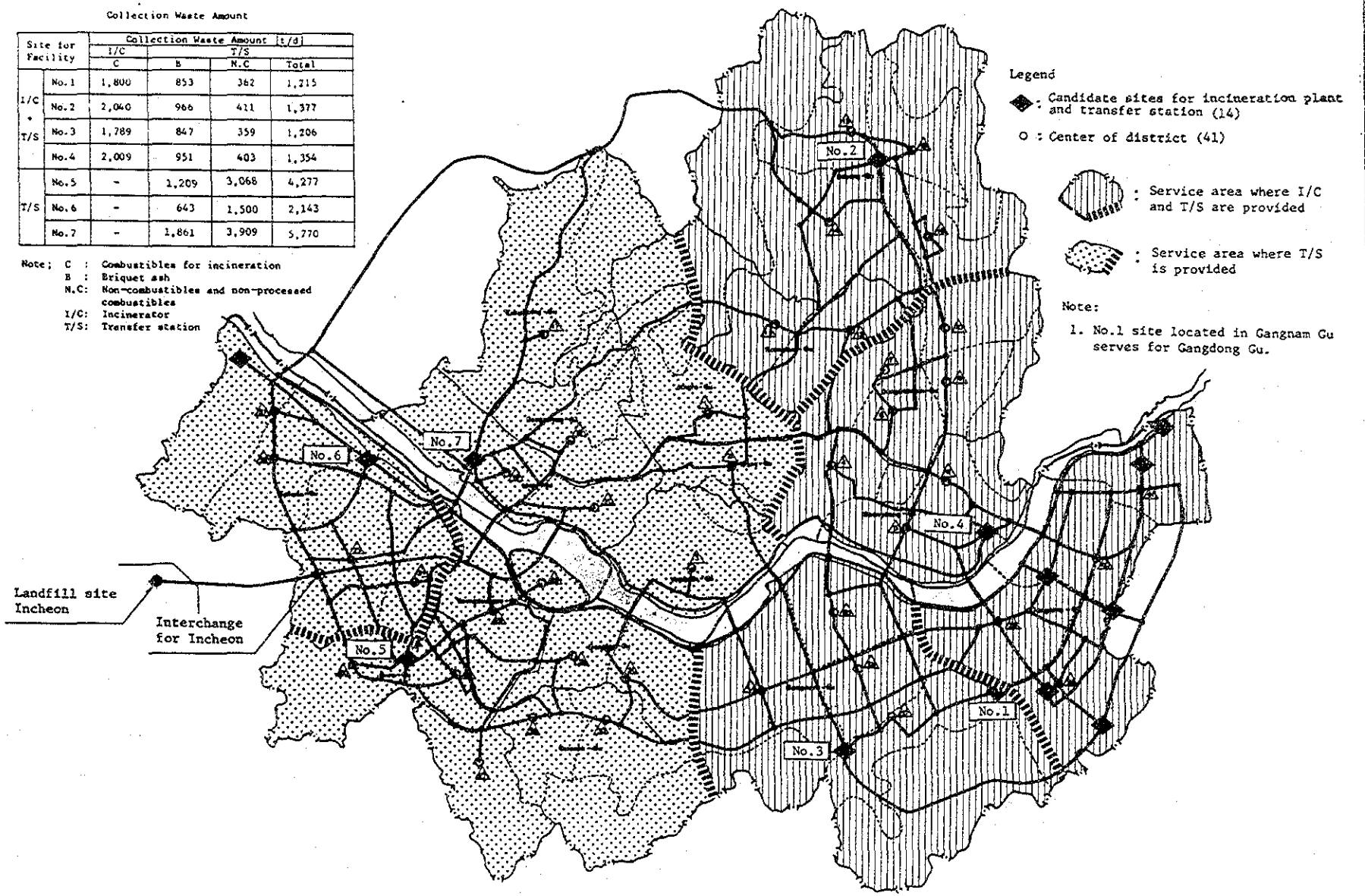


Fig. S-5 Proposed Facility Allocation and Expected Transportation Route

II-5 Economic and Financial Evaluation

Though solid waste management is indispensable to society, project capital availability may be controlled by economic factors. There may exist trade-offs between competing social needs, therefore, it will be necessary to establish priorities for alternative uses of capital. For this purpose, potential availability of capital for solid waste management was assessed by considering practices in Seoul City as well as other countries. Projections of the total capital availability during the planned period in Seoul City range from ₩985 billion down to ₩530 billion. Taking into account the economic development of Korea and Japanese experience, the likely capital availability is expected to be of the order of ₩700 billion. This scale of investment will make it possible to incinerate 50 to 60 percent of combustibles to be generated in Seoul City in the year 2005.

As shown in Fig. S-6 , however, a comparison of the annual capital requirements with the 0.2 percent allocation of gross investment reveals a possible capital shortfall in seven years out of the whole period of the Master Plan. On the other hand, cumulative capital requirements will be covered by the cumulative availability of capital from 1986 till 1993, but a cumulative shortfall will occur from 1994 when the investment on Incheon landfill will start.

These capital requirements from 1994 include about ₩80 billion for Incheon landfill. The investment cost of the landfill will take one third and 48 percent of the total capital requirements for the Master Plan in 1994 and 1995, respectively.

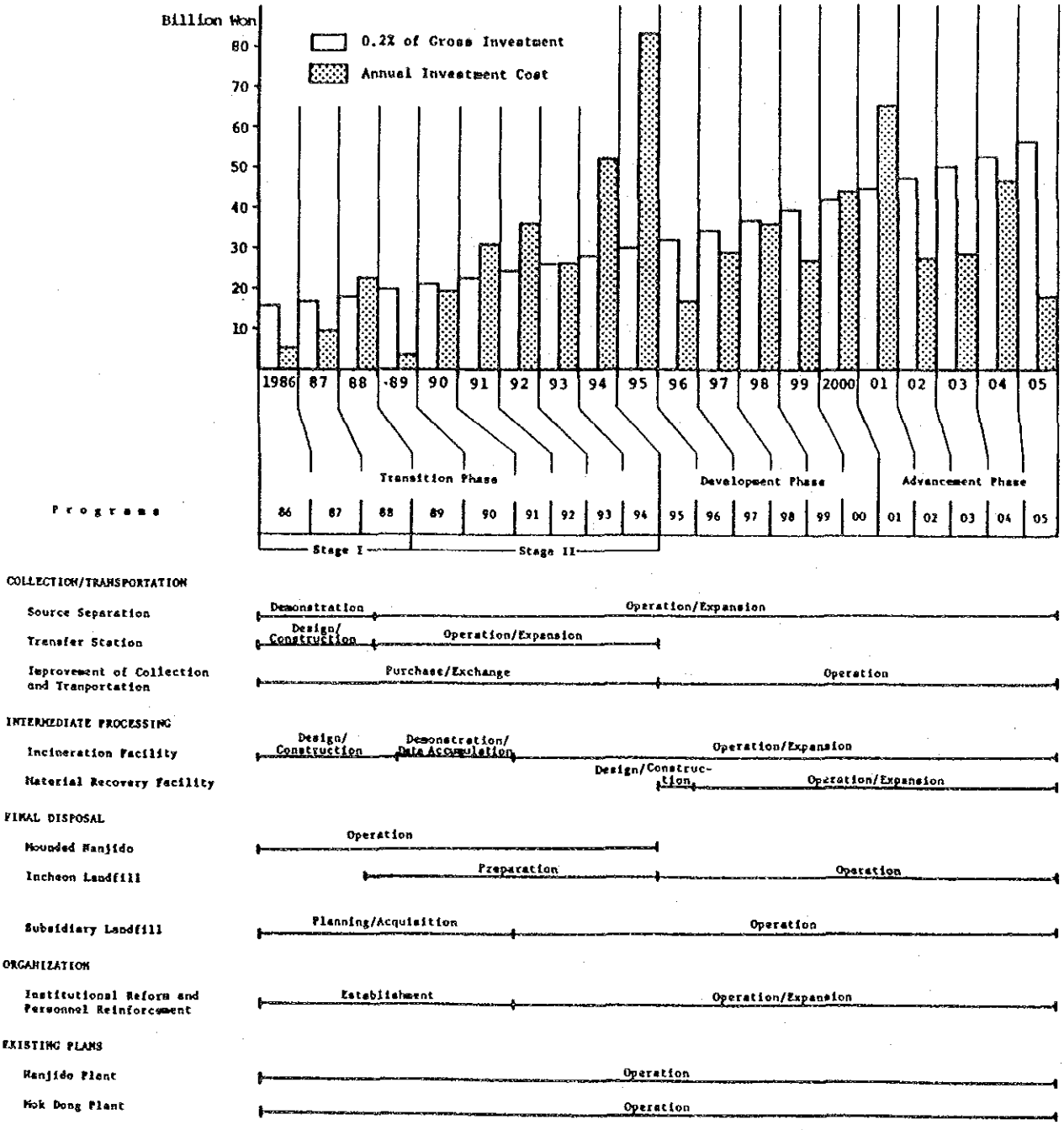


Fig. S-6 Comparison of Annual Investment Cost with Gross Investment

The self-sustaining degree drops sharply to 27.0 percent in 1996 when the operation of the Incheon landfill starts. However, if the collection fee is raised by around 10 percent, a 30-percent self-sustaining will be attained. This raise in collection fee may not be unrealistic when considering increase of family income in the future. On the contrary, the ability of rate payers will be high enough to attain more than 30-percent self-sustaining in solid waste management under the proposed system.

Table S-12 Estimated Self-Sustaining Degree

	1988	1991	1996	2001	2005
Unit Cost (₩/t)	8,013	8,227	12,322	12,530	13,002
Collection Fee (₩/t)	3,070	3,130	3,330	3,500	3,640
Self-Sustaining Degree(%)	38.3	37.5	27.0	27.9	28.0

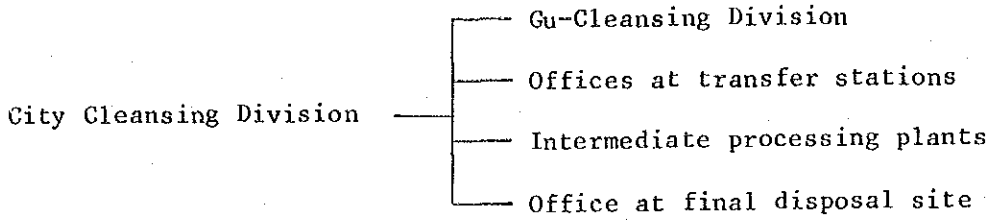
II-6 Administrative Aspects

6-1 Institutional Systemization

The study was made in line with the concept that an effective organization to cover the total system is required and the existing organization should be gradually reformed in a stepped manner.

Existing plans associated with the subject were considered in this study. These are those for the on-going material recovery plant, landfill plant at Nanjido and the soon-to-be constructed incineration plant at Mok Dong. In addition, present arrangements on the responsibilities were followed to meet the city's requirements (see Table 5-7-1 of main report).

Organizational recommendations were made only for refuse management. Jurisdiction for the municipality and Gu's is given in Table 5-7-2 of main report. The following is the recommended city management system.



Estimated number of staff members in 2005 as shown in Table S-13 reveals the following characteristics.

a. The number of collection workers will be reduced by this project.

b. The number of drivers, mechanical workers and intermediate processing operators will be increased greatly by this project.

c. The number of staff members of the city will be increased considerably.

d. The total member of staff and physical workers will be increased by 20% of present member.

It is recommended that the number of drivers and mechanical workers should be increased, and training conducted.

The reduction in numbers of collection workers of the city will be required within the limit to convert them to other occupation.

Table S-13 Present and Future Requirements in Number for Solid Waste Management in Seoul City

Position	1983	2005 Planned	2005 Without Plan	Remarks
Administrative Staff				
Division Manager (City)	1	1	1	
Division Deputy Manager (City)	0	2	1	No position at present
Section Chief (City)	3	5	4	
Division Manage (Gu)	17	21(+1)	17	
Staff (incl. Section. Chief of Gu)	148	(+14) 417 (+15)	148	
Sub-total	169	446	169	
Physical Workers				
Driver	878	3,375 (+33)	1,269	Including Private Co.
Mechanical Worker	86	623	124	ditto
Intermediate Processing Operation	0	376	0	ditto
Worker	9,813	8,234	13,455	ditto
Guard etc.	137	154	137	ditto
Sub-total	10,914	12,762 (+45)	14,985	ditto
Grand Total	11,083	13,208 (+60)	15,154	
%	100	119	137	

Notes: a. Numbers of staff members for construction are excluded
b. Figures in Parenthesis are required number at the Final Disposal Sites
c. Numbers include those from private companies

6-2 Utilization of Private Companies

Private companies are now partially engaged in waste collection after several changes in the contracts between the city authority and private companies. Work by private companies started in 1978 and the number of companies has been increasing yearly.

Management status of the private companies was examined using pertinent data from representatives of three companies. Present problems are discussed and identified as follows:

a. Management without adequate profit at present.
b. Difficulty in fund management.
c. Unsettlement of employees.
d. Necessity to collect waste from the areas with bad condition such as large seasonal fluctuation or lower income level if the collection areas are enlarged.
e. Considerable difference of unit revenue by zone.

Under these circumstances, the operations by private companies seems to leave no margin of profit. However, the City has been directing the promotion of business by private copmanies as shown by the increase in number of companies each year.

To solve the aforementioned problems, the following measures are recommended.

a. The number of private companies should be reduced and services should be provided by larger-sized companies. To avoid a monopoly by a limited number of companies it is suggested to assign one company to each Gu.

b. Funding with lower interest rates should be arranged for these private companies.

c. Collection of charges should be conducted by the City covering all the City service area, and the contract with private companies should be made in consideration of the characteristics of each Gu.

d. Feasibility study should be made to employ private companies for the exclusive collection of briquet ash during the winter season.

e. The average revenue should be at least 5,000 won per ton.

6-3 Separate Collection of Refuse

Although the refuse cleansing law states on the separate collection, it is not carried out except in some areas of the city.

With regard to the present situation, it is recommended that cooperation by the inhabitants should be promoted by providing some measures as suggested below. The required action should be taken into account for implementation of the pilot system in August 1985 planned by the City.

a. To obtain the agreement of women's and consumer's associations.

b. To have detailed explanations by Gu Cleansing Division representatives at meetings with Dongs and Tongs.

c. To give detailed explanations at visits to major waste generation sources.

d. Implementation of source separation in the public facilities governed by the City and Gu.

e. To ask for cooperation through various communication medias (e.g. television, radio, newspaper, paper for public relations).

f. To assign personnels in charge in the Cleansing Division of the City/Gu for the consultation of the problems and request from the inhabitants and business establishment.

g. Follow-up investigation through polling after implementation of separate collection.

h. Promotion by the City:
   - Observation trips to solid waste disposal facilities
   - Augmentation of surveillance system
   - To equip with advertising panels on the collection vehicles
   - Preparation of movies, leaflets and pamphlets

i. To organize and advisory committee consisting of those with experience in the field, related associations, and representatives of inhabitants.

PART III

FEASIBILITY STUDY

PART III F/S: (1) Chap. 6 IDENTIFICATION OF PROJECT FOR F/S:

6-1 Basic Concept
- -1 Objectives of F/S
- -2 Proposed themes immediate improvement
- -3 Constraint for improvement of project

→
- -1 Technical & financial examination
- -2 Adoption of incinerating system, improvement of collection/transportion & Nanjido mounding
- -3 Stage-wise manner of actual implementation due to shortage experience, man power & finance

↓

6-2 Establishment of Project Area
- -1 Criteria for selection
- -2 Preliminary screening
- -3 Final screening
  - (1) Screening of evaluation factor
  - (2) Evaluation of transportation improvement
  - (3) Comprehensive evaluation

→
- -1 Transportation distance to Nanjido & availability of suitable land
- -2 Selection of Dobong (Zone II), Gangdong (Zone V) due to big Ton-km
- -3 (1) Volume reduction, construction cost, adverse impacts, etc.
  (2) Gandong is favourable due to 1.3 times of truck-hours save merit when 600 tons are incinerated
  (3) Selection of Gangdong due to investment effect for entire Seoul city by means of least cost method and another factor

↓

Gangdong Gu

↓

6-3 Conceptual Planning
- -1 Summary of basic parameters
- -2 Long term plan for project area
- -3 Mass balance of waste in project area

→
- -1 Population & waste generation rate in Gangdon Gu
- -2 Provision of 600 t/d incineration due to minimize risks on starting new system/2nd plant 1,200 t/d due to rapid increasing of cumbustible waste & inducing of new collection/transportation system
- -3 Combustibles 864 t/d (50%), non-combustibles 165 t/d (9%), briquet ash 708 t/d (49%) Total 1,737 t/d) in 1988

↓

: (2) Chap. 7 BASIC DESIGN

7-1 General Framework
- -1 Population forecast
- -2 Waste generation rate forecast
- -3 Plant location

→
- -1 Population forecast by each dong
- -2 Generation rates in 1988 are 864 t/d, 165 t/d and 708 t/d for combustible, noncombustible and briquet ash, respectively
- -3 Gongnam Gu Ilwon Dong, eastern side of Tanchon waste water treatment plant

↓

7-2 Collection and Transportation
- -1 Basic conditions for planning
- -2 Collection and transportation
- -3 Transfer station
- -4 Cost estimation

→
- -2 Zoning of collection area, storage methods, collection frequency, vehicle assignment, comprehensive plan
- -4 1,348.5 million W of investment cost for transfer station, 2,499.5 million W of investment cost for operation vehicles and 3,174.2 W/yr of O/M cost (Nanjido), 5,725 W/yr of O/M cost (Incheon) for both transfer station and operation vehicles including depreciation

↓

7-3 Intermediate Processing
- -1 Capacity and recommended area for incineration
- -2 Incineration method
- -3 Preliminary planning of incinerator
- -4 Specification
- -5 Cost estimation

→
- -1 600 t/d incineration plant, Dong's with central heated apartments are recommended as collection area for incineration
- -2 Stoker type with heat recovery
- -3 Design of incinerator and layout plan in the plant
- -4 1,800 kW electric generator, other equipments
- -5 23,050 million W of investment cost and 2,077 million W/yr of O/M cost including depreciation

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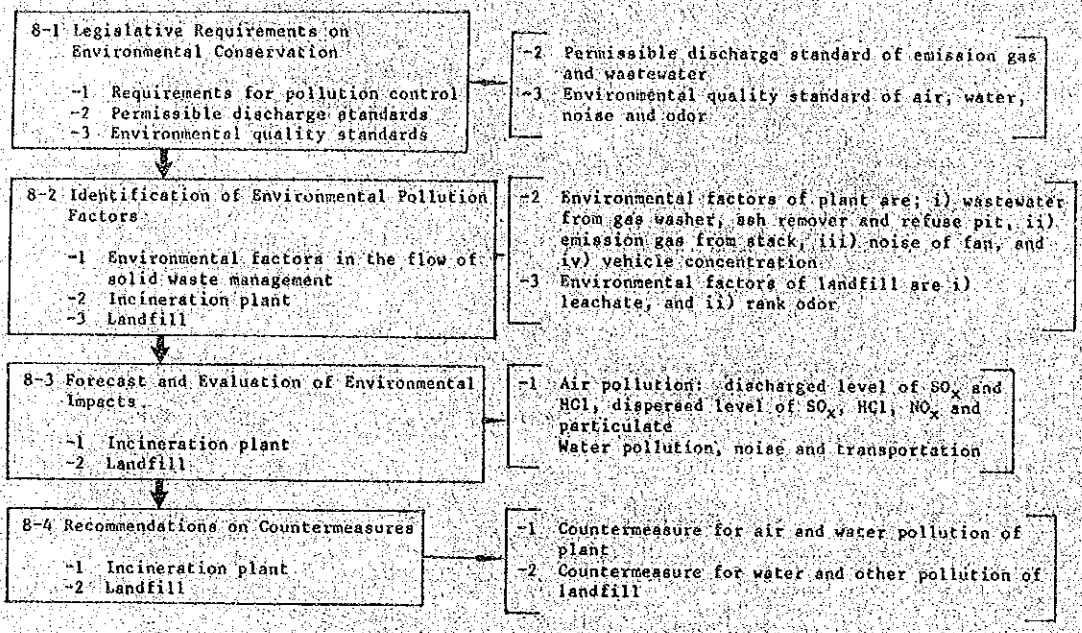
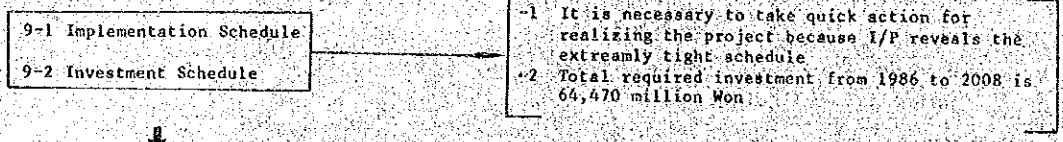
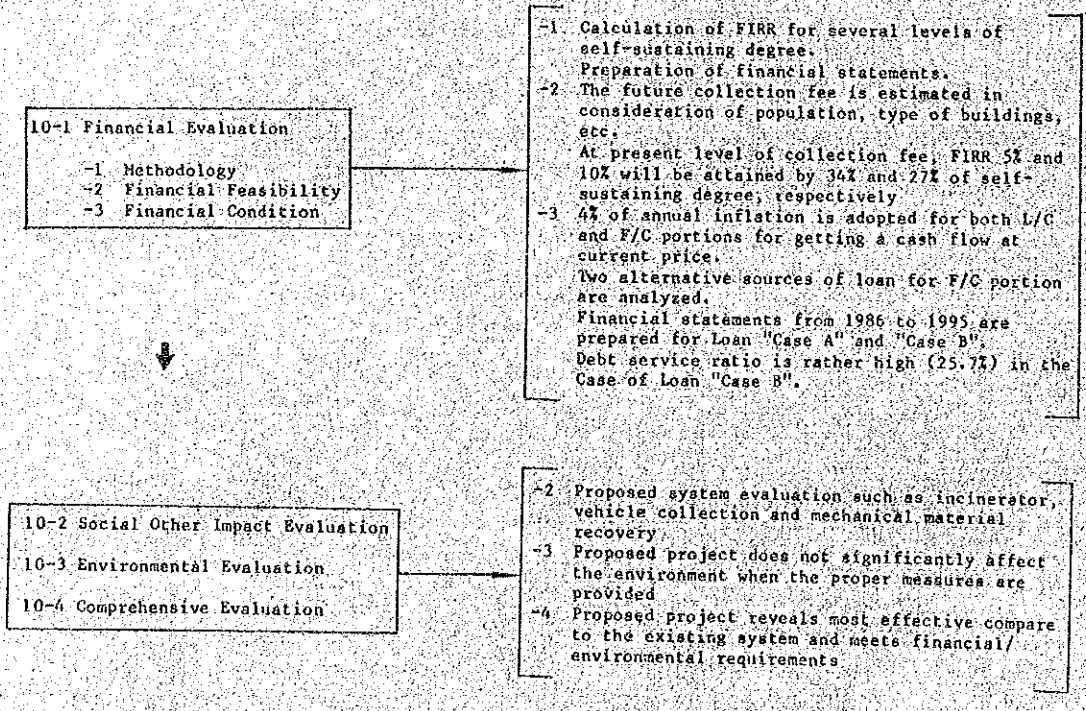
PART III F/S; (3) Chap. 8 ENVIRONMENTAL ASSESSMENT



: (4) Chap. 9 PROJECT SCHEDULE FOR IMPLEMENTATION



: (5) Chap. 10 PROJECT EVALUATION



PART III FEASIBILITY STUDY

III-1 Project Identification

1-1 Basic Concepts

A project to improve the existing solid waste management system of Seoul, which is urgently needed in the short term by 1988, is the subject of the feasibility study. The feasibility study encompasses basic planning of facilities and evaluation of financial matters and environmental aspects.

The principal themes which require immediate reform are derived from specified existing problems:

- Establishment and development of an intermediate processing system, in which emphasis should be given to volume reduction of waste.

- Improvement in the existing collection and transfer system, which is accompanied by adoption of the above intermediate processing system, and

- Improvement of the Nanjido landfill site

The master plan intends to establish (1) separate/mechanical collection and transfer system, (2) incineration and materials recovery system, and (3) landfill site acquisition. The above themes correspond to these three intentions. The intentions and themes are mutually interdependent and should not be carried out in isolation from each other, hence, these themes are combined to form a "Project", and studied comprehensively.

1-2 Preliminary Screening of High Priority Areas

Improvements in solid waste management with respect to intermediate processing in Seoul are gradually progressing. As of now, two of the four waste processing zones established for Seoul by the Waste Management Division have started the construction of some kind of process: a 1,500 t/day material recovery plant at Nanjido in the upper west zone and a 300 t/day incineration facility at Mok Dong in the lower west zone.

The two remaining zones in the east are yet without plans and are especially in need of improvement. Within these zones, the two Gu's farthest from Nanjido are Dobong Gu and Gangdong Gu (Fig. S-7). These two Gu's were selected therefore for this study.

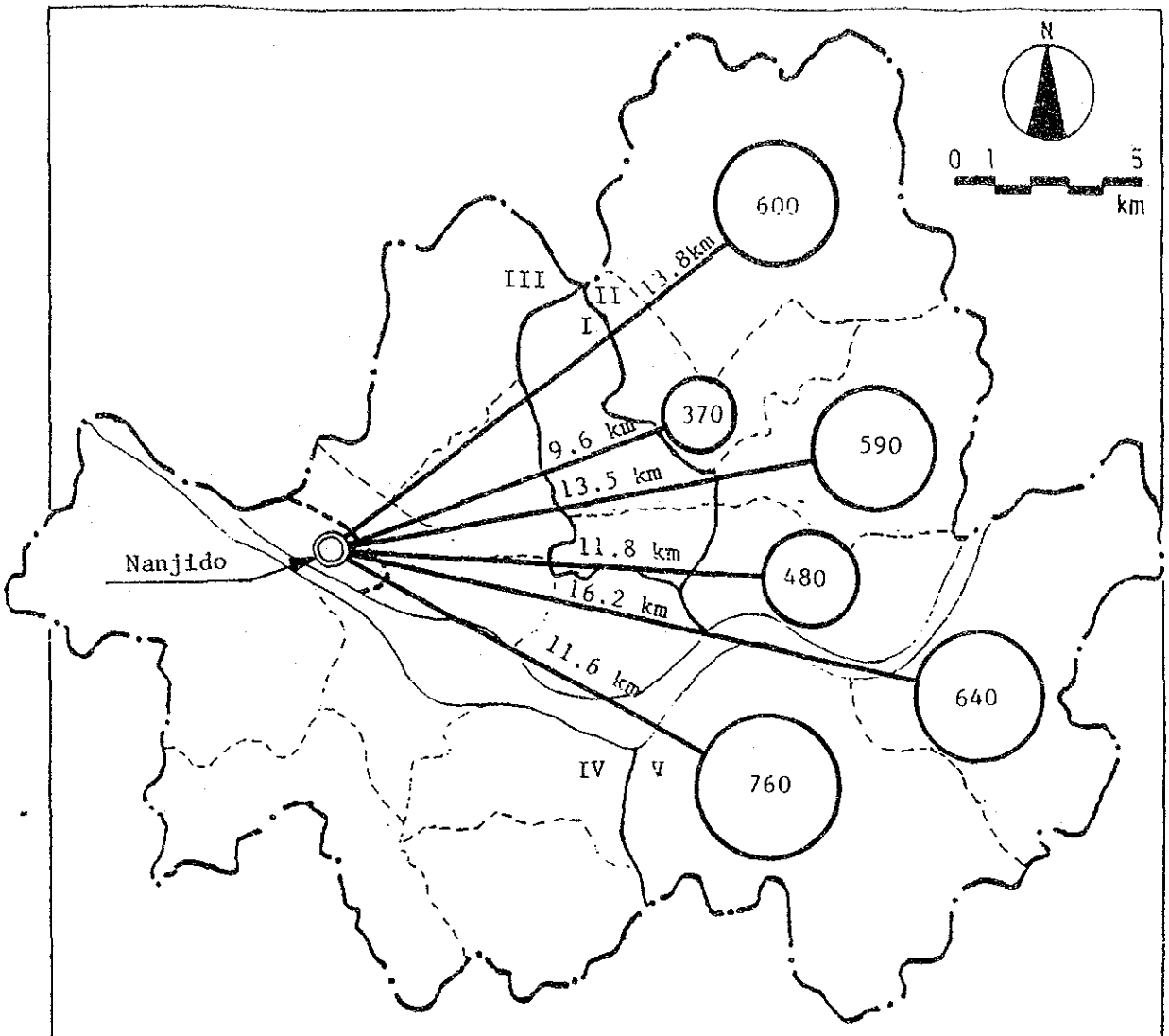
1-3 Establishment of the Project Area

Evaluation of the candidate sites were made with respect to transport effect regarding the indexes such as ton-km and truck-hours. In this section, quantitative evaluation is made by the least cost method for final screening of project area before performing the comprehensive evaluation. The purpose of quantitative evaluation is to determine the investment effect of the short term project on both transportation cost but also facilities cost of incineration plant and mechanical transfer station.

To make a quantitative evaluation, the following two criteria are established by using the principle of the least cost method:

- The amount of waste reduction is the same for the both Models.

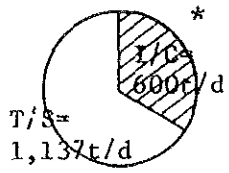
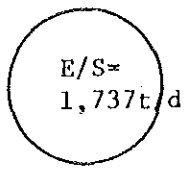
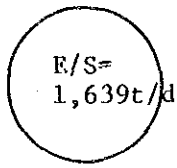
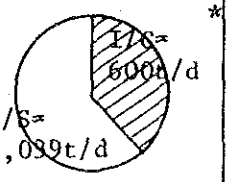
- Total of the refuse amount treated by the proposed facilities and the existing system are the same for the both Models.



Zone	Gu	Volume (1,000 t/year)	Distance (km)	Vol.x Dist. (1,000 t.km/year)	Rank
II	Seongdong	480	11.8	5,664	3
	Dongdaemun	590	13.5	7,965	2
	Seongbug	370	9.6	3,552	4
	Dobong	600	13.8	8,280	1
	Sub total	2,040			
V	Gangnam	760	11.6	8,816	2
	Gangdong	640	16.2	10,368	1
	Sub total	1,400			

Fig. S-7 Volume and Transport Distance from Each Gu in Zone II and V

Following models are established to evaluate the investment effect of the short term project and the calculated results are shown in Table S-14.

Gu	Solid Waste Volume(t/day)	Model-1	Model-2
Gangdong	1,737		
Dobong	1,639		
Total Volume	3,376	3,376	3,376

Note: I/C = Incineration Plant

T/S = Mechanical Transfer Station

E/S = Existing System (Hand Cart Manual Transfer)

* Optimum capacity for the first step as demonstration as discussed in Subsection 5-5-1 of the main report.

Table S-14 Comparison of Cost of Each Model

Item	Cost (₩1,000/year)	
	Model-1*	Model-2**
Vehicle Collection	4,501,711	4,524,351
Existing Collection	5,650,928	6,639,934
Large Scale Transfer Station	240,324	224,830
Incinerating Center	2,269,490	2,269,490
Total	12,662,453	13,658,605

* Incineration plnat is constructed in Gangdong Gu.
** Incineration plant is constructed in Dobong Gu.

From a cost viewpoint, the results indicate that:

1. The vehicle collection cost including transportation cost of Model-1 is less expensive than Model-2 although the transportation distance (L=26.5 km) from the proposed transfer station in Gandong Gu to Nanjido is longer than Dobong Gu (L=22.5 km) and refuse volume managed by the new system in Model-1 (1,737 t/d) is larger than Model-2 (1,639 t/d).

   This is because 4 ton vehicles are used in Gandong Gu, but only 2 ton vehicles are used in Dobong Gu due to topographic restrictions.

2. The existing collection cost, consists of hand cart collection cost and transportation cost of Model-1 is cheaper than Model-2, because the refuse volume managed by the existing system in Model-1 (1,639 t/d) is less than Model-2 (1,737 t/d). The transportation distance from Dobong Gu (L=22.5 km) is shorter than the distance from the existing transfer station in Gandong Gu (L=30 km).