3.11 Finance

(1) Solid Waste Management Costs

The expenditure for solid waste management (SWM) is a major part of the total municipal budget in both MPPP and MPSP. In 1987, the expenditure for SWM shares 37% of the total municipal revenue in MPPP, and 31% in MPSP, as shown in Table 3.11-1.

Table 3.11-1 Financial Situation on SWM

(M$1,000)

	MPPP (1987)	MPSP (1987)
a. SWM expenditure	18,792	9,864
b. Total municipal revenue	68,860	31,359
c. Total municipal expenditure	75,985	39,589
Ratio of a to b (a/b)	27%	31%
Ratio of a to c (a/c)	25%	25%

The above shown ratios are much higher than those found in most Japanese municipalities. It should be noted, however, that the financial system of the Local Authorities in Malaysia is different from that in Japan. In Malaysia, a major part of the investment or capital expenditure is included in the state and federal budget.

The cost of component solid waste management services such as collection, street sweeping, etc. cannot be accurately calculated because the separate accounting system has not been introduced in local authorities.

An estimation of SWM cost based upon the number of employees and vehicles involved in each service shows that the cost of refuse collection shares over 40% of the SWM cost, while the cost of refuse disposal shares only 3% in MPPP, as shown in Table 3.11-2. Corresponding figures for MPSP are 37% and 1% respectively as shown in Table 3.11-3.

The average cost of refuse collection by MPPP and its contractors is calculated as M$67/ton. And, the corresponding average cost of MPSP and its contractors is M$84/ton in MPSP. The said cost (M$84/ton) includes street/drain cleansing cost borne by the contractors as well. The cost of refuse collection and refuse disposal will increase because of the increment of the amount of solid waste and the future change of disposal system to sanitary landfill.

Additional expenditures are used for other services, namely, street sweeping, drain cleansing, grass cutting and beach cleansing.

The refuse collection service is partly contracted out. Contractors received 78% of the refuse collection expenditure in MPPP, and 32% in MPSP in 1987.

(2) Fee Collection

Fees for the collection of commercial waste and for special collections are charged, although the fee is not enough to cover the actual cost. On the other hand, fees for domestic waste collection are not collected because the assessment is supposed to cover almost all SWM costs.

A disposal fee (fee for the use of the dumpsite) is collected in MPPP. The amount does not depend on the amount of waste hauled. Instead, a fixed fee is charged per user, per month. It is said that the efficiency of the fee collections is nearly 100%. MPSP, on the other hand, does not collect either commercial waste collection fees and tipping fees.

Table 3.11-2 Cost of Public Cleansing Services in MPPP (in 1987)

(M$1,000)

	ADMINIS-TRATION	CLEANSING SERVICES				REFUSE COLLEC-TION	REFUSE DIS-POSAL	TOTAL
		STREET	DRAIN	GRASS	BEACH			
Personnel Expenditure	196	3,408	4,242	170	414	1,165	135	9,730
Contract Services		-	38	-	-	6,768	-	6,806
Material & Tool		57	72	2	4	30	2	167
Other Expenditures		229	285	11	28	80	5	638
Maintenance		72	89	4	9	394	206	774
- Vehicle		71	88	4	9	382	70	624
- Others		1	1	-	-	12	136	150
Fuel & Others		30	35	2	4	73	227	371
- Vehicle		14	16	1	2	73	13	119
- Others		16	19	1	2	-	214	252
Depreciation		27	33	1	3	145	27	236
Sub-Total	196 [1.0]	3,823 [20.4]	4,794 [25.6]	190 [1.0]	462 [2.5]	8,655 [46.2]	609 [3.3]	18,729 [100.0]
Other Dept. of MPPP	-	-	-	1,728	-	-	-	1,728
State Government	-	-	119	94	-	-	-	213
Total	196 [0.9]	3,823 [18.5]	4,913 [23.8]	2,012 [9.7]	462 [2.2]	8,655 [41.9]	609 [2.9]	20,670 [100.0]

Note:

1. Any amounts less than M$500 is shown as 0.
2. [ ] shows share (%)
3. Source: Belanjaan tahun 1988 of MPPP

Table 3.11-3 Cost of Public Cleansing Services in MPSP (in 1987)

(M$1,000)

	ADMINIS-TRATION	CLEANSING SERVICES				REFUSE-COLLEC-TION	REFUSE DIS-POSAL	TOTAL
		STREET	DRAIN	GRASS	BEACH			
Personnel Expenditure	160	1,538	1,926	83	139	3,083	62	6,991
Contract Services		382	479	21	-	916	-	1,832
Material & Tool		2	3	-	3	-	-	8
Other Expenditures		21	27	1	2	43	1	95
Maintenance		32	40	2	3	251	11	339
- Vehicle		-	-	-	-	187	10	197
- Others		32	40	2	3	64	1	142
Fuel & Others		7	8	-	1	84	4	104
- Vehicle		-	-	-	-	71	4	75
- Others		7	8	-	1	13		29
Land Rent		-	-	-	-	-	29	29
Depreciation		-	4	12	-	427	23	466
- Vehicle		-	-	-	-	427	23	450
- Others		-	4	12	-	-	-	16
Sub-Total	160 [1.6]	1,982 [20.1]	2,487 [25.2]	119 [1.2]	145 [1.5]	4,807 [48.7]	130 [1.3]	9,864 [100.0]
Other Dept. of MPSP	-	-	-	661	-	-	-	661
State Government	-	-	146	2,354	-	-	-	2,500
Total	160 [1.2]	1,982 [15.2]	2,633 [20.2]	3,134 [24.1]	145 [1.1]	4,809 [36.9]	130 [1.0]	13,025 [100.0]

Note:

1. Any amounts less than M$500 is shown as 0.
2. [ ] shows share (%)
3. Source: Belanjaan tahun 1988 of MPPP

Chapter 4. Evaluation of the Current Conditions of Solid Waste Management

4.1 Appreciable Current Management Practice

Appreciable points with respect to solid waste management of MPPP and MPSP include the following:

(1) MPPP

a. MPPP provides high level collection service (door-to-door collection on daily basis) in almost all the MPPP area.

b. MPPP has two independent collection systems: one for domestic waste, the other for business establishments which discharge large amount of waste. To have those two independent collection systems is more efficient than a case where there is only one collection system for the two types of wastes (domestic waste and large amount waste).

c. MPPP collects two kinds of fee from the service recipients: one is the fee for commercial waste collection, the other is tipping fee for disposal service. The fee collection system, if further developed, will contribute much to the strengthening of the financial base for solid waste management.

d. MPPP has made efforts for the standardization of storage and discharge system for highrise buildings (i.e. dust chute with bulk-bin).

e. Disposal standard at the existing site has greatly improved during the past few years through periodical soil covering.

f. MPPP uses a weighbridge for many years to monitor waste amount brought into the sites, through which contractors' performance has been evaluated.

g. MPPP under the leadership of the Ad Hoc Committee has served as a pioneer in the promotion of privatization of solid waste collection service, and gained valuable experience in this field.

h. MPPP has small incinerators to treat waste such as dead animals which cannot be directly disposed of.

i. The pilot project for introduction of 3-times-a-week-collection and once-a-week-cleansing in Bayan Baru area has been successfully executed.

(2) MPSP

a. MPSP has been making efforts to provide better collection and cleansing services under the financial constraint.

b. Health Department has a sub-office and a garage in each district in order to provide waste collection and street/drain services at respective districts. Such system is good in view of the geographical conditions in MPSP area.

c. MPSP has provided depo and improved hand-carts in new housing development area, through which waste collection efficiency has been increased.

d. MPSP has been making efforts to develop Local Authority Management Information Service (LAMIS) and some mapping system together with U.S.M.

e. MPSP demonstrated its ability to improve waste disposal standard within a short period by construction of on-site roads and application of covering soil.

f. MPSP has been actively and creatively using weighbridge in order to improve waste collection efficiency.

All the above appreciable points have been taken into account in the preparation of the master plan.

4.2 Major Deficiency of Current Management Practice

Major deficiency of the current management practice is caused by the following problems and issues.

(1) Low operational efficiency
(2) Inadequate sanitary landfill
(3) Weak management
(4) Inadequate citizens' cooperation
(5) Weak financial base for solid waste management
(6) Insufficient service coverage (MPSP)

4.2.1 Low Operational Efficiency

The operational efficiency of waste collection service provided by both MPPP and MPSP is low. There are many factors which lead to the low efficiency as shown in Fig. 4.2-1. Major factors include the following:

- Inappropriate storage and discharge system and practice which are caused by
  1) Insufficient instructions to the public by the Councils
  2) Inadequate residents' cooperation
- Door-to-door collection on daily basis
- Use of side-loaders and open-trucks and maintenance problems
- Dust-chute system (Poor access to dust-chute) and its maintenance problems
- Poor maintenance of communal containers (MPSP)
- Poor labor management

In view of the fact that the waste collection efficiency depends on both the Councils' effort and residents' cooperation, acquisition of more residents' cooperation is a very important subject.

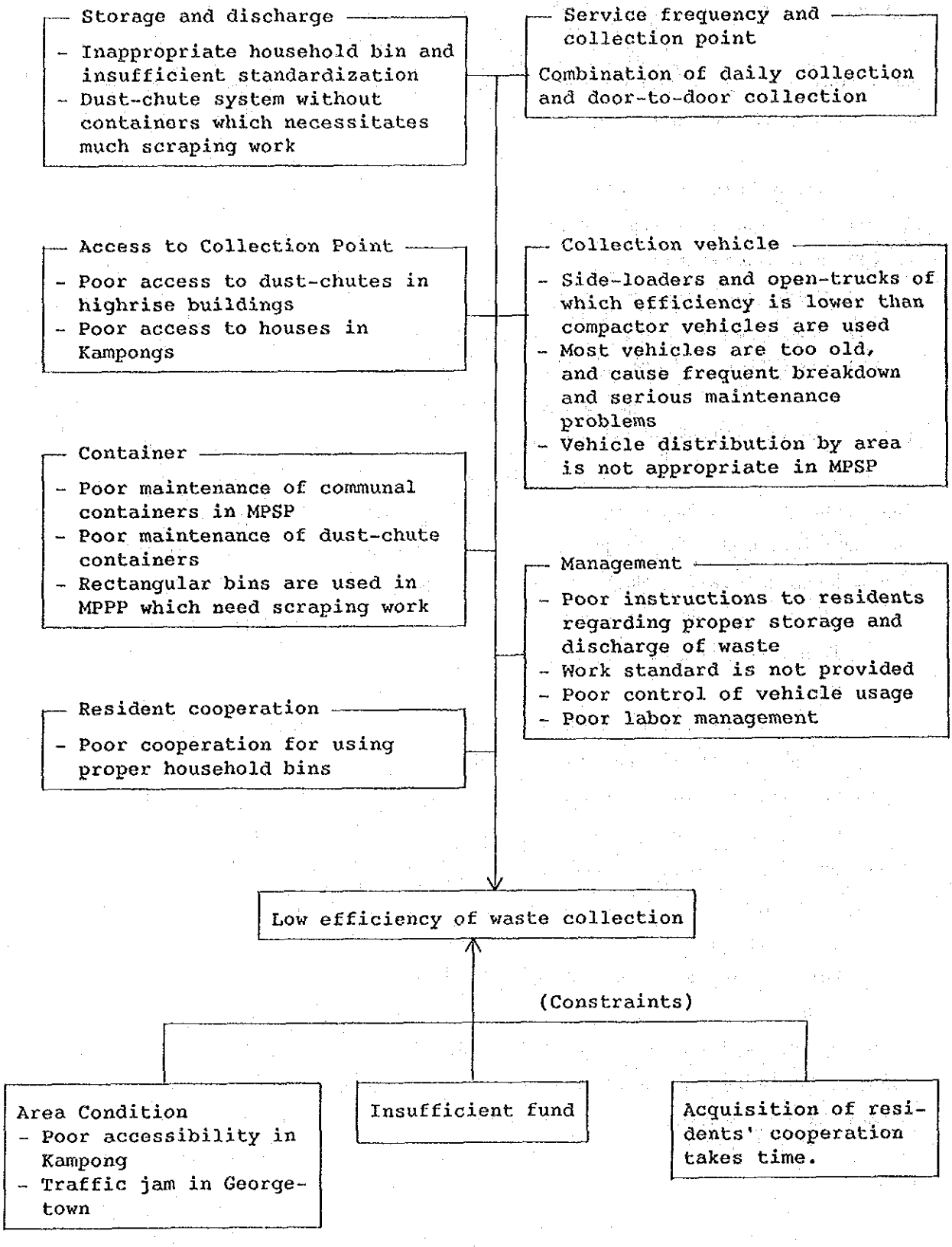


Fig. 4.2-1 Factors which Cause Low Operation Efficiency

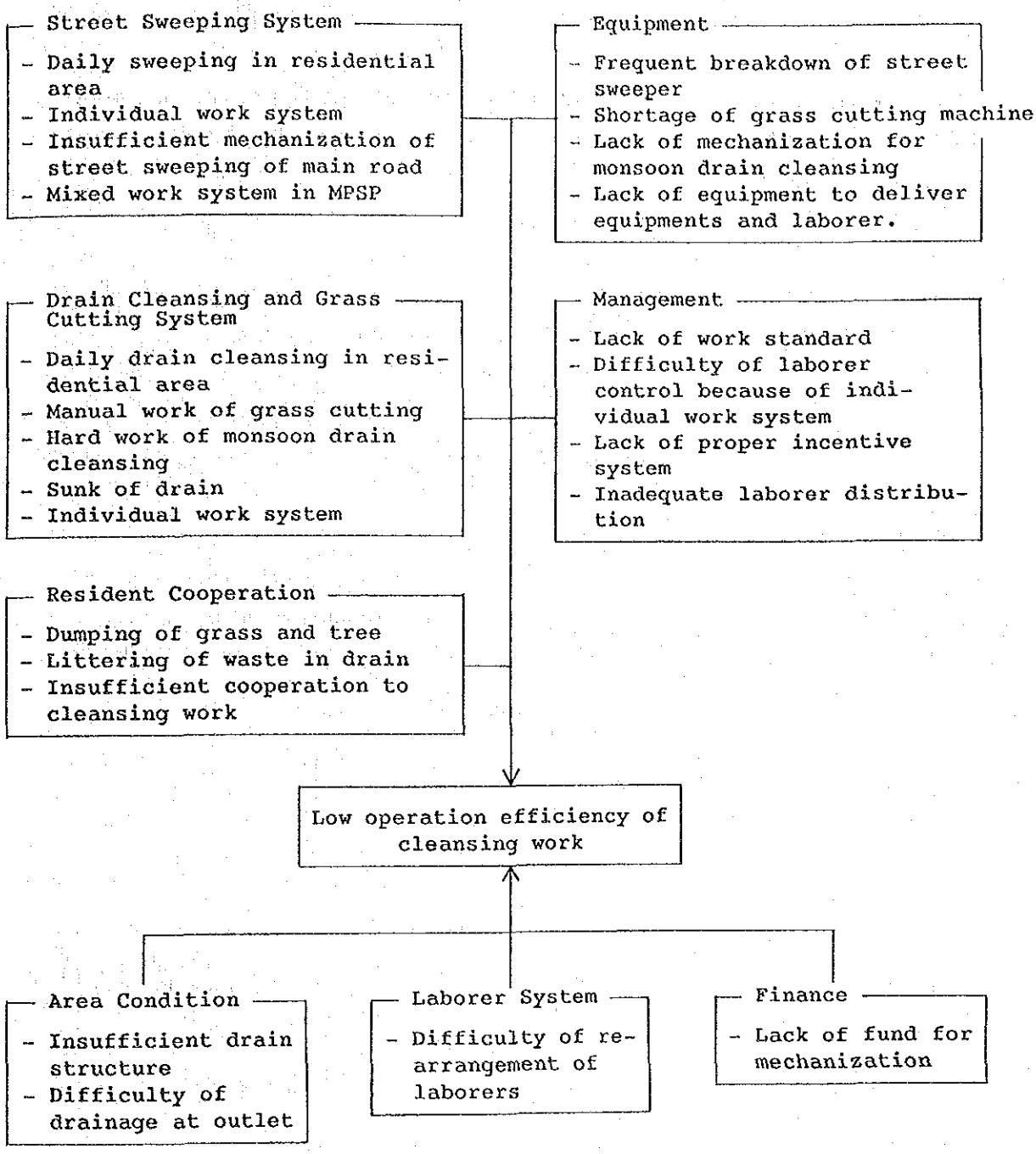


Fig. 4.2-2 Factors of Low Operation Efficiency of Cleansing Work

4.2.2 Inadequate Sanitary Landfill

The final disposal systems applied by both MPPP and MPSP, though improved greatly with the implementation of immidiate improvement plans, is still inadequate in view of the following:

- Insufficient application of covering soil
- Leachate treatment and control
- Occurrence of fire and smoke
- Inadequate provision of bund, fence and on-site-roads

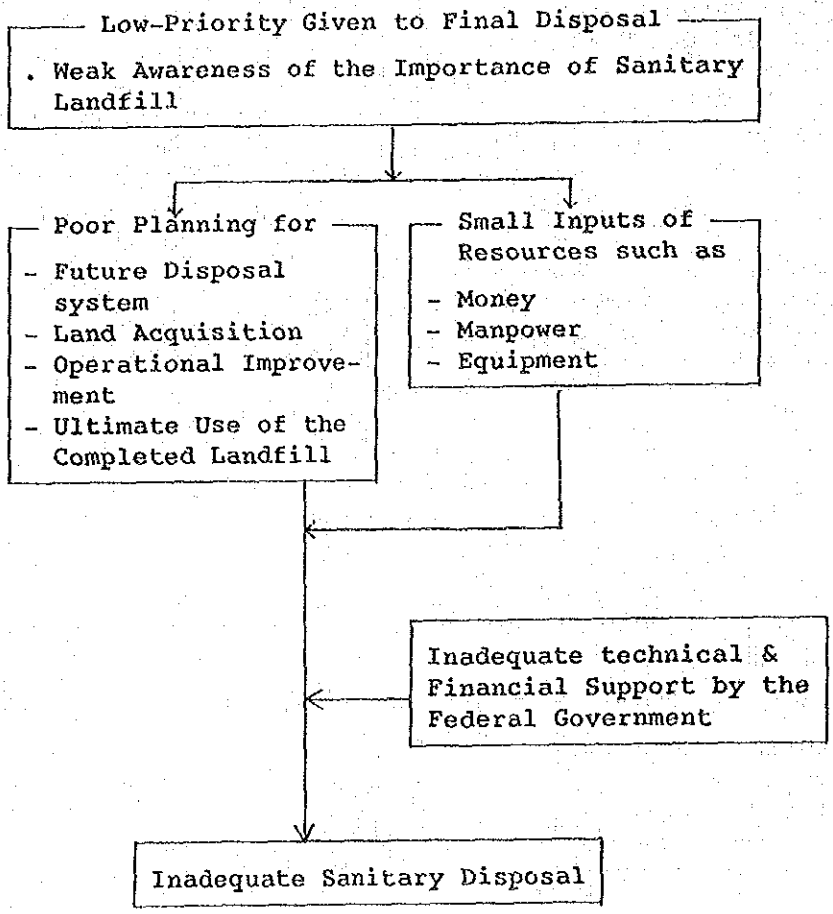


Fig. 4.2-3 Factors Leading to Inadequate Sanitary Disposal

4.2.3 Weak Management

The objective of the management, both in general and SWM, is to maximize the outputs, given a certain level of inputs (resources available) such as manpower, money, and technology through fuller and more effective utilization of those inputs.

Managerial capacity and efforts of both MPPP and MPSP are inadequate in the sense that the Councils' resources are not fully and effectively used, and hence the output (SWM Services) are not maximized. This follows that SWM services of both Councils can be further improved in terms of both quantity and quality by improving the managerial aspects.

Major factors responsible for the Councils' weak management regarding SWM include the following:

- General responsibility system applied to Public Health Inspectors (PHIs) in Health Department where no functional specialization and no concentration on SWM have been realized.

- Insufficient work-morale-support and disciplinary control by the Councils' top administrators.

The factors and consequence of the weak management are schematically shown in Fig. 4.2-4.

The importance of the functional specialization, work-morale-support and disciplinary control is further discussed in Sections 10.1.1 and 10.2.1.

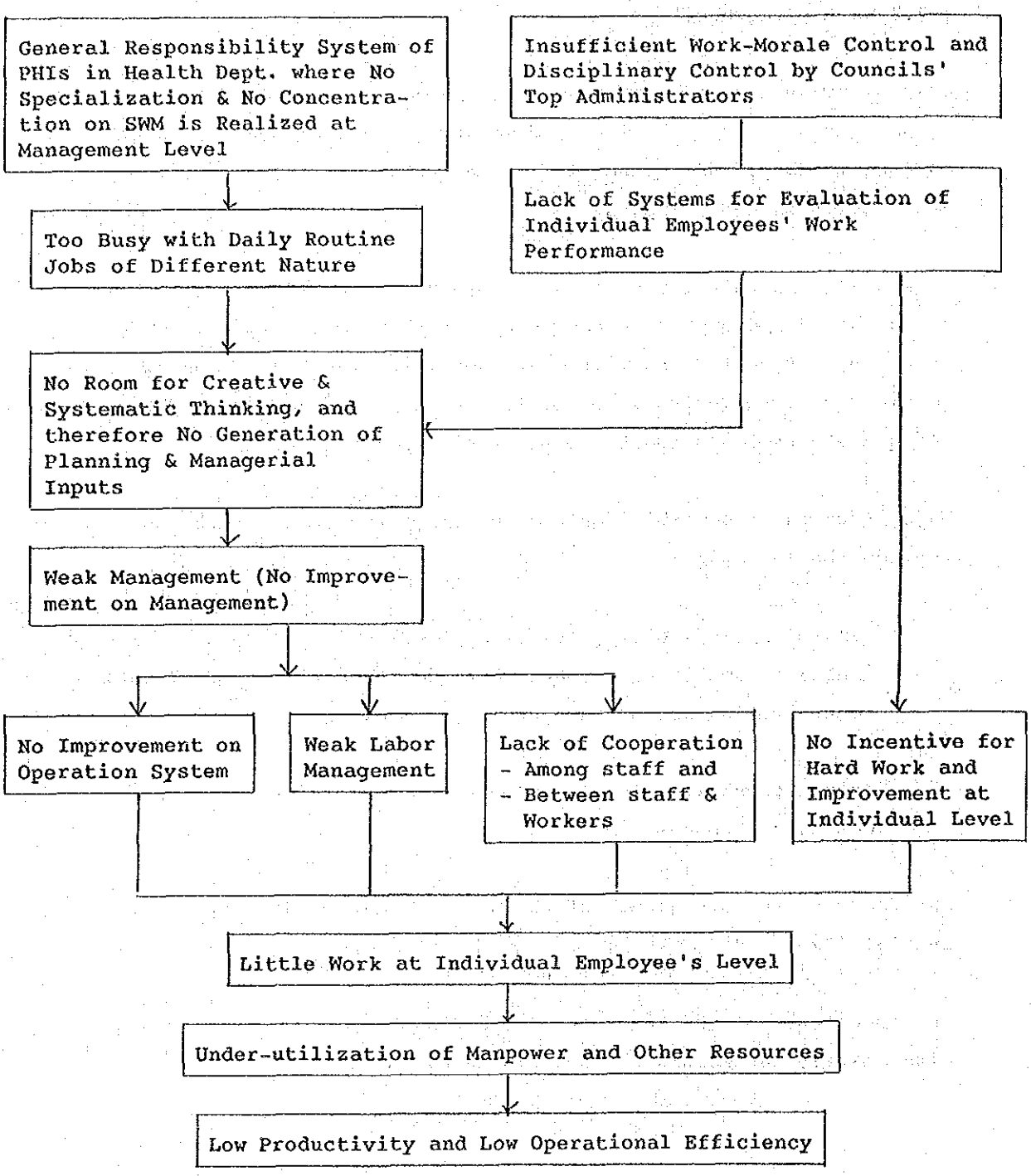


Fig. 4.2-4 Factors Related to the Weak Management

4.2.4 Inadequate Citizens' Cooperation

One of the major differences between solid waste management (SWM) and other public services such as water supply and sewage services is that SWM requires public cooperation for its successful and efficient operation, while other public services do not.

As discussed in Section 11.1, public cooperation is required in such aspects as:

- Waste storage and discharge manner
- Non-littering at public places

Public cooperation is inadequate in both Penang and Seberang Perai. Major reasons for the inadequate public cooperation include the following:

1) The Councils have not given clear and strong instructions to the public regarding what the public have to do.
2) The Councils have not resorted to the strong law enforcement.
3) Inadequacy in public education for children at home and schools.
4) Provision of door-to-door collection service on daily basis.

The last item needs an explanation. Under the system of door-to-door collection on daily basis, residents can discharge waste any time. In this situation, the residents do not feel the necessity for the public participation and cooperation in controlling storage and discharge of waste. Citizens would develop such feeling when the Councils introduce an alternate day or a 3 times/week collection system or a station collection system which requires the citizens to keep waste in their houses for certain period of time.

4.2.5 Weak Financial Base for Solid Waste Management

The weak financial base coupled with rapid increase in SWM expenditures have been causing the Councils to fall in financial difficulty. Fig. 4.2-5 schematically shows various factors which have caused the financial difficulty.

Major source of the Councils' revenue is the assessment. A basic problem is that the assessment revenue has not increased much in recent years while the expenditures have substantially increased. The following is important in view of improving Councils' revenue.

- Review of assessment rate
- Reduction of arrear through the strong enforcement

In reviewing the assessment rate, it is advisable for both Councils to estimate how much the Councils spend on their services according to area or types of service. Such estimation should be used in determining reasonable assessment rates.

It is also important for both Councils to establish Beneficiary-Pay-Principle regarding solid waste management. Based upon this principle, the following two kinds of fee should be collected.

- Tipping fee for accepting waste directly brought into municipal disposal sites
- Commercial waste collection fee

MPPP has been collecting those fees. The rates of fee should be gradually increased in the future so that the fee would cover the cost of the service.

MPSP, on the other hand, has not collected those fees. Earlier introduction of those fees is desired to alleviate financial difficulty which MPSP would have in the future.

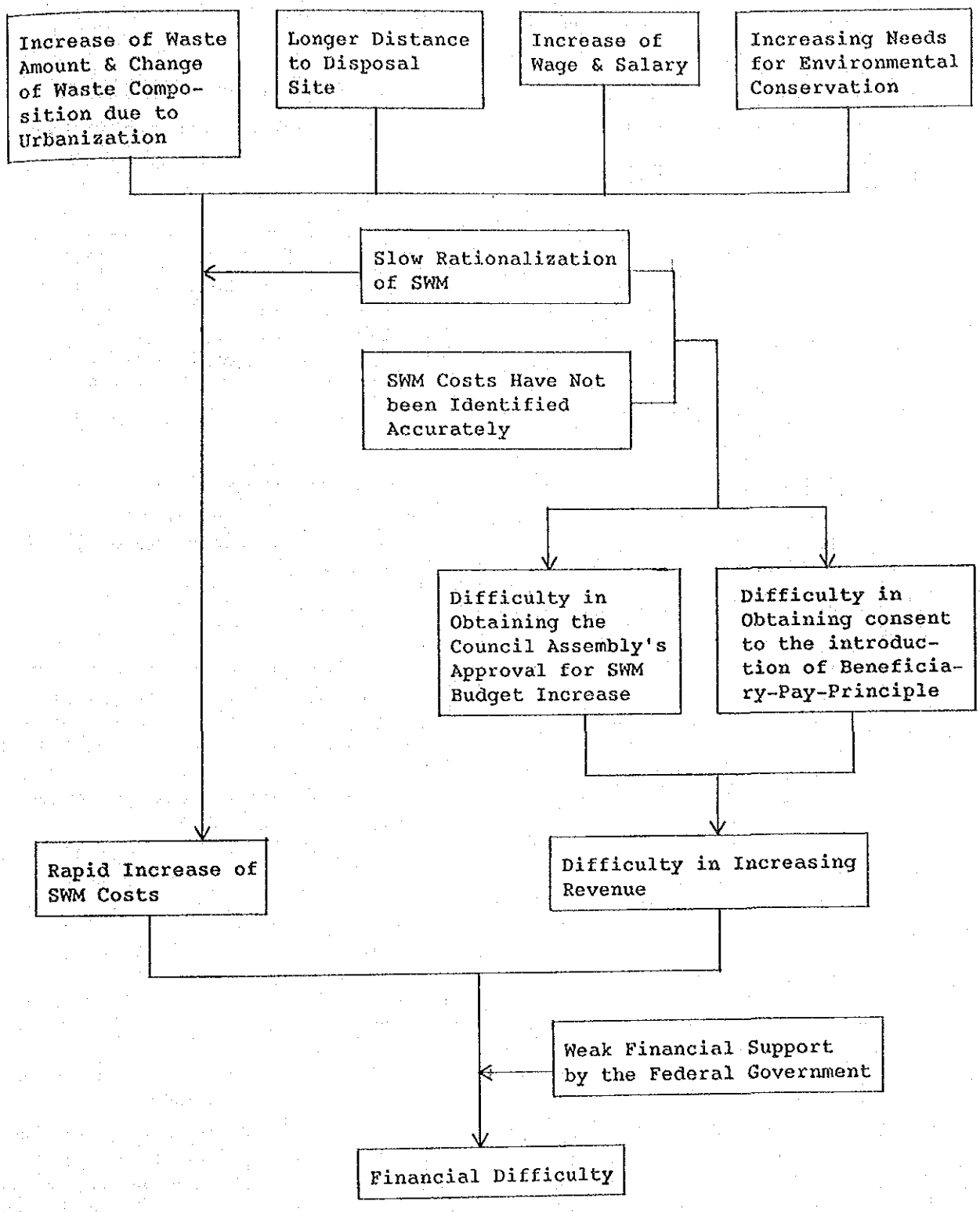


Fig. 4.2-5 Factors which Cause Financial Difficulty

4.2.6 Insufficient Service Coverage in MPSP

MPSP provides waste collection services for only 60% of the population in MPSP (MPPP's corresponding coverage is 90%.) Fig. 4.2-6 shows the factors which affect service coverage.

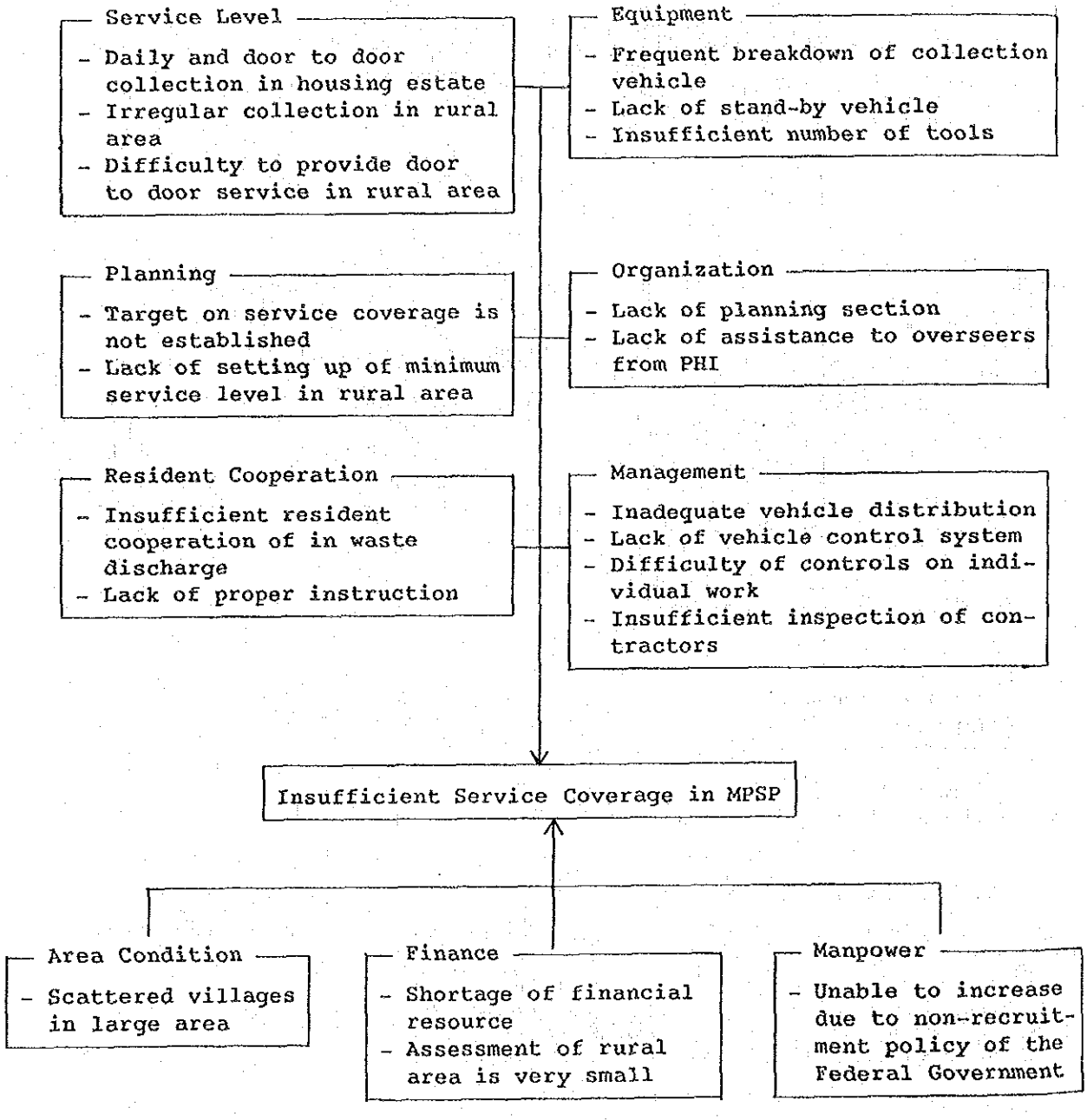


Fig. 4.2-6 Factor of Insufficient Service Coverage in MPSP

4.3 Needs for Short Term and Long Term Improvement Plans

The problems mentioned above are classified into two categories; those which may be possibly improved in short term and those which may only be solved in long term due to financial and social contraints.

Improvement plans which do not require large initial investment can be implemented immediately, while those which require a large initial investment may have to be implemented in a longer term and stepwise manner.

Execution of interim measures and immediate improvement plans including pilot projects will be usuful to examine the feasibility of long-term plans.

Chapter 5. Goals and Targets

5.1 Goal

The goal of the Master Plan is proposed as follows:

"Development of a Beautiful and Clean Living Environment towards the 21st Century through Citizen' Participation and Establishment of Self-Sustainable Solid Waste Management"

The following should be implemented to attain the above goal.

1) Establishment of an efficient solid waste management system
2) Establishment of reliable collection system under which regular service can be provided.
3) Construction of sanitary landfill which employs sufficient measures for environmental protection
4) Establishment of Beneficiary-Pay-Principle under which service recipients pay tipping fee and commercial waste collection fee.
5) Thorough control of hazardous and toxic waste
6) Provision of appropriate waste collection service for squatter area
7) Strengthening of the management and administration system
8) Rationalization of solid waste management through the promotion of privatization

5.2 Targets

(1) Collection Service Coverage

The entire population in the priority operational area will be served by 1995 and thereafter.

		MPPP		MPSP	
		1995	2005	1995	2005
- Population	Person	615,700	718,000	627,100	754,100
- Service Population	Person	584,400	695,500	485,200	641,000
- Service Coverage	%	95	97	77	85
- Non-Service Population	Person	31,300	21,500	142,100	113,100
- Collection Amount	t/d	470	670	342	540

(2) Final Disposal (Sanitary Landfill)

All the waste collected and hauled directly to disposal sites will be disposed of in sanitary landfill sites from 1995 and thereafter.

		MPPP		MPSP	
		1995	2005	1995	2005
- Disposal Amount	t/d	539	770	437	679
- Sanitary Landfill	t/d	539	770	437	679
- Ratio	%	100	100	100	100

(3) Securing Financial Resources for SWM

SWM expenses will be covered by assessment and waste collection fees which will be collected from business establishments as well as by tipping fees collected from disposal service recipients.

(4) SWM Cost Saving

Through improvements in efficiency, MPPP and MPSP can expect to save a respective cumulative total of M$2.2 million and M$2.0 million per year by

1995, as compared with the amounts that will have to be spent if the existing system prevails in the future.

(5) Percentage of Privatization

a. MPPP

It is proposed that MPPP will maintain the current degree (87%) of privatization of waste collection service.

b. MPSP

It is proposed that MPSP will increase the privatization of waste collection and street/drain cleansing services to about 50% or more in the future.

(6) Recycling of Reusable Materials

Recycling of reusable materials should be encouraged. Expected amounts in MPPP and MPSP are as follows:

		MPPP		MPSP	
		1995	2005	1995	2005
Amount to be recycled	t/d	11	16	10	15
Role of residents	- Source separation of reusable materials				
Role of recycling agent	- To collect reusable materials from source - To organize recycling agents' association				
Role of the Council	- To encourage recycling activities for residents and recycling agents - To provide subsidy equivalent to the amount to be saved through reduction of waste by recycling activities				

Cost to be Saved through Reduction of Solid Waste

	1987	1995	2005
MPPP (M$)	230,000	280,000	410,000
MPSP (M$)	180,000	260,000	380,000

Note: 9 t/d x 365 d/year x M$70/t = M$230,000/year

(7) To Analyze Yearly Expenses by Work Category

The following indicators should be used.

a. Collection and disposal work

- Collection : M$/collection amount
- Disposal : M$/disposal amount

b. Cleansing work

- Street sweeping : M$/km (street length)
- Drain cleansing : M$/km (length of drain)
- Beach cleaning : M$/km (length of beach)
  or M$/ha (area of beach)
- Grass cutting
  For roadside table : M$/km or M$/ha
  For parks & gardens: M$/ha

(8) Citizens' Cooperation in Solid Waste Management

a. Use of plastic bags

b. Provision of standard household bins

c. Discharge of solid waste at specified day, time and place

d. Source separation of solid waste

- Solid waste to be discharged for domestic waste collection
- Bulky waste and green waste
- Reusable materials

e. To keep own household bins clean

(9) To Reduce Scavengers

a. Construction of a fence around the disposal site to prevent free entrance of scavengers

b. Reduction of the number of scavengers allowed to enter disposal sites

(10) Campaign and Public Education

a. Sustainable campaign efforts

b. Establishment and Promotion of clean day with the participation of citizens

c. Public education on SWM at schools and various communities

d. Encouraging people to visit landfill disposal sites.

(11) Control of Industrial Waste

a. Registration of manufacturers that have own waste haulage system

b. Registration of private contractors that provide waste haulage service

c. Submission of report on control of toxic and hazardous wastes to the authorities concerned

d. Inspection system conducted by the authorities concerned

(12) Establishment of associated organization

a. Establishment of an inter-departmental committee related to the SWM.

b. Establishment of an association of suppliers of equipment

c. Establishment of an association of private contractors

5.3 Approach to the Attainment of Goals and Targets

Fig. 5.3-1 schematically shows goals of the Master Plan. Establishment of an efficient waste collection and street/drain cleansing systems as well as realization of sanitary landfill are two major goals. The attainment of those goals require 1) cost reduction through the introduction of a new collection system (3 times/week collection) and street/drain cleansing of reduced frequency as well as 2) acquisition of budget for construction and operation of landfill. The budget acquisition, then requires both the introduction of Beneficiary-Pay-Principle and the financial assistance by the Federal Government. Citizens' cooperation is prerequisite for both the introduction of a new waste collection system and Beneficiary-Pay-Principle.

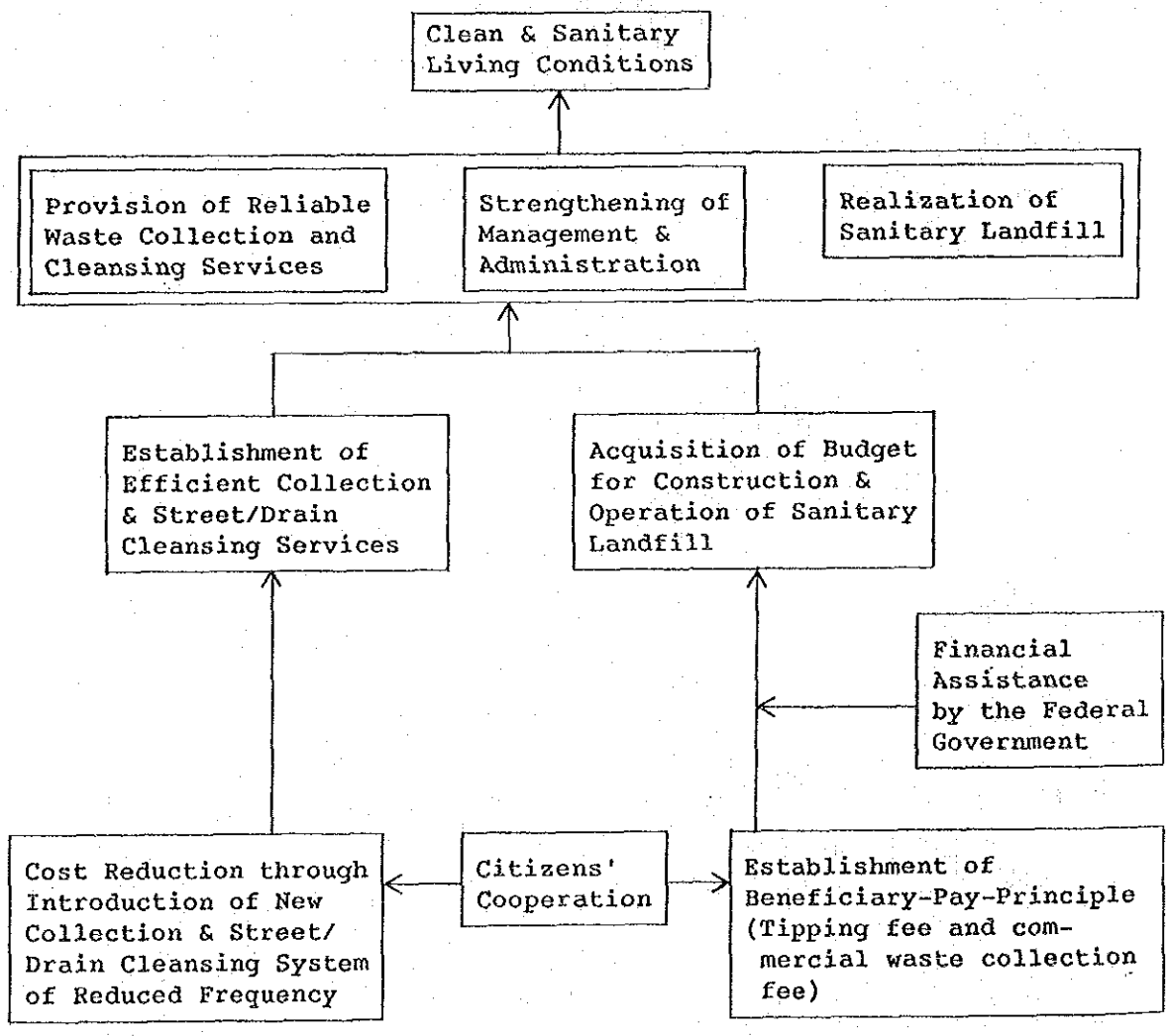


Fig. 5.3-1 Approach to the Attainment of Goals

Stepwise (Phased) Improvement

The Master Plan Goals cannot be attained in a short time. Stepwise improvement is a practical and wise approach for the attainment of the Master Plan goals. It has been proposed that the Master Plan period (from present to 2005) be divided into three Phases; Phase 1 (1991-1995), Phase 2 (1996-2000) and Phase 3 (2001-2005). Fig. 5.3-2 illustrates things to be done in each phase.

Immediate Improvement Plan and Interim Measure

Some of the improvement plans which do not require much initial investment can be implemented even before the start of Phase 1. The implementation of immediate improvement plans and interim measures are extremely important in the sense that it would lay a foundation for smooth execution of subsequent plans.

Pilot Projects

The execution of pilot projects will be required before the implementation of certain improvement plans if their feasibility needs to be proved beforehand. Examples of this type of plans include the introduction of a 3 times/week collection which has been successfully tried by MPPP in Bayan Baru and a waste station collection system which is recommended in the Master Plan as a future collection system in view of increasing efficiency.

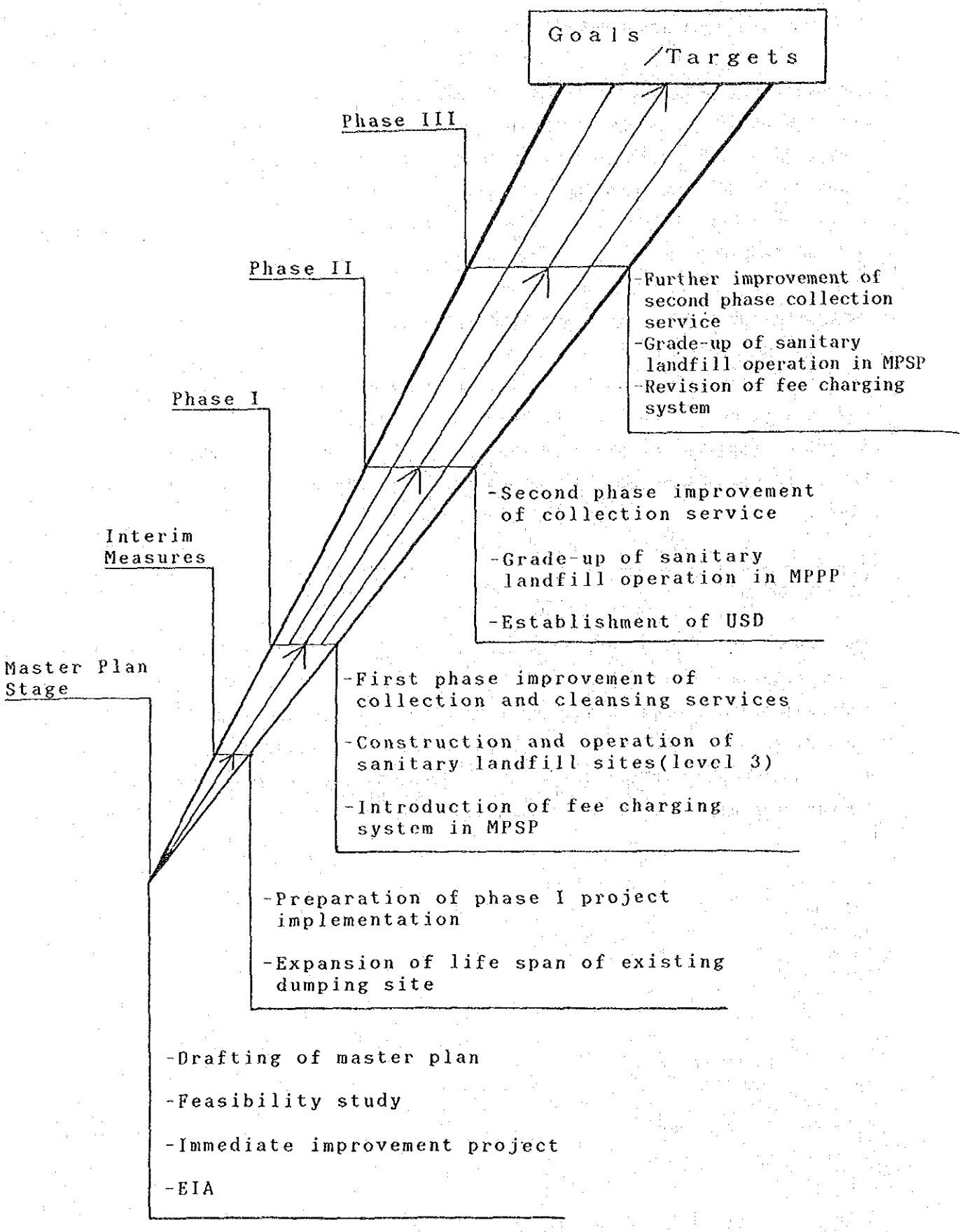


Fig. 5.3-2 Phasing to Goals and Targets

6. Basic Planning Conditions

6.1 Land Development Plan

Table 6.1-1 shows the planned land development in MPPP and MPSP respectively. Land development of 3,097 ha for residential purposes by 2005 is required for MPPP and MPSP.

Table 6.1-1 Planned Land Development (ha)

MPPP	1985-1990	1991-1995	1996-2000	2001-2005	Total
Residential	290	480	820	520	1,820
Others	200	340	570	220	1,130
Total	490	820	1,390	740	2,950

MPSP	1985-1990	1991-1995	1996-2000	2001-2005	Total
Residential	335	327	304	311	1,277
Others	207	329	345	283	1,164
Total	542	656	649	594	2,441

In the future development areas road length is projected to be 0.2 km/ha. for housing scheme and 0.05 km/ha. for parks, industrial/commercial and other purpose. Total road length is projected to be as shown in Table 6.1-2.

Table 6.1-2 Road Length (km)

	1987	1990	1995	2000	2005
MPPP	551	619	732	857	932
MPSP	1,133	1,210	1,292	1,370	1,447
Total	1,684	1,829	2,024	2,227	2,379

6.2 Population to be Served

(1) Population of All Area (Operational Area)

The planned population in 1995 is 615,700 for MPPP and 627,000 for MPSP, as shown in Table 6.2-1, i.e. 1.10 and 1.18 times higher respectively than the present population, while the planned population in 2005 is 718,000 for MPPP and 754,000 for MPSP, i.e. 1.28 and 1.42 times higher respectively than the present population. The aggregate population of MPPP and MPSP in 1995 and 2005 will be 1,242,800 in 1995 and 1,472,100 in 2005 respectively, i.e. 1.14 and 1.35 times higher respectively than the present population.

Table 6.2-1 Planned Population (Persons)

	1987	1990	1995	2000	2005
MPPP	559,300	568,300	615,700	667,400	718,000
MPSP	531,300	565,400	627,100	692,100	754,100
Total	1,090,600	1,133,400	1,242,800	1,359,300	1,472,100

(2) Priority Operational Area

a. Definitions of Priority Operational Area

Priority Operational Areas is defined as the areas to be provided waste collection and cleansing services at the target year 2005.

It is not practical to provide the same level of services to households which are isolated and remote from town center considering limited amount of resources, although the Operational Area of Penang State covers the entire area of the State. The Priority Operational Area should cover urban area, towns and villages which have high population density. Therefore, it is also acceptable in the low population density area that residents dispose of their waste by themselves according to the manner guided by the Councils.

b. The Priority Operational Area in MPPP

In MPPP, most of the agglomerations of population are in the flat land along the coasts of east and north of the Island. In the west there are towns of Sungai Pinanag, Balik Pulau, Pekan Genting, Pulau Butung, Kg. Bakar Kapur, Teruk Kumba and Gertak Sanggul.

Population of these agglomerations covers more than 93% of the total population of MPPP in 1985 and are provided waste collection and cleansing services at present. In future it is assumed to cover more than 97% of the total population of MPPP. Therefore, these are the Priority Operational Area of MPPP for the solid waste management.

c. The Priority Operational Area in MPSP

The population within the agglomeration areas including Butterworth, Bukit Mertajam and many towns scattered in MPSP is 357,236, which is 70% of the total population of MPSP. This agglomeration area is regarded as the Priority Operational Area. Population density within these areas is 28 persons/ha, while 2.5 persons/ha in the rest of MPSP.

It is assumed that the tendency of population concentration towards newly built-up areas will continue in future as it is now in Penang State. Accordingly, the population concentration in the Priority Operation Area, which is 70% in 1985, is assumed to be 85% in 2005.

Fig. 6.2-1 shows the area of Priority Operational Area.

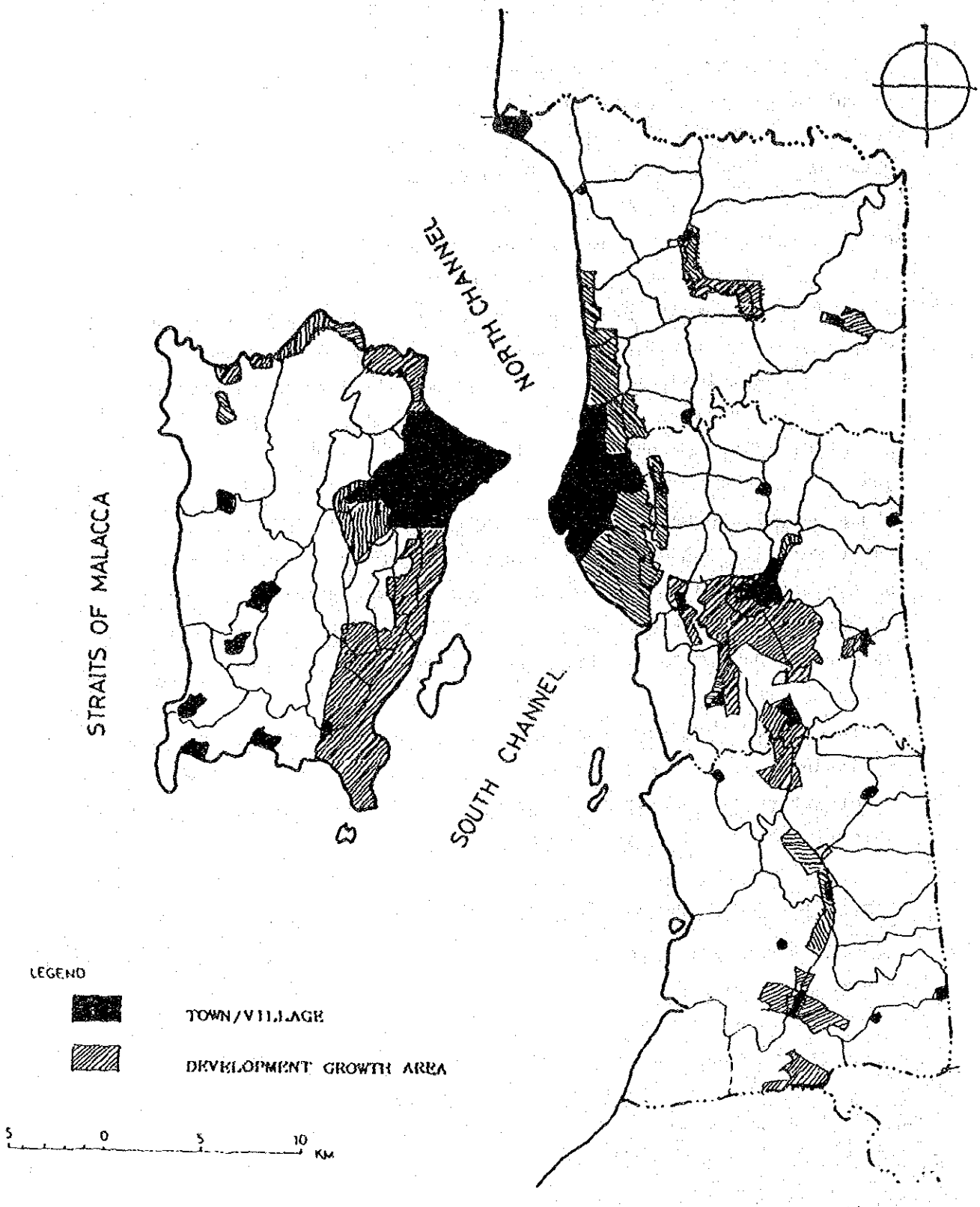


Fig. 6.2-1 Priority Operation Area

(3) Population to be Served

The population within Priority Operational Areas should be served and has been estimated as shown in Table 6.2-2, taking possible further urbanization in the Study Area into consideration.

Table 6.2-2 Population to be Served (persons)

	1987	1990	1995	2000	2005
MPPP	520,100 (93%)	532,000 (94%)	584,400 (95%)	641,000 (96%)	696,500 (97%)
MPSP	288,700 (54%)	355,900 (63%)	485,200 (77%)	564,300 (81%)	641,000 (85%)

6.3 Solid Waste Amount

The amount of solid waste to be generated will increase in accordance with the increase of the population and the increase in the rate of the waste generation per capita (generation rate), due to the rise in the living standard. The future generation rate is expected to increase by 2% a year as shown in Table 6.3-1.

The daily amounts of solid waste in MPPP and MPSP for specific years are shown in Table 6.3-2 based on these rates and the expected population referred to in Table 6.2-1. Collection and disposal amount are shown in Table 6.3-3 taking into account service coverage referred to in Table 6.2-2.

Table 6.3-1 Waste Generation Rate (kg/person/day)

	1987	1990	1995	2000	2005
MPPP	0.78	0.83	0.91	1.01	1.11
MPSP	0.70	0.74	0.82	0.90	1.00

Table 6.3-2 Forecast of Generation Amount of Solid Waste (t/day)

	1987	1990	1995	2000	2005
MPPP	432	464	556	660	784
MPSP	372	419	514	627	754
Total	804	883	1,070	1,287	1,538

Table 6.3-3 Forecast of Collection and Disposal Amount (t/day)

	1987	1990	1995	2000	2005
Collection amount					
MPPP	360	388	469	561	670
MPSP	191	239	342	434	540
Total	551	627	801	995	1,210
Disposal amount					
MPPP	414	446	539	644	770
MPSP	260	317	437	551	679
Total	674	763	976	1,195	1,449

6.4 Composition of Solid Waste

In general, the ratios of wood pieces and kitchen waste will decline and the ratios of paper, plastics and incombustible waste will increase in accordance with an improvement of the living standard and expansion of industrial activities.

The future composition of solid waste has been estimated based on the following assumptions and is shown in Table 6.4-1.

- annual increase rate of paper and plastic waste : 1%
- annual increase rate of incombustible waste : 3%
- annual decrease rate of wood pieces and kitchen waste : 1%

Table 6.4-1 Future Composition of Solid Waste

	DOMESTIC WASTE			COMMERCIAL WASTE		
	1987	1995	2005	1987	1995	2005
a. Composition (%)						
Paper	25.5	27.5	30.1	31.5	34.0	37.2
Textile	3.4	3.4	3.4	2.9	2.9	2.9
Plastic	11.2	12.1	13.2	11.8	12.7	13.9
Rubber	0.8	0.8	0.8	0.8	0.8	0.8
Wood	14.4	13.3	11.8	9.7	8.9	7.9
Garbage	32.8	30.2	26.9	30.9	28.5	25.4
Metal	2.6	3.3	4.1	3.3	4.1	5.1
Glass	1.4	1.7	2.1	1.0	1.2	1.5
Stone	0.2	0.2	0.3	1.0	1.2	1.5
Others	7.8	7.6	7.4	7.3	5.8	4.0
Total	100.0	100.0	100.0	100.0	100.0	100.0
b. Moisture Contents (%)	55.2	54.1	52.7	53.5	52.3	50.9
c. Organic (%)	35.4	35.6	35.8	36.1	36.3	36.6
d. Ash (%)	9.4	10.3	11.5	10.4	11.3	12.5
e. Net Calorific Value (kcal/kg)	1600	1600	1700	1600	1700	1700
f. Density (t/m^3)	0.19	0.19	0.18	0.17	0.16	0.16

6.5 Revenue

The annual growth rate of the GRDP of Penang State is assumed to be 5% until 1990, which is the same as that used in the 5th Malaysia Plan, and declines to 4.8% thereafter. This 4.8% is the minimum growth rate suggested in the Structural Plan for MPSP. Table 6.5-1 shows the resulting future GRDP of Penang State.

Table 6.5-1 Estimated Future GRDP of Penang State (1978 price)

	1987	1990	1995	2000	2005
Growth Rate (%)		5.0	4.8	4.8	4.8
GRDP (M$ million)	4,283	5,479	6,926	8,756	11,069

The same growth rates are used to estimate the future revenue sizes of MPPP and MPSP which are shown in Table 6.5-2 based on the actual revenue of 1987.

Table 6.5-2 Estimated Future Revenue of MPPP and MPSP

(M$1,000, 1987 price)

	1987	1990	1995	2000	2005
MPPP	68,860	79,714	100,772	127,394	161,047
MPSP	31,359	36,302	45,892	58,015	73,342

7. Immediate Improvement Needs and Plan

7.1 Immediate Improvement Needs

Immediate improvement needs have been identified considering following criteria:

a. Possibility of immediate improvement.

b. Efficient use of existing resources without large investment.

c. Achievement of tangible improvement effects in short time.

d. Possibility to become a model for future improvement.

There are two types of immediate improvement needs as shown below:

a. Improvement needs in crucial area which has specific problems.

b. Improvement needs to demonstrate the feasibility of introducing a future system. (Eg. Pilot project for the introduction of 3 times/week collection system in Bayun Baru)

The implementation of those immediate improvement projects is very important in view of the fact that the Master Plan targets will be achieved only through step-wise improvements.

Immediate improvement needs in MPPP and MPSP have been identified as follows:

(1) Collection and Cleansing

a. Conversion from the double handling system adopted in some areas to single handling
b. Discharge of solid waste by residents of medium and high rise buildings of flats to designated bin points (eradication of refuse chute system);
c. Discharge of solid waste using plastic bags;
d. Introduction of the three times a week collection system;
e. Improvement of collection service to kampongs by regular collection together with public cooperation in solid waste discharge;
f. Establishment of regular collection by the adequate vehicle control, and improvement of the collection vehicle efficiency;
g. Appropriate discharge of solid waste and reduction of road and drain cleansing frequencies.
h. Execution of the preventive maintenance for collection vehicles.
i. Steprise increase of rates of fees for commercial waste collection (MPPP)
j. Introduction of fee collection system for commercial waste collection (MPSP)

(2) Final Disposal

a. MPPP

The immediate improvement needs on the final disposal system in the MPPP are,

- Improvement of the surrounding environment of the present BSDS
- Strengthening of the present landfill operations
- Fuller utilization of the efficient use of existing manpower and equipment
- Madification to the proper disposal fee system

b. MPSP

The immediate improvement needs on the final disposal system in the MPSP are,

- to eliminate the adverse effect by the operation of the PPDS
- to improve the present landfill operations at the PPDS
- to achieve the efficient use of existing manpower and equipment

7.2 Immediate Improvement Plan

7.2.1 Collection and Cleansing in MPPP

(1) Proposed Immediate Improvement Plan

The following are basic proposals to solve the problems.

a. Change from double handling to single handling with residents cooperation

b. Introduce lower frequency service (three times a week) which has the following advantages and disadvantages.

- Termination of Sunday work which leads to the complications in labour control, inspection of works and maintenance of vehicles

- Concentration of work in smaller area in each day which will realize cycle time reduction, easy labourer control and better inspection of works

- Possible complaints from residents because of the lower service level

c. Use of plastic bags and standard household bin which will increase efficiency of collection work specially in single handling.

d. Introduction of team works for street sweeping and drain cleansing by reducing cleansing frequency in residential area.

The following are proposals to develop models for future system.

a. Introduction of three times a week and door to door collection system;

b. Use of plastic bags;

c. Introduction of bulk waste collection;

d. Introduction of once a week cleansing service and team work system.

(2) Selection of Area

Criteria for the selection of model areas to introduce new collection and cleansing systems are as follows.

- Area which has proper infra-structure, such as street, drain, etc.
- High or middle income area
- Area which has a resident association which will contribute to the better communication between residents and the authority.

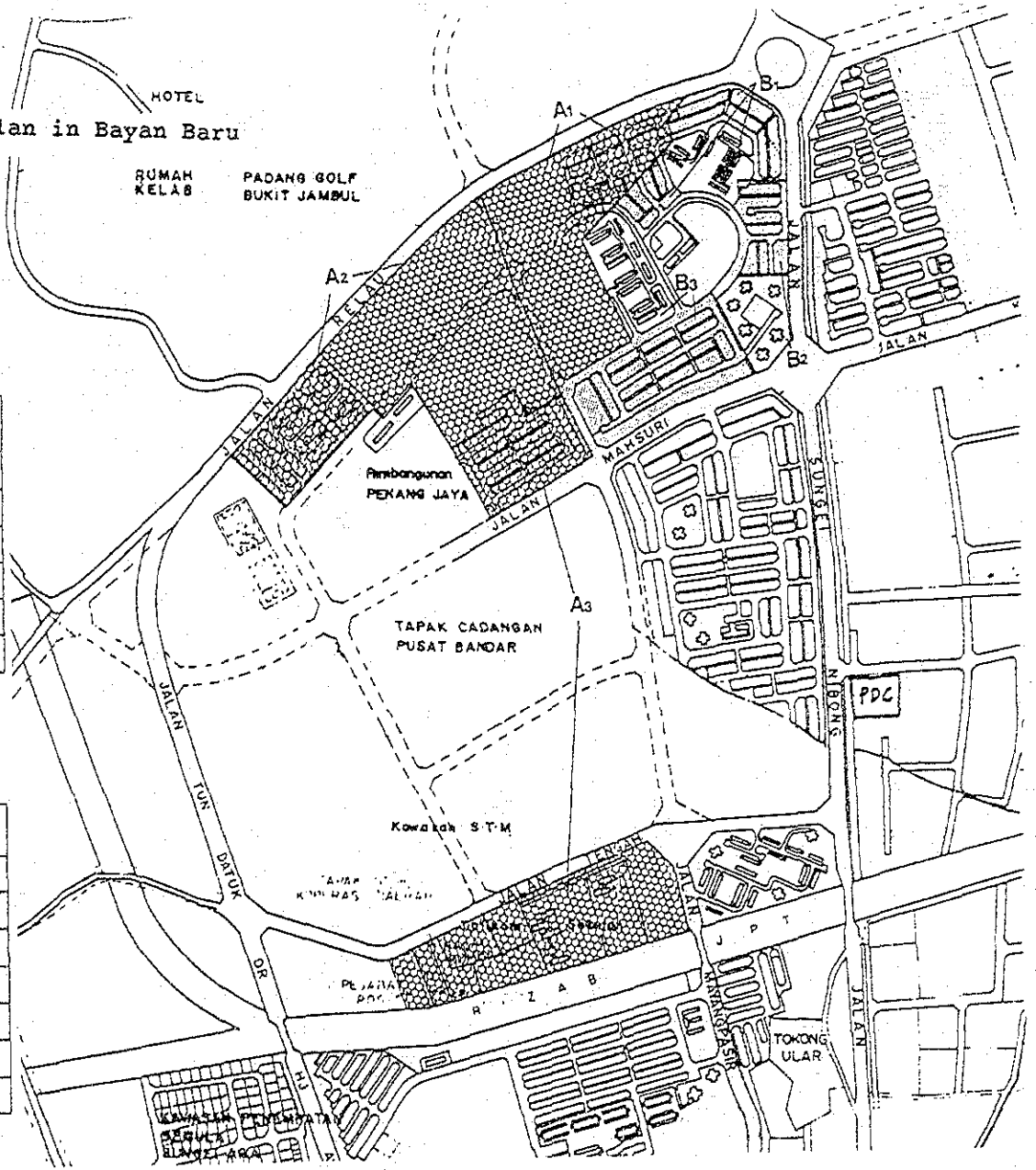
Through discussions with MPPP, Jelutong area as a crucial area and Tanjong Tokong area and Bayan Baru area as future model areas were selected initially. Concerning Jelutong area, the collection service had been contracted out already and MPPP could not receive any good answer from the Contractor to reduce the collection cost immediately. Therefore, other two areas which would become models for future system were selected to discuss the plans.

There were two areas proposed to check the possibility to introduce 3 times a week collection system. One was Tanjong Tokong and Tanjong Bungah area where the contracting-out of collection service was planned. Another one was Bayan Baru area where MPPP was providing the service using a compactor vehicle.

Concerning the former area, JICA Study Team recommended MPPP to receive from the prospective contractor proposals for the daily collection case as well as for the 3 times a week collection case. It turned out that the 3 times a week collection was offered at about 20% lower price.

Collection service of Bayan Baru area is provided by MPPP in principle, however, some area such as blocks of multi-storey building are served by contractors. Excluding these contracted blocks, the model area for the 3 times a week collection was established as shown in Fig. 7.2-1.

Fig. 7.2-1 Immediate Improvement Plan in Bayan Baru



Cleansing Service Weekly Schedule at Bayan Baru Area

	Refuse Collection	Street Sweeping	Drain Cleansing	Bulky & Garden Waste
Mon	A	A	A_1	A_1
Tue	B	B	B_1	B_1
Wed	A	A	A_2	A_2
Thu	B	B	B_2	B_2
Fri	A	A	A_3	A_3
Sat	B	B	B_3	B_3

* The collection vehicle which covers the Bayan Baru area on alternate day collection also covers Selayor Market, Boundary Court and Wayton Flat on daily collection.

Area		Number of Houses	Length of Road (Km)	Length of Drains (Km)
A	A_1	92	5.6	11.0
	A_2	81	6.9	13.8
	A_3	196	8.7	17.4
B	B_1	158	6.3	12.6
	B_2	81	5.8	11.6
	B_3	218	7.5	15.0
Total		827	40.7	81.4

(3) Plan for Introduction of 3 Times a Week Collection

It has been proposed that the following immediate improvement projects be implemented in Bayan Baru in a manner shown in Fig. 7.2-1.

a. 3 times a week and door to door collection in residential area

b. Use of plastic bags

c. Team works in street sweeping and drain cleansing and clearing of bulky and garden waste once a week.

Frequency of street sweeping	
- In front of shops	Daily sweeping
- Residential area	Once a week
Frequency of drain cleansing	Once a week
Grass cutting	Once a month

d. Monitoring Indicators

The following monitoring indicators should be used.

a. Cleanliness of town (Bulky and Garden Waste)
b. Ratio of plastic bag use
c. Waste amount collected by one vehicle (t/day/unit)
d. Waste amount collected by one laborer (t/day/person)
e. Street and drain length covered by one laborer (km/person)

(4) Schedule and Organization

The implementation of the above project have been started on 1st of March 1989.

Implementation schedule of immediate improvement plan is shown in Fig. 7.2-2. Organization for implementation was proposed as shown in Fig. 7.2-3.

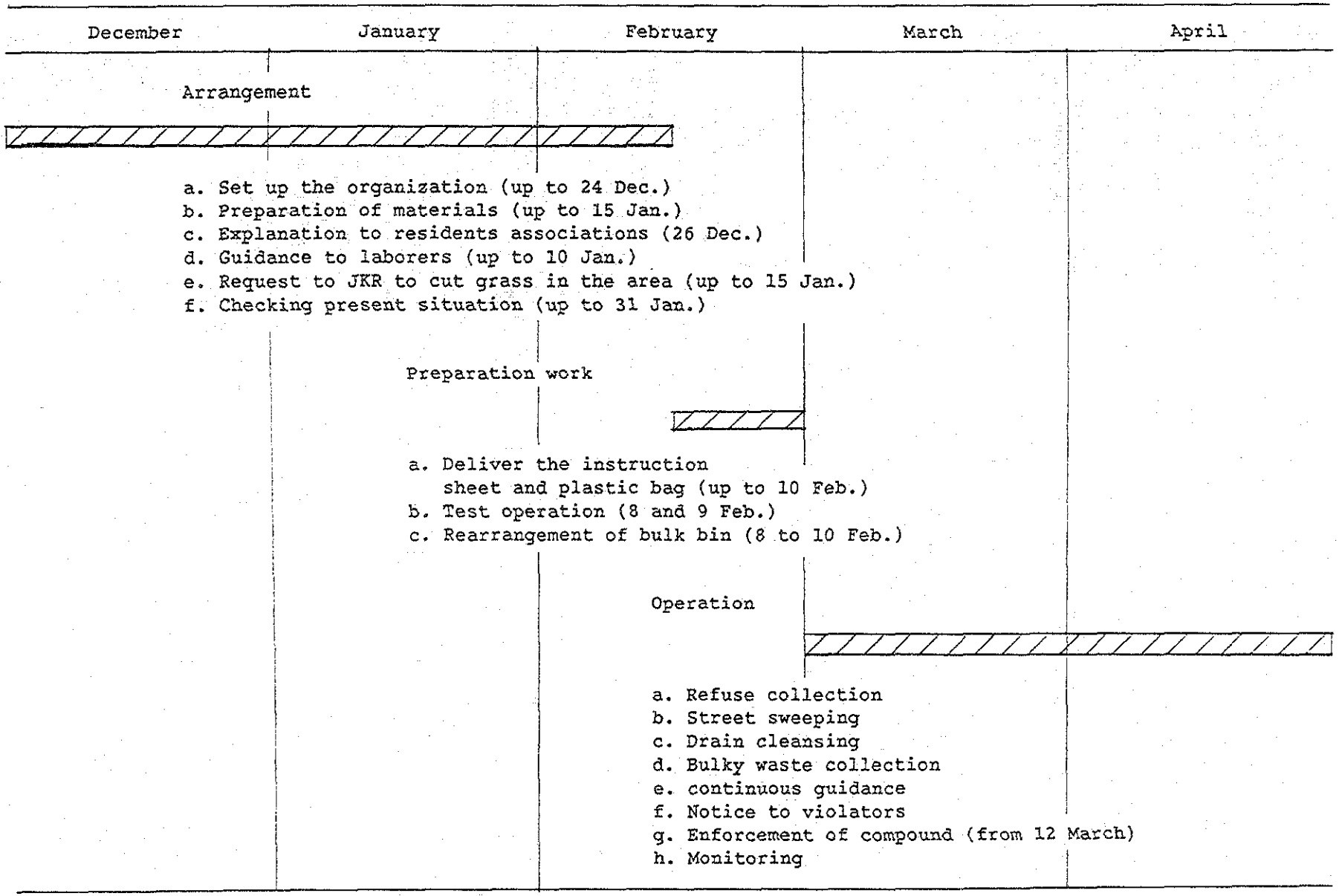


Fig. 7.2-2 Implementation Schedule for Introducing 3 Times a Week Collection

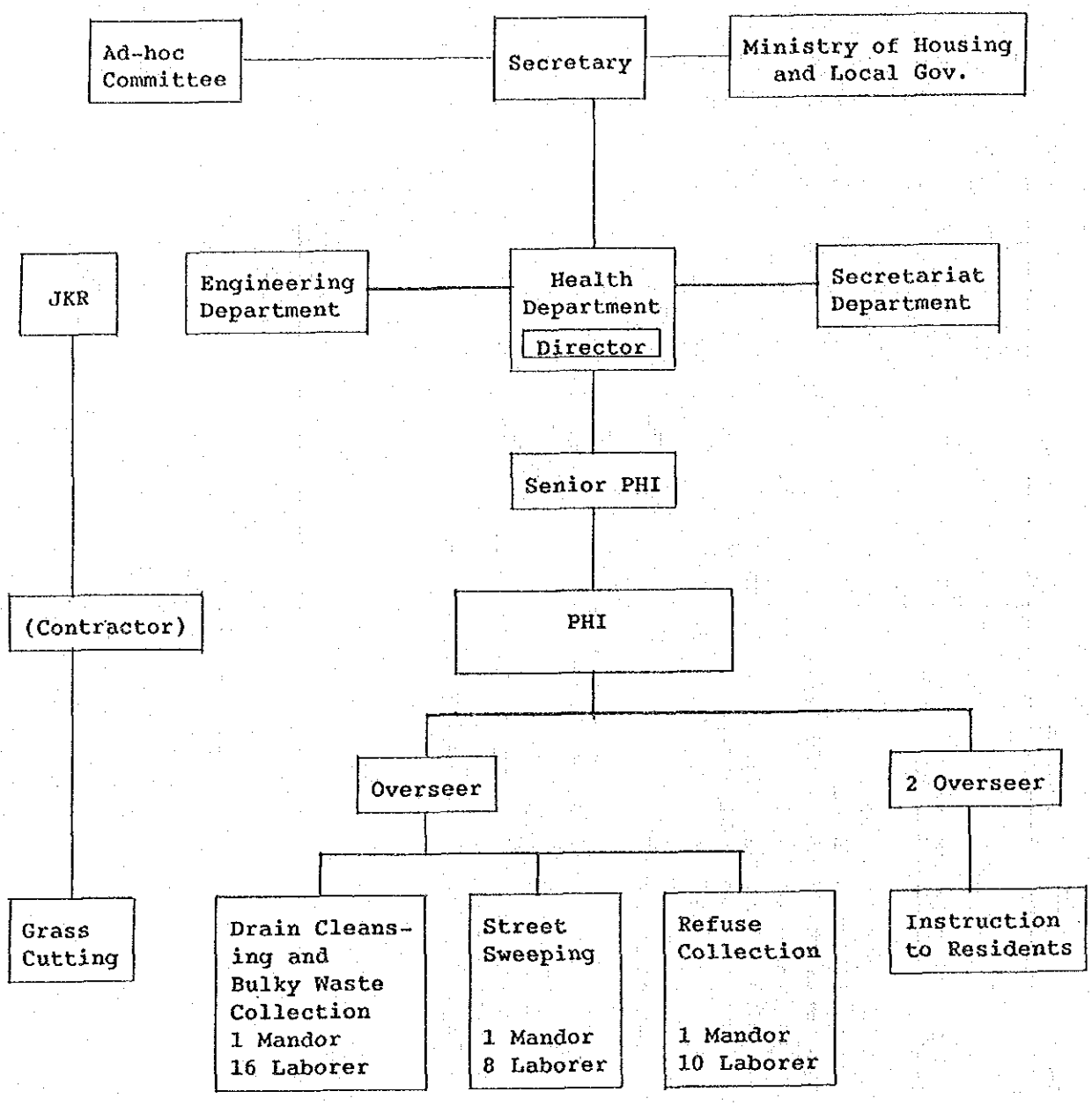


Fig. 7.2-3 Proposed Organization for Introduction of 3 times a Week Collection

7.2.2 Final Disposal for MPPP

(1) Proposed Immediate Improvement Plan

The immediate improvement plan on the final disposal system in MPPP, which can be achieved through the efficient use of the existing personnel and equipment and cooperation of the citizen without incurring large investment, has been discussed with the related organizations and is proposed as shown in Fig. 7.2-4.

a. Construction of Buffer Zone

Due to close proximity of the densely populated area, the BSDS have had many complaints from the neighbouring residents. This situation became worse by the completion of low cost housing next to the BSDS in November, 1988.

In order to mitigate the complaints, a buffer zone which consists of an embankment, vegetation and a gas removal facility has been proposed to be constructed in front of the new low cost housing.

b. Construction of an Enclosing Net Fence

Although the earth bund has been provided in the sea at the BSDS, it is not an enclosing embankment. Due to inefficiency of the bund, the bund cannot completely protect the wastes from being washed away by the tides. In order to prevent floating items from being washed away into the sea, it was recommended that an enclosing net fence be installed.

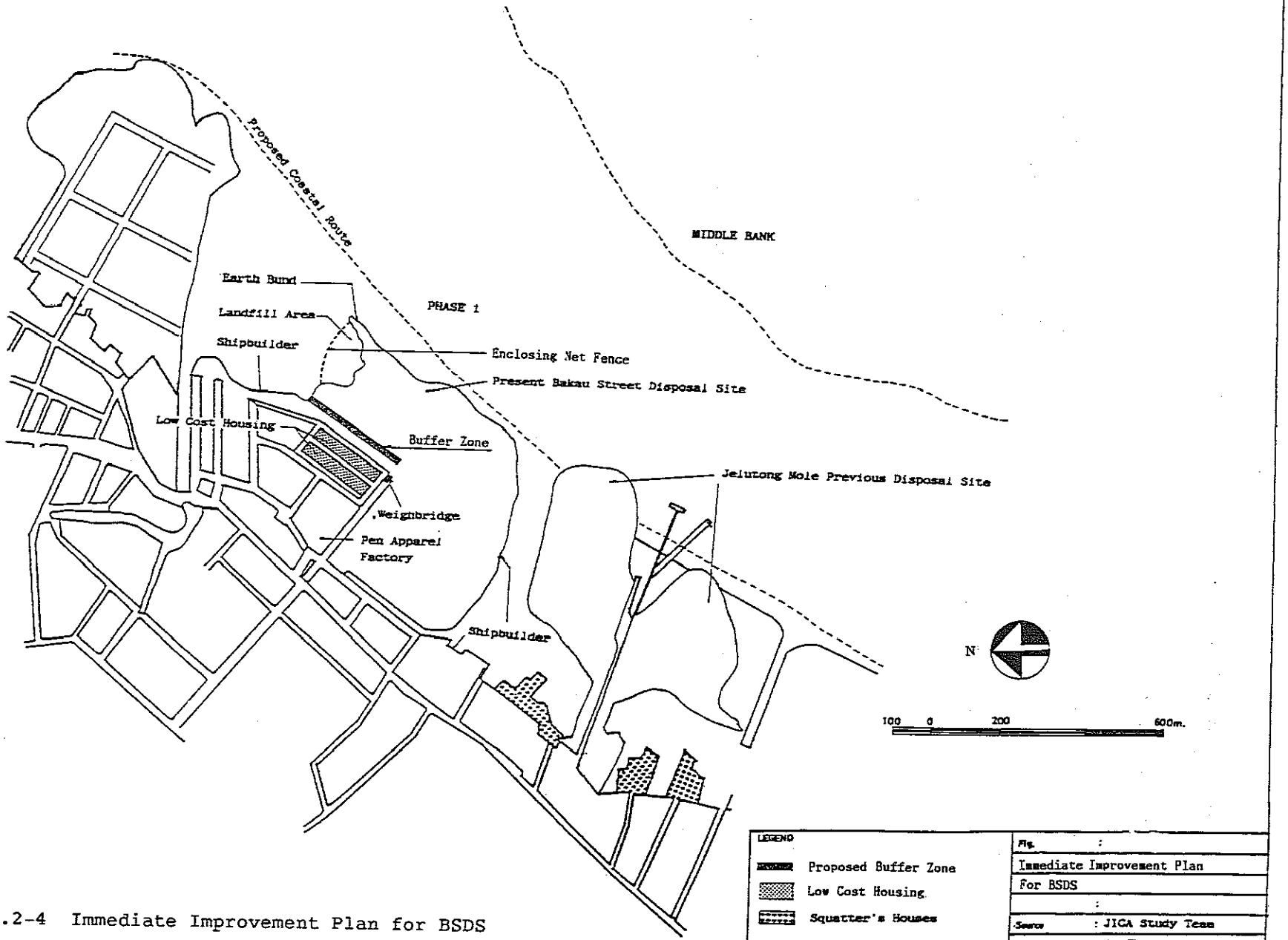


Fig. 7.2-4 Immediate Improvement Plan for BSDS

c. Reinforcement of landfill operations

In addition to the present operational plan for the BSDS, the following aspects have been proposed to reinforce the present landfill operations.

i) Preparation of weekly and monthly operational plans
ii) Execution of regular topographic survey
iii) Preparation of an ultimate use plan for the completed landfill

d. Reconsideration of disposal fee system

The present disposal fee is a uniform rate of M$60 per month for each applicant for the use of the BSDS for an unlimited disposal amount. The Study Team has proposed MPPP to reconsider the disposal fee system.

e. Close collaboration with relevant departments

The present final disposal system is managed by Health and Engineering Departments of MPPP. The State Secretariat co-ordinates with other relevant authorities concerned for acquisition of new disposal sites. Although collaboration between departments and sections at present seems to be established, lack of communication is observed due to the variety of organizations. Close collaboration with relevant departments has been therefore proposed.

f. Recognition of the importance of sanitary landfill for final disposal and consent for an increase in final disposal cost.

7.2.3 Collection and Cleansing Work in MPSP

(1) Problems to be Solved

According to the weighbridge data recorded in June and October 1988, a collection vehicle collects 4.1 ton of waste per day on overage. However, waste amount of each vehicle vary from 1.6 to 7.0 t/day depending on area. 7 vehicles in 3 particular areas collect only 1.9 t/vehicle/day on average. It is necessary to improve this situation through adequate control of collection vehicles using weighbridge data. But, it is also found that each overseer controls own vehicles independently without any stand-by vehicle and there is no system to make proper assignment of collection vehicles. Therefore, establishment of a control system of collection vehicles is important and crucial to improve the efficiency of collection vehicles and to provide punctual collection service.

(2) Systems to be Established

Control of collection vehicles should be done at garages of collection vehicle located in Mac Madin. The proposed organization scheme for vehicle control system is shown in Fig. 7.2-5. It shows that both a vehicle overseer and a research and planning section are responsible for vehicle control and its improvement. Their functions are as shown below.

a. Vehicle Overseer
   - Instruction of daily works
   - Recording on daily collection work of vehicles
   - Collection of data
     - Weighbridge data
     - Weekly drivers record
     - Maintenance record and schedule
   - Preparation and submission of weekly report.

b. Research and Planning Section
   - Preparation of monthly report
   - Preparation of plans for proper vehicle assignment.
   - Instruction and guidance to vehicle overseer

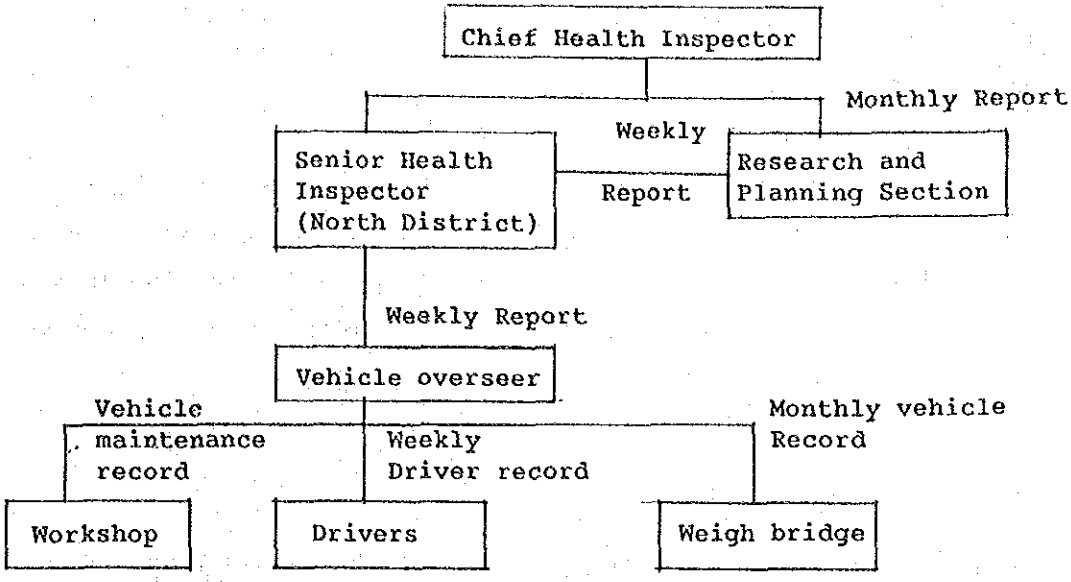


Fig. 7.2-5 Organization for Vehicle Control

(3) Schedule of Implementation

From first Dec, 1988, an overseer has been assigned as a vehicle overseer to the workshop in Mac-Madin which has 25 collection vehicles for North District and Perai area. The Time and Motion Study was also been conducted from Dec. 1989 to find actual problems for all vehicles.

7.2.4 Final Disposal for MPSP

(1) Proposed Immediate Improvement Plan

The immediate improvement plan on the final disposal system in MPSP, which can be achieved through the efficient use of the existing personnel and equipment and cooperation of the citizen without incurring large investment, has been discussed with the related organizations and is proposed as shown in Fig. 7.2-6.

a. Improvement of on-site road at the PPDS

On site road in the PPDS from the Jalan Permatang Pauh has not been properly prepared and maintained which makes it very difficult for truck drivers to manoeuvre their vehicles, specially during rainy days.

In order to maintain smooth access to the working face and to protect collection vehicles from frequent damages, it was proposed that MPSP improve the on-site road by embanking and gravel pavement.

b. Application of cover materials

The practice of open crude dumping almost completely with almost no cover materials in PPDS, has great impacts on to the surrounding environment, mainly caused by spontaneous ignition, littering of wastes, offensive odor, etc. These have made the surrounding residents often complain to the Council. Minimum application of cover materials was proposed to prevent surrounding environment from damage and nuisance.

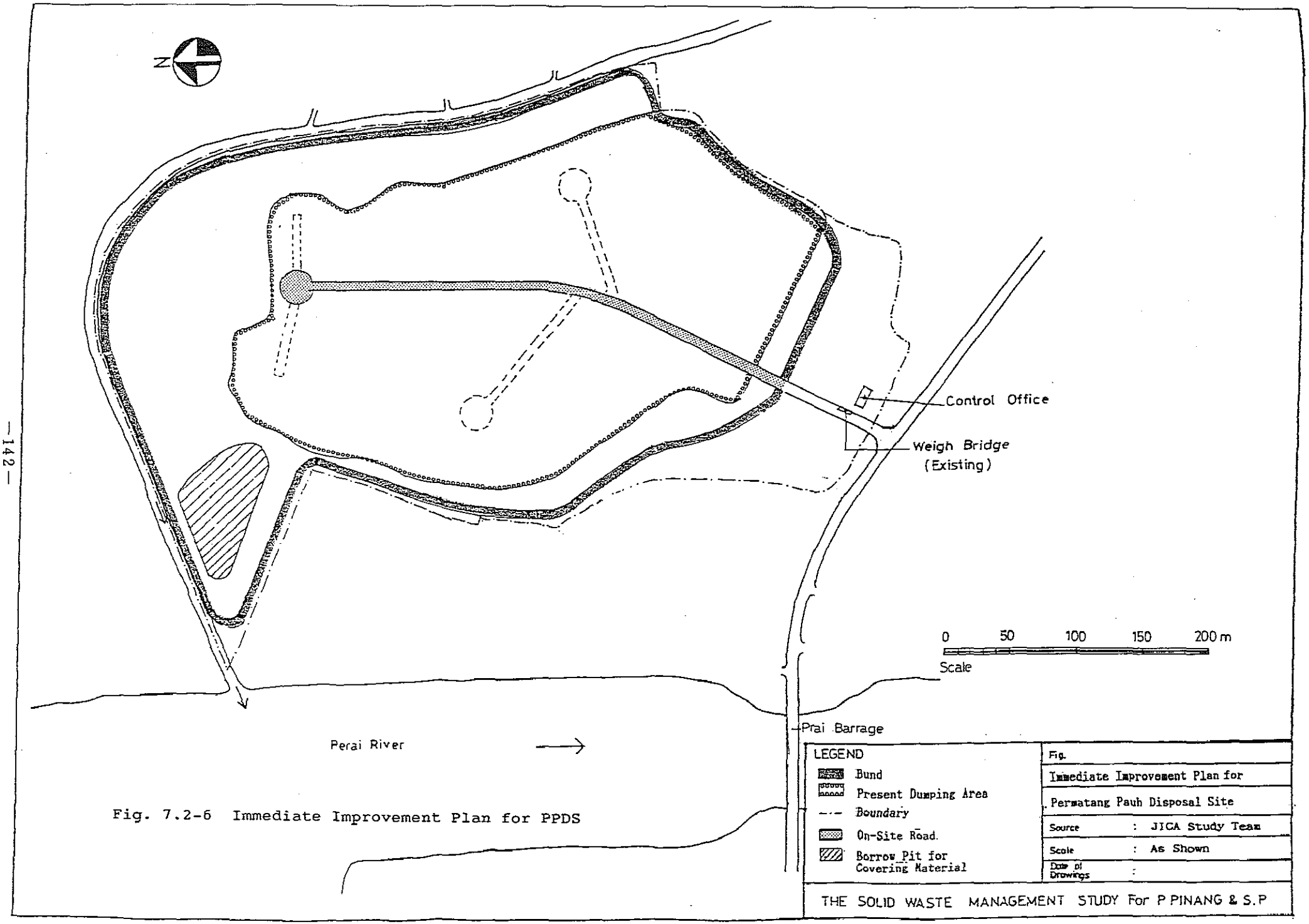


Fig. 7.2-6 Immediate Improvement Plan for PPDS

c. Establishment of disposal site boundary at the PPDS

Site boundary was not established at the PPDS which had caused much environmental impacts on the surroundings.

In order to minimize the surrounding area from being affected by operation at the PPDS, it has been proposed that a site boundary to be established as follows.

- To clear, compact and level the site boundary
- To construct an enclosing bund using burn-out waste and soil available at the site
- To cover the bund with soil

d. Strengthening of the organization for final disposal

Although Health Department, in principle, is responsible for planning, management and operation of disposal sites, there was no section or personnel responsible for such works as well as site acquisition. In fact, there were no records of incoming vehicle at Pulau Burong disposal site since its opening in 1981.

In order to strengthen the organization for final disposal the following measures were proposed.

i) Assignment of personnel for the control of PPDS and PBDS
ii) Assignment of a civil engineer
iii) Allocation of equipment and materials
iv) Establishment of close collaboration with relevant departments

e. Preparation of operational plan

In order to achieve sound operation and efficiency and to lengthen life expectancy, preparation of operational plan was proposed as follows.

i) Preparation of weekly and monthly operational plans
ii) Execution of regular topographic survey

iii) Preparation of an ultimate use plan for the completed landfill

iv) Strict inspection on incoming waste

f. Recognition of the importance of sanitary landfill for final disposal and consent for an increase in final disposal cost.

7.3 Interim Measure During 1989 - 1991

7.3.1 Collection and Haulage in MPPP

The new disposal site in Pantai Acheh located 30 km from Georgetown is scheduled to begin operation in 1992 and until that time, the present disposal site (Bakau Street disposal site) and the previous disposal site (Jelutong disposal site) will be used for final disposal site by mounting up methods mainly.

When the Pantai Acheh disposal site commences operations, the collection and haulage cost will increase. More collection vehicles and more laborers will be required because transportation to the disposal site takes about 2 hours for each trip. The reconsideration on contract amount will also be necessary. Measures to encourage the private sector to haul their waste to Pantai Acheh will be needed to prevent illegal dumping.

To mitigate this cost increase, changing the type of collection vehicles from sideloaders to compactors and introduction of the 3 times a week collection system are greatly required.

The increase in number of vehicles and change of vehicle type will require the following considerations by MPPP.

(1) Collection Vehicles of MPPP

a. Replacement of the Old Vehicles

MPPP should replace the old vehicles especially those bought before 1980 by compactor vehicles until 1991. However, the increase in number of vehicles is not needed for the three areas; Tanjong Tokong, Tanjong Bungah, North part and South part of Ayer Itam, since the contractors are scheduled to start operation from March 1989.

b. Strengthening of the Maintenance Capability of the Workshop

Long transportation to Pantai Acheh disposal site poses heavy burden and requires adequate maintenance of collection vehicles. The following points should be especially considered.

- Preventive maintenance;
- Proper replacement of collection vehicle based on economic life of vehicle (The losses caused by down time should be considered);
- Training of drivers to prevent overloading, to follow the specified haulage route and to maintain safe driving.

Adequate maintenance of collection vehicles is especially essential when the 3 times a week collection service is employed.

(2) Contract

a. Extension of the present contracts

The present contracts with the contractors are going to be terminated in 1990. A new landfill site is expected to open at Pantai Acheh in the beginning of 1992. It is recommended that MPPP will make extension of the present contract until the opening of the new landfill site due to the reasons given below:

i. Applicable vehicle type and contract conditions will be different from those applied at present after the opening of the new site which is remote from the city area.

ii. The remaining period (1990-1991) is less than two years.

iii. If MPPP and makes new contracts in 1990 instead of extending the present contract, such new contracts will have to be greatly modified at the time when the new landfill site is opened.

b. Review of Contract Zone

Since a compactor vehicle can haul larger amount of waste than a side loader does, wider collection zone will be required to keep reasonable number of stand-by vehicles.

A contract collection zone should be sufficiently wide so that the waste collection amount will be more than 30 tons per day in each contract zone, where 4 or 5 compactors, at least, can be employed. This recommendation is given due to the reasons given below.

i. Some stand-by vehicles are required to provide reliable and regular collection service. Ratio of stand-by vehicles to regularly-operating-vehicles should be 20% - 25% in view of both technical and economical view point.

ii. In order to keep the stand-by vehicle ratio at 20% - 25% as discussed above, a contract collection zone must be large enough. (collection amount being more than 30 t/day at least in a contract collection zone)

(3) Introduction of the 3 Times a Week Collection

Introduction of the 3 times a week collection is another measure for cost reduction.

Introduction of the 3 times a week collection should be started in 1989. Therefore, it will be desirable for the coming contracts to employ the 3 times a week collection system in establishing the model area for the contractors to develop the know how in the introduction of the new collection system; as a first step towards the implementation of the first phase project.

MPPP should keep stand-by compactor vehicles to assist the contractors when they have vehicle shortage due to the vehicle breakdown.

7.3.2 Final Disposal for MPPP

(1) Proposed Sites

Proposed PADS is planned to be opened in January 1992. Final disposal in MPPP during the transitionary period from the present system (i.e. controlled tipping) to the future system (i.e. sanitary landfill), is to be made as follows at the proposed sites as shown in Fig. 7.3-1.

i) Use of present BSDS
ii) Mounting up of present BSDS
iii) Mounting up of JMPDS (Jelutong Mole Previous Disposal Site)

(2) Interim Measures

a. Planning Conditions

Planning conditions for the interim measures are summarized as follows,

i) Service area: Pulau Pinang
ii) Waste to be disposed;
Municipal waste such as domestic, commercial, street sweeping, drain and beach cleansing waste and non-toxic industrial waste accepted by the Council, such as construction and demolition waste.
iii) Cumulative disposal amount; 500,000 ton (from Dec. 1988 to Dec. 1991)
iv) Daily disposal amount ; 446 t/day in 1990
v) Unit weight of waste ; $r = 0.8\ t/m^3$
vi) Cumulative landfill volume; 630,000 cubic meter (from Dec. 1988 to Dec. 1991)
vii) Cumulative landfill volume with cover soil ; 820,000 cubic meter
viii) Amount of cover soil ; 30% of landfill volume of waste to be disposed of

Disposal Sites for Interim Period

Items / Disposal site	Area (ha)	Period of Use	Remarks
①Extension of BSDS	3.2	Present to June.1989	Northern & Southern Edge
②Mounting-up of BSDS	4.8	June.1989 to Jan.1990	
③Mounting-up of JMPDS	Site A; 7.6 Site B; 13.0	Feb.1990 to Dec. 1991	

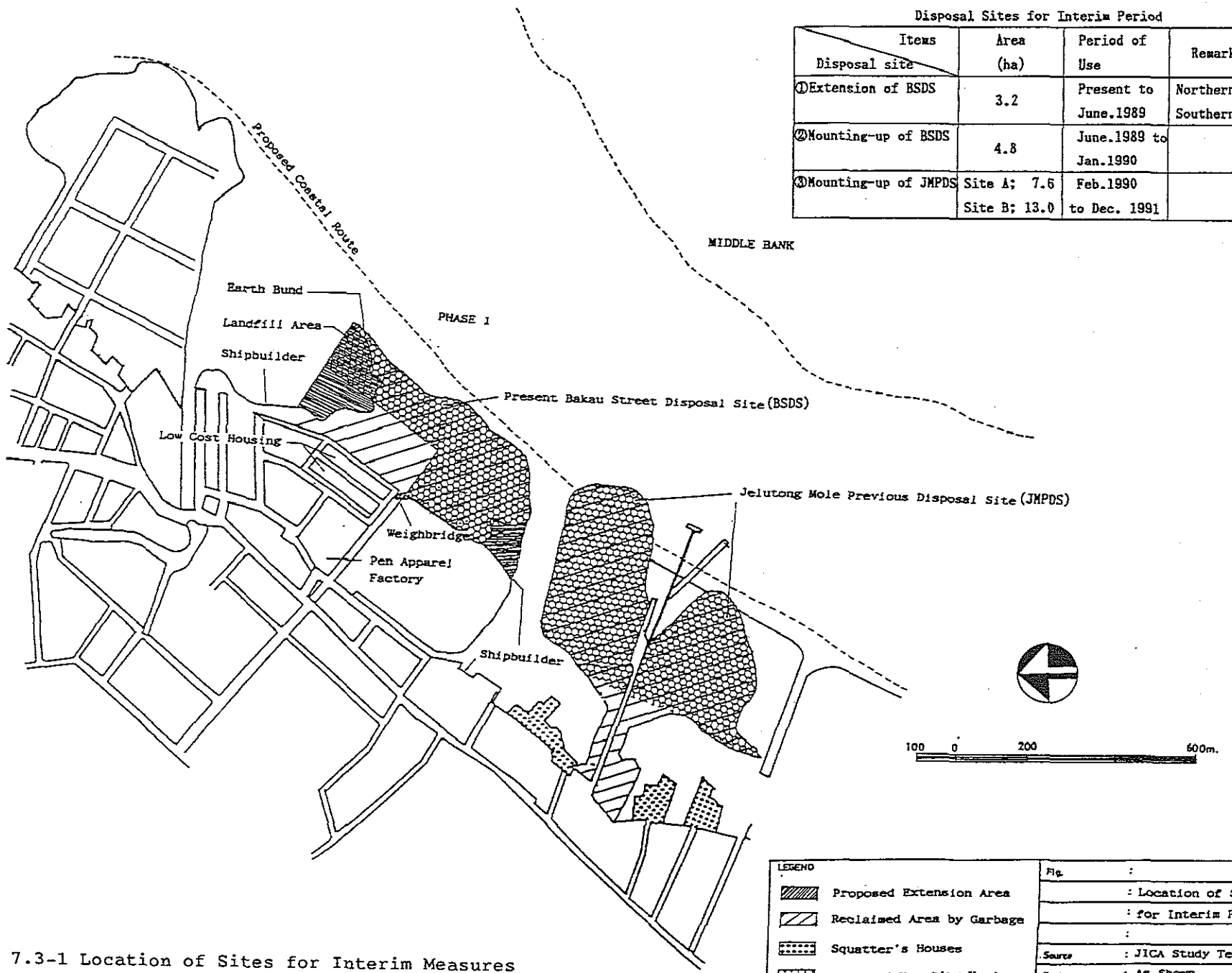


Fig. 7.3-1 Location of Sites for Interim Measures

b. Details of Interim Measures

Based on the planning conditions, interim measures are tabulated in Table 7.3-1 and plans of interim measure are illustrated in the Supplementary Report Volume VI Drawings.

Table 7.3-1 Interim Measures for Final Disposal in MPPP

ITEM / DISPOSAL SITE	DEPTH OF LANDFILL (METER)	AREA (HA)	PERIOD OF USE	CUMULATIVE LANDFILL VOLUME WITH COVER SOIL (1000 m^3)	REMARKS
Extension of BSDS	5	0.4	Present to Dec. 1988	22	Northern & Southern Edge
Mounting-up of BSDS	5	4.8	Jan. 1989 to Jan. 1990	240	
Mounting-up of JMPDS	Site A; 3 Site B; 2.5	Site A; 7.6 Site B; 13.0	Feb. 1990 to Dec. 1991	228 328	
Total	-	28.6		818	

c. Cost Estimation

Outline of project and project cost for the interim period are tabulated in Table 7.3-2.

Table 7.3-2 Outline of Project and Project Cost for the Interim Period (MPPP)

WORK ITEMS	SPECIFICATION	QUANTITY	COST (M$)	REMARKS
1. BSDS				
Enclosing Bund	Top width 1.5 m	730 m	41,600	
On-site Road	Road width 6.0 m	720 m	19,500	
Gas Removal Facility	W1.0 m x L1.0 m x D4.0 m	20 units	9,800	
Sub-Total			70,900	
2. JMPDS Site A				
Enclosing Bund	Top width 1.5 m	1,080 m	61,600	
On site Road	Road width 6.0 m	550 m	14,900	
Gas Removal Facility	W1.0 m x L1.0 m x D4.0 m	34 units	16,700	
Sub-Total			93,200	
3. JMPDS Site B				
Enclosing Bund	Top width 1.5 m	1,280 m	74,000	
On-site Road	Road width 6.0 m	730 m	19,700	
Gas Removal Facility	W1.0 m x L1.0 m x D4.0 m	57 units	27,900	
Sub-Total			121,600	
4. Detailed Design of PADS			346,000	Construction cost x 3%
Sub-Total			346,000	
Total			631,700	

7.3.3 Collection and Haulage in MPSP

The two new disposal sites, ; one in KuaLa Muda located 20 km from Butterworth and the other in Pulau Burong located 35 Km from Bukit Mertajam are scheduled to begin operation in 1992 and until that time, the present disposal site (Permatang Pauh disposal site) and the Pulau Burong disposal site will be used as final disposal sites by mounting up methods mainly.

When the Permatang Pauh disposal site is closed and Kuala Muda disposal site commences operations, the collection and haulage cost will increase. More collection vehicles and more laborers will be required because transportation to the disposal sites takes about 1.5 to 2 hours for each trip. The reconsideration on contract amount will also be necessary. Measures to encourage the private sector to haul their waste to both disposal sites will be needed to prevent illegal dumping.

To mitigate this cost increase, changing the type of collection vehicles from tipper trucks to compactors and introduction of the 3 times a week collection system are greatly required to reduce the collection and haulage cost.

The increase in number of vehicles and change of vehicle type will require the following considerations by MPSP.

(1) Collection Vehicles of MPSP

a. Replacement of the Old Vehicles

MPSP should replace the old vehicles especially those bought before 1980 by compactor vehicles until 1991.

It is necessary to increase the number of collection vehicles of MPSP if contract areas are not expanded. However, since most of the tipper trucks and 7 compactors were bought before 1980, these vehicles should be replaced as soon as possible. Also it is recommended that MPSP should provide stand-by vehicles that will provide vehicle back-up and ensure regular collection service.

b. Strengthening of the Maintenance Capability of the Workshop

Long transportation to Kuala Muda and Pulau Burong disposal sites poses heavy burden and requires adequate maintenance of collection vehicles. The following points should be especially considered.

- Preventive maintenance
- Proper replacement of collection vehicles based on economic life of vehicle (The Losses caused by down time should be considered).
- Training of drivers to prevent overloading to follow the specified haulage route and to maintain safe driving.

Adequate maintenance of collection vehicles is especially essential when the 3 times a week collection service is employed.

(2) Contract

Change of contract will require two consideration; the first is the schedule of contracts and the second is the change of vehicle types. It is also required to expand the area of contracts.

a. Present contracts

The present contracts which started in May 1988 is scheduled to finish in May 1991 unless the contracts are extended. At that time, there will be two choices, the first is to extend the present contracts until 1992 and the second is to extend until May 1993.

For the latter case, the contracts to be renewed should include the conditions for the change in location of disposal site, which may result in the changes of contract amounts. Therefore, an extension of present contracts until 1992 (the first choice) will be the better choice for MPSP. However, in the first choice total duration of the present contracts will be less than 4 years, which is short as compared to the duration of the economic life of collection vehicles.

b. Review of Contract Zone

Present area of contract zones are too small to have a stand-by vehicle. It is desirable to make contract zones large enough to have 4 or 5 vehicles to keep a stand-by vehicle. It is recommended to have a system for assisting each other (contractors and MPSP) during vehicle breakdown.

(3) Introduction of the 3 Times a Week Collection

Introduction of the 3 times a week collection is another measure for cost reduction.

Strong leadership is required in the introduction of the new collection system.

Therefore, re-organization including establishment of vehicle control system and a cleansing branch office in each district will be the first step of the interim measure.

7.3.4 Final Disposal for MPSP

(1) Proposed Sites

Proposed KMDS and PBDS are planned to be opened in January 1992. Final disposal in MPSP during the transitionary period from the present system (i.e. controlled tipping) to the future system (i.e. sanitary landfill), is to be made at the proposed sites as follows. (Refer to Fig. 7.3-2 & 7.3-3).

i) Mounting up of present PPDS
ii) Use of the extension area of PPDS
iii) Use of present PBDS (Pulau Burong Disposal Site)

As for the PBCS (Prai Barrage Candidate Site) which MPSP intended to use for the interim period instead of the PPDS, a site investigation on the PBCS was conducted by a MHLG expert and an evaluation report was prepared by the expert. Based on the report, the use of PBCS for interim period was not recommended.

(2) Interim Measures

a. Planning Conditions

In addition to the above-mentioned proposed sites, planning conditions for interim measures are summarized as follows.

ITEMS	PPDS	PBDS	REMARKS
i. Service Area	North & Central District	South District	
ii. Wastes to be Disposed	Municipal waste such as domestic, commercial, street sweeping, drain and beach cleansing waste, and non-toxic industrial waste accepted by the Council, such as construction and demolition waste.		
iii. Cumulative Disposal Amount (thousand ton)	320	40	from Dec. 1988 to Dec. 1991
iv. Daily Disposal Amount (t/day)	283	34	in 1990
v. Unit Weight of Wastes	$r = 0.8$ ton/m^3		
vi. Cumulative Landfill Volume (thousand m^3)	390	50	from Dec. 1988 to Dec. 1991
vii. Cumulative Landfill Volume with Cover Soil (thousand m^3)	510	60	
viii. Amount of Cover Soil	30% of landfill volume of waste to be disposed of		

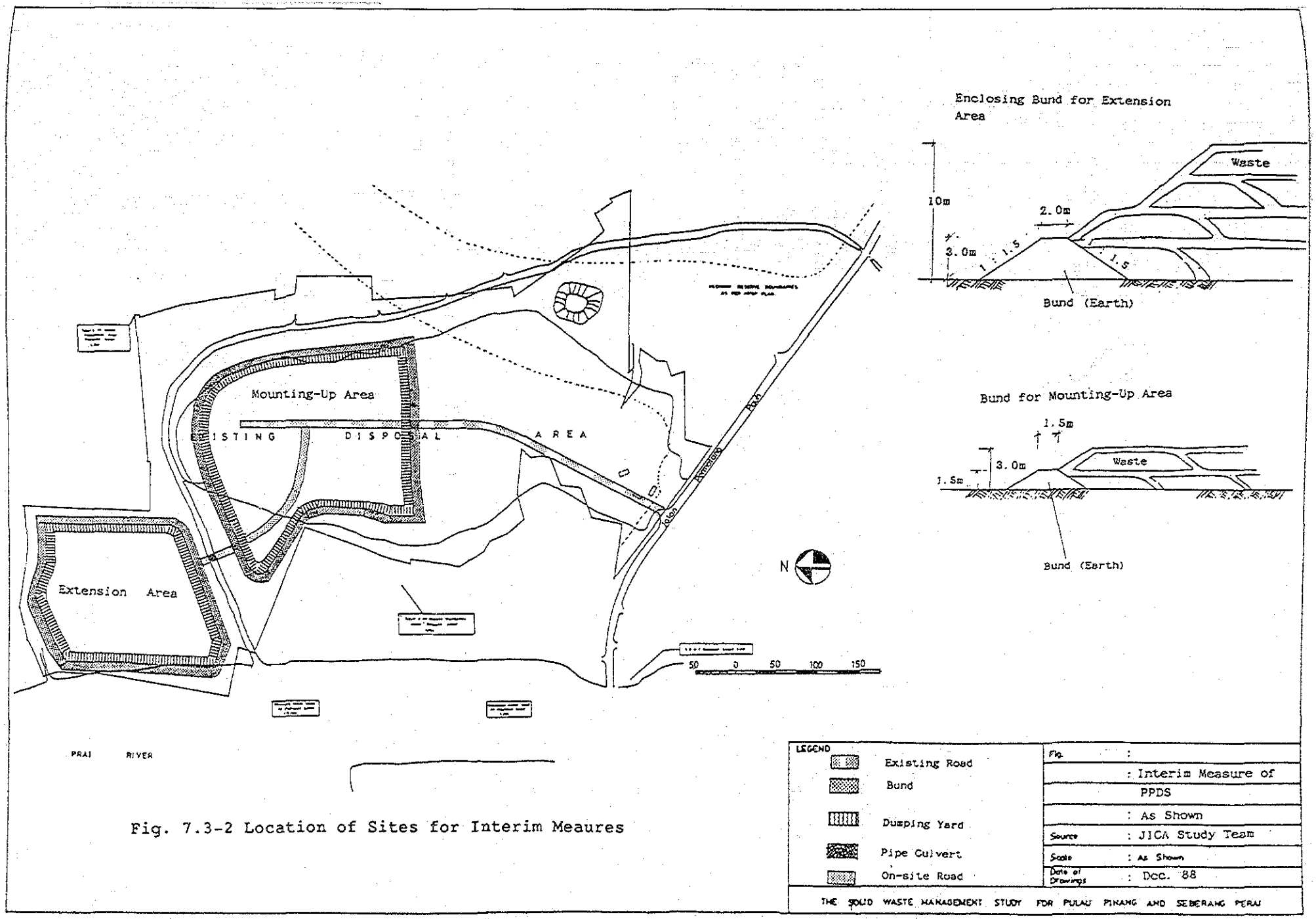
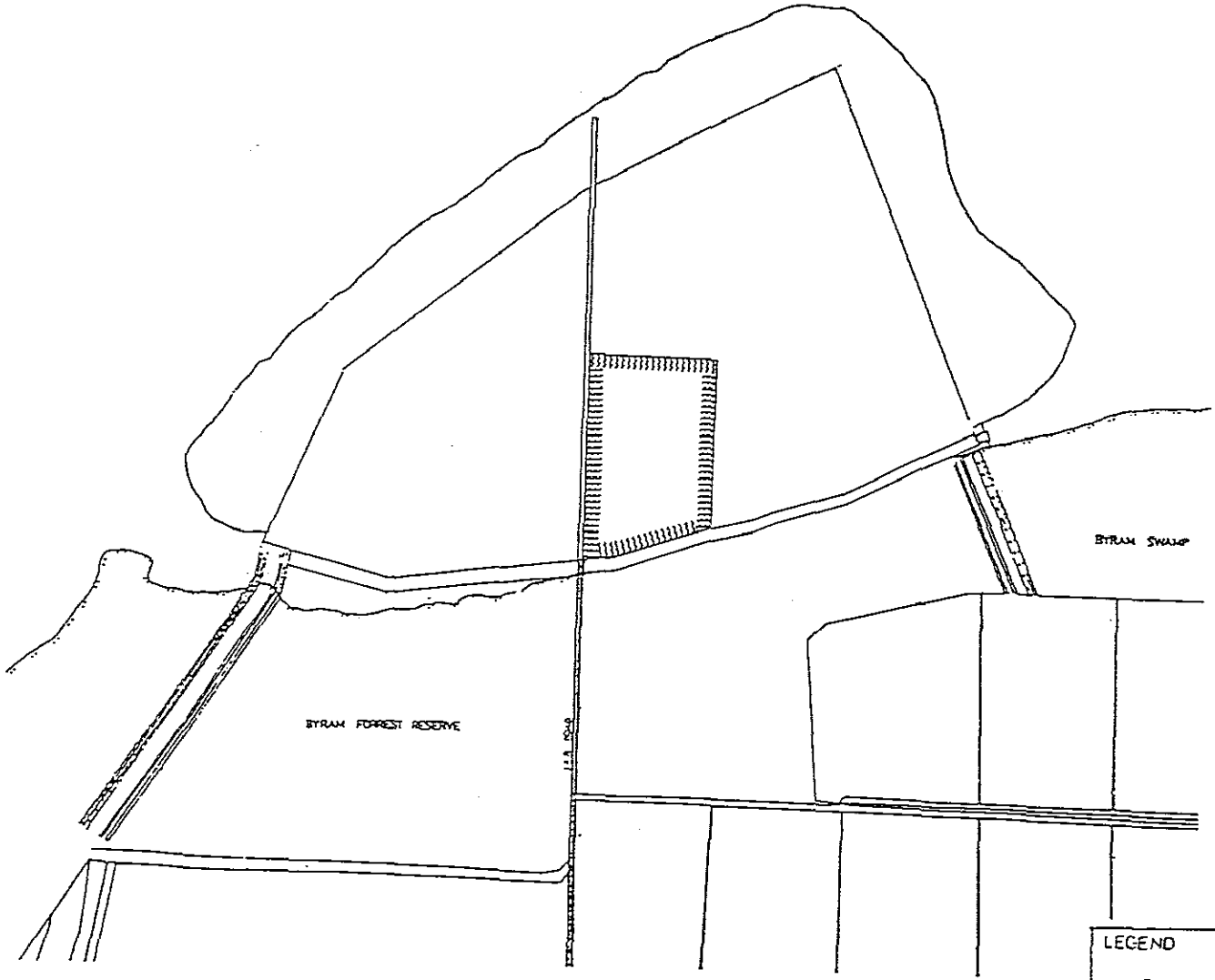
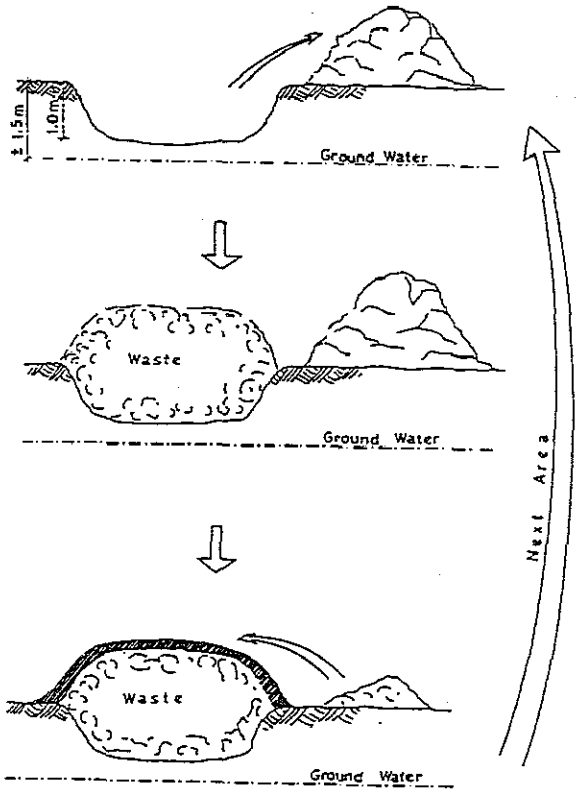


Fig. 7.3-2 Location of Sites for Interim Meaures





TRENCH METHOD

LEGEND

Proposed site for Interim Period (Present PBDS)

Fig. Interim Measure of PBDS

SCALE AS SHOWN

DATE AUG. 1988

PREPARED BY: JICA STUDY TEAM

THE SOLID WASTE MANAGEMENT STUDY For P PINANG & S P

Fig. 7.3-3 Location of Site for Interim Measures

b. Details of Interim Measures

Based on the planning conditions, an interim measure is tabulated in Table 7.3-3 and plans of interim measure are illustrated in the Supplementary Report Volume VI Drawings.

Table 7.3-3 Interim Measures of Final Disposal in MPSP

ITEMS / DISPOSAL SITE	SERVICE AREA	DEPTH OF LANDFILL (METER)	AREA (HA)	PERIOD OF USE	CUMULATIVE LANDFILL VOLUME WITH COVER SOIL (1000 M^3)	REMARKS
Mounting up of PPDS	North & Central District	3	11.0	Dec. '88 to Nov. '90	330	
Extension Area of PPDS	North & Central District	5	3.6	Dec. '90 to Dec. '91	180	
Present PBDS	South District	2	3.2	Dec. '88 to Dec. '91	62	Trench Method of Landfill
Total		-	17.8		572	

c. Cost Estimation

Outline of project and project cost for the interim period are made and tabulated in Table 7.3-4.

Table 7.3-4 Outline of Project and Project Cost for the Interim Period

WORK ITEMS	SPECIFICATION	QUANTITY	COST (M$)	REMARKS
1. Mounting up of PPDS				
Enclosing Bund	Top width 1.5 m	1,850 m	105,500	
Gas Removal	W1,0 m x L1.0 M x D4.0 m	44 units	21,600	
Sub-Total			127,100	
2. Extension of PPDS				
Clearing		40 ha	1,500	
Enclosing Bund	Top width 2.0 m	770 m	43,900	
On-site Road	Road width 6.0 m	250 m	18,800	
Pipe Culvert	ø1.2 m PC. Pipe	7.5 m	5,300	
Gas Removal Facility	W1.0 m x L1.0 m x D5.0 m	15 units	9,200	
Sub-Total			78,700	
3. Landfill Equipment for PPDS				
Bulldozer	18 ton class	1 unit	366,000	
Excavator	24 ton class	1 unit	270,000	
Tipper Truck	12 ton class	1 unit	65,000	
Sub-Total			701,000	
4. Landfill Equipment for PBDS				
Bulldozer	18 ton class	1 unit	366,000	
Sub-Total			366,000	
5. Detailed Design of KMDS & PBDS			235,000	Construction cost x 3%
Sub-Total			235,000	
Total			1,454,900	

8. Site Selection

8.1 Site Selection Process

The selection of sites for main facilities (final disposal sites, incineration plants and transfer stations, etc.) consists of 3 stages as shown in Fig. 8.1-1, and the following 5 points are considered key factors in site selection:

- Possibility of land acquisition;
- Possibility of obtaining neighbouring consensus;
- Compatibility with regional development plans;
- Economic feasibility;
- Environmental acceptability.

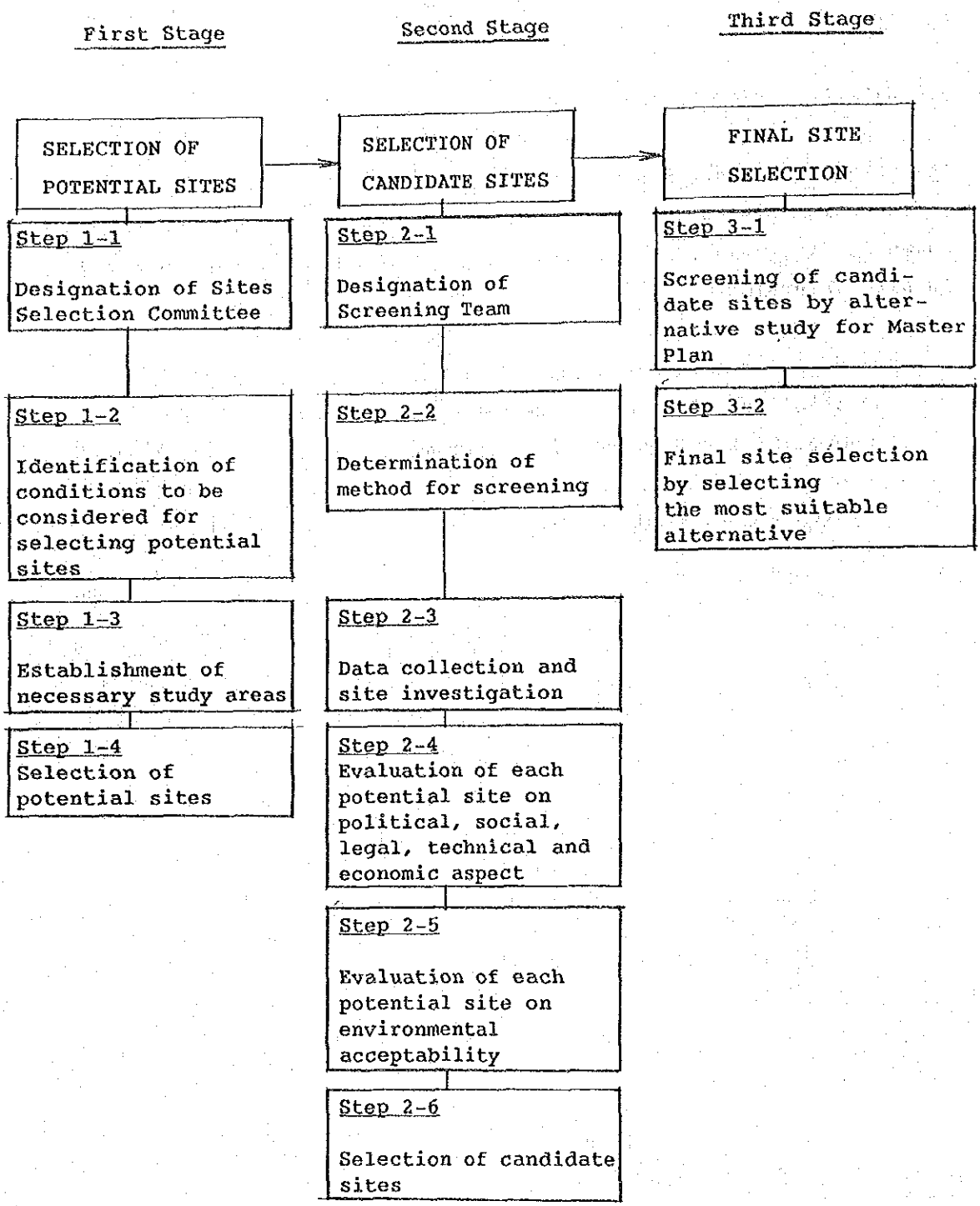


Fig. 8.1-1 Site Selection Process

8.2 Site Selection

(1) Selection of Potential Sites

The Site Selection Committee selected the 21 potential sites based on 3 key factors, i.e. i) possibility of land acquisition, ii) possibility of obtaining neighbouring consensus and iii) compatibility with regional development plans, consisting of 13 sites for disposal, 3 for incineration plants and 5 for transfer stations as shown in Fig. 8.2-1.

(2) Selection of Candidate Sites

Candidate sites are selected in the second stage by examining the potential sites selected in the first stage. In addition to the 3 key factors considered in the first stage, the factors of iv) economic feasibility and v) environmental acceptability are also considered in the examination process.

The potential sites were evaluated on the basis of the 5 key factors given above, and the following 3 rankings were set up for the detailed evaluation criteria.

- O : Most of the evaluation items are cleared.
- Δ : Further studies are required for the clearance of some evaluation items.
- X : There is a critical barrier which cannot be cleared, or there are some unsuitable points for a candidate site.

Those potential sites given an "X" ranking would not be selected as candidate sites. The results of the evaluation are given in Tables 8.2-1, 8.2-2 and 8.2-3.

As a result of the above selection process, the following sites were selected as candidate sites in order to incorporate them in the technical alternatives which have been examined in Chapter 9.

a. Final Disposal Sites
   - Pantai Acheh in MPPP
   - Kuala Muda in MPSP
   - Pulau Burong in MPSP

b. Incineration Plants
   - Free Trade Zone in MPPP
   - Prai Industrial Complex in MPPP

c. Transfer Stations
   - Jelutong Mole in MPPP
   - Free Trade Zone in MPPP
   - Balik Pulau in MPPP
   - Mak Mandin in MPSP

Note: Selection of incineration plants and terms for stations were necessary to examine the feasibility of those facilities though they turned out to be infeasible as a result of the feasibility study made in Chapter 9.

(3) Final Site Selection

The Site Selection Committee decided that Pantai Acheh in MPPP and Kuala Muda and Pulau Burong (Byram Forest Reserve) in MPSP would be the new disposal sites for Penang State.

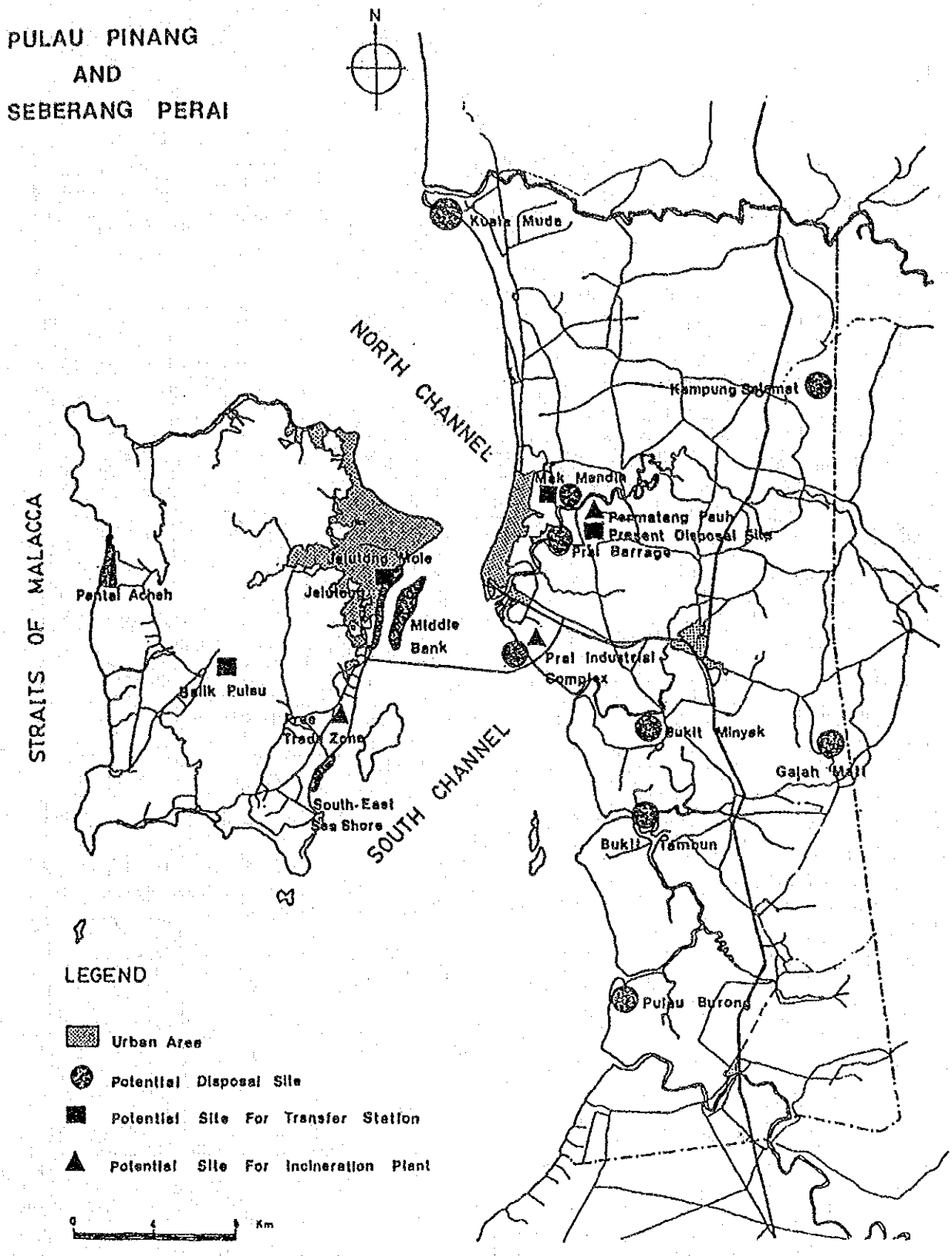


Fig. 8.2-1 Potential Sites for Major Facilities

Table 8.2-1 Potential Site Evaluation Results for Disposal Sites

	Potential Sites	Key Factors Evaluated				
		Possibility of Land Acquisition	Possibility of Getting Neighbouring Consensus	Compatibility with Regional Development Plan	Economic Feasibility	Environmental Acceptability
MPPP	Jelutong Area	Δ	×	×	Δ	×
	Middle Bank	○	Δ	Δ	Δ	×
	South Eastern Sea Shore	○	○	×	○	Δ
	Pantai Acheh	○	○	○	Δ	Δ
MPSP	Kuala Muda	○	Δ	○	○	Δ
	Kampong Selamat	×	○	×	○	×
	Mak Mandin	○	Δ	Δ	×	Δ
	Prai Barrage	○	Δ	×	Δ	×
	Prai Industrial Complex	○	○	×	○	×
	Bukit Minyak	×	Δ	Δ	Δ	Δ
	Gajah Mati	×	○	Δ	○	Δ
	Pulau Burong	○	○	○	Δ	Δ
	Bukit Tambon	○	○	×	○	Δ

Note:

o: most of the evaluation items are cleared
Δ: further studies are required for the clearance of some evaluation items
X: there is a critical barrier which cannot be cleared, or there are some unsuitable points for a candidate site

Table 8.2-2 Potential Site Evaluation Results for Incineration Plants

Potential Sites		Key Factors Evaluated				
		Possibility of Land Acquisition	Possibility of Getting Neighbouring Consensus	Compatibility with Regional Development Plan	Economic Feasibility	Environmental Acceptability
MPP	Free Trade Zone	○	○	○	○	○
MP	Prai Industrial Complex	○	○	○	○	○
SP	Permatang Pauh Disposal Site	×	○	○	×	△

Note:

○: most of the evaluation items are cleared
△: further studies are required for the clearance of some evaluation items
X: there is a critical barrier which cannot be cleared, or there are some unsuitable points for a candidate site

Table 8.2-3 Potential Site Evaluation Results for Transfer Stations

Potential Sites		Key Factors Evaluated				
		Possibility of Land Acquisition	Possibility of Getting Neighbouring Consensus	Compatibility with Regional Development Plan	Economic Feasibility	Environmental Acceptability
MPP	Jelutong Mole	○	○	△	△	△
MPP	Free Trade Zone	○	○	○	○	○
MPP	Balik Pulau	△	○	○	○	○
MP	Mak Mandin	○	○	○	○	○
SP	Permatang Pauh Disposal Site	×	○	○	△	△

Note:

o: most of evaluation items are cleared
Δ: further studies are required for the clearance of some evaluation items
X: there is a critical barrier which cannot be cleared, or there are some unsuitable points for a candidate site

8.3 Environmental Acceptability

The environmental evaluation from view-points of various elements described below is made and tabulated in Tables 8.3-1, 8.3-2, 8.3-3 and 8.3-4. respectively.

- Possibility of drinking water pollution
- Impact by surface water pollution
- Impact by flooding
- Impact by groundwater pollution
- Distance from airport and other public facilities
- Distance from densely populated areas
- Possibility of dust, noise and odour hazards
- Compatibility with land use of adjacent areas
- Slope stability
- Impact on inshore or river fishery
- Impact on terrestrial vegetation and wildlife
- Impact on aquatic/marine flora and fauna
- Impact on natural landscape
- Impact on historical places or structures
- Impact on religious places or structures

Upon the evaluation of these elements together with the evaluation of political, social, legal and technical aspects, the selection of candidate sites is made.

Table 8.3-1 Evaluation of Potential Site for Final Disposal on Environmental Acceptability (1)

Final Disposal (I)

Evaluation Items	M P P P				M P S P		
	Jelutong Area	Middle Bank	South-Eastern Sea Shore	Pantai Acheh	Kuala Muda	Kampong Selamat	Mak Mandin
Overall Environmental Acceptability	×	×	△	△	△	×	△
a. Possibility of drinking water pollution	Nil	Nil	Nil	Nil	Nil	Nil	Nil
b. Impact by surface water pollution	Low	Low	Low	Low	Low	High	Fair
c. Impact of flooding	Low (If proper plan were prepared)	Nil	Low	Low	Low	Very high	Low
d. Impact by groundwater pollution	Low	Nil	Low	Low	Low	High	Fair
e. Distance from airport and other public facilities	Adequate	Adequate	Adequate in case of strict sanitary landfill	Adequate	Adequate	Adequate	Adequate
f. Distance from densely populated area	Adequate if proper measures were taken	Adequate	Adequate	Adequate	Adequate if buffer zone were prepared	Adequate	Adequate if buffer zone were prepared
g. Possibility of dust, noise and odour hazards	High	Low	Low	Low	Fair	Low	Fair
h. Compatibility with land use of adjacent area	Fair	Poor	Good	Fair	Fair	Good	Fair
i. Slope stability	Good	Good	Good	Good	Good	Good	Good
j. Impact on inshore or river fishery	Very high	High	High	Fair	Fair	Low	Fair
k. Impact on terrestrial vegetation and wildlife	Low	Low	Low	Further study	Further study	Low	Low
l. Impact on Aquatic/Marine flora and fauna	Fair	High	Fair	Further study	Further study	Low	Low
m. Impact on natural landscape	Low	Very high	Low	Fair	Fair	Low	Low
n. Impact on historic places or structures	Low	Low	Low	Low	Low	Low	Low
o. Impact on religious places or structures	Low	Low	Low	Low	Low	Low	Low

Note : The following ranking is used in Table 8.3-1, 8.3-2, 8.3-3 and 8.3-4
For Items a, b, c, d, g, j, k, l, m, n, & o
; Very high, High, Fair, Low and Nil.
For Items h & i
; Good, Fair and Poor.
For Items e & f
; Adequate and inadequate.

Table 8.3-2 Evaluation of Potential Site for Final Disposal on Environmental Acceptability (2)

Final Disposal (2)

Evaluation Items	M P S P						
	Prai Barrage	Prai Industrial Complex	Bukit Minyak	Gajah Mati	Pulau Burong	Bukit Tambun	
Overall Environmental Acceptability	×	×	△	△	△	△	
a. Possibility of drinking water pollution	Nil	Nil	Nil	Nil	Nil	Nil	
b. Impact by surface water pollution	Fair	Low	Fair	High	Low	Low	
c. Impact of flooding	Fair	Low	Fair	Nil	Nil	Low	
d. Impact by groundwater pollution	Fair	Low	Fair	High	Low	Low	
e. Distance from airport and other public facilities	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate	
f. Distance from densely populated area	Adequate if buffer zone were prepared	Adequate	Adequate	Adequate	Adequate	Adequate	
g. Possibility of dust, noise and odour hazards	Fair	Low	Fair	Nil	Nil	Nil	
h. Compatibility with land use of adjecent area	Fair	Good	Fair	Fair	Good	Good	
i. Slope stability	Good	Good	Good	Further study	Good	Good	
j. Impact on inshore or river fishery	High	Fair	Low	Low	Further study	Further study	
k. Impact on terrestrial vegetation and wildlife	High	High	Fair	Fair	Further study	Further study	
l. Impact on Aquatic/Marine flora and fauna	High	High	Low	Nil	Further study	Low	
m. Impact on natural landscape	High	Very high	Low	Low	Low	Low	
n. Impact on historic places or structures	Low	Low	Low	Low	Low	Low	
o. Impact on religious places or structures	Low	Low	Low	Low	Low	Low	

Table 8.3-3 Evaluation of Potential Site for Incineration on Environmental Acceptability

Incineration Plant

Evaluation Items	M P P P	M P S P					
	Free Trade Zone	Prai Industrial Complex	Permatang Pauh Disposal Site				
Overall Environmental Acceptability	○	○	△				
a. Possibility of drinking water pollution	Nil	Nil	Nil				
b. Impact by surface water pollution	Nil	Nil	Nil				
c. Impact of flooding	Nil	Nil	Nil				
d. Impact by groundwater pollution	Nil	Nil	Nil				
e. Distance from airport and other public facilities	Adequate in case that height of chimney were designed properly	Adequate	Adequate				
f. Distance from densely populated area	Adequate	Adequate	Adequate				
g. Possibility of dust, noise and odour hazards	Low	Low	Fair				
h. Compatibility with land use of adjacent area	Good	Good	Good				
i. Land stability	Good	Good	Poor				
j. Impact on inshore or river fishery	Nil	Nil	Nil				
k. Impact on terrestrial vegetation and wildlife	Nil	Nil	Nil				
l. Impact on Aquatic/Marine flora and fauna	Nil	Nil	Nil				
m. Impact on natural landscape	Low	Low	Low				
n. Impact on historic places or structures	Low	Low	Low				
o. Impact on religious places or structures	Low	Low	Low				

Table 8.3-4 Evaluation of Potential Site for Transfer Station in Environmental Acceptability

Transfer Station

Evaluation Items	M P P P			M P S P			
	Jelutong Mole	Free Trade Zone	Balik Pulau	Mak Mandin	Permatang Pauh Disposal Site		
Overall Environmental Acceptability	△	○	○	○	△		
a. Possibility of drinking water pollution	Nil	Nil	Nil	Nil	Nil		
b. Impact by surface water pollution	Nil	Nil	Nil	Nil	Nil		
c. Impact of flooding	Nil	Nil	Nil	Nil	Nil		
d. Impact by groundwater pollution	Nil	Nil	Nil	Nil	Nil		
e. Distance from airport and other public facilities	Adequate	Adequate	Adequate	Adequate	Adequate		
f. Distance from densely populated area	Adequate if proper measure were done	Adequate	Adequate	Adequate	Adequate		
g. Possibility of dust, noise and odour hazards	High	Low	Fair	Fair	Fair		
h. Compatibility with land use of adjacent area	Fair	Good	Fair	Good	Good		
i. Land stability	Fair	Good	Good	Good	Poor		
j. Impact on inshore or river fishery	Nil	Fair	Nil	Nil	Nil		
k. Impact on terrestrial vegetation and wildlife	Nil	Nil	Nil	Nil	Nil		
l. Impact on Aquatic/Marine flora and fauna	Nil	Nil	Nil	Nil	Nil		
m. Impact on natural landscape	Low	Low	Low	Low	Low		
n. Impact on historic places or structures	Low	Low	Low	Low	Low		
o. Impact on religious places or structures	Low	Low	Low	Low	Low		

8.4 Conditions of Candidate Disposal Sites

The conditions of the selected disposal sites are given in Table 8.4-1.

Table 8.4-1 Conditions of Selected Disposal Sites

	MPPP	MPSP	
Items	PANTAI ACHEH	KUALA MUDA	PULAU BURONG
Location	West coast of Penang Island; 35 km from Georgetown	North coast of MPSP; 20 km from Butter-worth	South coast of MPSP; 35 km from Butter-worth
Area	100 ha	Inland: 18 ha Lagoon: 60 ha	29 ha
Present Land Use	Natural forest	Inland: low marshland Lagoon: lagoon	Byram Forest Reserve (man-made forest)
Neighbouring Land Use	Mangrove forest; Man-made forest; Scattered houses	Inland: man-made forest; low marshland; scattered houses Lagoon: lagoon; scattered houses	Farmland; mangrove forest, man-made forest
Topography	Flat marshland	Inland: flat marshland Lagoon: lagoon	Flat marshland
Geology	Thick deposit of marine clay	Thick deposit of marine clay	Thick deposit of marine clay
Surface-water hydrology	Part of larger drainage catchment area	Inland: independent catchment area Lagoon: part of larger drainage area	Independent catch-ment area
Climate	High temperature & high humidity; tropical rain zone	High temperature & high humidity; tropical rain zone	High temperature & high humidity; tropical rain zone
Covering Soil	Purchased soil (use of Bukit Kechil if possible)	Purchased soil	Purchased soil

Chapter 9. Alternatives for Technical System

9.1 Examination of System Components

9.1.1 Basic Approach

Solid waste management system consists of various sub-systems such as storage/discharge, collection/haulage, intermediate treatment, final disposal. Some of the sub-systems are always necessary, while the necessity of some other sub-systems such as intermediate treatment systems depends on local conditions such as financial, geographical and waste conditions.

This Chapter will examine whether or not certain sub-systems are required, as well as their types, methods, facilities if required. The following table explains the scope of examination made, in this Chapter, with respect to each sub-systems.

Table 9.1-1 Scope of Examination

SUB-SYSTEMS	SCOPE OF EXAMINATION
- Storage & Discharge	C
- Collection & Haulage	C
- Transfer	B
- Intermediate Treatment	
. Incineration	A
. Compost	A
. Shredding	A
. Sorting	A
- Final Disposal	C

A: Examination was made as to:
- whether or not the sub-system is necessary

B: Examination was made as to:
- whether or not the sub-system is necessary
- types, methods and facilities

C: Examination was made as to types, methods and facilities as the sub-system is absolutely necessary.

Note: A study was made regarding possible specifications of low-cost incinerators. The results of the study is shown in the Supplementary Report Part X.

9.1.2 Storage and Collection

(1) Basic Consideration of Storage and Discharge

The storage and discharge methods at the generation sources of solid waste not only have a close relationship with the subsequent process, i.e. collection, but also play a crucial role in the entire solid waste management system, from haulage to intermediate treatment (recovery of valuable items) and further to final disposal.

Since the process from discharge to collection is a point of contact between the public and the local authority responsible for collection, a consensus on the discharge and collection methods should be reached through administrative influence on the public and public demands on the administration.

The introduction of uniform storage and discharge methods at the source of solid waste generation is impossible due to the diversity of the solid waste in terms of volume, shape and quality and also because of the different forms of land use.

With the advancement of urbanization, however, storage and discharge methods increasingly affect the collection efficiency and, therefore, the adoption of specific methods should be encouraged as much as possible.

Alternative storage and discharge methods can be suggested by adopting different methods in terms of the following aspects, in turn determined by the consideration of where, how and what types of solid waste should be stored and when they should be discharged.

- Separate discharge
- Types of storage and discharge containers
- Places of storage and discharge
- Discharge frequency

Table 9.1-2 shows different methods of solid waste storage and discharge including those currently employed.

Table 9.1-2 Solid Waste Storage and Discharge Methods

Solid Waste Separation	Not separated	Mixed discharge
	Separated	Solid waste separated into 2 or 3 types before discharge
Storage and Discharge Containers	Use of same containers	Storage container is also used as discharge container.
	Use of different containers	Solid waste stored is discharged with containers designated by collection side.
	Containers not used	Solid waste stored is either directly discharged to collection vehicle or discharged in bulk at location designated by collection side.
Storage and Discharge Places	Same place	Inside or outside of generation site
	Different place	Storage at inside of generation site and discharge outside
Discharge Frequency	Not designated	Discharge at any time
	Designated	Discharge only at designated times

Alternative plans with different storage and discharge methods vis-a-vis land use types are given in Tables 9.1-3 and 9.1-4.

Although there are many types of storage and discharge methods, as outlined above, there is no single conclusion as to which methods should be selected on the basis of their direct connection to actual collection systems.

The separate collection of solid waste where the solid waste is separated in accordance with the functions of the intermediate treatment system (i.e. separated into combustible waste and incombustible waste, etc.) will not be introduced as described in (5). However, the following bulky waste and tree cutting waste should be separately collected in view of its irregular generation:

- Old furniture and household electrical appliance , etc.
- Felled trees and branches
- Large volumes of waste following house removal, etc.

Table 9.1-3 Relationship between Type of Land Use and Storage/Discharge Containers

Container used inside house and shop	Container used at Collection point		Detached house		High Rise Building	Commercial Area	Large Amount Discharges
			Housing estate	Company			
Bins	- Without container - Stand + Bin - Bin (at curbside)						
	Station (Large Amount Discharge)	- Without continer	X	· X	X	X	X
		- Bin	0	0	0	0	X
		- Container $1m^3$	· 0	· 0	0	0	· 0
		- Handled Container $10m^3$	X	· X	0	X	· 0
	Dust Chute	- Without container	X	X	· X	· X	· X
		- With container	X	X	· 0	X	· 0
Bags	- Stand + Bin + Bag		· 0	X	X	0	X
	- Bag (at carb side)		· 0	· X	X	0	X
	Station (Large Amount Discharge)	- Without continer	X	· X	X	X	X
		- Bin	0	0	0	0	X
		- Container $1m^3$	· 0	· 0	0	0	· 0
		- Handled Container $10m^3$	X	· X	0	X	· 0
	Dust Chute	- Without container	X	X	· X	· X	· X
		- With container	X	X	· 0	X	· 0

· Present Method
X Method not to be used
0 Method to be used

Table 9.1-4 Relationship Between Types of Land Use and Storage/Discharge Containers

		DETACHED HOUSING						HIGH-RISE HOUSING		COMMERCIAL AREAS		LARGE AMOUNT DISCHARGE (MARKETS, ETC.)	
		HIGH DENSITY		LOW DENSITY		KAMPONG							
On Premises (Side of Front Door)		•	x	•	x		x		x	•	x		x
On Roadside Next to Source of Generation		•	Δ	•	x	•	x		x	•	o		x
Solid Waste Station			o		x		x		o		x		x
Container	Large		x			•	x		x		x	•	o
	Medium		x	•	o	•	o		x	•	o	•	o
	Small		x				o		x		x		
Dust Chute	(Container)		x		x		x	•	o		x		x
	Bulk		x		x		x	•	x		x		x

Note: o: Method to be examined
•: Present method
x: Method not to be examined

(2) Storage and Discharge

a. Residential Areas

Storage and discharge methods in residential areas will depend on the type of collection method, i.e. door-to-door or station collection. In the case of door-to-door collection, the following principles must be met.

- Fixed stands should be provided to prevent the waste being scattered by cats and dogs if the solid waste is to be left outside overnight. The solid waste should be discharged in plastic bags.

- Fixed stands are unnecessary if the solid waste is to be placed outside in accordance with designated collection times.

- If portable bins are used, the weight of the bin, including the solid waste should not exceed 20 kg to avoid backache of collection workers.

Based on the above principles, the following three methods can be used for solid waste storage and discharge in residential areas:

- fixed bin + plastic bag
- portable plastic bin
- plastic bag

Table 9.1-5 shows the advantages and disadvantages of each method of the above.

Table 9.1-5 Comparison of Household Solid Waste Discharge Method

	IN HOUSEHOLDS		AT DISCHARGE POINTS			PUBLIC
	CLEANLINESS	HANDLING	CLEANLINESS	HANDLING	COST	COOPERATION
- Portable plastic bin	A	A	B	B	A	Much requirement
- Plastic bag (disposable)	A	A	B	A	B	Less requirement
- Fixed plastic bin + plastic bag	A	A	A	A	B	Much requirement

A: Good
B: Not good

Note: - A bin should have the capacity of 40 - 70 litre.
(Preferably, the weight of bins with solid waste should be less than 15 kg.)
- Bins should be washable.
- Portable bins should be taken to a collection point, and taken back to the house after collection. Bins should have lids.

In view of collection efficiency, fixed bins + plastic bags or portable plastic bins are recommended. In the case of plastic bag without bins, the public should discharge their bags in the morning of the collection day to prevent the waste being scattered by cats and dogs.

In the case of station collection, a container may or may not be provided at the station. As the solid waste must be brought to the station by the residents of the area, a fixed type bin for each household cannot be used. Therefore, there are three possible collection methods as follows:

- Communal Container + Plastic Bag
- Plastic Bin
- Plastic Bag.

Table 9.1-6 shows the advantages and disadvantages of each method of the above.

Table 9.1-6 Comparison of Solid Waste Discharge Methods for Station Collection

	IN HOUSEHOLDS		AT DISCHARGE POINTS			PUBLIC
	CLEANLINESS	HANDLING	CLEANLINESS	HANDLING	COST	COOPERATION
- Plastic bin	A	A	B	B	A	Most requirement
- Plastic bag (disposable)	A	A	B	A	B	Less requirement
- Communal container + Plastic bag	A	A	A	A	B	Much requirement

A: Good
B: Not good

In the case of plastic bins, residents would have to take back their plastic bins to home after collection. Reliable punctual collection is essential for station collection, especially in the case of plastic bags to prevent the scattering of the waste by cats and dogs.

The container system has the problem of securing sites for container to be located due to the limited available land. It is, however, advantageous in that the solid waste can be discharged at any time, making it the preferred choice for such places as kampongs where a long carrying distance is involved.

The use of plastic bags should be adopted in ordinary residential areas except in those places where containers may be installed without any special site arrangements.

b. Kampongs

Since access to kampongs by collection vehicles is generally difficult, the discharge of solid waste in plastic bags for collection at stations is the most realistic method. Waste stations should be established as many as possible and the provision of communal containers is preferable.

Door-to-door collection in kampongs necessitates the employment of heapers to bring the solid waste to the main road by carts or other means and, therefore, is an expensive operation.

c. Commercial Areas

As the provision of communal containers or fixed household bins is difficult in commercial areas, either portable bins or plastic bags should be used. The latter is preferable in view of easy collection.

d. Housing Complexes

Two types of dust chute systems are currently employed in housing complexes, i.e. (i) a container is provided in a storage room at the bottom of the dust chute and (ii) no container is provided.

In principle, it is preferable that the use of dust chute be terminated in view of their adverse effect on the environment vis-a-vis bad odours and the scattering of waste, etc. and that a system be employed whereby the residents of housing complexes take their solid waste to specified points by using plastic bags.

For those housing complexes where dust chute with a container is provided for each 25 flats and where collection vehicles can be accessible to the container, the use of dust chute may be continued. In this case, the solid waste should be collected daily to prevent its overflow and bad odour.

e. Premises Generating Large Amounts of Waste (Hotels and Markets)

Particularly large containers are required to deal with the large amounts of waste generated by hotels and markets, etc. The provision of hauled containers is preferable for markets, while containers for compactor collection should be provided for hotels, as in the case of housing complexes.

f. Bulky Waste Discharge Method

Tree trunks and branches should be shortened to less than 1m in length and bundled together for easy collection. In view of the scheduled regular collection of bulky waste, it should be discharged at designated collection points on designated days.

g. Cost Sharing of Discharge Equipment

In principle, the cost of the household bins and plastic bags should be borne by the residents. The cost of containers used in housing complexes should also be borne by the residents in view of the required daily collection.

The Council should bear the cost of containers used in kampongs while the cost of containers provided for hotels and markets should be borne by those using them.

h. Discharge Points

In principle, solid waste discharge points should be located at roadsides for easy access by collection vehicles. The actual discharge points are as follows.

i)	Residential areas (door-to-door collection)	: Roadside
ii)	Residential areas (station collection)	: Station
iii)	Kampongs	: Station (or Communal container)
iv)	Commercial areas	: Roadside
v)	Housing complexes	: Dust chute or station
vi)	Generators of large amounts	: on premises

(3) Basic Consideration of Collection System

The solid waste collection has a close relationship with storage and discharge methods at sources of waste generation, and there is a clash of interest between the generating side and collection side.

The nature of the conflict not only reflects the social and natural conditions of the areas but also relates to the types and functions of buildings where solid waste is generated. Consequently, it is virtually impossible to provide the same service for all residents.

The boundary between the two sides cannot be uniformly separated, as shown by broken line a-b in Fig. 9.1-1. Both sides are intertwined as shown by solid line c-d, causing different service levels for the generating side and different collection costs for the collection side.

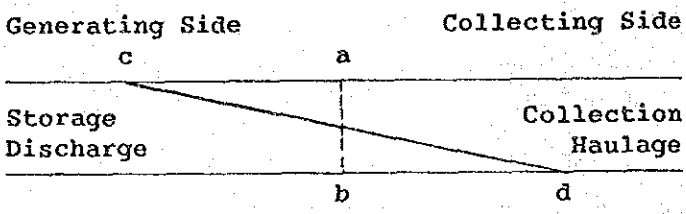


Fig. 9.1-1 Divided Responsibility of Generating and Collecting Sides

For example, if curb-side collection is adopted for the door-to-door collection service, the generating side would have to carry the solid waste for quite a distance. If the backyard of the generation source is designated as the collection point, however, the collection efficiency, i.e. collection cost, would vary in accordance with the type of generation source.

Given these characteristics of a solid waste collection service, there are always complaints from one side or the other, or from both, no matter which collection method is employed.

Nevertheless, if these characteristics are carefully examined from the viewpoint that solid waste management is inherently an administrative service provided by the local authority, it can also be said that these characteristics provide a challenge for the local authority vis-a-vis implementing its own solid waste policies with consideration given to its specific geographical and social conditions, etc.

(4) Collection Frequency for Domestic Waste

The cost of solid waste collection is largely influenced by the haulage distance to the disposal site and by the generation density of waste. In turn, the generation density depends on the population density and the collection frequency. The generation density is double that of daily collection if the collection frequency is three times a week.

As a result, only half of the subject area for daily collection is covered on each collection day in the case of three times a week collection and the collection cost will be reduced. This reduction in the collection cost is much more noticeable in rural areas where the houses are scattered.

As shown in Fig. 9.1-2, the loading efficiency increases in proportion to the waste volume at each station. In addition, the speed of the collection vehicles between stations declines when the distance between the stations is shorter.

The waste volume at each station is small in the case of daily collection, and the distance between stations is shorter in the case of door-to-door collection. Consequently, the collection efficiency decreases, increasing the collection cost. In short, daily door-to-door collection is fairly expensive.

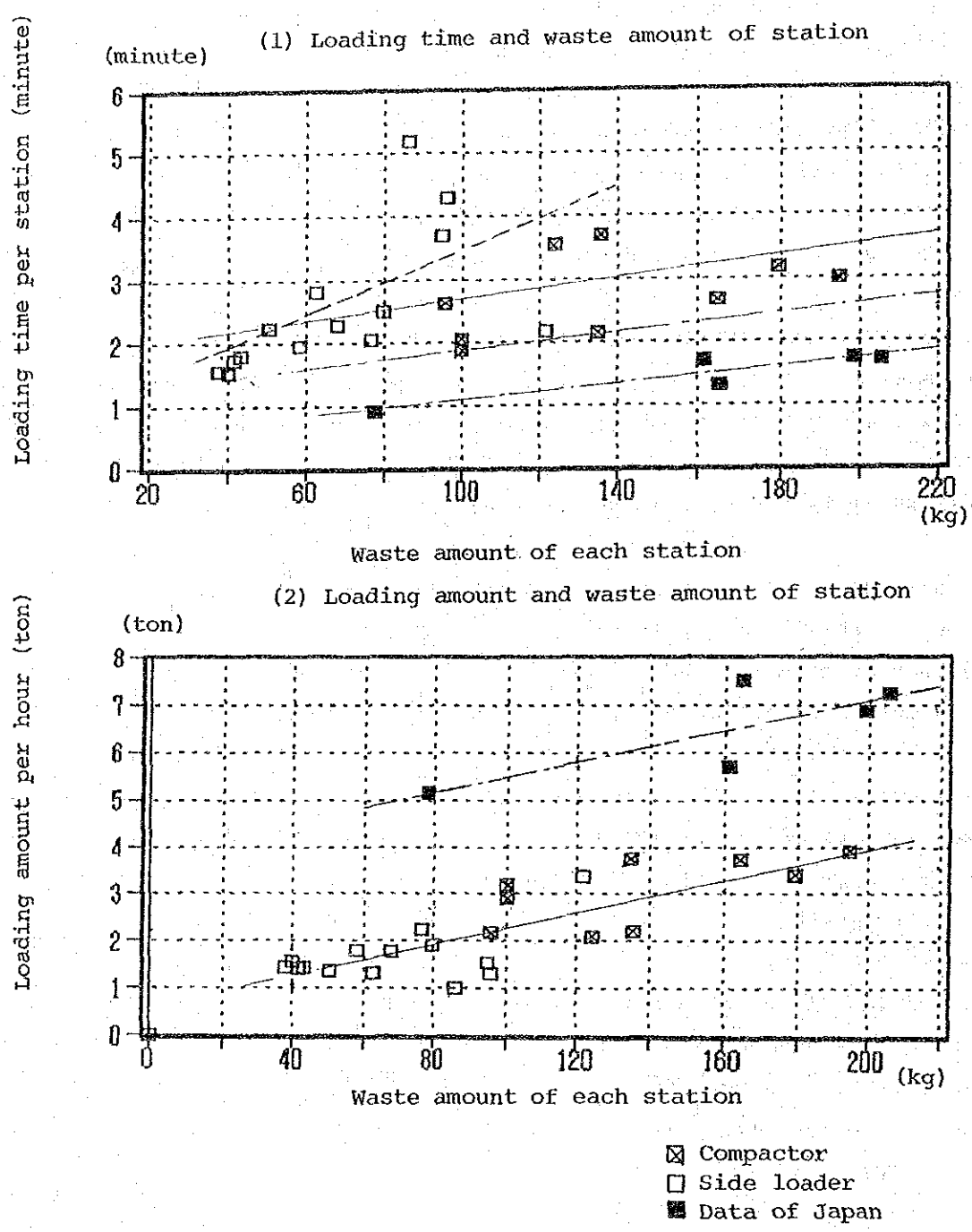


Fig. 9.1-2 Loading Efficiency, Loading Time and Solid Waste Volume at Station

There are two basic ways of reducing the collection cost, both of which require public cooperation in regard to waste discharge.

One is reduction of collection frequency, the other is adoption of the station collection.

Assuming a collection frequency of three times a week, the collection cost will be some 20% less than the cost of daily collection. If the station collection method is employed, a cost reduction of some 10% will result because heaping becomes unnecessary.

Collections are conducted by collection crews consisting of a driver, 4 - 5 collection workers and 1 - 2 heapers. Since these workers not only load the waste onto the vehicle but also collect it from each household, the volume of waste at a station (pick-up point) is 70 kg for side loaders (equivalent to the solid waste volume of 20 households).

As the side loaders used for door-to-door collection load an average of 70 kg of solid waste at each station, the following four alternatives can be suggested in terms of collection frequency and collection points.

a.	Daily door-to-door collection	70 kg, collection at station by heaper
b.	3 times/week door-to-door collection	140 kg, collection by heapers
c.	Daily station collection	70 kg, residents take waste to station
d.	3 times/week station collection	140 kg, residents take waste to station

The cost and the required number of workers largely depends on the collection system, as shown in Table 9.1-7.

Table 9.1-7 Collection Costs of Various Systems for Domestic Waste Collection in 2005

	MPPP			MPSP		
	Vehicles (unit)	Workers (person)	Cost (M$million)	Vehicles (unit)	Workers (person)	Cost (M$million)
a. Daily door-to-door collection	143	997	17.6	117	814	13.6
b. 3 times/week door-to-door collection	108	751	12.6	86	600	10.1
c. Daily station collection	143	713	15.2	117	582	11.6
d. 3 times/week station collection	108	537	10.8	86	429	8.7

The selection of either daily collection or three times a week collection depends not only on cost but also on the labour management. In view of the present excessive labour force in MPPP, daily collections can be maintained. In comparison, however, an extension of the present collection services require additional labourers in MPSP and, therefore, an efficient system should be introduced.

Consequently, station collection of 3 times a week is recommended for both MPPP and MPSP in order to extend the collection service area with efficient system in 2005.

(5) Collection Methods

Although there are many solid waste collection methods, the possible introduction of the following three methods is discussed here.

a. Independent Collection System for Large Amount Discharger

As in the present case of MPPP, hauled containers and bulk-bin are used for the generators of large amounts. This system will be continued in the future.

If the use of hauled containers is dropped in favour of bulk-bin, collection by large compactors will be possible along with domestic waste collection because type of vehicle is same.

Nevertheless, such large containers as hauled containers will still be required in such places as markets which generate particularly large volumes of waste. Since Sunday collection from markets is essential, the introduction of an independent collection system will be required.

On the other hand, an independent collection system for large amount waste will be introudced by using compactor vehicle with container in MPSP.

As the beneficiaries should be charged for the collection service based on the Beneficially - Pay - Principle and as the fee should be equivalent to the collection cost, an independent collection system is also desirable so that correct cost calculation can be made.

b. Bulky Waste and Garden Waste Collection System

The independent collection of bulky waste and garden waste should be continued with the improvement of the discharge methods and collection frequency.

c. Separate Collection System

The separate collection system has the advantage of preventing the secondary pollution associated with treatment and disposal. It also assists in the efficient operation and maintenance of intermediate treatment and final disposal facilities.

The separate collection system will, however, require independent collection services for each category of separating items, causing a decrease in the collection efficiency due to decrease of waste amounts. The reduced collection efficiency will result in the increase of cost by some 12%.

In addition, the public cooperation for the introduction of this system cannot be anticipated at present. Due to these reasons, separate collection systems will not be considered in the master plan.

d. Night Collection

Night collection is desirable in central Georgetown where the traffic is extremely congested during the day time. The expected cost reduction by night collection is up to 10%. In view of the fact that the ratio of solid waste subject to night collection is 20%, however, the overall cost reduction will be less than 2%.

As night collection necessitates the simultaneous operation of transfer stations and disposal sites, 2 shifts are required. This will subsequently increase the personnel, lighting and other costs.

As the expected cost reduction by night collection is minimal based on the above, night collection will not be considered as an alternative collection system.

(6) Introduction of Large Collection Vehicles for Domestic Waste

The positive effects of using large collection vehicles increase in accordance with the longer haulage distance and higher personnel cost. Side loaders should be replaced by compactors when the haulage distance exceeds 30 km. The current compactor size of 10 m^3 is large enough and little cost reduction can be expected by increasing.

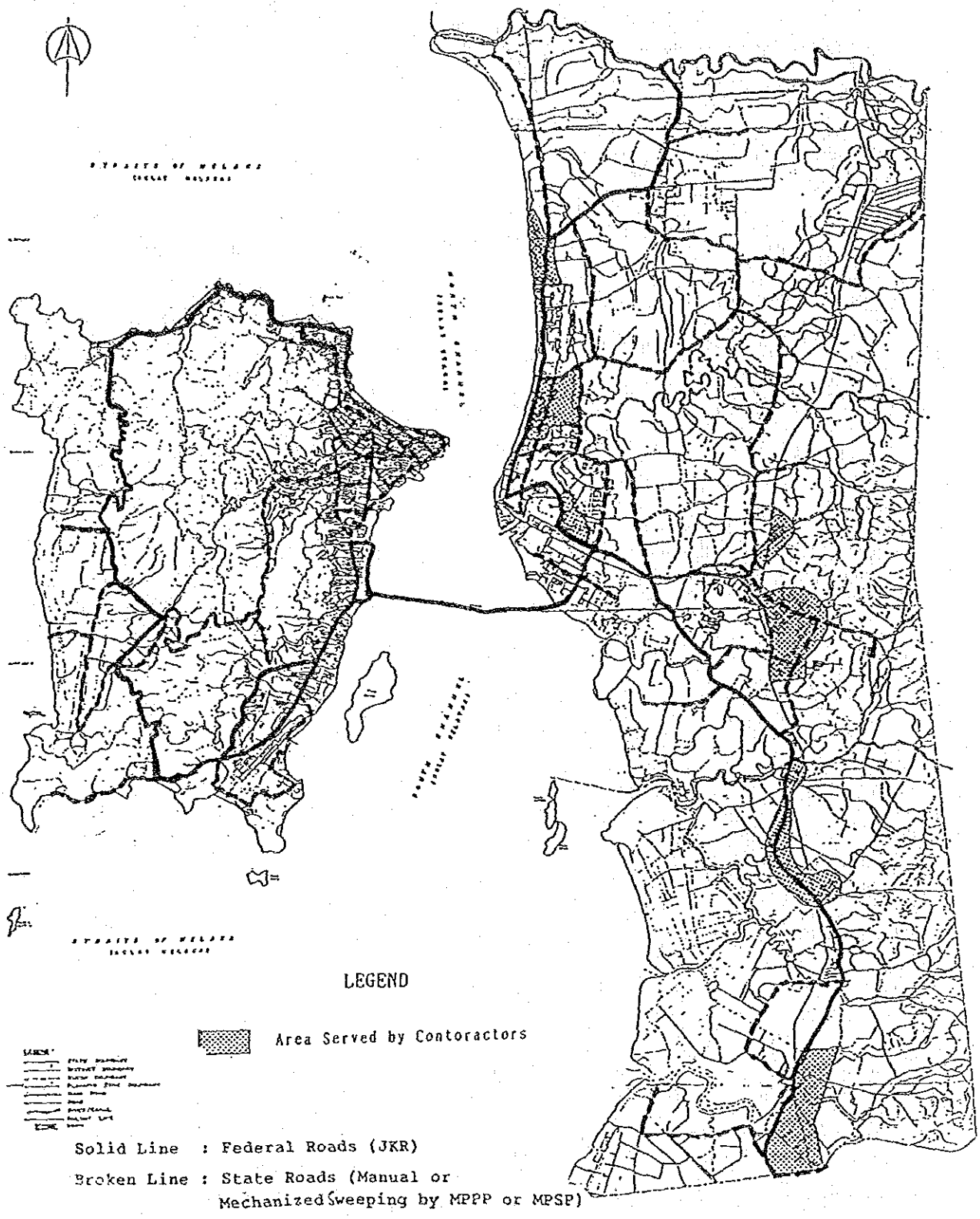
9.1.3 Street and Drain Cleansing (Including Grass Cutting and Beach Cleaning)

(1) Responsible Bodies for Cleaning

The respective responsibilities of these agencies must be clearly determined. Street sweeping, drain cleansing and the cutting of grass at the curb, etc. are all part of road maintenance work. At present, street sweeping and drain cleansing are conducted by the Councils while grass cutting is conducted by the JKR. As the cost of this cleansing work is

fairly high, it is desirable from the Councils' point of view that the JKR bear all the costs or at least increase its share. However, it may be difficult to achieve such an arrangement in the near future, in view of the fact that streets in residential areas are all state roads.

For the present purpose of examining alternatives for the Master Plan, therefore, it is assumed that the street sweeping, drain cleansing and grass cutting for federal roads will be conducted at JKR's expense. The total length of subject state roads is 68km in MPPP area and 62km in MPSP area. Fig. 9.1-3 shows roads to be swept. The division of cleansing work is shown in Table 9.1-8.



Note: Streets in residential area does not indicate.

Fig. 9.1-3 Roads to be Swept

Table 9.1-8 Division of Cleansing Work

	MPPP	MPSP
Street Sweeping		
- Federal roads	JKR	JKR
- State roads	USD	USD
- City roads	USD	-
- Village roads	-	USD
Drain Cleansing		
- Rivers	DID	DID
- Monsoon drains	DID	DID
	Engineering Dept.	-
- Roadside drains	USD	USD
Grass Cutting		
- Federal roads	JKR	JKR
- State roads	JKR	JKR
- City roads	Engineering Dept.	-
- Village roads	-	Residents
- Parks	Secretary Dept.	Secretary Dept.
- Drain sides	USD	USD
Beach Cleaning	USD	USD

Note: USD stands for Urban Service Department which will be established in both MPPP and MPSP.

(2) Cleansing Frequency

The frequency of street and drain cleansing must be increased if they are heavily littered by the public. The implementation of solid waste collection and the strong enforcement of measures to prevent illegal dumping are required to prevent the littering of streets and drains, making public cooperation indispensable as in the case of collection.

The volume of litter is generally large in shopping streets and markets, etc. where many people congregate and the health environment of these areas must be maintained at a high level.

In comparison, the volume of litter is relatively small in residential areas where there are not many pedestrians.

The frequency of cleansing should, therefore, be determined on the basis of the actual requirements of specific areas. Street and drain cleansing is typically labour-intensive work in which a few public agencies are involved.

Daily sweeping is necessary in shopping streets where there are many people and lots of litter. In comparison, the daily sweeping of streets in residential areas is unnecessary. For example, street sweeping in the Kuantan residential area only once every three weeks maintains standards of hygiene. Since the required sweeping frequency relates to the amount of litter or scattered waste, it is difficult to decide the optimal frequency.

Using Kuantan as an example, however, weekly sweeping is considered adequate if a thorough collection service is provided and the prohibition of illegal dumping is implemented.

A large proportion of the solid waste and litter found in drains is associated with illegal dumping and, therefore, this practice must be prevented. The weekly cleansing of drains in residential areas should be sufficient, as in the case of street sweeping. Similarly, grass cutting once a month should be sufficient, while beaches should be cleaned every day to give the clean and beautiful image of Penang to tourist. Table 9.1-9 shows the desirable frequency for each type of cleansing.

Table 9.1-9 Cleansing Frequencies

Street Sweeping	:	Commercial areas	daily
	:	Streets in residential area	once a week
	:	Main roads in rural areas	once a week
	:	Other roads	once a month
Drain Cleansing	:	Drains which are likely to be blocked frequently	daily
	:	Drains in residential areas	once a week
	:	Other roads	once a week
Grass Cutting	:	Drain sides	once a month
Beach Cleansing			daily

(3) Mechanization

The following work should be mechanized in view of the difficulty of its manual implementation.

a. Sweeping of main roads
b. Cleansing of monsoon drains
c. Grass cutting

(4) Work System

Each road is generally swept once a week and the work will be conducted by a team.

9.1.4 Transfer Haulage

(1) Possible System Alternatives

As for the possible system alternatives of transfer haulage methods, the followings are to be considered;

- Motor vehicles
- Railroads
- Ocean-going vessels (Barge)
- Pneumatic and hydraulic systems

In addition to the above, the following transfer methods are to be considered as possible system alternatives of transfer stations;

- Direct re-loading type
- Indirect re-loading type with storage and compactor
- Indirect re-loading type with storage and bailing
- Indirect re-loading type with storage and loading equipment
- Indirect re-loading with compactor without storage
- Indirect re-loading with bailing without storage

(2) Selection of Haulage Method

As described in Chapter 8, the candidate disposal sites, the locations of which are a precondition for the selection of the haulage method, are as follows.

- MPPP: Pantai Acheh Disposal Site (PADS)
- MPSP: Kuala Muda Disposal Site (KMDS)
  Pulau Burong Disposal Site (PBDS)

As there is no railway service near these three sites, and pneumatic and hydraulic systems are too expensive, haulage by railway and pneumatic and hydraulic systems would not be applicable in this study. The transfer haulage system by vehicle or barge methods was, therefore, examined.

(3) Selection of Transfer Station Type

In order to select the types of transfer stations, the following aspects are to be considered; (Details are available in the Supplementary Report Volume I Section 6.4)

- Economic feasibility according to the capacity requirements
- Easiness and stability in operation
- Flexibility
- Safety
- Operation and maintenance
- Space for the transfer stations
- Environmental acceptabilities

Based on the above mentioned considerations, the following types are selected for the proposed transfer stations.

i. Transfer haulage by motor vehicles

- Direct re-loading type to the transfer haulage vehicles for small scale
- Indirect re-loading type with compactor and without storage facilities for large scale

ii. Transfer haulage by ocean-going vessels

- Direct re-loading type to the ocean-going vessels
- Indirect re-loading type with crane and without storage facilities for unloading from ocean-going vessels

The reasons are described as follow,

As for small scale:

- The capacity requirements of the station is only 60 t/day.
- Construction is the cheapest and simplest.

As for large scale:

- The capacity requirements of the transfer stations are over 500 t/day. The transfer stations are classified as large scaled transfer stations.
- Collection vehicles proposed in the study are compaction type and large (10 m^3). Therefore, without compaction facility the proposed transportation vehicles become too big.
- This type of transfer station can transfer large amount of wastes efficiently.
- From the environmental point of view, reception yards and bailing types are not recommended to wastes which contain large amount of garbaga.
- Construction of storage facilities requires large investment.

As for ocean-going vessels:

for loading
- This type of facility is the simplest.
- Construction cost is the cheapest.

for unloading
- Construction cost is cheap.
- Operation and maintenance are easy.

(4) Candidate Sites for Transfer Stations

Transfer stations become a necessity when haul distances to disposal sites or intermediate treatment plants increase to the point that direct hauling is no longer economically feasible. They also become a necessity when disposal sites or intermediate treatment plants are in remote locations and cannot be reached directly by highway.

The necessary conditions to determine the locations of transfer stations are as follows:

- Proximity to the center of the collection area;
- Easy access to a main road;
- Minimum opposition by the public and minimum environmental impact;
- Low costs for construction and operation.

The following candidate sites were selected, taking the above into consideration.

- MPPP: Jelutong Mole Transfer Station (MJTS)
  Fee Trade Zone Transfer Station (FTZTS)
  Balik Pulau Transfer Station (BPTS)
- MPSP: Mak Mandin Transfer Station (MMTS)

(5) Locations of Candidate Sites

Fig. 9.1-4 shows the locations of the candidate sites for final disposal and transfer stations.

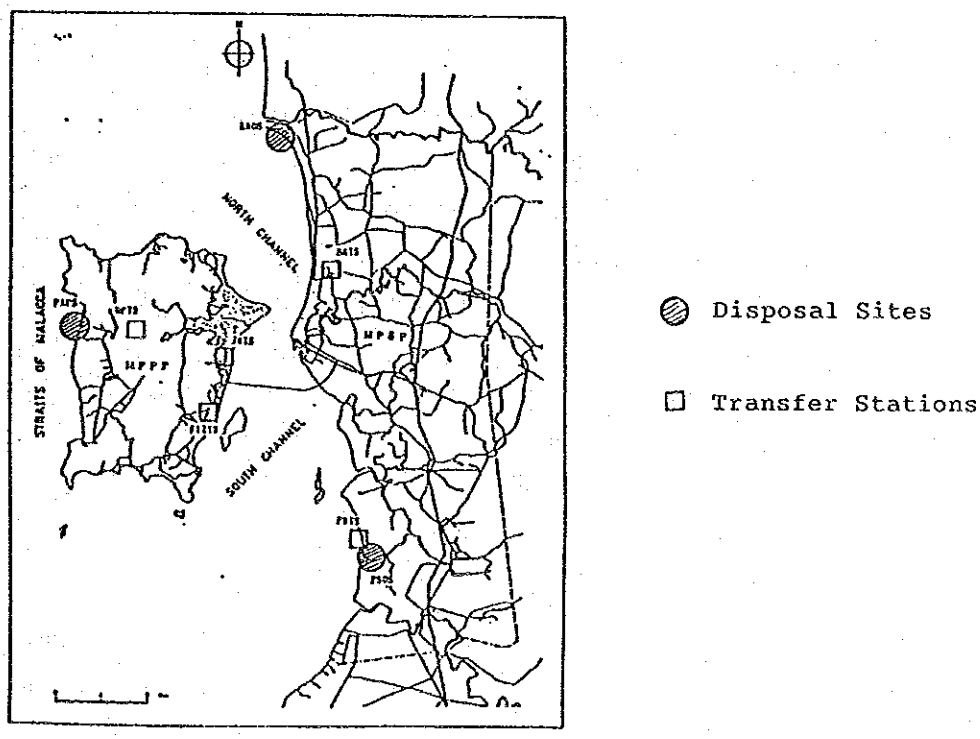


Fig. 9.1-4 Locations of Candidate Sites for Final Disposal and Transfer Stations

(6) Basic Design of Each Transfer Station

For the alternative study, transfer stations for motor vehicles (i.e. JMTS, BPTS and MMTS) and for ocean-going vessels (i.e. FTZTS) are designed. The details of them are described in the Supplementary Report Volume I 6.4 Transfer Station. Secondary transportation systems from each incineration plant are also available in the Supplementary Report Volume I 6.5.4.

Outlines of facilities to be required for each transfer station are as follows:

i. Direct re-loading type for motor vehicles (for BPTS)

- Approach road
- Site office
- Secondary transport equipment

ii. Direct re-loading type for ocean-going vessels (for FTZTS)

- Loading facilities (dock, platform, etc.)
- Unloading facilities (dock, crane, etc.)
- Boats (barge, etc.)
- Tertiary transport equipment

iii. Indirect re-loading type (for JMTS and MMTS)

- Mechanical and electrical facilities (compaction equipment, hopper, loader, etc.)
- Office
- Secondary transportation

9.1.5 Intermediate Treatment

(1) Selection of Possible Methods

The possibility of introducing appropriate intermediate treatment facilities must be examined in view of the facts that the acquisition of new disposal sites is becoming increasingly difficult and that better environmental conservation measures should be introduced.

a. Selection Criteria for Intermediate Treatment Facilities

The following criteria are considered in the selection of possible intermediate treatment facilities.

i) The facility should be capable of reducing the solid waste volume for final disposal, thereby contributing to extend the life of disposal sites.

ii) The facility should assist the recycling of resources.

iii) The facility should contribute to the improvement of environmental conditions.

b. Evaluation of Possible Intermediate Treatment Facilities

The following seven methods are considered to meet the criteria given in a. above and can be employed independently or jointly:

- composting;
- RDF;
- pyrolysis gassification;
- slagging pyrolysis;
- incineration;
- crushing and shredding;
- mechanical or manual sorting.

These methods have their own advantages and disadvantages vis-a-vis such local characteristics as the solid waste volume, solid waste quality, marketability of recycled items and difficulty in securing disposal sites, etc. (refer to the Supplementary Report Volume I 6.5.1)

Table 9.1-10 gives the results of the examination of possible intermediate treatment methods, taking the above points into consideration.

Table 9.1-10 Examination of Intermediate Treatment Methods

Intermediate Treatment Facilities	Recovered Material	Main Target of System	Contribution to Landfill			Special Cautions								Remarks
			Volume Reduction	Harmless	Stabilization	Stability of Technology	Pre-treatment	Back-end treatment	Rejected Substances	Acceptability of Refuse Qualit	Initial & Operation Cost	Marketability of Recovered Material	Environmental Impact	
① Composting Plant	Compost	Conversion to Fertilizer	△	△	△	Good ◎	Necessary △	Necessary △	Glass, Stone, Plastic, Dry Cell	Limited △	△	△	Odor △	・Stability of Market of Products
② R D F Plant	Solid Fuel	Conversion to Fuel	△	△	△	Fair △	Do △	Do △	Incombustible	Limited △	△	?	Noise & Dust △	・Marketability of Products
③ Pyrolysis Gasification Plant	Gas or Oil		○	○	○	Poor △	Do △	Do △	Incombustible, Carbon	Do △	Much ×	×	○	・Incompletion of Technology ・Initial/Running Cost
④ Slagging Pyrolysis Plant	Gas or oil	Volume Reduction & Prevention of Water Polution	◎	◎	○	Difficult to operate △	If Necessary △	Not Necessary ○	—	Fair ○	Additinal fuel Expense ×	?	○	・Large consumption of Supplemental Fuel ・Difficulty of Operation
⑤ Incineration Plant (Residue) ---> Ash (cover soil) ---> Ferrous (Reuse)	Heat	Volume Reduction & Energy Conversion	○	○	○	Excellent ◎	Not Necessary ○	Not Necessary ○	—	wide ◎	Much Expenditure, but Revenue will be expected △	Electricity or Energy Heat (Possibility) △	○	・Initial/Running cost ・Possibility to get Revenue ・Possibility to find User of Heat
⑥ Crusher Plant	Ferrous etc	Volume Reduction	△	△	○	Good ○	Extraction of Explosive Object △	—	Discarded Material	Limited △	—	△	Noise & Dust △	・Large Consumption of Electricity ・Much Expense for Maintenance ・Possibility of Explosion
⑦ Sorting Plant (Mechanical or Manual Sorting)	Ferrous, Glass Paper, Plastic etc.	Recycling	△	△	△	Good ◎	If Necessary △	Necessary △	Discarded Material	Limited △	△	○	○	・Stability of Market for Salvaged Material

◎ : Excellent
○ : Good
△ : Fair or ( ) to be considered
× : Poor and ( ) shows reason

Based on the examination results given in Table 9.1-10, the incineration and composting methods were selected for inclusion in the alternative study. The excluded methods and the reasons for their exclusion are as follows.

- RDF : restricted by solid waste quality and technical immaturity
- Pyrolysis Gassification : restricted by solid waste quality technical immaturity and operation difficulty
- Slagging Pyrolysis : technical immaturity and operation difficulty
- Crushing and Shredding : limitations on subject waste
- Mechanical or Manual Sorting: limitations on subject waste

With regard to composting, the marketability of compost was examined taking the main agricultural products, farming land and total fertilizer demand in Penang State into consideration, as well as the effects of compost use, etc.

In addition, the comparative cost of composting (production, transportation and application costs), the actual composition of solid waste and the question of possible contamination due to heavy metals were examined in detail and examples of neighbouring countries were studied. Details of the study are available in the Supplementary Report Volume I 6.5.3 Compost Market Study.

According to the detailed examination, the following problems were identified in regard to the composting of solid waste in Penang State.

i. The market size for compost is limited due to the wide use of various types of organic fertilizer such as chicken and cow dung.

ii. The production and transportation costs for composting are very high while the actual application of compost involves heavy labour.

iii. The composting of solid waste is not very effective in reducing the solid waste volume and weight.

iv. Raising livestock, which provides organic fertilizer, is expanding.

Composting was dropped from consideration in view of these problems, leaving only incineration.

While the incineration method involves a large initial cost, it has the following advantages:

- suitable for various solid waste qualities;
- conspicuous reduction of solid waste volume and weight;
- possible income through heat recovery;
- good effect on environmental conservation for disposal.

(2) Basic Design of Incineration Plant

A basic design of incineration plant was carried out and the following items were designed. Details of the design are described in the Supplementary Report Volume I 6.5.4 Preliminary Design of Incineration Plant.

- plant size and design waste quality
- operating conditions and incinerator type
- waste heat utilization methods
- pollution control measures
- operation system
- secondary transportation plan for incineration ash

In regard to heat recovery, a waste heat boiler is introduced in the exhaust gas cooling process so that the generated steam could be supplied to a turbine generator to generate power, the sale of which was intended to cover the maintenance and repair costs of the plant.

Outlines of facilities to be required for incineration plant are as follows,

- Reception facilities (weighbridge, pit, crane, etc.)
- Combustion facilities (furnace, etc.)
- Draft equipment
- Heat recovery facilities (waste heat boiler, generator, steam condenser, etc.)
- Pollution control facilities (dust collector, HCl-gas removal, waste water treatment, etc.)
- Building
- Accessories (electrical switch gear, instrument and automatic controllers, etc.)

Outlines of facilities, equipment and manpower for each incineration plant are summarized in the section 9.2.3.

(3) Study on the Introduction of an Incineration Plant

The amount of municipal waste has increased remarkably with the increase in population and the rise of living standards. The State of Penang is one example where the industrial development and the elevation of living standard are significant. On the other hand, acquisition of suitable land for final disposal has become more and more difficult. The present situation shows that the time has come for the Penang State to start considering the introduction of an incineration system for her future SWM.

In order to assist the introduction of a proper incineration system for future SWM in the Penang State, a study on the introduction of an *incineration plant is carried out and reported in the Supplementary Report* Volume I section 6.5.5 and 6.5.6. The study includes the following aspects,

- Purpose, merits and acceptability of incineration system
- Current situation of incineration system in advanced and developing countries
- Incineration system in Malaysia (present situation and issues)
- Approach towards introduction of incineration plant in Penang State (waste quality and desirable system)
- Economic Evaluation Result (sensitivity analysis)
- Privatization of Incineration Plant (example of privatization and issues)
- Proposals in consolidating the introduction of incineration plant (stage plan and consideration for the introduction)

9.1.6 Final Disposal

(1) Possible System Alternatives

Upon consideration of the possible system alternatives of final disposal, the following aspects are to be considered;

- Final disposal methods
- Landfill structure
- Recovery of methane gas
- Level of sanitary landfill development and operation

(2) Final Disposal Methods

There are several final disposal methods as listed below:

- open dumping;
- controlled tipping;
- sanitary landfill.

Although the open dumping and controlled tipping methods are generally employed in Malaysia, the use of these methods should not be tolerated in the future in view of their adverse effects on the landscape, public health and environment.

Therefore, it was decided that the sanitary landfill method should be adopted as the final disposal method for the Master Plan.

(3) Landfill Structure

There are five types of landfill structure, as follows:

- anaerobic landfill;
- anaerobic sanitary landfill;
- improved anaerobic sanitary landfill;
- semi-aerobic sanitary landfill;
- aerobic sanitary landfill.

The contribution to the mitigation of environmental pollution is improved in accordance with the above list. Fig. 9.1-5 shows the structure of each landfill type.

a. Anaerobic Landfill

As the leachate generated in the landfill layers is hardly drained, the landfill layers constantly maintain anaerobic conditions. The quality of the leachate is very poor, causing bad odour and the propagation of vector and vermin.

b. Anaerobic Sanitary Landfill

Covering soil is applied on each layer of waste. This covering soil contains the bad odour, incidental fires and the propagation of harmful insects to a certain extent. However the problems of leachate and gas generation remain. As in the case of anaerobic landfill, the disposed solid waste maintains anaerobic conditions.

c. Improved Anaerobic Sanitary Landfill

In addition to covering soil, a drainage facility for the leachate is introduced at the bottom of the disposal site. The quality of the leachate is accordingly improved, although the anaerobic conditions are still maintained.

d. Semi-Aerobic Sanitary Landfill

As the leachate is constantly drained by drainage pipes, the quality of the leachate is fairly improved. These drainage pipes stimulate natural ventilation, achieving aerobic conditions in the landfill layers. As a result, the decomposition of the solid waste is accelerated.

e. Aerobic Sanitary Landfill

In addition to the drainage pipes used in semi-aerobic landfill, air supply pipes are introduced for forced air injection to achieve aerobic conditions in the layers, accelerating the decomposition and stabilization of the solid waste and improving the leachate quality.

Landfill sites in Penang State currently employ either the anaerobic or anaerobic sanitary landfill structures.

In view of the above advantages and disadvantages of the landfill structure types, it is planned that final disposal sites in the master plan will employ the semi-aerobic sanitary landfill structure with leachate drainage pipes. However, this method will be dropped in cases where the site is located in a water area (i.e. sea reclamation by solid waste disposal) where semi-aerobic sanitary landfill is difficult.

(4) Recovery of Methane Gas

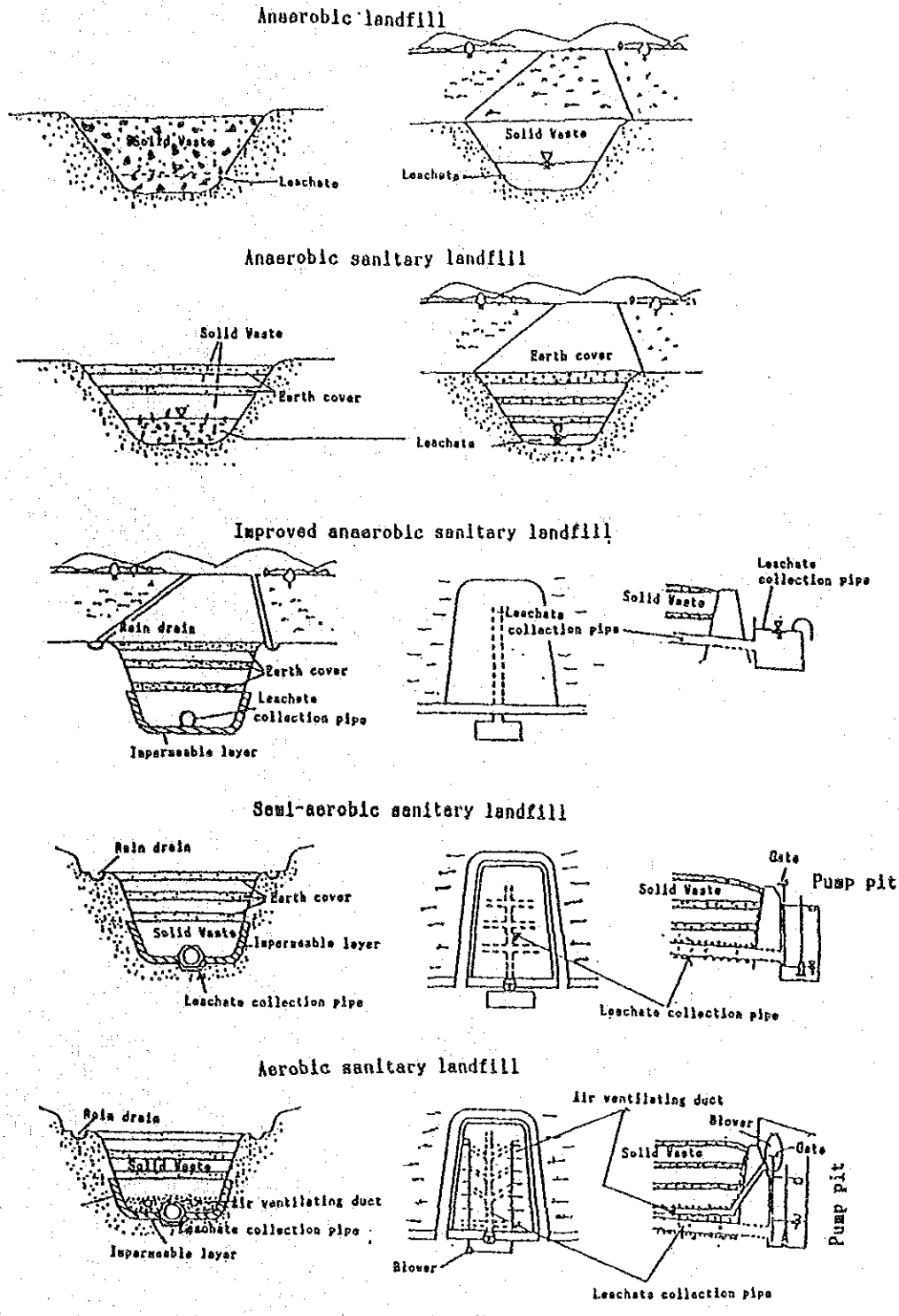
The recovery of methane gas will not be considered in the alternative study in view of low methane prices and low demand in areas around the planned disposal sites.

(5) Level of Sanitary Landfill Development and Operation

The level of sanitary landfill development and operation can be classified into the following four levels.

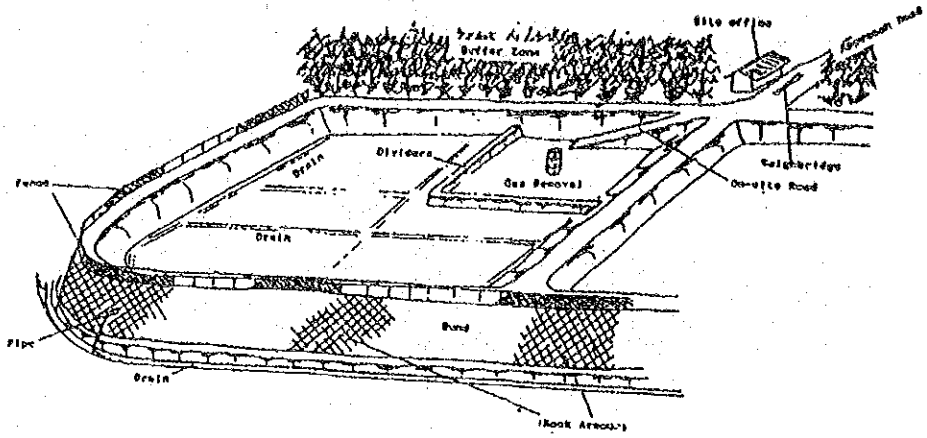
a. Level 1 Controlled tipping
b. Level 2 Sanitary landfill with a bund and daily soil covering
c. Level 3 Sanitary landfill with leachate circulation
d. Level 4 Sanitary landfill with leachate treatment

The details of above mentioned level of sanitary landfill development and operation are described in the Supplementary Report Volume II and III section 1.2. The prospective levels of sanitary landfill development and operation are illustrated in Fig. 9.1-6.

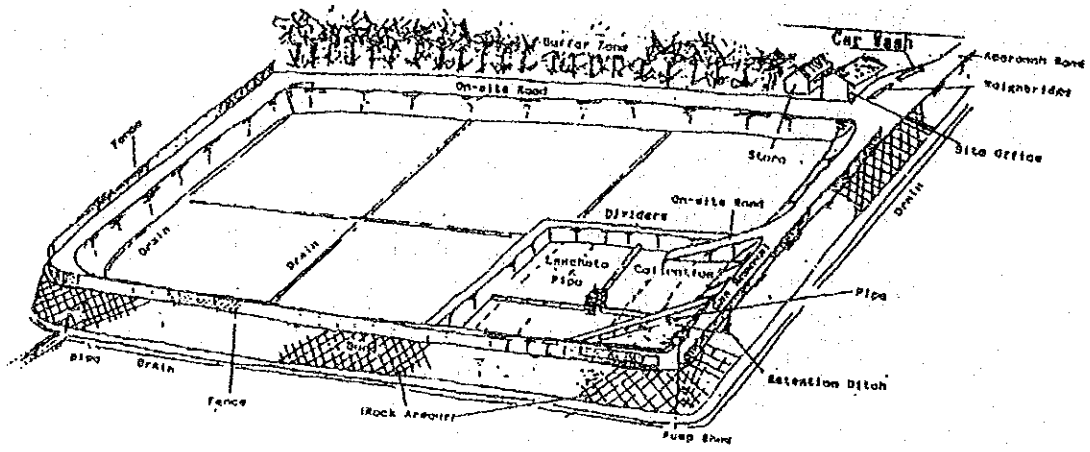


Source; Japan-United States Governmental
Conference on Solid Waste Management,
Oct.1976 by Dr.Masataka Hanashima

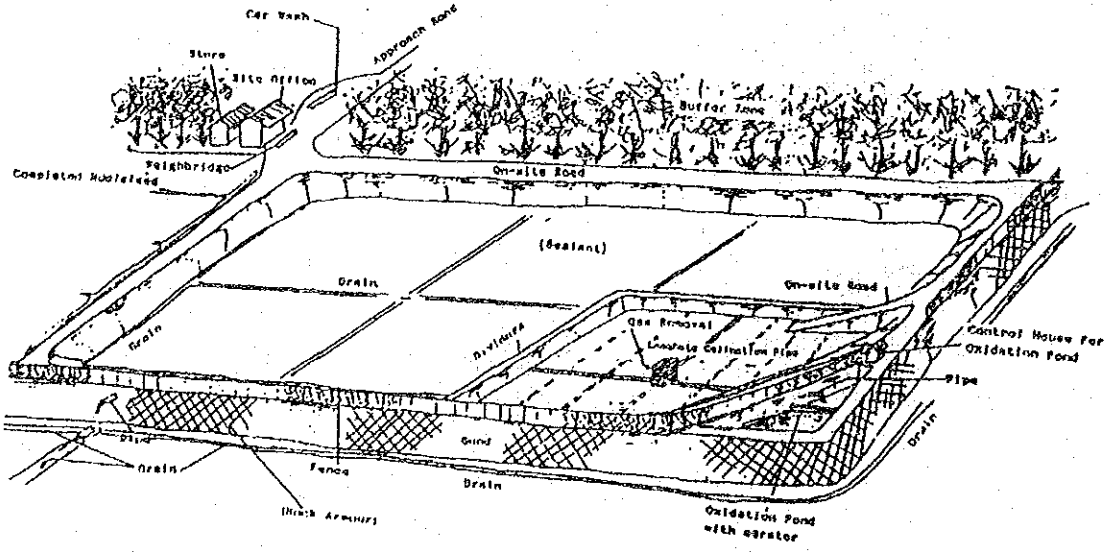
Fig. 9.1-5 Landfill Structures



Level 2



Level 3



Level 4

Fig. 9.1-6 Prospective Illustration of Sanitary Landfill Development and Operation in Level 2, 3 and 4

a. Level 1; Controlled tipping (present level)

- Establishment of access to site
- Soil covering in order to prevent fire and to lessen blown waste and bad odor
- Introduction of inspection, control and operational recording system of incoming waste.

b. Level 2; Sanitary landfill with a bund and daily soil covering

- Establishment of site boundary in order to distinguish the disposal site and to eliminate scavenging
- Execution of sufficient cover over waste disposed
- Establishment of disposal site by the construction of enclosing bund
- Introduction of divider between present landfill area and future landfill area
- Establishment of drainage system in order to divert stormwater and seepage from surrounding area and to reduce leachate
- Introduction of environmental protection facilities in order to lessen direct impact on surroundings such as buffer zone, litter control and gas removal facilities.
- Introduction of semi-aerobic sanitary landfill by the installation of gas removal facilities
- Introduction of amenities for the staff.

c. Level 3; Sanitary landfill with leachate circulation

- Establishment of leachate control by the installation of leachate collection, circulation and monitoring facilities
- Establishment of semi-aerobic sanitary landfill in order to facilitate the stabilization of waste disposed through the active decomposition in semi-aerobic condition
- Establishment of dust prevention system by introducing water sprinkling.

d. Level 4; Sanitary landfill with leachate treatment

- Establishment of leachate treatment by the installation of oxidation pond
- Establishment of seepage control by the sealant (liner)

In order to satisfy the following standards and guideline, the sanitary landfill level for the alternative study is set up at the level 4.

i. DOE Standards

- Recommended Code of Practise for the Disposal of Solid Waste on Land
- Environmental Quality (Sewage and Industrial Effluents) Regulations 1979, Regulation 8 Standard-B

ii. A guideline on the Storage, Collection, Transport and Disposal of Solid Waste in Malaysia, Technical Unit of Local Government Division, Ministry of Housing and Local Government.

iii. Other aspects

- Social acceptability on noise, littering, landscape, odor, etc.
- Eco-system acceptability
- Operational acceptability

(6) Design Conditions

The major design conditions are as follows:

a. subject solid waste and unit weight of waste disposed

- municipal solid waste; 0.8 t/m^3
- incineration ash ; 1.2 t/m^3

b. required volume of covering soil; 30% of the disposed waste volume

c. landfill height;

The embankment height is set at 5 m. If this height is found to be insufficient, additional embanking of 5 m in height will be conducted. The landfill area for the upper section will be 90% of the lower section.

The preliminary design of the disposal sites was completed. Details are described in the Supplementary Report Volume I section 6.6.

(7) Outline of Facilities

Outlines of facilities to be required for each final disposal sites are as follow;

- Main facilities (enclosing bund, drain, access road, etc.)
- Environmental protection facilities (buffer zone, seepage control, leachate collection, oxidation pond, etc.)
- Building and accessories (site office, weigh bridge, etc.)
- Equipment (bulldozer, water sprinkler truck, etc.)

Outlines of facilities, equipment and manpower for each disposal site are summarized in the section 9.2.3.

9.2 System Alternatives

9.2.1 Basic Policy

Like any other services of a public nature, solid waste management service is only viable when the necessary technical systems, ranging from the storage system at sources of generation to the final disposal system, and appropriate organizational and financial operation systems are properly provided as examined in 10 and 11. Chief characteristic of solid waste management is that the subject waste is constantly changing in terms of both quality and quantity according to socioeconomic development. In addition, an attention should be paid to the fact that the construction method as well as system management are subject to constraints imposed by local, natural and socioeconomic conditions.

In view of the above, it was decided that the present Study would first evaluate the 8 alternative plans to examine the possibility of implementing inter-municipal solid waste management for MPPP and MPSP, considering the geographical and socioeconomic conditions of both the municipalities. The flow of solid waste between these facilities is indicated in Fig. 9.2-1.

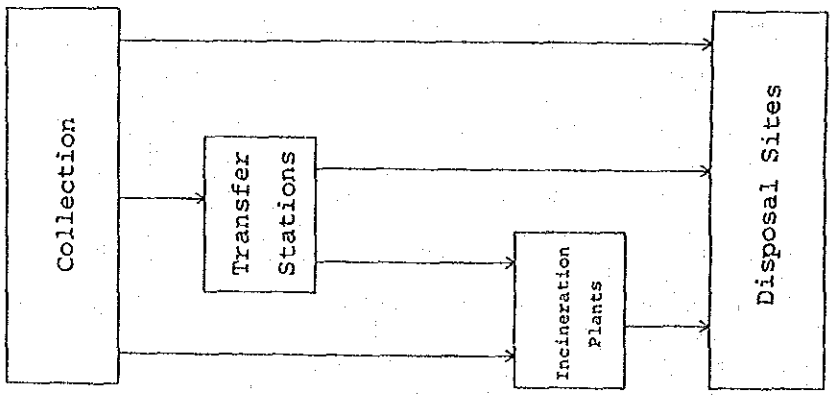


Fig. 9.2-1 Flow of Solid Waste Between Related Facilities