Table 6.5-8 Average Waste Composition (Penang State)

Type of Sample		Wet			Dry		
Type of Waste		Domestic	Commercial	Average	Domestic	Commercial	Average
Apparent Specific Gravity		0.18	0.19	0.19	—	—	—
CLASSIFICATION %	Paper	25.4	30.3	27.8	25.7	30.2	28.0
	Textile	4.2	2.6	3.4	5.4	3.1	4.3
	Plastic	11.3	9.2	10.2	13.4	12.1	12.7
	Rubber, Leather	1.5	0.5	1.0	4.4	0.6	2.5
	Wood, Bamboo	13.3	11.1	12.2	11.7	8.4	10.0
	Garbage	28.2	29.0	28.6	21.1	25.5	23.3
	Metal	3.5	2.9	3.2	5.1	5.9	5.5
	Glass	2.9	2.9	2.9	4.9	4.6	4.7
	Stone, Ceramic	0.5	1.6	1.1	0.4	3.3	1.9
	Others	9.2	9.9	9.6	7.9	6.3	7.1
	Total	100.0	100.0	100.0	100.0	100.0	100.0
Moisture (%)		50.4	51.8	51.1	—	—	—

Table 6.5-9 Chemical Analysis and Carbon : Nitrogen Content of Penang Solid Waste.

Constituent	Dry Solid Point	Carbon		Hydrogen		Oxygen		Nitrogen		Sulphur		Ash	
		%	Points	%	Points	%	Points	%	Points	%	Points	%	Points
Food Waste	23.3	48.0	11.2	6.4	1.5	37.6	8.8	2.6	0.6	0.4	0.1	5.0	1.2
Paper	28.0	43.5	12.2	6.0	1.7	44.0	12.3	0.3	0.0	0.2	0.0	6.0	1.7
Plastic	12.7	60.0	7.6	7.2	0.9	22.8	2.9	1.0	0.1	—	—	4.5	0.6
Textiles	4.3	55.0	2.4	6.6	0.3	31.2	1.3	4.6	0.2	0.15	0.0	10.0	0.4
Rubber	2.5	78.0	2.0	10.0	0.3	—	—	2.0	0.1	—	—	2.5	0.1
Wood	10.0	49.5	5.0	6.0	0.6	42.7	4.3	0.2	0.0	0.1	0.0	1.5	0.2
Glass, Stone, etc.	19.2	13.0	2.5	0.1	0.0	1.0	0.2	0.2	0.0	0.1	0.0	85.6	16.4
Totals :	100		42.9		5.3		29.8		1.0		0.1		20.6

Carbon : Nitrogen Ratio = 43 : 1

Note : Element percentages taken from "Solid Waste" by George Tchobanoglous (Table 4-8)

Table 6.5-10 Forecast of Future Physical Average Composition of Penang Solid Waste

Physical composition (wt% on wet basis)	Year 1990	1995	2000	2005
1. Combustibles	87.6	87.7	87.4	87.4
Paper	29.4	30.8	32.2	33.7
Textile	3.2	3.2	3.2	3.2
Garbage	30.9	29.4	27.7	26.2
Wood	11.5	11.1	10.5	9.9
Plastics	11.8	12.4	13.0	13.6
Rubber & Leather	0.8	0.8	0.8	0.8
2. Incombustibles	5.2	5.9	6.7	7.3
Metals	3.3	3.7	4.2	4.6
Glass	1.3	1.5	1.7	1.8
Stones, ceramics	0.6	0.7	0.8	0.9
3. Miscellaneous	7.2	6.4	5.9	5.3
4. Total	100.0	100.0	100.0	100.0
Moisture content (wt%)	53.9	53.2	52.5	51.8
Bulk density	0.18	0.17	0.17	0.17

Estimated by the Study Team.

Table 6.5-11 Forecast of Physical Composition of Solid Waste (Bangkok)

Physical composition (wt% on wet basis)	Year		
	1990	1995	2000
1. Combustibles	84.1	84.0	83.9
Paper	20.8	21.5	22.1
Textile	4.2	4.3	4.4
Garbage	28.3	28.0	27.6
Grass and wood	20.7	19.9	19.4
Plastics	8.7	9.0	9.2
Rubber & Leather	1.4	1.3	1.2
2. Incombustibles	9.9	10.0	10.0
Ferrous metal	2.1	2.1	2.2
Non-ferrous metal	0.1	0.1	0.1
Glass	2.5	2.6	2.6
Stones, ceramics	2.1	2.1	2.0
Bones, Shells & Crusts	3.0	3.0	3.0
Dry cells	0.1	0.1	0.1
3. Miscellaneous	6.0	6.0	6.1
4. Total	100.0	100.0	100.0
Moisture content (wt%)	56.0	55.7	55.4
Bulk density (in reception pit)	0.28	0.28	0.28

Source : Bangkok Solid Waste Management Study.

(6) Composting Experience in Other Countries

a. Cost of production

The total estimated amount of garbage collected in the state of Penang is estimated about 550 tons per day in 1987. Supposing if all these wastes were to be brought in for composting treatment, it is estimated that about 165 tons of compost could be produced daily (based on 30% of incoming garbage being treated and converted to compost).

Based on the Thailand and Eygpt experience, the cost of production (including depreciation of compost plant) is $140/ton and $128/ton respectively. Due to the many similarities of the solid waste (refer to Tables 6.5-10 and 11), environmental and geographical parameters exhibited, it is predicted similar compost may be derived and that the cost of production of compost in Penang State would be about $140/ton, i.e. typical as those in Thailand.

Although at the qualities of compost may be similar, these qualities in terms of N-P-K values from Thailand compost shall not be expected to exceed those composed in barnyard manure consumed locally. Refer to Table 6.5-12.

Table 6.5-12 Comparison of Nutrient Contents in Composts

	Municipal Compost			Nanure Compost		
	%N	$\%P_2O_5$	$\%K_2O$	%N	$\%P_2O_5$	$\%K_2O$
Japan *	1.57	6.46	3.09	3.64	6.7	2.99
Thailand **	0.9	1.04	1.06	1.0	1.8	0.8
Penang ***	NA	NA	NA	2.1	1.6	1.0

* Source : * Tokyo (Ebara Corporation)

** Bangkok Solid Waste Management Study

*** State Agriculture Department

b. Sale price of compost

In many countries such as India, Egypt, Japan, Thailand and others, the sale price of compost are subsidized by their authorities. For comparison studies, Thailand is taken as the example because of its close regional similarities to the study area.

The cost of manufacturing compost in bulk form in Thailand is about M$140-00 per ton (including cost of depreciation of compost plant). While the price of locally produced manure is about $48-00/ton at source in Penang State, the compost price must be subsidized in order to sustain a market equivalent to those captured by the barnyard manure. Currently, the Bangkok Metropolitan Authority has already borne 60 percent ofthe total production cost of compost. Hence, to ensure that compost has a conpetitive price, it is also necessary for the local authorities to subsidize compost sale price. At the rate of 66% subsidy ($92/ton), the sale price of compost would be about $48/ton, making it competitive in price compared to manure.

Past experience in Thailand has shown that sales price of BMA compost in bulk is from $45 to $93 per ton, and in 50 kg package from $88 to $138 per ton. This has made the cost of compost non competitive and purchase sharing in a total agricultural management cost extremely high. When the price of compost is remained at this price, it is difficult to expand demand for compost in the future. This will also discouraged many general farmers (who dominantly exist in Penang State) from using it on a profitable scale, as experienced in Thailand.

c. Subsidy for composting

In consideration of composting with direct disposal of solid waste, it is found that the operation of composting is significantly higher than direct haulage.

In case of direct disposal of solid waste, $11-00/ton of the cost in Kuantan which is one of the highest in Malaysia is applied to this study. In other words, to disposed 550 tons of waste daily from the study area, the local government would spend about $6,050 per day ($11-00/ton ×550t/day). This is considered as the benefit of composting.

If the cost of production of compost is $140-00 per ton and the sale price of the organic compost from manure is about $48 per ton, the authorities concerned have to subsidize $92/ton of compost in order to make it competitive in price with other organic compost from manure. In addition to this, composting would have about 40% of its "contraries" as residue from treatment which must be disposed to the disposal site. This disposal costs of residue is also incurred by the authorities.

Thus, the estimated cost of subsidy is :-

Items	Calculation	Cost/day
Subsidy for sale	$92/ton × 165 ton/day	$15,180
Disposal cost of residue	550 ton/day × 0.4 × $11/ton	$ 2,420
Disposal cost of 550 ton of wastes	$11/ton × 550 ton/day	- $ 6,050
Subsidy for composting		$11,550

Compared to cost involved in direct disposal, the authorities would have to spend an extra of $11,550 per day (i.e. $4.2 million per year). This cost should be compared in other terms such as cost-benefit of land acquisition which may or may not justify its necessity. Otherwise, this cost may only prove to be a burden to the local authorities.

d. Concept of restriction of hazardous substance contained in compost

The solid waste compost has problem of hazardous substance contained in the solid waste, being different from compost made from the remains of plants and animals. Therefore, it is absolutely necessary to thoroughly examine and prove the safety and effect from use of these fertilizers from both viewpoints of immediate influence to growth of crops and of influences to farmland soil.

It is also important to examine whether or not the solid waste compost which contains more minor elements such as Cu and Zn, including main components such as N, P and K and also hazardous heavy metals, can produce crops having good market values as in the case of conventional compost.

Therefore, restriction of hazardous substance in solid waste compost should be determined from a view point of fertilizer science.

Adequate applying volume of fertilizer is determined based on the nitrogen contents in many cases. In the case of compost, however, it is necessary to take into consideration minor elements contained in compost. It will be difficult to place restrictions against all these heavy metals. Zn which is contained in a large volume in compost, has weak toxity on human beings. Therefore, it is not necessary to be too nervous about its absorption in plants.

On the contrary, Pb and Cr show the toxity on human beings but do not appear as harm on plants because a small volume of these metals is absorbed in plants.
Cd and Hg have strong toxity on human beings. Therefore, it is absolutely necessary to pay serious attention to absorption of these metals in plants.

The waste composition in Thailand is compared to those in Penang. There are possibilities that similar type of compost can be deduced from the waste generated in the state of Penang. The maximum permissible compost application volume stated in the solid waste management study for Bangkok (to omit the negative influence from heavy metals, based on British Standards) in Thailand is less than 5 ton/ha per year for mercury hazards and less than 8 ton/ha per year for cadmium hazards, expanded over 30 years of continuous applications.

The average normal rate of application of compost in the state of Penang, which had been equated to rate of application of manure is 4.25t/ha/month (51t/ha/yr). Compared to those in Thailand, this rate is considerably higher. This means that under the normal rate of continuous application of compost, occurence of detrimental influence of heavy metals are possibly higher than Thailand.

Each country places different restrictions on concentration of these heavy metals. The concept of restrictions against total volume of heavy metals has already been adopted in Great Britain and USA from a standpoint of soil protection.

Thus, the continuous use of compost for long periods of application differs from common inorganic fertilizer and is less practicable, in addition to the heavy metal influence that it may pose. Therefore, to avoid such risks, rate of application of compost may have to be restricted to an acceptable level as realized in other countries in the world. Restrictions on usage, however, may not be appreciated by the farmers and this may divert their interest to other competitive fertilizer that has no complications.

e. Existence of Other Competitive Organic Fertilizer

The prevailing supply of organic and chemical fertilizers is adequate to satisfy demands from the agriculture sector. With increasing activities of livestock and poultry breeding in the state of Penang, coupled with the long history of utilization, it is possible that the organic fertilizers derived from manure would be very much prefered than the newly introduced compost in the future. The limited market open to these organic fertilizers, is likely to cause price of manure to decline further as supply increases in future, thus making it hard for the higher priced compost to secure a stable demand. On top of this, the usage of existing organic fertilizer on agricultural fields is helping to minimise the total amount of agricultural waste for disposal. If composting is introduced then, ways of disposing some of the manure must be considered to avoid any nuisance and pollution that it may cause.

Another factor to be considered is the diminishing cultivation of lands in terms of agricultural crops in the region. There are significant growth in the poultry and livestock husbandry. However except for the large scale plantations, ploughed fields have significantly decreased in terms of area and this is justified with the increase in idle land in the region as reported in the Structurel Plan Survey Report. There are little indications that this portion of agriculture sector would significantly improve in the near future, thus implying that the realistic demand and market for compost in the same future may be smaller if not at the same level now.

The composting study in Thailand has indicated that only 17% of vegetable farmers actually utilized compost from garbage (BMA compost). The study has also shown that there has been an equal shift of users of compost to other kinds of organic fertilizers, and vice-versa, which simply indicates that there has been no definite interest in compost. A similar outcome can also be expected of the compost demand for Penang. Thus, the actual compost utilization is far smaller in quantity than the estimated amount as mentioned in (4) of this section, due the existence of other market forces that share equivalent influence in the agriculture sector.

(7) Other Studies on Composting

a. Transportation cost

To determine the sale price of compost and its transportation cost, information on cost of barnyard manure and its transportation rates were gathered as follows :-

i. Unit weight of barnyard manure (Chicken dung)		: 0.5 t/m^3
ii. Unit weight of compost		: 0.4 t/m^3
iii. Price of barnyard manure at source		: $ 48/ton
iv. Transportation cost of $5m^3$ lorry	Up to 10km	: $ 15/lorry ($3/$m^3$)
	Up to 50km	: $ 75/lorry ($15/$m^3$)
	Up to 100km	: $ 150/lorry ($30/$m^3$)

Using these information, sale price of solid waste compost according to transported distances are calculated and tabulated in Table 6.5-13. From these calculations, the following can be deduced :-

i. An additional subsidy of $7-50/ton is required for the sale of compost if it were to be marketed up to 50km from the source of production.

ii. The subsidy required for compost if it were to be marketed up to 100km from production source is $115/ton. The significant difference compared to cost of barnyard manure is due to the easy avilability of barnyard manure at about every 50km radius in the state.

iii. The total amount of subsidy required to market compost up to 50km from source is about $4.6 million per year.

iv. If compost were to be marketed up to 100km, then the total subsidy per year to be borne by the Local Governments is $6.8 million per year.

Based on the above calculations, it would be significant to consider marketing compost up to 50km radius to minimise the burden of transport cost and put up a fairly competitive price for compost.

Table 6.5-13 Sale Price and Subsidy Required According to Transported Distance

Items	Transported Distance			
	At source	Up to 10km	Up to 50km	Up to 100km
Transportation cost per 5m³ lorry	0	$ 15-00	$ 75-00	$150-00
Transportation cost per m³	0	$ 3-00	$ 15-00	$ 30-00
Transportation cost of barngard manure per ton (0.5 ton/m³)	0	$ 6-00	$ 30-00	—
Transportation cost of solid waste compost por ton (0.4 ton/m³)	0	$ 7-50	$ 37-50	$ 75-00
Sale price of barnyard manure per ton	$ 48-00	$ 54-00	$ 78-00	$ 48-00
Sale price of solid waste compost per ton	$ 48-00	$ 55-50	$ 85-50	$123-00
Subsidy required for sale of solid waste compost per ton	※$ 70-00	$ 71-50	$ 77-50	$115-00

※ This figure is calcutated as follow ; $ 11,550/day ÷ 165 ton/day = $ 70/ton

b. Labor cost study

Similarly, the labour cost involved during sowing of compost would be higher compared to labour cost incurred in sowing of manure. Based on the rate of application of 4.25t/ha/month, for every square meter of fertilizer application, the following equivalent volumes of compost and manure would be required ;

		Remarks
Amount to be applied	4.25t/ha	
Equivalent volume of compost ($0.4t/m^3$)	$10.6m^3/ha$	25% extra volume compared to manure fertilizer volume.
Equivalent volume of manure ($0.5t/m^3$)	$8.5m^3/ha$	

This increase in costs are significant in the sale price of the produce by the anticipated compost user. Therefore, usage of compost may not be beneficial for the vegetable farmers in the region. In Penang, where mechanization in agriculture (which reduces the extensive labor incurred), has not been widely practized, it is doubtful that compost could be effective and economically be used at the present time.

(8) Conclusion

Based on the study that was carried out, composting is not recommended based on the following findings.

a. Existence of other competitive organic fertilizer

Due to prosperous livestock industry and favorable climatic conditions, other types of organic fertilizers are easily produced. These other organic fertilizers derived from animal dung are competitive and easily obtained in the region. Besides, utilization of animal dung is a form of resource recovery and disposal of these animal waste. It would help to mitigate the total amount of wastes for disposal.

b. High cost of production of municipal compost

Past experience on composting has shown that compost has high cost of production, making it less competitive in price compare to other organic fertilizers.
In most cases, subsidies on the sale price are necessary to compensate for the higher production cost in order to give compost a competitive price to compete in the fertilizer market. The subsidy may be a financial contrain to the authorities.

c. Inadequate market demand for municipal compost.

The major problem with composting as a solid waste management system is not with the technology of the process but with the lack of a sufficient market for the product, adversely affecting system economics. To absorb any substantial amount of the compost which would be produced from municipal wastes, the product would have to be used in large-scale agriculture. And more often than not, the compost would not obtain the expected or calculated demand to make it a truly marketable product.

d. High cost of transportation and labour of municipal compost.

Because of its bulky and low nutrient characteristics, utilization of compost has been limited and large-scale agriculture has never been interested in the material, finding it more economical to use easy-to-handle inorganic fertilizer.
Concentration of market is mostly found in the small scale vegetable farmlands.

e. Less volume reduction

Composting of solid waste has always has an appeal in that the process converts a waste product to something useful. In terms of a disposal method, however, only about 60% of the collected wastes (the organic or incombustible) are reduced in volume, while the other 40% would still required disposal as residue.

f. Possibilities of occurence of detrimental heavy metals accumulation in the soil and ecological system.

Since compost derived from solid wastes may contain heavy metals, considerations on the extend of utilization or application should be careful observed. Otherwise, it may be doubtful that compost may be recommendable for long term utilization in the agriculture field, especially on food crops and vegetables.

g. Diminishing cultivation of agricultural lands.

Agricultural changes in land use and activities from agriculture ploughing to non-ploughing activities, in the state of Penang, are limiting the possible markets for compost and other organic fertilizers. In view of these, compost may have even smaller portion or percentage of the total demand for organic fertilizer.

h. Increase in animal husbandry.

Increasing activities of animal husbandary would stimulate more production of organic fertilizers derived from animal dung. Being established and lower in price, these organic fertilizers would give very stiff competition to compost from solid wastes in the market.

i. Production of odor and blowing of loose materials.

In composting, it is inevitable to consider some important enviromental concerns related to production of odor and the blowing of loose materials especially in case of windrow composting which is the cheapest way of composting. Unless proper control is exerted, the production of odors can become a problem, especially in windrowing composting.

Generally, due to the many limitations and the constraints explained of compost as a marketable product, it is not recommended that composting be considered now. It would be interesting to note that so far, only about 1% of refuse has been composted in solid waste management, even in Europe.

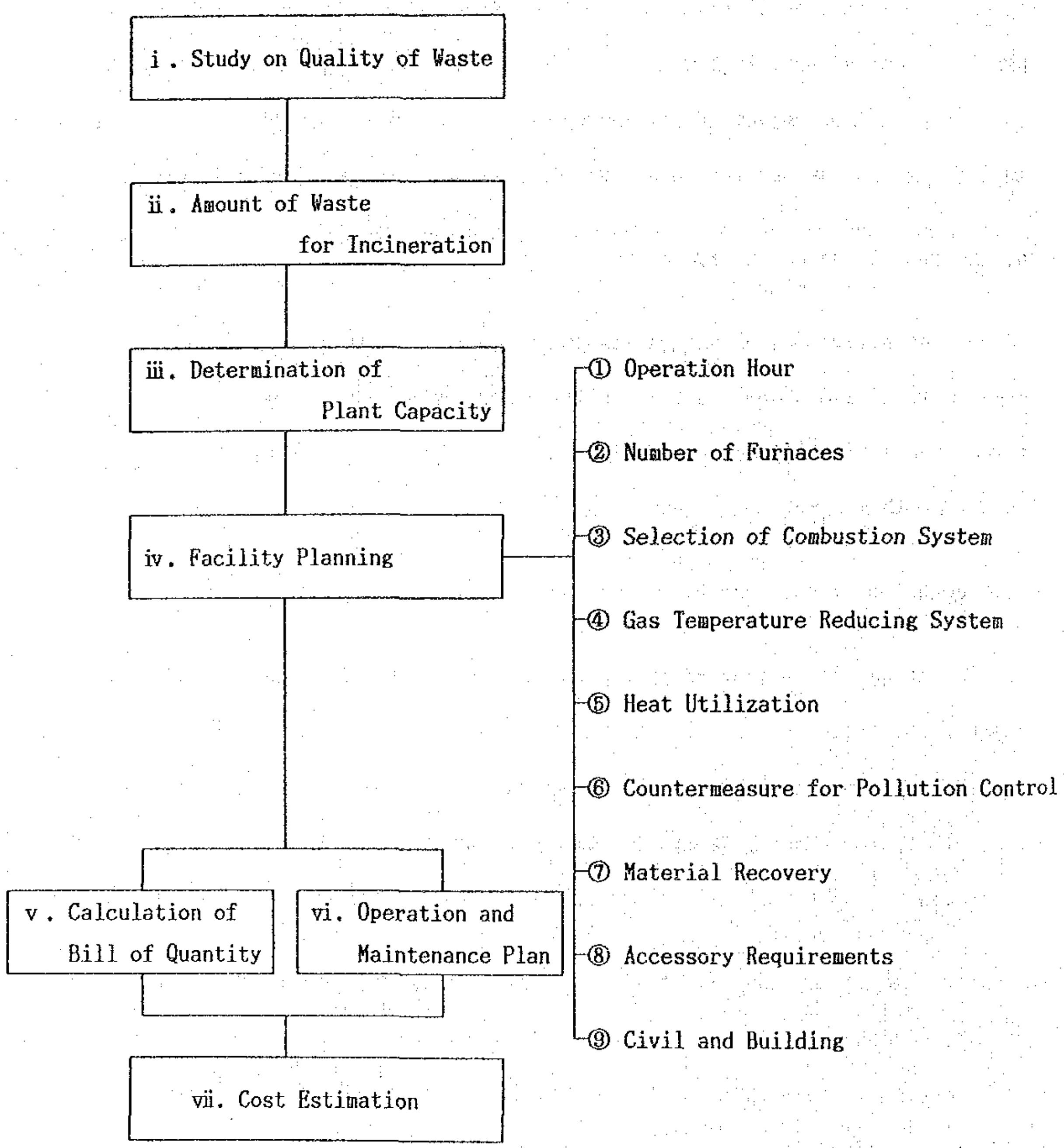
6.5.4 Preliminary Design of Incineration Plants

(1) Planning Procedure of Incineration Plant

a. Planning flow

In planning an incineration plant, it is necessary to undertake the study according to the planning flow as shown below in Fig. 6.5-4.

Fig. 6.5-4 Planning Flow of Incineration Plant



b. Considerations for planning

In the application of the above mentioned planning flow, the following items are to be considered.

i. Quality of waste

Quality of waste is an important factor in coscideration of an incinerator. Therefore, the following items must be checked carefully from the data obtained through past survey and from the estimated future quality of waste.

- Acceptability to incineration
- Pre-treatment requirements
- Annual change of calorific value
- Seasonal variation of calorific value

ii. Amount of waste for incineration

Based on the collected date, the real amount of waste that need to be incinerated must be determined. This factor is as important as studying the quality of waste mentioned above. Seasonal change in amounts may also affect the decision on plant capacity.

iii. Capacity (ability) of plant

Plant construction plan must be done according to the conditions such as availability of landfill site, financial condition, and economics point of view.

Sometimes stage extension of plant units according to the increase in quantities of waste and to the improvement in financial conditions may be advantageous.

Plant capacity should be determined after considering the seasonal variation.

iv. Facility planning

① Operation hours

There are two kinds of operation system. One is partial operation (8 to 16 hrs/day),the other is continuous operation.

The availability of plants varies according to the selected operating system. Generally, partial operation system is selected for small scale plant, but for middle or large scale plant, continuous operation system is preferred because of its higher availability in terms of workability.

Selection of full continuous operation system is suggested specially when heat recovery system is being considered.

② Number of furnace

The method to determine the number of furnace required is very important and should take into consideration of the followings.

- It must consider the decreasing plant capacity while each furnace is shut down for scheduled overhaul or unexpected plant failure.

- Especially, in the case where landfill site is located far from the collection zone, and where necessitate long distant haulage by small collection vehicles and the increase of haulage cost, the above-mentioned factor should be carefully considered.

- Furthermore allowance to the haulage system in terms of preparation of stand-by vehicles with drivers have to be considered when each furnace is shut down.

- Usually, when plant is constituted of many incinertor units, severe influence to the capacity down of plant could be avoided, but it increases total construction cost.

③ Selection of combustion system

There are two types of combustion systems of the incinerator. One is the widely used conventional Mass-Burning system and the another Pyrolysis-Combustion system which is rarely used.

Selection of these systems must be done carefully after considering the plant capacity, advantages and disadvantages of each system.

④ Gas temperature reducing system

To avoid corrosion and failure of dust collector and draft equipments, high temperature gas leaving from incinerator furnace must be cooled before entering these equipments.

For gas temperature reducing device, there are two systems available. One is water spray tower system, and the other is waste heat boiler system.

Water spray tower system can be constructed at lower cost compared to waste heat boiler system. But this system has disadvantages in that it consumes much water, and that the generated heat from combustion of waste cannot be recovered.

Therefore, except for small scale incineration plant , waste heat boiler system (that can recover heat) is most recommended for larger scale continuously operated incineration plant.

⑤ Heat utilization

In case when the waste heat boiler system is selected, recovered heat can be utilized for many purposes as shown below.

- Direct supply of steam or hot water to industries
- Electricity generation for in-plant use
- Electricity generation for sale to NEB

- Auxiliary machine drive by steam turbine, etc.

After studying eacmentioned h system above the most favorable selection should be made.

⑥ Countermeasure against pollution

In an incineration plant, among the many countermeasure against pollution, dust collector and harmful gas eliminator for anti-air pollution are most important.

Selection of each system for pollution control should satisfy the regulations gas-setted in Malaysia, with respect to simple construction, easiness of operation, in expensive running cost, etc.

⑦ Material recovery

Recovery of scrap metal contained in incinerated ash is often studied in the planning stage.

Expected revenue obtainable from sale of recovered metal is normally small.

But, this system can be evaluated from another view in terms of reduction of landfill volume and ash haulage cost.

⑧ Accessory requirements

Following the selection of system for each item described above, type and capacity of electrical equipment and instrumentation etc., to support the plant operation shall be planned.

⑨ Civil works and building

Civil works and building construction which encases incinerators, boilers and all other equipment must also be planned.

(2) Preliminary Design of Incineration Plant.

As for the altrernatives study for the Master Plan, the 3 different capacities of incinerator plants required are identified as follows.

Service Area	Candidate Site	Remarks
MPPP	Free Trade Zone	Alternative 3 & 7
MPSP	Prai Industrial Complex	Alternative 3 & 7
MPPP & MPSP	Prai Industrial Complex	Alternative 8

Study for each case are executed according to the planning procedure shown in Fig 6.5-4.

a. Quality of waste

According to the study, the quality of waste in 1987 and in 2005 are as shown in Table 6.5-14.

Physical composition of domestic and commercial waste are very similar and the moisture content is considered low, with the net calorific value of waste in 2005 estimated to be 1700 kcal/kg.

This calorific value indicates that all the waste can be burned up satisfactorily without any additional auxiliary fuel.

b. Amount of waste for incineration

i. Daily average amount of waste being hauled into the plant

Amount of waste being hauled into the plant estimated as in Table 6.5-15.

Table 6.5-14 Quality of Waste (Penang State)

Wet Base

		1987		2005	
		Domestic	Commercial	Domestic	Commercial
Paper	%	25.5	31.5	30.1	37.2
Textile	%	3.4	2.9	3.4	2.9
Plastic	%	11.2	11.8	13.2	13.9
Rubber	%	0.8	0.8	0.8	0.8
Wood	%	14.4	9.7	11.8	7.9
Carbage	%	32.8	30.9	26.9	25.4
Metal	%	2.6	3.3	4.1	5.1
Grass	%	1.4	1.0	2.1	1.5
Stone	%	0.2	1.0	0.3	1.5
Other	%	7.8	7.3	7.4	4.0
Total		100.0	100.0	100.0	100.0
Moisture	%	55.2	53.5	52.7	50.9
Organic	%	35.4	36.1	35.8	36.6
Ash	%	9.4	10.4	11.5	12.5
Nat Carolific Value (kcal/kg)		1600	1600	1700	1700
Density (t/m³)		0.193	0.170	0.176	0.155

Table 6.5-15 Waste Quantity for Alternatives

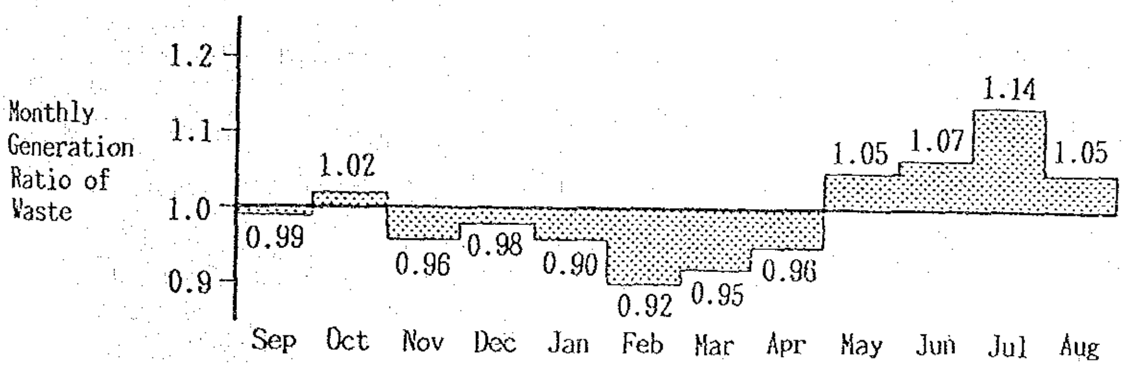
Service Area	Amount of Waste (ton s/day)			Applied Alternative
	Collected	Directly Carried -in*	Total	
MPPP	669.6	29.96	700	Alt. ③ & ⑦
MPSP	539.5	45.38	585	Alt. ③ & ⑦
MPPP & MPSP	1,209.1	75.35	1,285	Alt. ⑧

* Amount of waste directly brought into the plant means 40% of industrial waste and 20% of other waste.

ii. Seasonal Variation of Waste Amount

Seasonal variation of waste being generated (in 1987) is as shown below. Maximum and minimum generation month to the average generation month is 1.14 and 0.9 respectively.

Figure 6.5-5 Seasonal Variation of Waste Amount (1987)



c. Plant capacity

Several cases in the design of plant capacity are considered as follows.

Case-A : No landfill site for excess wastes during overhaul period is not available

a-1. One stand-by furnace will be provided so that total waste can be burned through out the year.

a-2. During the period of scheduled overhaul, another solution is to incinerate the excess amount of waste in other plants which may accept the excess waste.

Case-B : Landfill site for excess waste during overhaul period is available

b-1. To select the plant with a capacity which will meet the maximum amount of incoming waste, and any excess amount of waste is hauled to the landfill site directly during overhaul period of the furnaces.

b-2. Starting from smaller scale capacity that meets with the budget, and then increase the plant capacity gradually later in stages.

As mentioned above, there are several alternatives which may be considered. However, in this case, the purpose is limited to comparative evaluation of each alternatives which are included in the Master Plan.
Therefore, the most representative case i .c. b-1, is selected.

With reference to the amount of waste being collected and the peak month generation ratio of 1.14 times to the average, each plant capacity is decided as shown in Table 6 .5-16.

Table 6.5-16 Average Waste Quantities and Plant Capacities (2005)

	MPPP	MPSP	MPPP & MPSP
Average Daily Amount of Waste (t/d)	700	585	1,285
Amount of Waste in Peak Month (t/d)	×1.14 = 798	×1.14 = 667	×1.14 = 1,465
Plant Capacity	810	675	1,500

d. Preliminary planning of each facility

i. Operation hour

For all of these cases, the plant capacity is considered large, therefore, it is most favorable that continuous operation system is adopted.

ii. Number of furaces

Upon consideration of several factors, 3 units of incinerators for alternatives ③ and ⑦, and 5 units for alternatives ⑧ are recomended.

According to calculations, the 3 units constituent, will burn up more than 94% of the total waste with due considerations to down time due to overhaul shut down of each furnace.

In view of the life expectancy of landfill site, this figure means that effect of introduction of incineration system may be quite sufficient.

In the case of Alternative ⑧ with 5 unit constituent, approximately 98% of waste can be incinerated.

The results are shown below in Table 6.5-17.

Table 6.5-17 Number of Constituents (Furnaces) in Each Plant

Alternative	Alt. ③ & ⑦	Alt. ③ & ⑦	Alt. ⑧
Service Area	MPPP	MPSP	MPPP & MPSP
Constituent of Plant	3 Unit × 270 t/d = 810 t/d	3 Unit × 225 t/d = 675 t/d	5 Unit × 300 t/d =1500 t/d

iii. Selection of combustion system

As aforementioned, there are two types of combustion systems.

① Mass-burning system :

This system is conventional and being widely used in many municipalities in the world today.

All technologies included in this system has already been stabilized based on long history of experience.

① Pyrolysis-combution system :

This system was first invented for small scale incinerator plant. The unit capacity is generally limited up to 100 tons per day.

Because of its simple construction and cheaper cost, once this system spread widely in U.S.A. The incinerator in Malaysia located in Kuala Tregganu is constructed based on this technology.

In the case of mass-burning system, perfect combustion of organic matter is achieved in the furnace with the aid of sufficient air supplied to the furnace. But in pyrolysis-combustion, combustion takes place in two stages. First, pyrolizing and gasification of organic matter in primary combustion furnace under relatively low temperature condition, then after, secondary combustion takes place in the secondary chamber, with the aid of additional air supply.

Compared to these two systems, the disadvantages of the later system are :

- The incinerated ash in pyrolysis combustion system, contains carbonaceous substance such as charcoal remained due to starved primary air supply, as a result of low combustion efficency.

- Effect to volume reduction is lower than that of mass-burning system due to the unburned residue.

- To avoid the fluctuation in combustion temperature, additional fuel is generally required.

- In many cases, air pollution control equipment is usually omitted.

To overcome the defiencies above, selection of mass-burning system is becoming more popular, even in the U.S.A.

For the same reasons described previously, the mass-burning system is adopted in this study.

iv. Gas temperature reducing system

Because of the large scale plant capacity and for the purpose of energy recovery, the waste heat boiler system is adopted in this study as the gas temperature reducing system.

v. Heat utilization

As aforementioned, the steam which is generated from waste heat boiler is available for many purposes. But at this stage of the Master Plan, special users, amount nor type of heat supply etc., cannot be determined now.

Therefore, electricity generated by turbine generator system is adopted.

Assuming the type of steam turbine is of vacuum condensing type, then, air cooled finned tube condenser is provided.

Electricity generated in each plant, consumed for in-plant use, and the saleable amount to outside consumers are calculated as shown in Table 6.5-18.

According to NEB, the average unit price of electricity saleable to NEB is estimated as $ 0.1025/kwh. The normal rates are as follows, obtained from NEB.

- Peak hour (08:00 - 18:00) --- $ 0.14/Kwh
- Off peak hour (18:00 - 08:00) --- $ 0.05/Kwh

Table 6.5-18 Estimation on heat utilization

Service Area	MPPP	MPSP	MPPP & MPSP
Plant Capacity (t/d)	810	675	1,500
Waste Amount Collected (t/yr)	255,500	213,490	469,000
Amount Incinerated (t/yr)	240,170	200,700	459,600
Gross Heat Input (G cal/yr)	408.3×10^3	341.2×10^3	781.3×10^3
Electricity Generated (Mwh/yr)	60×10^3	50×10^3	115×10^3
Consumed in-Plant Use (Mwh/yr)	12×10^3	10×10^3	23×10^3
Electricity Saleable (Mwh/yr)	48×10^3	40×10^3	92×10^3

vi. Countermearures for pollution control

To avoid air pollution, the regulation gassetted in Malaysia states that :

- Dust emission --- below 0.4 g/Nm³ ※ (at 12% Co_2)
- HCl emission --- below 400 g/Nm³ (at 12% Co_2)

※ Nm³ ; Normal cubic meter

Dust collector :

For dust collector the electrostatic precipitator is the most appropriate selection, and dust emitted at the exit of the selected precipitator will be under 0.1 g/Nm³.

This figure is relatively lower than the regulation and it will tend to raise he cost slightly as this figure is decreased.

But since electrostatic precipitator has the ability to achieve the required figure easily and the emission from top of the stack with regards to 0.1mg/Nm³ is colorless, this figure is widely accepted and used.

HCl gas eliminator :

As for HCl gas eliminator, two types of methods are usually used, i.e. the wet scrubber system and the dry chemical injection system.

The wet scrubber usually has higher efficiency, but the disadvantages of this system are higher initial cost, difficulty in waste water treament, possibility of corrosion, higher running cost, etc.

Whereas the dry chemical (Ca $(OH)_2$ powder) injection system has advantages of, cheaper initial and running cost, simple construction, easily operation, etc.

Therefore, dry chemical injection system is selected in this study.

vii. Material recovery

To recover ferrous metals contained in the ash, magnetic separators are provided in each ash discharge line.

viii. Accessory requirements

Base on each system described above, studies on the items as shown below are done.

· Electric power station

· Instruments and automatic controllers

· Waste water treatment system

· Civil and building

e. Transportation from incineration plant

Transportation from incineration plant is studied on the following three cases stated for the alternatve study. The aims of this study is to calculate 1) the proposed number of vehicles and 2) the cost for transportation from the incineration plant.
The three cases stated for the alternative study are as follows : -

① Alternative 3: FTZIP (Free Trade Zone Incineration Plant) → PADS (Pantai Acheh Disposal Site)

② Alternative 7: FTZIP → PBDS (Plau Burong Disposal Site)

③ Alternative 3, 7 and 8: PICIP (Prai Industrial Complex Incineration Plant) → PBDS

Procedure in planning for transportation is shown in Fig. 6.5-6 below.

Fig. 6.5-6 Procedure in Planning for Secondary Transportation

i. Planning Condition of Incineration Plant

- Amount of refuse collected at incineration plant
- Type and loading capacity of vehicles

↓

ii. Number of Transportation Vehicles Proposed

- Total number of trips
- Number of trips per vehicle per day.
- Number of spare vehicles on stand-by

↓

iii. Transportation Cost

- Cost of fuel
- Toll fee at Penang Bridge

i . Basic data

The following basic data is established in order to calculate the proposed number of vehicles and the cost of transportation from the incineration plants.

① Vehicles used for transportation : Open Tipper Truck (OT)

To be used for transportation from incineration plant
(FTZIP, PICIP)

Capacity: 10m^3

Loading capacity : 6.3ton (10×0.7×0.9)
Where 0.7 is the apparent specific gravity
0.9 is the loading ratio

② Driving speed of vehicle for transportation

- Driving speed is established at 30km/hr in the case of trip through the mountains in Penang Island.

- Driving speed is established at 35km/hr in other cases than those mentioned above.

③ Working time

- Total working time in a day is established as 7 hours per day

- Loading time is established as 0.3 hours at incineration plant.

- Discharging time is established as 0.3 hours at disposal site.

④ Cost of fuel is established at M$ 0.468/liter (including cost of oil)

⑤ Distance covered per liter of fuel consumed : 2km/liter

⑥ Toll fee of Penang Bridge : M$15/trip

Information on transportation, based on above mentioned basic data, is shown in Table 6.5-19.

ii. Number of transportation vehicles required

Using the previous information, the following items are calculated.

① Total number of trips per day.

Total number of trips per day = Average amount of ash per day/Loading capacity of vehicle

② Number of trips per vehicle per day

Number of trips per vehicle per day = 7 hours /Cycle time per vehicle

Basically, the number of trips for each vehicle in a day (7 hours/day) is determined by the above quotient. However, if the remainder time (hours) after division is over 70% against time of the cycle, one more cycle is considered with regards to the over time.

③ Number of vehicles required in a day

Number of vehicles required per day = Total number of trips per day/Number of trips per vehicle per day

④ Stand-by Vehicles

Stand-by vehicles are needed for maintenance and repairing period, and also to effectively execute transportation of the ashes.

⑤ Number of vehicles proposed

Number of vehicles proposed is calculated as follows.

(Total No. of trips per day/No. of cycles per vehicle per day) + (Stand-by vehicles)

Results are shown in Tables 6.5-20.

iii. Transportation Cost

Transportation cost are calculated as follows.

Transportation Cost = (Cost of fuel) + (Toll fee of Penang Bridge)

where

(Cost of fuel) = ((Total No. of trips per day × One round-trip distance)/2 (km/liter) ×0.468 (M$/liter)

Results are shown in Table 6.5-21

Table 6.5-19 Calculation of Transportation from Incineration Plant

Items		A-3		A-7		A-8
(1)Type of waste		Ash	Ash	Ash	Ash	Ash
(2)Origin and destination		(FTZ-PA)	(Prai-PB)	(FTZ-PB)	(Prai-PB)	(Prai-PB)
(3)Average out-going amount of waste from incineration plant (ton/day)		78.9	66.0	78.9	66.0	151.1
(4)Average incoming amount of waste at incineration plant (ton/day)		657.6	549.8	657.6	549.8	1258.8
(5)Type of vehicle		OT	OT	OT	OT	OT
(6)Loading capacity (ton/vehicle)		6.3	6.3	6.3	6.3	6.3
(7)One-way distance (km)		22.0	34.5	50.5	34.5	34.5
(8)Round-trip distance(km)	(7)x2	44.0	69.0	101.0	69.0	69.0
(9)Speed(km/hr.)		30	35	35	35	35
(10)Round-trip time required (hr.)	(8)/(9)	1.47	1.97	2.89	1.97	1.97
(11)Loading time(hr.)		0.30	0.30	0.30	0.30	0.30
(12)Discharging time(hr.)		0.30	0.30	0.30	0.30	0.30
(13)Cycle time(hr.)	(10)+(11)+(12)	2.07	2.57	3.49	2.57	2.57

*CCT:Compacted Container Trailer(40x0.5=20TON)

*OCT:Open Container Trailer(40x0.2x0.9=7.2TON)

*OT:Open Tipper Truck(10x0.7x0.9=6.3TON)

Table 6.5-20 Number of vehicles proposed at incineration plant

Items		A-3		A-7		A-8
(1)Type of waste		Ash	Ash	Ash	Ash	Ash
(2)Origin and destination		(FTZ-PA)	(Prai-PB)	(FTZ-PB)	(Prai-PB)	(Prai-PB)
(3)Average out-going amount of waste from incineration plant (ton/day)		78.9	66.0	78.9	66.0	151.1
(4)Type of vehicle		OT	OT	OT	OT	OT
(5)Loading capacity (ton/vehicle)		6.3	6.3	6.3	6.3	6.3
(6)Total number of trips	(3)/(5)	13	11	13	11	24
(7)Cycle time(hr.)		2.07	2.57	3.49	2.57	2.57
(8)Number of trips per vehicle per day	7hours /(7)	3	3	2	3	3
(9)Number of vehicles required per day	(6)/(8)	5	4	7	4	8
(10)Number of vehicles proposed		6(1)	5(1)	8(1)	5(1)	9(1)

*CCT:Compacted Container Trailer(40x0.5=20TON)
*OCT:Open Container Trailer(40x0.2x0.9=7.2TON)
*OT:Open Tipper Truck(10x0.7x0.9=6.3TON)

Table 6.5-21 Cost of Transportation from incineration plant

Items		A-3		A-7		A-8
(1)Type of waste		Ash	Ash	Ash	Ash	Ash
(2)Origin and destination		(FTZ-PA)	(Prai-PB)	(FTZ-PB)	(Prai-PB)	(Prai-PB)
(3)Average out-going amount of waste from incineration plant (ton/day)		78.9	66.0	78.9	66.0	151.1
(4)Average incoming amount of waste at incineration plant (ton/day)		657.6	549.8	657.6	549.8	1258.8
(5)Type of vehicle		OT	OT	OT	OT	OT
(6)Total number of trips		13	11	13	11	24
(7)Round-trip distance(km)		44.0	69.0	101.0	69.0	69.0
(8)Cost of fuel(M$)	(6)x(7)/2 km /1x0.468 M$/1	134	178	307	178	388
(9)Toll fee of Penang Bridge(M$)		0	0	195	0	0
(10)Total cost for transportation (M$)	(8)+(9)	134	178	502	178	388
(11)Transportation cost of waste per ton(M$/T)	(10)/(4)	0.20	0.32	0.76	0.32	0.31

*CCT:Compacted Container Trailer(40x0.5=20TON)
*OCT:Open Container Trailer(40x0.2x0.9=7.2TON)
*OT:Open Tipper Truck(10x0.7x0.9=6.3TON)

Table 6.5-22 Calculation Sheet for TransportatioSystem from Incineration Plant

Items		A-3		A-7		A-8
(1)Type of waste		Ash	Ash	Ash	Ash	Ash
(2)Origin and destination		(FTZ-PA)	(Prai-PB)	(FTZ-PB)	(Prai-PB)	(Prai-PB)
(3)Average out-going amount of waste from incineration plant(ton/day)		78.9	66.0	78.9	66.0	151.1
(4)Average incoming amount of waste at incineration plant (ton/day)		657.6	549.8	657.6	549.8	1258.8
(5)Type of vehicle		OT	OT	OT	OT	OT
(6)Loading capacity (ton/vehicle)		6.3	6.3	6.3	6.3	6.3
(7)Total number of trips	(3)/(6)	13	11	13	11	24
(8)One-way distance (km)		22.0	34.5	50.5	34.5	34.5
(9)Round-trip distance(km)	(8)x2	44.0	69.0	101.0	69.0	69.0
(10)Speed(km/hr.)		30	35	35	35	35
(11)Round-trip time required (hr.)	(9)/(10)	1.47	1.97	2.89	1.97	1.97
(12)Loading time(hr.)		0.30	0.30	0.30	0.30	0.30
(13)Discharging time(hr.)		0.30	0.30	0.30	0.30	0.30
(14)Cycle time(hr.)	(11)+(12)+(13)	2.07	2.57	3.49	2.57	2.57
(15)Number of trips per vehicle per day	7hours /(14)	3	3	2	3	3
(16)	(7)/(15)	5	4	7	4	8
(17)Number of vehicles required per day	(16)x7/6	5	4	7	4	8
(18)Cost of fuel(M$)	(7)x(9)/2 km /1x0.468 M$/1	134	178	307	178	388
(19)Toll fee of Penang Bridge(M$)	(7)x15	0	0	195	0	0
(20)Total cost for transportation (M$)	(18)+(19)	134	178	502	178	388
(21)Transportation cost of waste per ton(M$/T)	(20)/(4)	0.20	0.32	0.76	0.32	0.31

*CCT:Compacted Container Trailer(40x0.5=20TON)
*OCT:Open Container Trailer(40x0.2x0.9=7.2TON)
*OT:Open Tipper Truck(10x0.7x0.9=6.3TON)

f. Calculation of quantity

According to the procedure described above, each items are studied technically and calculated.

The contents of each incineration plant are summerized as shown in the outline of each incinerator.

g. Operation and maintenance

The manpower and utilities required for the operation of incineration plant, are as shown in Table 6.5-23.

Surplus electricity generated from each plant except those for in-plant use is available for sale to the NEB.

h. Cost estimation

The cost estimation is based on the bill of quantity and the construction price data collected. It is described in Chapter 7.

Table 6.5-23 Manpower, Utility and Revenue

Site	MPPP	MPSP	
Alternatives	③ & ⑦	③ & ⑦	⑧
Name of Plant	FTZ IP	PIC IP	PIC IP
Capacity of Plant (t/d)	810	675	1,500
Manpower for Plant			
Manager	6	6	9
Engineer	5	5	7
Junior Engineer	4	4	7
Operator	36	30	47
Laborer	9	9	13
Sub-total	60	54	83
Manpower for Transport	6	5	9
Total	66	59	92
Utilities; *1			
Electrocity (Mwh/yr)	525	439	964
Water (1000m³/yr)	22.8	19	42.2
Fuel (kl/yr)*2	40	33.3	74
- Revenue;			
Electricity (Mwh/yr)	48,000	40,000	92,000

Note:

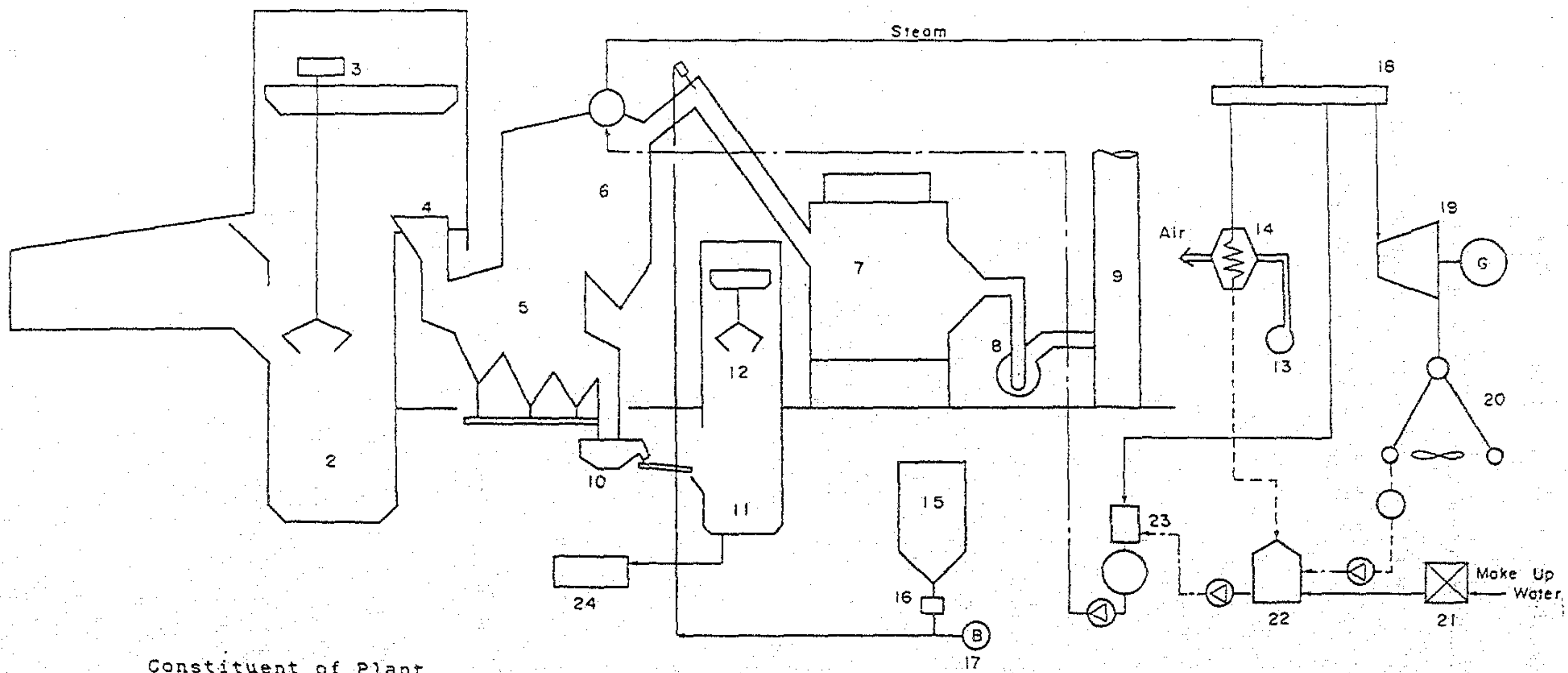
*1 Some amount of electricity to be supplied by NEB is needed during the overhaul period of steam turbine.

*2 Fuel is needed for the purpose of starting up of each furnace.

(3) Outline of Each Incinerator

Based on the preliminary design, which is illustrated in Fig.6.5-7 and 6.5-8 respectively, basic data on planning and outline of each incineration plant summarized and tabulated in Table 6.5-24 and 6.5-25 respectively.

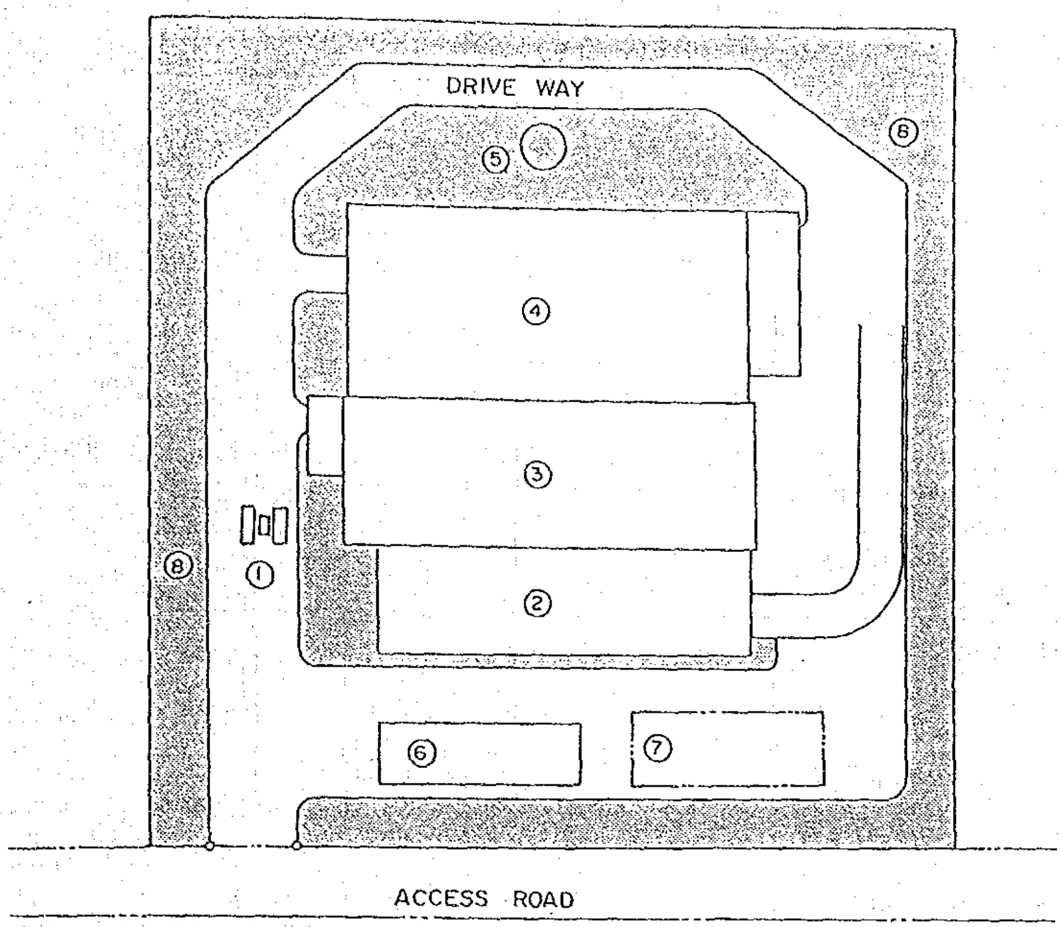
Fig.6.5-7 Schematic Flow Diagram of Incineration Plant



Constituent of Plant

1.Tipping Yard
2.Storage Pit
3.Waste Charging Crane
4.Charging Hopper
5.Incinerator
6.Waste Heat Boiler
7.Electrostatic Precipitator
8.Induced Fan
9.Stack
10.Ash Discharger
11.Ash Pit
12.Ash Crane
13.Forced Fan
14.Air Pre-heater
15.Lime Storage Silo
16.Table Feeder
17.Ejector Blower
18.Steam Header
19.Turbine/Generator
20.Steam Condenser
21.Water Purifier
22.Condensed Water Tank
23.Deaerator
24.Waste Water Treatment Equipment

Fig.6.5-8 Plan of Incineration Plant



LEGEND

① Weighbridge
② Platform
③ Pit & Crane House
④ Incinerator House
⑤ Stack
⑥ Administration Office
⑦ Car Park
⑧ Green Belt

Details of Master Plant Alternative for Incineration Plants

Alt.	Name of Plant	Plant Capacity (t/d)	Proposed Site Area
③&⑦	FTZ IP	810	145m × 150m = 2.2 ha
③&⑦	PIC IP	675	145m × 130m = 2.0 ha
⑧	PIC IP	1500	160m × 270m = 4.3 ha

Table 6.5-24 Basic Data on Planning of Incineration Plant

Alternative	③ & ⑦	③ & ⑦	⑧
Service Area	MPPP	MPSP	MPPP MPSP
Name of Plant	FTZ IP	PIC IP	PIC IP
Average Waste Amount (t/d)	700	585	1,285
Designed Plant capacity (t/d)	810 (3 unit x 270 t/d)	675 (3 unit x 225 t/d)	1,500 (5 unit x 300 t/d)
Average Net Calorific of Waste (kcal/mg)	1,700	1,700	1,700
Condition of Pollution Control: - Dust Emission (g/Nm^3)	0.1	0.1	0.1
- HCl Gas (mg/Nm^3)	400	400	400
- Waste Water Treatment	With respect to the regulation		
Workability of each Furnace (%)	89	89	89
Amount of Waste to be incinerated (t/yr)	255,500	213,490	469,000
Incinerated Amount (t/yr)	240,170	200,700	459,600
Rate of Incineration in a year in 2005 (%)	94	94	98

Table 6.5-25 Outline of Each Incineration Plant

Site		in MPPP	in MPSP	
No. of Alternative		Alt. ③ & ⑦	Alt. ③ & ⑦	Alt. ⑧
Name of Plant		FTZIP	PICIP	PICIP
Capacity of Plant (tons/day)		810	675	1,500
1. Mechanical & Electrical Equipment:				
- Weighbridge	30 ton scale	2	2	2
- Waste charging systems	Pit & Crane System	1 lot	1 lot	1 lot
- Incinerator furnace	- Full Continuous Operation, Mass-burning with water wall	3	3	5
- Waste Heat Boiler	- Water Tube Boiler, Natural Circulation	3	3	5
- Draft Equipment	- Forced & Induced Fan	3	3	3
	- Stack	1	1	1
- Turbo Generator Set	- Vacuum Condensing Type	1	1	1
- Steam Condenser	- Air-cooled Vacuum Condensing type	1 lot	1 lot	1 lot
- Ash Discharge Systems	- Semi-wet type	3	3	5
- Dust Collector	- Electrostatic Precipitator	3	3	5
- HCl-gas Removal Equipment	- Injetion of Lime-power System	3	3	3
- Waste Water Treatment System	- PH, SS, BOD	1 lot	1 lot	1 lot
- Feed Water Treatment System	- Demineralizer	1 lot	1 lot	1 lot
- Electrical Switch Gear		1 lot	1 lot	1 lot
- Instrument & Automatic Controllers		1 lot	1 lot	1 lot

- continued

		Alt.	Alt.	Alt.
		③ & ⑦	③ & ⑦	⑧ MPPP &
2. Civil and Building: - Site Area - Incinerator House	Reinforced Concreate & Steel Structure	MPPP 2.2h a 5,000m^2	MPSP 1.95ha 4,600m^2	MPSP 4.3ha 8,300m^2
3. Secondary Transportation - Ash Transportation Vehicle	Open Tipper Truck 10m^3	6 for Alt.③ 8 for Alt.⑦	5	9

6.5.5 Study on the Introduction of an Incineration Plant

(1) Preface

The municipal waste generated daily have increased remarkably with the increase in population and the rise of living standards. The state of Penang is one example where the industrial develoment and the elevation of living standard are significant.

As an intermediate treatment measure of the waste to couter-balance the increased amount of waste generated is through the introduction of an incineration system. This system has satisfactory effect on the sterilization, volume reduction and stabilization of waste.

The incineration plant proposals included in the eight altenatives submitted by JICA study Team were however not included in the Feasibility Study mainly due to financial reasons. However, the world wide trend has shown the necessity of this system in future.

This is especially true when difficulties in obtaining landfill sites are encountered. The present situation shows that the time has come for Penang to start considering this system for her future SWM.

In this section, the following items are discussed and a proposal for future incineration plant with regards to consolidation of problems and a new proposal have been given.

- Recognizing the condition in the Malaysia.
- Study on the suitable incineration plant for MPPP.
- Result of the economic evaluation.
- Examples of the installation and management through privatization, and its problems.
- Consolidation of conditions necessary for the introduction of incineration plant in future.

(2) The purpose, merits and acceptability of incineration-system.

a. Trend of Waste Disposal

The trend of waste disposed normally corresponds to population growth and income levels. The generation of waste increases with increasing population and national income level. And consequently, to manage the increased amount of waste, more collection and disposal services are required which accounts for more vehicles, manpower and land for final disposal.

In recent years, acquisition and availability of land for final disposal site have become more difficult, especially those situated at the periphery of urban centers where plenty of waste are being generated, consequently, a final disposal site has to be lcocated far from the generation areas which requires long distance haul. These factors are substantiating to the increase in waste disposal costs.

Open crude dumping has been practiced since ancient times and is the least expensive method. However, open dumping causes environmental problems such as groundwater comtamination pollution, generation of animal scavengers, offensive odor, air pollution, etc.. In short, open dumping is unsanitary. Therefore, it is necessary to shift to a new disposal system known as sanitary landfill which is more sanitary and if strictly carried out, will maintain a healthy environment.

The shift has resulted to more intensive land reclamation, leachate treatment, and other environmental protection facilities that consequently require considerable financial investment. In many developing countries where economic and population growths and centralization of people to the cities are rapid against the intense need for solid waste generation-reduction and volume-reduction have become one of major improvement issues.

This includes Penang State where the industrial activities are brisk and continuing increase in living standard has been observed.

Thus, at this stage, even though the introduction of an incineration seems difficult due to financial reasons, it is time to consider proper introduction of it for the future waste disposal.

b. Merits of incineration versus landfilling method.

Simply, the merits of incineration over landfill disposal methods are the sterilization and high volume-reduction of waste, rapid stabilization of landfills and mitigation of environmental impacts.

i. Sterilization of waste.

The putrescible matters contained in waste are dissolved and oxidized to steam and odorless gas through the incineration under high temperature. Only the sterilized ash and incombustible matter remain as residues of incineration. Thus when disposed, sanitary condition is maintained at the final disposal site.

ii. High Volume Reduction.

Incineration can reduce down to 1/15 or less of the initial volume of waste. Thus, it would suffice to prepare minimal land for disposal or it may lengthen the life of landfills.

iii. Rapid Stabilization of Waste.

Landfill by untreated waste requires 15 or 20 years before the waste complete its decomposition and final settlement being achieved. Unlike conventional disposal, ash stabilizes in a far shorter period and the ground of where ash is disposed are much stronger compared with conventional disposal land. Thus, it makes possible to construct buildings on ash reclaimed land.

iv. Mitigation of environmental impacts.

Open dumping poses the following main environmental problems;

- genaration of offensive odor from decomposition of wastes
- smoke due to spantenous combustion that results to air pollution
- Groundwater contamination caused by seepage of leachate

- Infestation and generation of insects and vectors/to the environment

The environmental damage caused by open dumping as mentioned above are normally extensive and cannot be artificially controlled.

While in the case of incineration, the following factors may cause environmental problems.

- stack emission that results to air pollution
- noise and vibration from incineration plant
- waste water effluent
- odor from flue gas.

However, the prevailing incineration technology has managed to curb the above factors to within stipulated values of the regulations through provision of pollution counter measure facilities in the plant.

c. Factors affecting acceptability of incineration system in developing countries.

Despite of the advancement and merits of the incineration system, many developing countries have hesitations in development of incineration systems due to the reasons below (full discussion is given in (3)c.).

i. The high investment cost in the adoption of an incineration system.

ii. The per capita waste generation is low and still there are inexpensive land available for final disposal.

iii. The public has less recognition on the importance of environment and there has been no considerable claims against adverse affects by open dumping.

(3) Current situation of incineration system in advanced and developing countries.

a. Current Situation in advanced countries.

Table 6.5-26 shows the rate of treatment by incineration system in advanced countries.

Table 6.5-26 Rate of Treatment by Incineration in Advanced Countries

Country	GNP	Generation Rate		Type of Treatment(%)			
	(US$)	1000t/yr	g/cap/day	Incine-ration	Landfill	Resource Recovery	other
United Kingdom	8,920	16,600	982	10	88	1	1
West Germany	12,080	19,000	858	19	79	-	2
France	10,740	14,000	685	-	-	-	-
Denmark	12,640	1,200	651	34	62	-	4
Sweden	13,170	2,500	-	30	70	-	-
USA	17,551	154,000	1,746	-	>90	-	-
Japan	12,850	43,450	986	71	26	-	3

Note:GNP per capita in 1986

In Japan, the preference in utilization of incineration system may be explained by the following factors.

- The availability of land for final disposal is scarce (especially level terrains)
- *The government have assisted positively and expedited* the construction of incineration plants.

- The Japanese society have received and understood well of the many advantages brought by incineration system such as remarkable volume-reduction, its high sanitary standards, energy recovered and benefit by the ultimate use of landfills.

b. Current situation in developing and less developed countries.

The main method of waste disposal in many developing and less developed countries is the landfill disposal method.

Table 6.5-27 shows the incineration plants and its operational problems recently constructed in Asian counties.

c. Factors against development of incineration system in developing and less developed countries.

The factors that hinders introduction of incineration plants in developing and less developed countries can be viewed from the historical, economics and technical aspects.

i. Historical aspect

- Open dumping is the least expensive method
- In the past, there have been plenty of land available for waste disposal purposes
- The population density is relatively small
- The average income level is lower and the waste generation per capita was relatively low
- The concern of the people to environmental issues has not been serious.

Due to the reasons above, there are obviously in no urgent need of an incineration system.

ii. Economics and technical aspects

- the construction of an effective and reliable incineration system requires a lot of money. Under the ordinary SWM budget in these countries, the shock in financial requirement of the

Table 6.5-27 Incineration Plants in Asian Countries

Country & Place		GNP US $*1	Year of Commencement	Plant Capacity (tons/day)	Equipped Accessories	Operational Problems
Hong Kong,	Kenedy Town	6,720	1966	650	WHB & T/G	Improper Design
	Lei Chi Kok-1		1969	550	ditto	ditto
	Lei Chi Kok-2		1974	450	no WHB	ditto
	Kwai Chung		1979	870	WHB & T/G	
Singapore,	Ulu Pandan	7,410	1979	1,600	ditto	
	Tuas		1986	2,760	ditto	
South Korea,	Uijongbu	2,370	1985	50	no WHB	Improper Design
	Mok Dong		1986	150	only WHB	Poor Calorie Waste
Rep.China,	Shen Zhen	300	1988	300	WHB & T/G	
Taiwan,	Taipei	3,670	1987*2	900	ditto	
India,	New Delhi	270	1987	300	ditto	Poor Calorie Waste
Macau,	Taipa Island	—	1991*3	576	ditto	
Malaysia,	K.Terengganu	1,850	1987	100	ditto	Plant Shut-down

Note : *1 GNP Per Capita in 1986
*2 Construction work has begun
*3 Expected completion in 1991
*4 WHB means waste heat boiler
*5 T/G means turbine generator set

incineration sytem is too great against the ordinary monetary allocations for SWM.

- there are no experienced personnel to operate and maintain the incineration plants. Often the technical and logistics support are inadequately ready for the complex incineration plant smooth-going.

- In the past, satisfactory results could not be obtained from the plants already constructed. Many of these plants had problems such as unreliable make, shortage of spare parts, inexperienced crew, etc.

Thus, all the reasons gathered above have affected the acceptability of incineration system in many developing and less developed countries.

(4) Incineration system in malaysia.

a. Current situation in malaysia.

The one and only incineration plant for municipal solid waste in Malaysia was built in Kuala Terenggann in July 1987. The general plant facilities, progress and problems with respect to its operations were gathered through a visit to the plant in Kuala Terengganu, are described below.

i. Composition of incineration plant

Receiving and feeder facility	1 unit
Incineration furnace with 100 t/day capacity	1 unit
Waste heat boiler with evaporation rate of 12.3t/hr.	1 set
Draft equipment	1 lot

Turbine/genarator facility	1 lot
Electrical instrumentation and control switch board facility	1 lot
Auxiliaries	1 lot

ii. Construction cost

The total plant cost including civil and mechanical works is 6.5 million ringgit. The unit price of waste incineration is 65,000 ringgit per ton. The figure is about one third of the average plant unit cost commonly found.

iii. Status of operations

Since the start of operation in 1987, the plant has often been shut down due to failures and had only 2 continuous months of operation. During the shut-down, modifications and adjustments were made however, all attempts have been futile to produce satisfactory results. To date, revenue from sale of power is still not possible.

b. Problems and Improvement tasks.

The plant in Kuala Trengganu faces the following problems.

i. The plant is under inefficient and unsanitary working conditions due to poor planning.

ii. The plant cannot maintain continuous operation because of poor design and inadequate specification of the facilities.

iii. Inappropriate selection of combustion system.

iv. Inadequate training given to the operators.

v. The contractors were not warranted to guaranty performance of the plant or facilities.

Future introduction of incineration plant would require the following precautions and improvements with reference to the Kuala Terengganu incineration plant.

i. Planning execution should be done by a qualified and experienced incineration system consultant.

ii. An experienced and knowledgeable manufacturer should be the prequalifictaion criteria in selection of facilities make.

iii. Preparation of adequate stock of spare parts, having qualified operation engineers and well trained operations crew for smooth running of the plant.

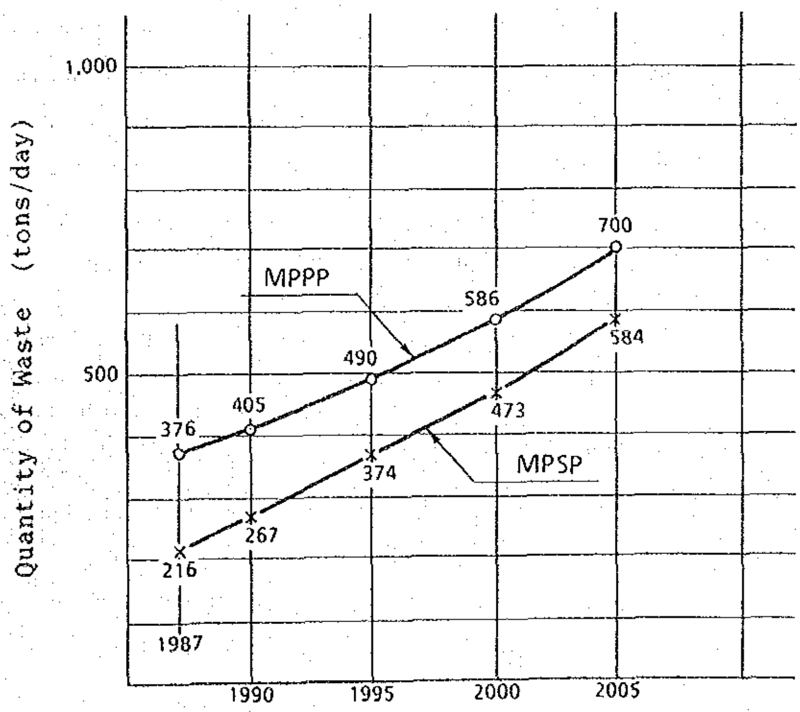
If Penang State were to consider introducing an incineration plant, it is important that the above mentioned precautions be considered to avoid repeating similar failures as those in Kuala Terengganu incineration plant.

(5) Approach towards introduction of incineration plant in penang state.

a. A countermeasure against increase in volume of waste generated.

The periodical increase of waste quantity generated in Penang state was estimated and shown in Fig 6.5-9.

Fig. 6.5-9 Estimated Waste Generation in Penang State



The estimations on the generation quantity has been based on the population increase, increase in per capita waste discharged and expansion of service areas. The estimated quantity of waste available for incineration is 700t/day in MPPP and 584t/day in MPSP in the year 2005.

The economics and financial evaluation has revealed that MPSP is especially weak and uncapable of introducing and incineration system for her solid waste treatment in the near future.
MPPP on the other hand have some financial difficulties at present in having an incineration plant. However, the situation may be reversed with an up-turn in her financial aspect.

Thus, the following study has been performed based on the possibilities of MPPP having her own incineration plant.

b. Qualities of Waste in MPPP

i. Whether or not waste quality is acceptable to an incineration plant is a major criteria in the introduction of an incineration system, Fig. shows some examples of waste qualities in other countries as well as those in Malaysia.

The quality of wastes in less developed and developing countries contains substantial green and putrescible wastes as shown in Fig. 6.5-10 c,d. These types of waste reduces the calorific values of the waste. In most cases, auxiliary fuel are required to incinarate these wastes. And this is why incineration is not a proper selection for waste treatment in many developing and less developed countries.

However, the refuse quality in Penang State has a calorific value of 1600 kCal/kg and is estimated to increase to 1700 kCal/kg in 2005 (based on study by JICA Study Team).

These values resembles to that of Japan or that of Singapore and the refuse can support stabilized combustion wihtout any

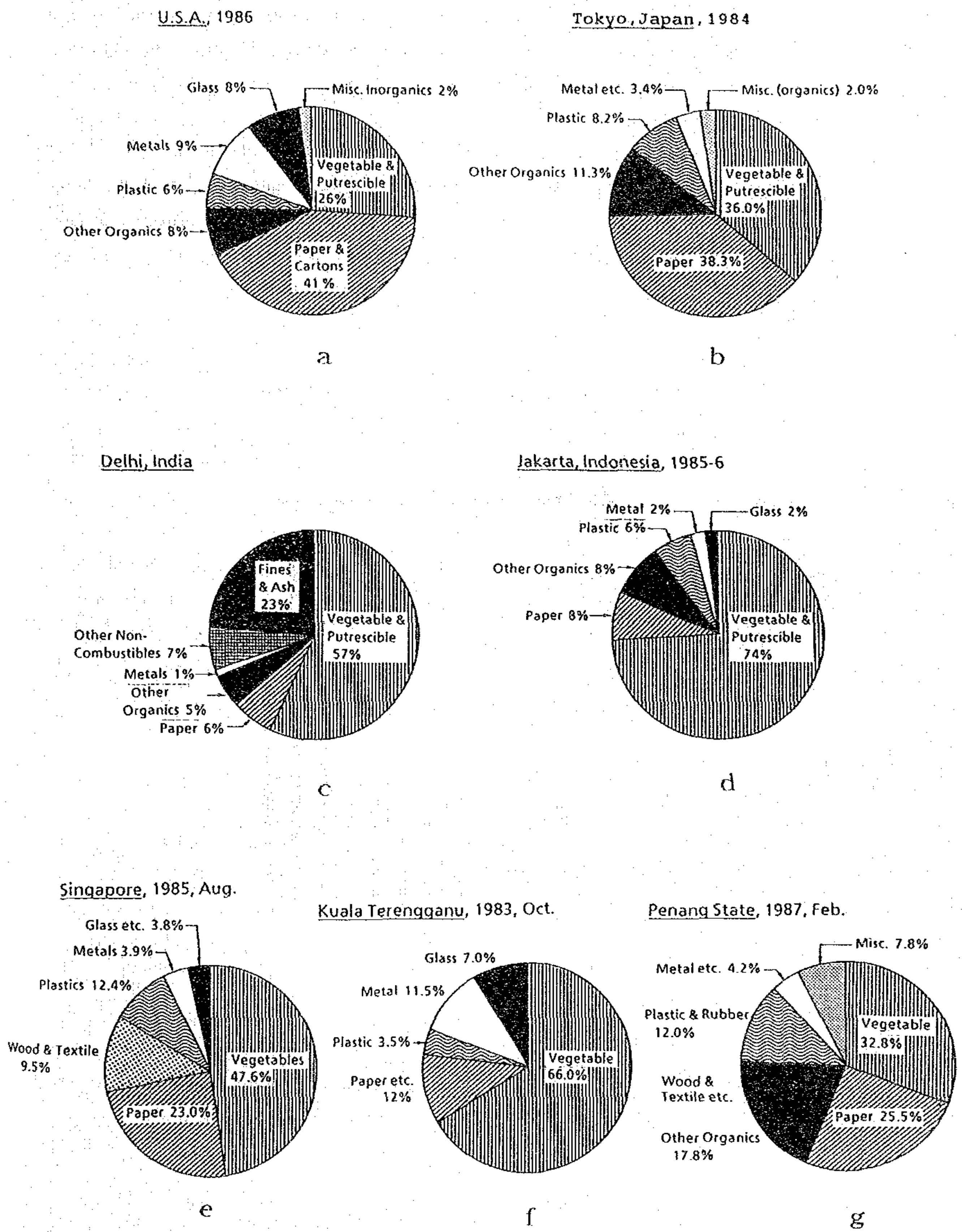
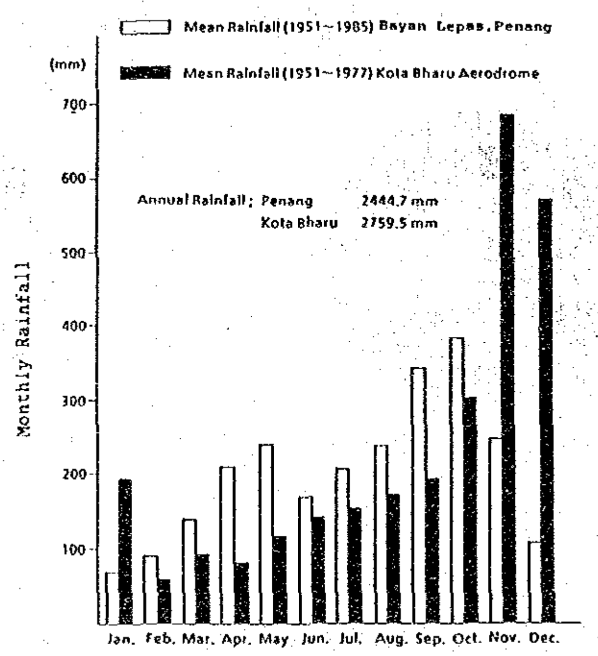


Fig.6.5-10 Comparison of Waste Quality

additional fuel. The heat of combustion can be expected to generate considerable power. Thus in short, the waste quality in Penang is acceptable for an incineration system.

ii. The meteorological conditions in Penang is shown in Fig.6.5-11. There is no remarkable change in rainfull that may affect the moisture or water content of the solid waste in Penang. This would stabilize the refuse quality of Penang state and is better in quality than those found in Kuala Terengganu.

Fig. 6.5-11. Monthly Variation of Rainfall in a Year



The reasons that maintains better quality waste in Penang for incineration compared with those from other places are summerized below.

Table 6.5-28 Reasons for Better Quality Waste in Penang.

Condition in Penang	Result
* The average income level is relatively higher.	. Increases the content of combustible matter in waste
* There is no significant wet season.	. Stabilizes or constant amount of moisture content in waste.
* Streets are well paved.	. Little earth, sand or inert materials are found in collected waste.
* Strees are not littered	. Higher paper and combustible matter content in collected waste.
* Efficient materials recovery and recycling.	. Less insert matter or incombustible found in waste.

c. Consideration on components of incineration plant.

i. Type of incineration plant

When the investment effect is considered, it should be based on 24 hour operation of higher availability (higher utilization rate). That is to say that the incineration full-continuous-combustion type should be selected.

ii. Gas temperature reducing system (Gas desuperheater system)

Gas desuperheater system is classified into the water injection desuperheater system which main purpose is incineration and volume reduction, and the temperature reducing system by employing waste heat boiler used for both incineration and heat recovery.

The former water injection type desuperheater system is suitable for small scale plant, and the initial investment cost per ton is less, however, revenue cannot be expected and the operation cost is accounted as a loss. The system would only be advantageous and effective for reducing the landfill volume and environmental problems.

In the latter waste heat boiler system, clinker trouble can be prevented by the water wall provided in the combustion chamber and a longer term of stable operation can be performed, and the recovery of energy can be maintained.

In this case, the initial investment cost per ton may be slightly higher compared with the former system, however, the power generated can be utilized to counter-balance the expenditure of power cost (which is the main item in the operational cost which normally account for 70 to 80 % of the operational cost), can be saved. Any surplus power would become a revenue which can be appropriated to repayment in the plant investment. More profit can be expected if heat consumers are within the surrounding areas. In such situations, the waste heat boiler system should be chosen.

iii. Heat utilization system

When the waste heat boiler is chosen, the recoverd heat energy can be utilized for many purposes such as the followings:

. Steam or hot water supply to factories.

. In-plant use of the generated power.

. Sale of surplus power to National Electricity Board.

. Turbine driving of auxiliary equipments in plant,etc.

When the outside heat consumers are not found, a recommendable choice is the self-supply for in-plant use of power and the sale of surplus power.

The National Electricity Board would purchase the power generated at the cost of about 0.1025$/kw, and this figure is relatively better compared with the price of some commodities in Malaysia.

iv. Countermeasure against pollution

The dust precipitator and harmful gas elimination facility are the most important among many anti-pollution contermeasure of the incineration plant. When simple construction, easy operation and moderate running cost are taken into consideration, it is recommended that the desirable system would have the following performance shown in Table 6.5-29.

Table 6.5-29 Proposed Anti-Air Pollution System

Equipment	System	Design Figure	Remark: Malaysian Regulation
Dust Collector	Electrostatic Precipitator	Dust Emission Less than 0.1 g/Nm^3	0.4 g/Nm^3
HCl Gas Eliminator	Lime Powder Injection System	HCl Emission Less than 400 mg/Nm^3	400 mg/Nm^3

d. Proposed scale of incineration plant for year 2005 and financial study of the plant.

The outline of MPPP's incineration plant in the year 2005 is described below, extracted from previous studies by the Study Team.

i) General description of Plant

Plant scale(Incineration capacity): 810t/day (3 units x 270t/day)

Plant construction cost : About 150 million ringgit

The basic planning data and general description of the plant is as shown in Table 6.5-30 and 6.5-31

Table 6.5-30 Basic Planning Data

Item	Planned Figure
Amount of Wastes, (tons/day)	700
Capacity of Plant (tons/day)	810
Net Calorific Value of Waste (Kcal/kg)	1,700
Condition of Anti-Air Pollution	
- Dust Emission(g/Nm³)	0.1
- HCl Gas Emission(mg/Nm³)	400
Availability of each Furnace through a year (%)	89
Amount of Wastes to be collected (t/yr)	255,500
Expected Incineration Amounnt (t/yr)	240,170
Rate of Implementation (%)	94

Table 6.5-31 Major Component of Incineration Plant

1. Mechanical and Electrical Equipment:		
-Weighbridge	-30 ton Scale	2
-Receiving & Feeding Equipment	-Pit & Crane System	1 lot
-Incinerator	-Full continuous operation, Mass-burning with Water wall	3
-Waste Heat Boiler	-Water Tube Boiler, Natural Circulation	3
-Draft Equipment	-Forced & Induced Fan	3
	-Stack	1
-Turbine/Generator	-Vacuum condensing Type	1
-Steam Condenser	-Air-cooled Vacuum Condensing Type	1 lot
-Ash Extractor	-Semi-wet Type	3
-Dust Collector	-Electrostatic Precipitator	3
-HCl Eliminator	-Injection of Lime-powder system	3
-Waste Water Treatment System	-pH, SS, BOD	1 lot
-Feed Water Treatment System	-Demineralizer	1 lot
-Electrical Equipment		1 lot
-Instruments and Controllers		1 lot
2. Civil and Building:		
-Area Required		2.2ha
-Incineration Plant	Reinforced Concrete & Steel Structure	5,000m²

ii) Operational cost, revenue and disposal cost per ton is given in Table 6.5-32

Table 6.5-32 Cost, Revenue and Unit Disposal Cost

Item	Annual Quantity	Unit Price $	Annual Amount ×1000$/Year
Operation Cost;			
Man Power	(60persons)	10,100 $/head	607
Fuel *1	40 kl	0.47 $/l	18.8
Chemicals	1 lot	—	810
Electricity (Purchase)*2	525 Mwh	0.21 $/kwh	110.4
Water	22,800m³	0.524 $/m³	11.9
Sub Total			1,558.1
Revenue; Electricity (For Sale)*3	48,000 Mwh	0.1025 $/kwh	Δ4,920
Maintenance Repair Cost	3% of total plant investment		4,177.2
Depreciation	civil(for30years)	1,115	6,993
	Mech(for18years)	5,878	
Total *4			7,808.3
Amount of *5 Incinerated Waste	240,170 tons		
Waste Disposal Cost = *4/*5		32.5 $/ton	

(Note) * 1. Fuel: The auxiliary fuel is required only when to start each furnace.
* 2. Electricity (Purchase of power): Purchase of power is necessary during turbine shut duwn for maintenance purposes of the turbines.
* 3 Power(Sale of power): Purchase of power by National Electricity board in calculated at daily avarage unit price per hr.
the rate of: Peak Hour 08.00-18.00$ 0.14/kwh
Off Peak Hour 18.00 -08.00$0.05/kwh

Thus it can be seen in Table 6.5-32 that the revenue from sale of power exceeds the necessary expenditure of plant operational cost and the sale of surplus energy can cover 80 % of the maintenance charges.

The income from sale of power is equivalent to about 44% of the total of maintenance cost and depreciation of plant. This shows that there is a big avantage in the power generation scheme through energy recovery of the incineration plant. (At the stage, however, the repayment of loans for the plant construction and the interest involved are not considered).

iii) Energy recovery effect.

The heat content of waste in converted to steam by waste heat boiler and it is estimated about 14.7% of the energy can be recovered and utilized.

Value this heat energy recovered corresponds to the annual savings of about 40,000kl of fuel.

iv) Volume reduction effect

The ash volume after incineration is reduced to about 1/17 compared to direct disposal of raw refuse at the landfill site,the volume reduction contributes much to the reducing the haulage costs.

After the addition of covering material required, the volume of incinerated ash would require about 1/10 of the conventional landfill method of disposal site volume. However, during overhaul period, furnace shutdown and repairing work are performed that malfunctions the incineration of waste, direct disposal of raw refuse is necessary. Therefore, some landfill margin should be considered.

v. Other effects

- Administrators, engineers and operation crew having the required qualifications are necessary for the operation of the incineration plant. this would create employment opportunities.

- Through introduction of incineration plant, the pollution at landfill sites can be eliminated and sanitary disposal is possible.

- Through introduction of incineration plant, the maintenance, repairing and overhaul work are indispensable, which creates development of high technology engineering in this field.

(6) Economics Evaluation Result

5-1 Master Plan Economics Evaluation of Incineration Facilities.

The conclusion of financial evaluation has shown that:

- The repayment of loans for incineration plant project is impossible by only redusing the investment cost, so long as the growth of the budget allocation for SWM is limited to the annual increase of 0.1 % .... Fig 6.5-12, a to c.

- The materialization of incineration project is more prospective if the investment cost can cover 80 % of the initial $150 million ringgit estimate for the plant and that the annual budget growth for SWM is 4.5 % ...... Fig. 6.5-12d.

- If grant of 25% the estimated incineration plant cost is allowed, there are better chances of materializing the incineration plant...... Fig 6.5-12e.

Thus in short, 3 factors governing the materialization of an incineration plant in MPPP are as follwos;

* Reduced construction cost of incineration plant investment.

* Favourable growth in budget allocation for SWM

* Availability of grant to subsidize the investment for the plant.

However, currently grants from the Government is most unlikely and it has greyed the prospects of an incineration system in MPPP. Therefore, alternative plans to facilitate the introduction of incineration plant such as privatization will have to be examined.

- Through introduction of incineration plant, the maintenance, repairing and overhaul work are indispensable, which creates development of high technology engineering in this field.

Fig.6.5-12a Alternative 1-A with Proposed Investment Cost of Incinerator and 0.1% Annual Increase in Annual Budget Allocation to SWM: Debt, Annual Investment, Expense and Allocation

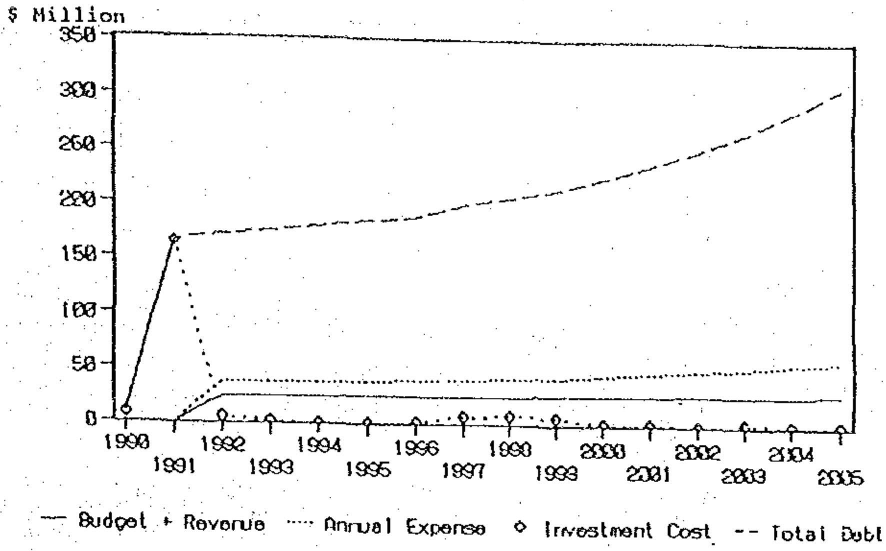


Fig.6.5-12b Alternative 1-A with 20% Reduction in Incinerator Cost: Debt, Annual Investment, Expense and Allocation

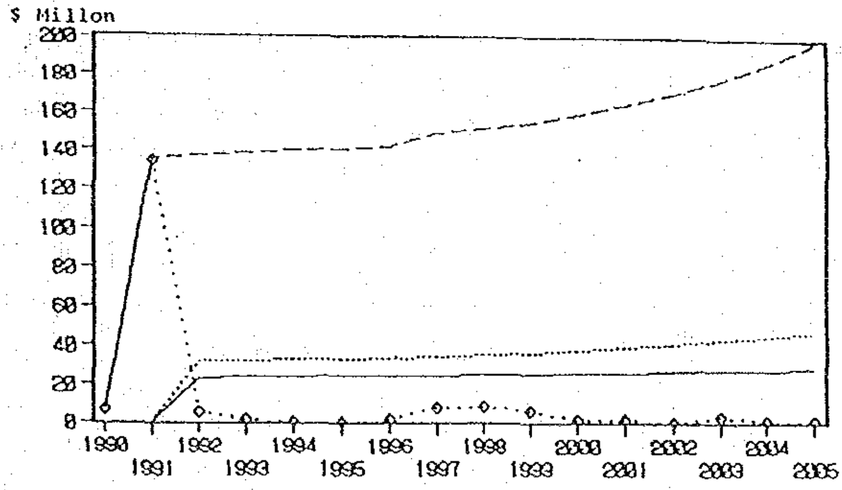


Fig.6.5-12c Alternative 1-A with 40% Reduction in Incinerator Cost: Debt, Annual Investment, Expense and Allocation

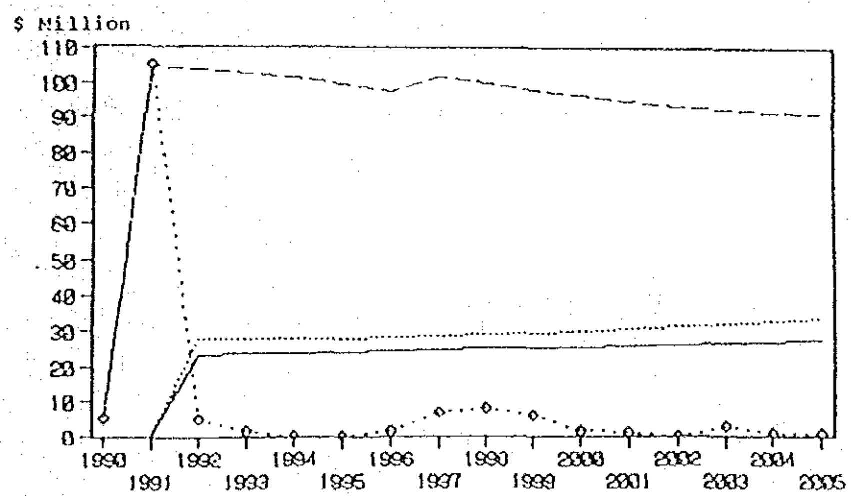


Fig.6.5-12d Alternative 1-A with 20% Reduction in Incinerator Cost and 4.5% Annual Increase in Annual Budget Allocation to SWM: Debt, Annual Investment, Expense and Allocation

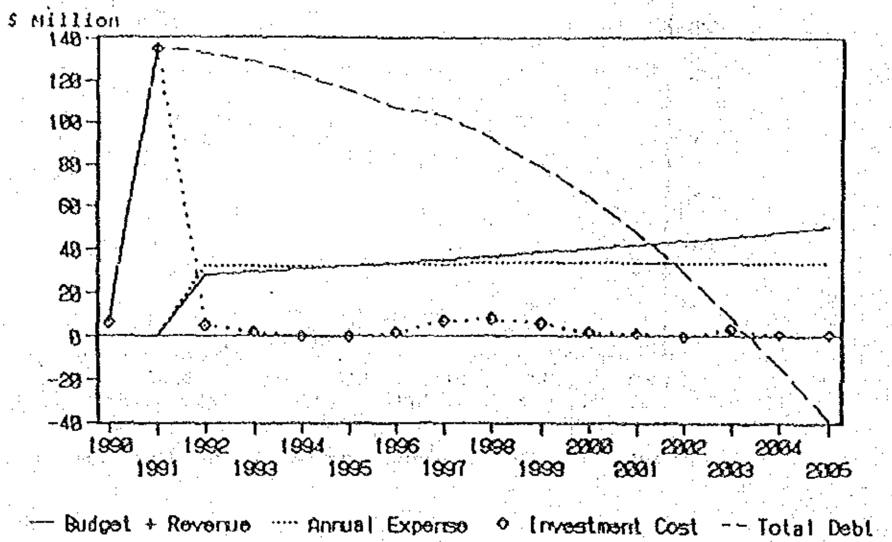
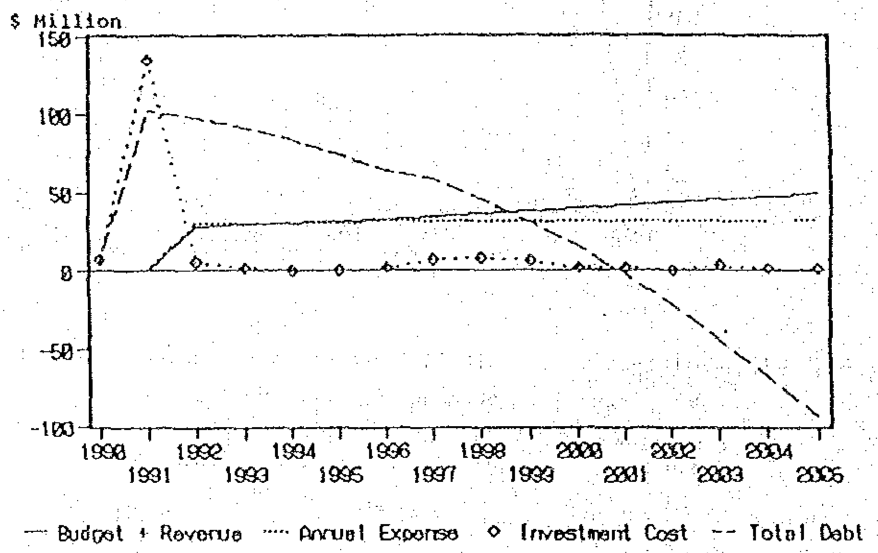


Fig.6.5-12e Alternative 1-A with 20% Reduction in Incinerator Cost and 4.5% Annual Increase in Annual Budget Allocation to SWM, and Grant Covering 25% of Investments for Incineration and Disposal system: Debt, Annual Investment, Expense and Allocation



(7) Privatization of Incineration Plant.

The high investment in construction and operations of an incineration plant has already been discribed. Owing to the financial limitations of the country and her states coupled with the low priority given to the incineration system, compared to other governmental priorities, privatizing the incinaration plant is another option that should be considered.

However, detailed examination should be carried out whether privatization and private undertaking is feasible or not.

a. Examples of successful privatization of incineration plants.

The examples of successful privatization of intermediate waste disposal facilities are described below.

i) Privatization of industrial waste disposal in several countries in Europe(especially chemical or toxic waste disposal)

ii) Power generation and heat supply activities in Northern Europe.

iii) Power generation and heat supply activities in the U.S.A.

b. The reasons for successful privatization of the above are as follows.

Reasons for successful privatization of industrial waste disposal :

- Due to difficulties in disposal of industrial waste which require reliable and safe facilities of disposal.

- Specially designed centralized treatment plant has proved advantogous from the cost savings aspects.

- Adequate and good tipping fees to cover the cost of disposal.

Reason for successful privatization of energy sale in Europe.

- The cold climatic conditions boosts the heat demands. With high annual availability of the plant, heat can be constantly provided.

Reasons for successful privatization of energy sale in USA.

- Due to propagation of disposer, etc., refuse calorie is high and the power generation is much.

- The refuse quantity is sufficiently adequate and due to big plant scale , the scale merit is obtainable.

- Through favourable PURPA regulations, the produced power is purchased at sufficiently higher cost. (PURPA Regulation ... Public Utilities Regulatory Policies Act)

- Collection of tipping fee from the refuse is in guaranteed.

- Incineration plant contractors are given special incentives such at financing at of low interest rates, rates and the reduction of exemption in tax. Moreover, shorter depreciation period for energy production facility is allowed.

- The consultants have emphasized on the qualifications of the manufacturers and suppliers in procuring the facilities.

Therefore, it should be noted that there are significant differences in conditions and requirements set abroad compared with those in Malaysia.

In the Malaysian case however, similar condisions to the above may not be achived. Detailed study on the profitability in privatizing the incineration plant is required.

b. Problems of Privatization in USA.

The privatization rate of incineration system in USA was rapid and very progressive. The situation however has changed and seems to have reached its turning point.

One of the main reasons for the decline in response to privatization of incineration systems is the contract specification for the performance guaranty of the plant for 20 years. The contractors are subjected to high risks if there are social and environmental impacts resulting from the plant operation during the contract period. This is one factor that had discouraged private sector participation.

Since 1986, when PURPA and other favorable Acts were abolished, the management by private companies have been driven into difficulties and the materialization of new plants have been retarded seriously.

Privatization of incineration system differs greatly that those privatized in solid waste collection and haulage. Therefore, through study should be carried out to identify the differences between the two mentioned systems.

c. Proposed measures to avoid irresponsible contractors.

When the incineration is privatized there should be no toleration in plant failure. The main reason to this is to protect the public from any impact due to the plant failure.

The ABC plan has indicated the presence of a private contractor who claims that disposal fee(tipping fee) is not necessary if they are allowed to undertake incineration because the cost and expenses is compensated through revenue gained from sale of power generated from the plant. This claim differs and contradicts current global practice and in this case, the responsibility of each party involved should be clearly be defined.

Measure to intensify the responsible undertaking by the contractors.

1) The performance bond is set 20 to 30 % higher than the normal case.

2) The joint liability company guaranty system should be included in the contract. If the contracter fails in the specified work, the joint liability company who guaranties should be responsible in completion of the work.

3) If the works by the contractor is unsatisfactory, the client is entitled instruct the joint surety company to undertake and complete the unsatisfactory works by utilizing the surety bond or the client may request other contractors to perform the works with all costs being borne by the original contractor.

If the above conditions are included in the contract agreement of the incineration plant management, irresponsible contractors can be omitted and sound operating plant can be delivered.

(8) Proposals in consolidating the introduction of incineration plant.

a. Recommendation for stage plan

When difficulties in privatization are found in the introduction of incineration plant, the following Model Plant Plan is proposed.

In the construction of an incineration plant, it is advantageous to have a bigger scale plant in view of scale merit. However, to have an incineration plant that is capable of incinerating the total quantity of waste generated involves high initial investment cost.

From financial management aspect, the annual expenditure inclusive of the repayment of loans would considerably be increased. Therefore, it would not be a good selection.

However, if the present dependence on only landfill is continued, SWM will face serious problems when there are no more suitable landfill sites available. Hence to overcome such problems, incineration is necessary.

However, in order to secure smooth operation of incineration plant, besides from the considerable training given to the operators, the consolidation of the technical background which makes the maintenance and repair feasible, are also necessary. This technical know-how requires considerable practice and time.

In relation to the above, initially, it would be better to begin with a smaller capacity plant which is moderate in price and offer a practical scheme where the factors below could be easily monitored.

- Progress in the mastering of skillful plant operations

- Confirmation on the operational expenses and revenue

- Identification and extraction of technical problems of the plant and its ultimate solution to the problems.

- Consolidation of the collection and haulage system of waste generated.

After achieving satisfactory results of the factors above, additional furnaces can be constructed through gradual increase in number of furnaces. This would eventually reduce the landfill site required.

b. Proposed First Stage Plan

The proposed first stage plan (Model Plant Plan), is aimed at achieving satisfactory results of the factors mentioned in (8).a. above and can utilize the knowledge gained for future development of the incineration plant.

The proposed model plant is outlined below.

- Capacity of plant is 200t/day, 24hr operation system.

- Number of furnace: 2 sets.

- Small Scale Power generation facility suitable to the scheme.

- Installation of minimum anti-pollution facilities and still comply with environmental regulations.

- Components of plant is simple.

The construction cost of the model incineration plant (excluding land cost) is estimated approximately 32 million ringgit.

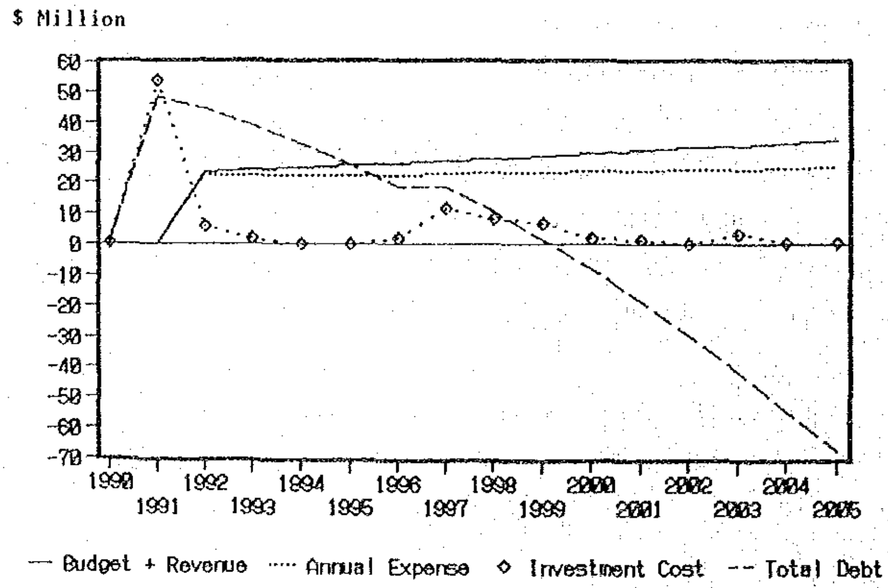
MPPP's Model Plant financial flow is shown in Fig.6.5-13. The calculation has taken into consideration the construction cost of landfill site, purchase of collection vehicles, operational and maintenance costs, besides the initial investment on the plant.

Although the proposed model plant is a miniature compared to that mentioned in Alternative 1-A, the investment in the model plant does not result to financial shock. This would make incineration a possibility.

The model plant shall only be capable of incinerating 30% of waste generated by 1995(490t/day). It is however important to consider that the plant has been set up to assist in understanding and gathering valueable experience in proper incineration operations for the full sized plant in the future.

Fig. 6.5-13 MPP's Model Plant Financial Flor

(with 2.5% Budget Increase)



c. The Extension Plan

The Extension Plan does not always necessarily correspond to the increase in the quantity of waste generated but must have no unreasonable financial burden.

The Extension Timing should be determined carefully based on the standard achieved in practice and technical know-how listed below.

1. Mastering of the operation techniques and traning for operations engineer.

2. Maintenance and management capabilities in the maintenance and repair of apparatus, instrumentation and control equipment in the plant.

3. Capabilities in overhaulling (mastered through technology transfer and shall be set up by the Malaysian side).
4. Wider availability of Local-made products of equivalent superiority to the original specification that are cheeper to lower the cost of future plant development.

d. Precautions in the introduction of incineration plant

The precautions in the introduction of incineration plant are as follows:

1. The appropriate planning should be performed by knowledgeable consultant or experts in the incineration field.

2. The proper stage plan is suitable to the financial capacity.

3. Only experienced and knowledgeable manufacturers are to be selected through pre-qualification requirements.

4. Thorough educational and training programme are given to the operation engineers and crew.

5. Fostering abilities in overhaulling the incineration plant facilities.

6. Usage of more local made products that complies with specifications should be encouraged to reduce the cost of plant.

7. Establishment of the plant management organization and source of investment should be secured.

(9) Summary

The introduction of the incineration plant has been advocated in MPPP because the MPPP has limited landfill sites and that the environmental integrity is especially important as a tourist city.

The incineration plant requires high investment for construction, operation and maintenance. Therefore, developing countries tend to be discouraged in the introduction of the incineration system.

However, the merits of incineration plnat are;

- It enables incineration of large quantity and wide variety of waste efficiently.

- Remarkable in volume reduction.

- *Sanitary disposal of organic substance and preservation of good* environment.

- The landfill by incineration ash is stabilized earlier than ordinary landfill by garbage and the availability of the reclaimed land is higher.

Penang generates high colorie waste as described in section (5).b. and this makes it easy for incineration and produces much heat for energy recovery. This is a favorable condition for the introduction of an incineration plant.

Accordingly, it should be a desirable for Penang to proceed towards incineration considering the future increase in GNP (or GRDP) and expected improvements in the financial standing.

The Final Report shows a Feasibility Study based on the present situation. Therefore, the incineration plant planning is not included in the contents of the Feasibility Study. While the introduction of the reduced scale Model Plant was described in this Report, it is proposed that the Malaysian side should continue their interests in prospects of introducing incineration plant in the futere.

6.5.6 Cost Analysis for an Incineration Plant

(1) Cost analysis of Alternative 1-A

The cost analysis of modified version of Alternative I with incineration plant(i.e. Alternative 1-A for MPPP) is established to consider the possible cost reduction on incineration plant.

The economic sensitivity of this alternative was detailed out in Chapter 2 of Progress Report IV A. This appendix is to give technical support on the sensitivity analysis discussed in Chapter 2. This appendix contains the following discussions.

i. Total Investment Cost of Incineration Plant in Alternative 1-A
ii. Criteria of Cost Estimation of Incineration Plant
iii. Cost Reduction - The Acceptable Level
iv. Further Cost Reduction and Consequences

(2) Total Cost of Incineration Plant (in Alternative 1-A)

a. The total investment cost of the incineration plant considered in Alternative 1-A is shown below:-

- Service Area — MPPP
- Average amount of Waste to be incinerated: — 700 tons/day (daily)
- Plant Capacity: — 810 tons/day (3 units x 270 tons/day)
- Estimated Investment Cost (x 1000) :-

Mechanical and Electrical Equipment	$ 122,200
Civil and Building works	$ 33,400
Total	$ 155,600

(3) Criteria of Cost Estimation of Incineration Plant.

a. The total estimated cost of incineration plant (investment) is calculated based on the following criterias.

i. All equipment and incineration facilities are of the best quality and supplied by an established and top rank manufacture of incineration plant.

ii. All raw materials and equipment will comply with the standards and codes practised world wide such as B.S., DIN, ASME, JIS, etc.

iii. The electrical components, instrumentation and all automatic control systems, etc are technologically sound to meet the requirments of the year 2005. This will enhance safety and suitable working condition for the operation crew.

iv. The anti-air pollution facilities will comply with the specifications below:-

- Dust emission from stack: under 0.1 g/Nm^3
- HCI gas emission from stack: under 400 mg/Nm^3

v. All plant equipment will have sufficient capacity to enable continuous operation throughout the year for incineration of waste that has 1700 Kcal/Kg calorific value.

b. In the cost estimation of the incineration plant components, the following conditions were also considered to substanciate the savings in cost.

i. Componenet equipment that are not available locally or cannot be manufactured locally will have to be imported Such equipment are normally expensive and there are no discounts or reductionin prices.

ii. Some parts of an equipment or material may have to be imported while the remaining part of the equipment may be furnished by local suppliers. In such a case, savings or reduction in cost of equipment is possible in the parts where domestic made products are being installed.

iii. Equipment or components of incineration plant that can be manufactured wholly by the domestic suppliers or manufacturers contributes the most significant savings in cost of the incineration plant.

c. Fig.6.5-14 shows the distribution of percentage of components cost of an incineration plan available in Malaysia. These figures were obtained after having considered possible cost reductions for the components. The composition of the pie chart in Fig.1 is described in the following page.

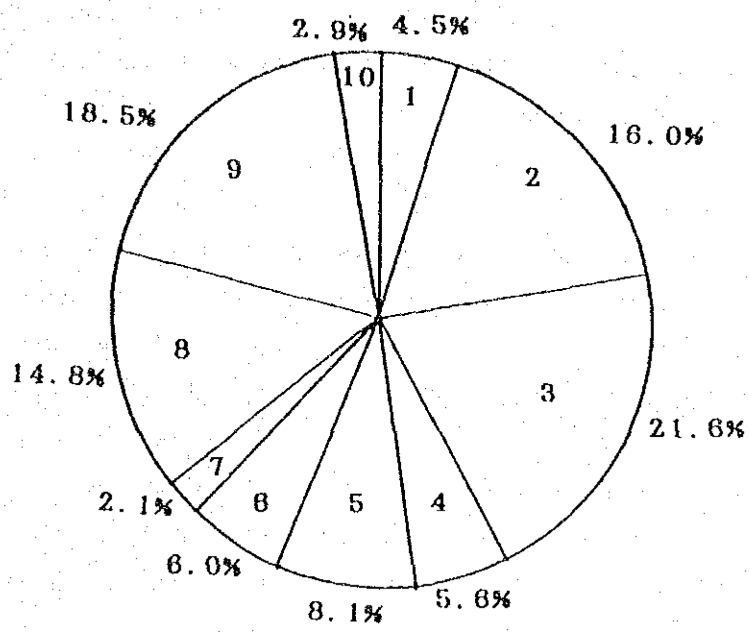


Fig. 6.5-14 Components of incineration plant cost in Malaysia

1 Receiving and Feeding Equipment
2 Stoker and Furnace
3 Waste Heat Boiler and its Accessories
4 Draught Equipment and Ash Discharger, Ash Crane.
5 Turbine/Generator and Steam Condenser.
6 Anti-pollution Equipment.
7 Piping and Miscellaneous.
8 Electrical Equipment, Instrumentation and Automatic Controller.
9 Refuse Storage Pit, Concrete Basement Works and Incinerator House Building.
10 Foundtion and Infrastructual Works.

(4) Cost Reduction - The Acceptable Level

Introduction of incineration plant requires economic considerations such as its investment cost, operation and maintenance cost, revenue from sale of recovered energy, financial condition of the Municipality Council, budget allocation, availability of subsidies or loans, etc.

In relation to the economic considerations and the technical requirments, possibilities of reducing the cost of incineration plant are discussed here.

The investment cost on the incineration plant for alternative 1-A was derived after having satisfied all the conditions for cost estimation and requirments expects expected from year 2005. The price or cost derived from this method would be the master plan price of the incineration plant.

To reduce the cost of the acceptable level means some changes in specification of the plant has to be made without sacrificing the quality of the incineration plant (i.e. neither the plant abilities nor exclusion of anti-pollution facilities will be affected by the cost cutting measure).

There are 5 possible wasy of reducing the cost of incineration plant, which does not sacrifice the acceptable quality of plant.

i. Simplification of instrumentation and automatic control system.
ii. Simplification of incinerator building by exclusion of less necessary walls, adoption of an outdoor type electrostatic precipitator, etc.
iii. Wider use of selected refractory briks which are produced locally.
iv. Wider use of Malaysian made products in boiler parts and its accessories.
v. Increasing the percentage of Malaysian made products through technology transfer and supervision by foreign experts. The stoker and its operating device construction is one example where the locals can participate under an experts supervision and also cut the cost.

If all the cost cutting measures are utilized and satisfied, the price of the incineration plant would be reduced to about 80% of the original investment. At this level it should be noted that the quality of incineration plant is still acceptable with regards

to the environmental conservation and regulation.
The probable rates of cost reduction are shown in Table.

(5) Further Cost Reduction and Consequences

The Study Team does not recommend the adoption of any of the measures below. Although the initial price of incineration plant may be reduced but the quality of incineration plant will inevitably be lowerd and subjected to non-compliance environmental quality requirements.

Methods of cost reduction and problems arising from qualities of plant due to the cost cutting mesure are described below.

Table 6.5-33 Probable rate of cost reduction

Items	Acceptable Cost Reduction (80 % of M/P Price)	Further Cost Reduction (60 % M/P Price)
1. Simplification of Instrumentation and Automatic Control System	4.4 %	
2. Simplification of Incinerator House etc.	4.6 %	
3. Selected Use of Locally made Bricks etc.	2.4 %	
4. Wider Use of Malaysian made Boiler Parts	4.3 %	
5. Licensed Manufacturing of Combustion Equipent	3.2 %	
Sub Total	18.9 %	18.9 %
1. Reduction of E.P Efficiency		0.9 %
2. Exclusion of HCl-gas Eliminator		2.1 %
3. Exclusion of Noise Countermeasure		2.8 %
4. Assemble of Cheapest		3.7 %
5. Wider Selection of Manufacturers		9.6 %
Sub total		19.1 %
Grand total	18.9 % ≒ 20 %	38 % ≒ 40 %

i. Lowering the electrostatic precipitator's efficiency and increasing the dust emission level from $0.1g/Nm^3$ to $0.4g/Nm^3$ ($0.4g/Nm^3$ is the legal permissible limits set by the Government).

The problem accompanying this measure is the possibility of visible stack emission (visible smoke) which may be objectionable to the surrounding residents.

ii. Exclusion of HCl gas removal equipment to reduce investment cost.

The exclusion of this equipment may result to non-compliance of the legal standards of Environmental Quality (Clean Air) Regulations 1978 i.e. HCl gas emission shall be less than 400 mg/Nm^3.

iii. Exclusion of noise protection measure if sufficiently wide land is available to buffer the noise generated from the incineration plant.

The crew however, will have to work under server noise level condition.

iv. Selection and assembling of the cheapest equipment is the easiest way to obtain the cheapest plant.

The above measure would involve many different component manufacturers resulting to the problems listed below.

- Difficulties in operation and maintenance work because many different operation and maintenance procedure will have to be observed.
- Many different kinds of spare parts will have to be stocked. Management and proper detail records of all stocks shall have to be kept.
- For overhaul works, simultaneous service from all the different manufacturers during the specified overhaul period may not be obtainable and observing the stipulated overhaul schedule may be difficult.

v. Wider choice of selection on type of incinerator plant. Such as the introduction of modular furnace may signify the cost reduction.

However, the adoption of modular furnace requires the following considerations:-

- To avoid fluctuation of furnance temperature, more fuel will be requied under normal operation of the modular furnace.
- Efficiency of energy recovery in the modular furnace system is usually lower than that of Mass Burning furnace.
- Volume reduction rate (from waste to ash) is usually low due to imperfect combustion.
- Generally, the modular furnace capacity of each unit is limited up to 100 tons/day. Therefore, to incinerate waste of more than the unit capacity,several incineration units have to be installed into one plant. Maintenance and operation will be more difficult because it involves more difficult becouse it invoves more number of furnaces. Consequently, the crew required for operation may also have to be increased.

  It should be stressed here that the plant cost would widely depending on the quality and reliability of the plant manufacturers participating in the bidding.

  Therefore, an open tender system without any pre-qualification set by a qualified consultant must not be encouraged.

6.6 Final Disposal

6.6.1 Selection of System Components

(1) System Alternatives

In consideration of the system alternatives of final disposal, the following three aspects are to be considered ;

a. Location and number of final disposal sites.

Location and number of final disposal sites are discussed in the chapter 3. Through the site selection, the location and number of final disposal sites are determined as the candidate sites for the Master Plan alternatives study.

b. Means of final disposal

The means of final disposal are classified into the followings ;

- Open dumping
- Control tipping
- Sanitary landfill

A sanitary landfill should be used as the means of final disposal. A sanitary landfill has proved to be the most economical and acceptable method for the disposal of solid wastes. The term sanitary landfill means an operation in which the wastes to be disposed of are compacted and covered with a layer of soil at the end of each day's operation. When the disposal site has reached its ultimate capacity — that is, after all disposal operations have been completed — a final layer of 60cm or more of cover material is applied. Open dumping and control tipping, as distinguished from sanitary landfilling, are used in the country, but is no longer an acceptable means of land disposal from an aesthetic, environmental or sanitary standpoint.

The advantages of sanitary landfills are shown below.

- Where land is available, a sanitary landfill is usually the most economical method of solid waste disposal.

- The initial investment is low compared with other disposal methods, such as composting and incineration.

- A sanitary landfill is a complete or final disposal method as compared to incineration and composting which require additional treatment or disposal operations for residue, quenching water, unusable materials, etc.

- A sanitary landfill can receive all types of solid wastes, eliminating the necessity of separate collections.

- A sanitary landfill is flexible ; increased quantities of solid wastes can be disposed of with little additional personnel and equipment.

- Submarginal land may be reclaimed for use as parking lots, playgrounds, golf courses, botanical garden, etc.

c. Recovery of methane gas

As the price of fuel gas is cheap and demand for heat is small in the vicinity of candidate sites, it is excluded from the technical systems considered.

(2) Selection of Candidate Sites

After the evaluation of the 13 potential sites for final disposal, the following 3 candidate sites are selected. These are screened through the alternative study for the Master Plan. Then finally, some of it will be selected as the final disposal sites.

- Pantai Acheh in MPPP
- Kuala Muda in MPSP
- Pulau Burong in MPSP

6.6.2 Preliminary Design of Disposal Sites

(1) Planning Procedure

a. Planning flow

In order to plan a disposal site at the Master Plan Stage, a planning flow is illustrated in Fig. 6.6-1.

b. Considerations for planning

In the application of above-mentioned planning flow, the following items are to be considered ;

i. Study on wastes to be disposed

- Waste quality (types of wastes)
- Unit weights of wastes
- Calculation of disposal amount

ii. Study on condition of sites

In the study of conditions of the disposal sites, the following items are to be considered with regards to the sites.

① Haul distance from main waste generation area

② Available land area

③ Soil conditions and topography

④ Availability of cover soil

⑤ Climatologic conditions

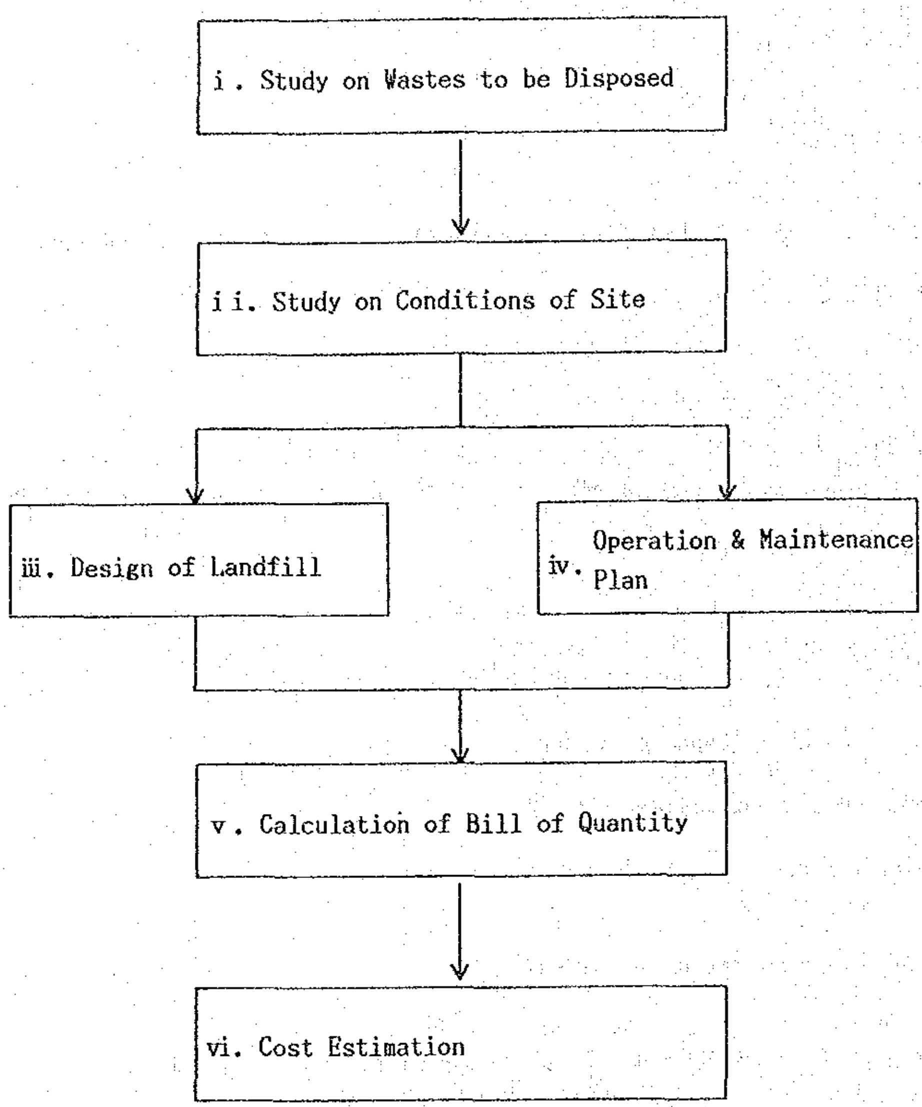
⑥ Surface-water hydrology

⑦ Geologic and hydrogeologic conditions

⑧ Local environmental conditions

⑨ Ultimate uses

Fig. 6.6-1 Planning Flow of Disposal Site



iii. Design of landfill

Among the important factors that must be considered in this stage are the following ;

- Types of wastes that must be handled
- Landfill volume

And the facilities which are needed to be preliminarily designed at this stage are as follows ;

- Site preparation works
- Access
- Enclosing structures
- Environmental prevention measures
- Leachate collection and treatment
- Drainage and ground water protection
- Gas removal
- Administration and inspection
- Basic utilities

iv. Operation and maintenance plan

- Operation plan
  : days and hours of operations
  : codisposal
  : recovery of gas
  : cover materials
- Equipment requirements
- Personnel requirements

v. Calculation of bill of quantity.

Based on the desing of landfill, operation and maintenance plan, bill of quantity of each site for each alternative is calculated in regards to the followings;

- civil and mechanical works
- equipment required
- personnel, utilities, fuel, covering materials and maintenance accessories

vi. Cost estimation

Cost estimation are derived based on the calculated quantities and the scheduled rates obtained during the study.

(2) Preliminary Design of Each Landfill

a. Study on waste to be disposed

i . Types of wastes

In order to calculate wastes amount to be disposed in terms of volume landfill volume), types of waste are classified into the following categories.

① Municipal waste without treatment

This category of waste include all councils - collected waste and carried-in waste from the private sector.

② Direct haul wastes

This wastes include some of carried-in wastes from the private sector and they are incombustible like construction demolitions.

③ OH wastes

These wastes are the same as municipal wastes without treatment. In the introduction of incineration plants,there will be "overhaul" periods for maintenance purposes. During these periods, some incoming waste shall not be able to be incinerated and are directly disposed of to the disposal sites without any treatment. These kind of waste is known as OH waste.

④ Residues

After the combustion, the incineration plants produce some amount of ash including some incombustible wastes. Those are called as the residues.

ii . Treatment and disposal amount

According to the collection plan, the treatment and disposal amount per day for each facility in each alternative is calculated below.

— Alt.1 Independent Disposal - Direct Haulage

① MPPP

	1990	1992	1995	2000	2005	Year
PADS	446.0	483.2	539.0	644.3	770.0	ton/day

② MPSP

	1990	1992	1995	2000	2005	Year
KMDS	147.5	168.1	199.1	252.7	311.4	ton/day
PBDS	169.5	196.9	238.0	298.1	368.0	ton/day

— Alt.2 Independent Disposal - Introduction of Transfer Station

① Transfer Station

	1990	1992	1995	2000	2005	Year
MPPP JMTS	408.9	442.1	491.9	582.2	686.4	ton/day
MPSP MMTS	229.1	260.7	308.1	381.4	462.2	ton/day

② Final Disposal

	1990	1992	1995	2000	2005	Year
MPPP PADS	446.0	483.2	539.0	644.3	770.0	ton/day
MPSP KMDS	53.9	62.5	75.3	99.2	126.7	ton/day
PBDS	263.1	302.6	361.8	451.6	552.7	ton/day

— Alt.3 Independant Disposal - Introduction of Incineration Plant

① Transfer Station

	1990	1992	1995	2000	2005	Year
MPPP BPTS	29.2	31.1	34.0	38.4	44.1	ton/day

② Incineration Plant

	1990	1992	1995	2000	2005	Year
MPPP F T Z I P	381.0	412.8	460.5	550.5	657.6	ton/day
MPSP P I C I P	250.7	291.1	351.8	444.6	549.8	ton/day

③ Final Disposal

	1990	1992	1995	2000	2005	Year
MPPP P A D S	110.7	119.9	133.8	159.9	191.3	ton/day
Residues	45.7	49.5	55.3	66.1	78.9	ton/day
OH waste	24.3	26.3	29.4	35.1	42.0	ton/day
Direct Haul	40.7	44.1	49.1	58.7	70.4	ton/day
MPSP P B D S	96.4	108.8	127.5	159.6	195.6	ton/day
Residues	30.1	34.9	42.2	53.4	66.0	ton/day
OH waste	16.0	18.6	22.5	28.4	35.1	ton/day
Direct Haul	50.3	55.3	62.8	77.8	94.5	ton/day

— Alt.4 Intermunicipal Disposal - Direct Haulage

① Final Disposal

	1990	1992	1995	2000	2005	Year
K M D S	147.5	168.1	199.1	252.7	311.4	ton/day
P B D S	615.5	680.1	777.0	942.4	1138.0	ton/day

— Alt.5 Intermunicipal Disposal - Introduction of Transfer Station for Motor Vehicles

① Transfer Station

	1990	1992	1995	2000	2005	Year
MPPP B P T S	29.2	31.1	34.0	38.4	44.1	ton/day
J M T S	416.8	452.1	505.0	605.9	726.0	ton/day

② Final Disposal

	1990	1992	1995	2000	2005	Year
KMDS	147.5	168.1	199.1	252.7	311.4	ton/day
PBDS	615.5	680.1	777.0	942.4	1138.0	ton/day

— Alt.6 Intermunicipal Disposal - Introduction of Transfer Station for Ocean-going Vessels

① Transfer Station

	1990	1992	1995	2000	2005	Year
MPPP BPTS	29.2	31.1	34.0	38.4	44.1	ton/day
FTZTS	446.0	483.2	539.0	644.3	770.0	ton/day
MPSP MMTS	229.1	260.7	308.1	381.4	462.2	ton/day

② Final Disposal

	1990	1992	1995	2000	2005	Year
KMDS	53.9	62.9	75.3	99.2	126.7	ton/day
PBDS	709.1	785.8	900.8	1095.9	1322.7	ton/day

— Alt.7 Intermunicipal Disposal - Introduction of Incineration Plant

① Transfer Station

	1990	1992	1995	2000	2005	Year
MPPP BPTS	29.2	31.1	34.0	38.4	44.1	ton/day

② Incineration Plant

	1990	1992	1995	2000	2005	Year
MPPP FTZIP	381.0	412.8	460.5	550.5	657.6	ton/day
MPSP PICIP	250.7	291.1	351.8	444.6	549.8	ton/day

③ Final Disposal

	1990	1992	1995	2000	2005	Year
MPSP PBDS	207.1	228.8	261.3	319.5	386.9	ton/day
Residues	75.8	84.5	97.5	119.5	144.9	ton/day

OH waste	40.3	44.9	51.9	63.5	77.1	ton/day
Direct Haul	91.0	99.4	111.9	136.5	164.9	ton/day

— Alt.8 Intermunicipal Treatment and Disposal - Introduction of Incineration Plant

① Transfer Station

	1990	1992	1995	2000	2005	Year
MPPP BPTS	29.2	31.1	34.0	38.4	44.1	ton/day

② Incineration Plant

	1990	1992	1995	2000	2005	Year
MPSP PICIP	658.6	733.9	846.9	1037.4	1258.8	ton/day

③ Final Disposal

	1990	1992	1995	2000	2005	Year
PBDS	183.4	202.4	230.8	282.2	341.7	ton/day
Residues	79.0	88.0	101.6	124.5	151.1	ton/day
OH waste	13.4	15.0	17.3	21.2	25.7	ton/day
Direct Haul	91.0	99.4	111.9	136.5	164.9	ton/day

iii. Cumulative disposal amount and volume

Based on the above calculation, the cumulative disposal amount and volume for each disposal site in each alternative is calculated below in Table 6.6-1. The final density of solid wastes placed in a landfill varies with the mode of operation of the landfill, the compactability of the individual solid waste components, and the percentage distribution of the components. The types of wastes that must be handled have been classified in 6.6.2.(2).a.i. The final density of each type of solid wastes placed in a landfill, the unit weight of each type of waste is decided as follows;

① Municipal wastes without treatment; 0.8 ton/m^3

② Direct haul wastes; 0.8 ton/m^3

③ OH wastes; 0.8 ton/m^3

④ Residues; 1.2 ton/m^3

Table 6.6-1 Cumulative Disposal Quantities for Each Disposal Site in Each Alternative

(1)

Alt. 1

Site	Item	Unit	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
MPPP PADS	Disposal Amount per Year	(1000ton)	176	183	190	197	204	212	220	227	235	244	254	263	272	281
	Cumulative Amount	(1000ton)	176	360	549	746	951	1163	1383	1610	1845	2090	2343	2606	2878	3159
	Cumulative Amount	(1000m3)	220	449	687	933	1188	1453	1728	2013	2306	2612	2929	3257	3597	3948
MPSP KMDS	Year		1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	Disposal Amount per Year	(1000ton)	61	65	69	73	77	80	84	88	92	97	101	105	109	114
	Cumulative Amount	(1000ton)	61	126	195	268	345	425	510	598	690	787	887	993	1102	1216
	Cumulative Amount	(1000m3)	77	158	244	335	431	531	637	747	863	983	1109	1241	1377	1519
PBDS	Disposal Amount per Year	(1000ton)	72	77	82	87	91	96	100	104	109	114	119	124	129	134
	Cumulative Amount	(1000ton)	72	149	231	317	409	504	604	709	818	932	1051	1175	1304	1438
	Cumulative Amount	(1000m3)	90	186	288	397	511	630	756	886	1022	1164	1313	1468	1630	1798

Alt. 2

Final Disposal

Site	Item	Unit	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
MPPP PADS	Disposal Amount per Year	(1000ton)	176	183	190	197	204	212	220	227	235	244	254	263	272	281
	Cumulative Amount	(1000ton)	176	360	549	746	951	1163	1383	1610	1845	2090	2343	2606	2878	3159
	Cumulative Amount	(1000m3)	220	449	687	933	1188	1453	1728	2013	2306	2612	2929	3257	3597	3948
MPSP KMDS	Year		1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	Disposal Amount per Year	(1000ton)	23	24	26	27	29	31	33	34	36	38	40	42	44	46
	Cumulative Amount	(1000ton)	23	47	73	101	130	161	194	228	264	302	343	385	429	475
	Cumulative Amount	(1000m3)	29	59	91	126	162	201	242	285	330	378	428	481	536	594
PBDS	Disposal Amount per Year	(1000ton)	110	118	125	132	139	145	152	158	165	172	180	187	194	202
	Cumulative Amount	(1000ton)	110	228	353	485	624	769	921	1079	1244	1416	1595	1782	1977	2179
	Cumulative Amount	(1000m3)	138	285	441	606	780	961	1151	1348	1555	1770	1994	2228	2471	2723

Alt. 3

Incineration Plant

			1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	Year		1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
MPPP	FTZIP Disposal Amount per Year	(1000ton)	413	429	445	461	479	497	515	533	551	572	593	615	636	658
MPSP	PICIP Disposal Amount per Year	(1000ton)	291	311	332	352	371	390	409	428	447	467	488	509	529	550

Final Disposal

MPPP

PADS	Year		1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	Residue Amount per Year	(1000ton)	18	19	19	20	21	22	23	23	24	25	26	27	28	29
	Residue Cumlative Amount	(1000ton)	18	37	56	77	97	119	142	165	189	214	240	267	295	324
	Residue Cumlative Volume	(1000m3)	15	31	47	64	81	99	118	138	158	179	200	223	246	270
	OH Waste Amount per Year	(1000ton)	10	10	10	11	11	12	12	12	13	13	14	14	15	15
	Direct Haul Amount per Year	(1000ton)	16	17	17	18	19	19	20	21	21	22	23	24	25	26
	Total Cumlative Amount	(1000ton)	26	52	80	109	138	169	201	234	269	304	341	380	419	460
	Total Cumlative Volume	(1000m3)	32	65	100	136	173	212	252	293	336	380	427	474	524	575

MPSP

PBDS	Year															
	Residue Amount per Year	(1000ton)	13	14	15	15	16	17	18	19	19	20	21	22	23	24
	Residue Cumlative Amount	(1000ton)	13	26	41	56	73	90	107	126	146	166	187	210	233	257
	Residue Cumlative Volume	(1000m3)	11	22	34	47	60	75	89	105	121	138	156	175	194	214
	OH Waste Amount per Year	(1000ton)	7	7	8	8	9	9	10	10	10	11	11	12	12	13
	Direct Haul Amount per Year	(1000ton)	20	21	22	23	24	25	26	27	28	30	31	32	33	34
	Total Cumlative Amount	(1000ton)	27	55	85	116	149	183	219	256	295	335	377	421	467	514
	Total Cumlative Volume	(1000m3)	34	69	106	145	186	229	273	320	368	419	472	527	584	643

(3)

Alt. 4 & 5

Final Disposal

MPSP	Year		1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
KMDS	Disposal Amount per Year	(1000ton)	61	65	69	73	77	80	84	88	92	97	101	105	109	114
	Cumulative Amount	(1000ton)	61	126	195	268	345	425	510	598	690	787	887	993	1102	1216
	Cumulative Volume	(1000m3)	77	158	244	335	431	531	637	747	863	983	1109	1241	1377	1519
PBDS	Disposal Amount per Year	(1000ton)	248	260	272	284	296	308	320	332	344	358	373	387	401	415
	Cumulative Amount	(1000ton)	248	508	780	1064	1359	1667	1987	2319	2663	3021	3394	3780	4182	4597
	Cumulative Volume	(1000m3)	310	635	975	1330	1699	2084	2484	2899	3329	3776	4242	4726	5227	5746

Alt. 6

Final Disposal

MPSP	Year		1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
KMDS	Disposal Amount per Year	(1000ton)	23	24	26	27	29	31	33	34	36	38	40	42	44	46
	Cumulative Amount	(1000ton)	23	47	73	101	130	161	194	228	264	302	343	385	429	475
	Cumulative Volume	(1000m3)	29	59	91	126	162	201	242	285	330	378	428	481	536	594
PBDS	Disposal Amount per Year	(1000ton)	287	301	315	329	343	357	372	386	400	417	433	450	466	483
	Cumulative Amount	(1000ton)	287	588	902	1231	1574	1932	2303	2689	3089	3505	3938	4388	4854	5337
	Cumulative Volume	(1000m3)	359	735	1128	1539	1968	2414	2879	3361	3861	4382	4923	5485	6068	6671

Alt. 7

Incineration Plant

			1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
MPPP	FTZIP Disposal Amount per Year	(1000ton)	413	429	445	461	479	497	515	533	551	572	593	615	636	658
MPSP	PICIP Disposal Amount per Year	(1000ton)	291	311	332	352	371	390	409	428	447	467	488	509	529	550

Final Disposal

MPSP

PBDS	Year		1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	Residue Amount per Year	(1000ton)	31	32	34	36	37	39	40	42	44	45	47	49	51	53
	Residue Cumlative Amount	(1000ton)	31	63	97	133	170	209	249	291	335	380	428	477	528	581
	Residue Cumlative Volume	(1000m3)	26	53	81	111	142	174	208	243	279	317	356	397	440	484
	OH Waste Amount per Year	(1000ton)	16	17	18	19	20	21	21	22	23	24	25	28	27	28
	Direct Haul Amount per Year	(1000ton)	36	38	39	41	33	25	16	8		12	24	36	48	60
	Total Cumlative Amount	(1000ton)	53	108	165	225	277	323	360	391	414	450	499	562	637	725
	Total Cumlative Volume	(1000m3)	66	135	206	281	347	403	450	489	518	563	624	702	796	907

Alt. 8

Incineration Plant

			1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
MPSP	PICIP Disposal Amount per Year	(1000ton)	734	772	809	847	885	923	961	999	1037	1082	1126	1170	1215	1259

Final Disposal

MPSP

PBDS	Year		1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	Residue Amount per Year	(1000ton)	32	34	35	37	39	40	42	44	45	47	49	51	53	55
	Residue Cumlative Amount	(1000ton)	32	66	101	138	177	218	260	303	349	396	446	497	550	605
	Residue Cumlative Volume	(1000m3)	27	55	84	115	148	181	216	253	291	330	371	414	458	504
	OH Waste Amount per Year	(1000ton)	5	6	6	6	7	7	7	7	8	8	8	9	9	9
	Direct Haul Amount per Year	(1000ton)	36	38	39	41	43	44	46	48	50	52	54	56	58	60
	Total Cumlative Amount	(1000ton)	42	85	131	178	227	278	332	387	445	505	567	632	699	769
	Total Cumlative Volume	(1000m3)	52	107	163	222	284	348	415	484	556	631	709	790	874	961

b. Conditions of candidate site

The conditions for the planning of each candidate site are described and tabulated in Table 6.6-2.

c. Design of Landfill

i. Landfill volume

Based on the cumulative disposal amount, volume and conditions of each candidate site, the landfill volume of each candidate site for each alternative is calculated and tabulated in Table 6.6-3.

The items in the table, are described as follows;

① Total disposal amount

Based on the Table 6.6-1, total disposal amount from year 1992, when the site will start operation, to year 2005 is calculated. Municipal wastes here include municipal waste without treatment, direct haul wastes and OH wastes.

② Total disposal volume

Total disposal volume is calculated using formula;

$$TDV = MWA \div 0.8\ (ton/m^3) + RA \div 1.2\ (ton/m^3)$$

TDV ; Total Disposal Volume

MWA ; Municipal Waste Amount

RA ; Residue Amount

③ Required area for facilities

A site development plan for each candidate site is made and shown in Fig. 6.6-2, -3, -4, -5 and -6. As shown is the figures, the area for the following facilities is required.

- Bund and operation facilities
- Buffer zone and others
- Oxidation pond

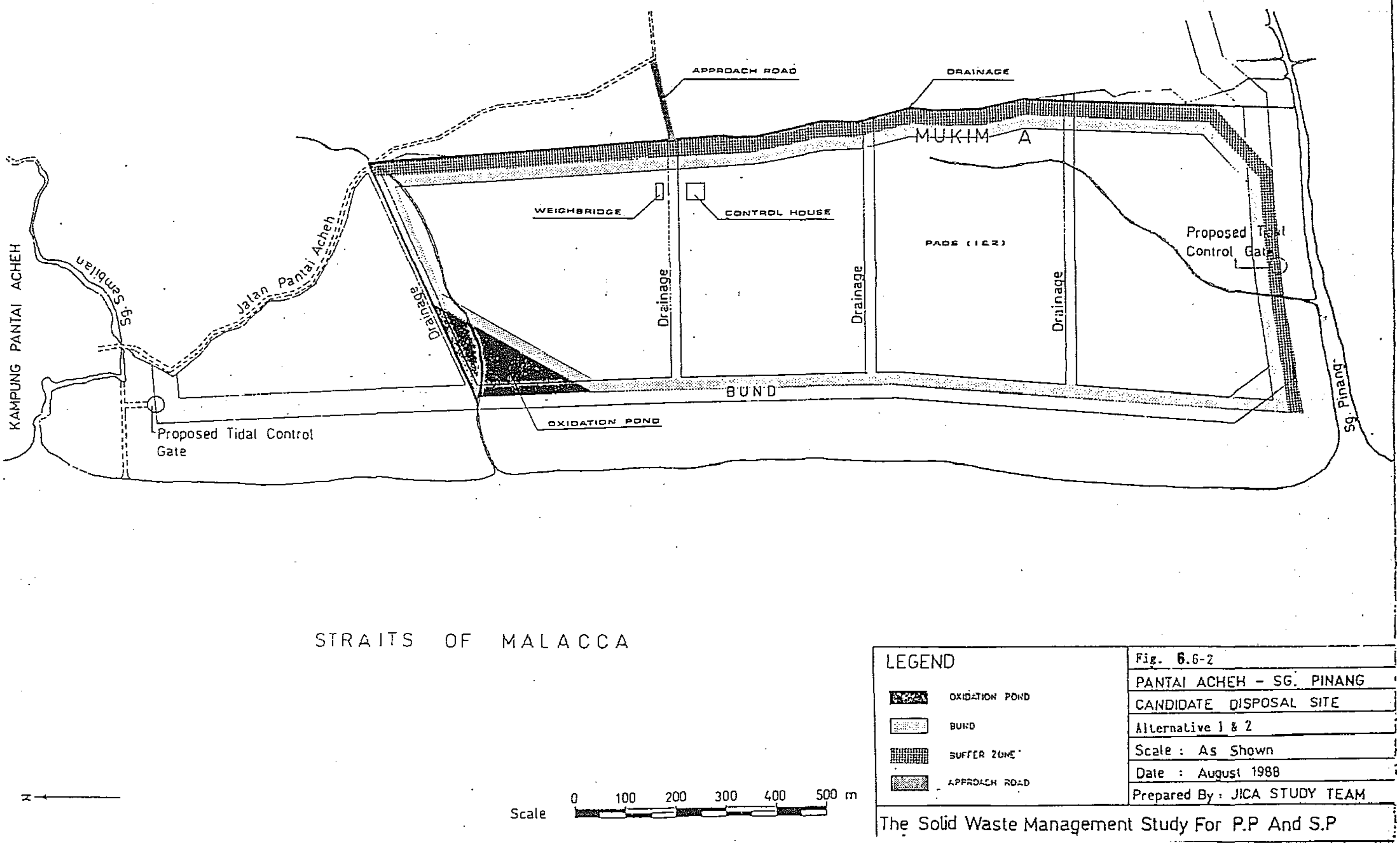
Table 6.6-2 Conditions of Candidate Sites for Final Disposal

Items \ Site	MPPP	MPSP	
	Pantai Acheh	Kuala Muda	Pulau Burong
① Haul distance from main waste generation area (km)	35.0 (from Georgetown)	20.0 (from Butterworth)	35.0 (from Butterworth)
② Available land area (ha)	85.0	more than 78.0	more than 35.0
③ Soil conditions and topography	Silty clay and lowlying marsh	Silty sand and lowlying marsh	Silty clay and lowlying marsh
④ Availability of cover soil	Availability shall be checked in subsequent study	Availability shall be checked in subsequent study	Availability shall be checked in subsequent study
⑤ Climatology conditions	Subsequent study	Subsequent study	Subsequent study
⑥ Surface-water hydrology	Part of larger drainage catchment and plain land	Part of larger drainage catchment and plain land	Independant catchment area and plain land
⑦ Geologic and hydrogeologic conditions	Quaternary alluvial soil (clay and silt). Ground water in unconsolidated soil. Alluvium: consisting of loose clayey-sandy-gravelly deposits generally bordering foothills of highlands commonly of limited thickness.	Quaternary alluvial soil (clay and silt). Ground water in unconsolidated soil. Alluvium: essentially of loose clayey-sandy-gravelly deposits generally along the coastal plains, commonly of extensive thickness.	Quaternary alluvial soil (clay and silt). Ground water in unconsolidated soil. Alluvium: essentially of loose clayey-sandy-gravelly deposits generally along the coastal plains, commonly of extensive thickness.
⑧ Local environmental conditions	Away from both residential and industrial development areas.	In close proximity to residential area	Away from both residential and industrial development areas.
⑨ Ultimate uses	Subsequent study	Subsequent study	Subsequent study

TABLE 6.6-3 Landfill Volume and Required Height of Each Candidate Site for Each Alternative

I T E M S	Unit	Disposal Site and Alternatives											R e m a r k s
		P A D S		K M D S **		P B D S							
		1 & 2	3	1,4 & 5 Lagoon	2 & 6 Inland	1	2	3	4 & 5	6	7	8	
1 Total Disposal Amount	1000t	3159	784	1216	475	1438	2179	771	4597	5337	1556	1374	
Munincipal Wastes	1000t	3159	460	1216	475	1438	2179	514	4597	5377	975	769	Unit weight 0.8t/m3
Residues	1000t		324					257			581	605	Unit weight 1.2t/m3
2 *Total Disposal Volume of Waste*	*1000m3*	3949	845	1520	594	1798	2724	857	5746	6721	1703	1465	
Total Landfill Volume	1000m3	5133	1099	1976	772	2337	3541	1114	7470	8738	2214	1905	
3 Available Land Area	Ha	85.0	31.0	53.5	18.0				35.0				
4 *Effective Disposal Area*													
Area of Buffer Zone	Ha	11.0	5.0	5.0									
Area of Bund and Others	Ha	8.5	4.0	6.5	3.8				5.7				
Area of Oxidation Pond	Ha	2.0	2.0	2.0	2.0				2.0				
Effective Disposal Area	Ha	63.5	20.0	40.0	12.2				27.3				
5 *Total Landfll Volume* *													
1st Mount	m3	3175	1000	2000	610				1365				
2nd Mount	m3	2858	900	1800	549				1229				90% of 1st
3rd Mount	m3	2572	810	1620	494				1106				90% of 2nd
4th Mount	m3	2315	729	1458	445				995				90% of 3rd
5th Mount	m3	2083	656	1312	400				896				90% of 4th
6th Mount	m3	1875	590	1181	360				806				90% of 5th
7th Mount	m3	1687	531	1063	324				725				90% of 6th
8th Mount	m3	1519	478	957	292				653				90% of 7th
9th Mount	m3	1367	430	861	263				588				90% of 8th
6 Required Height by Year 2005	m	8.5	6.0	5.0	6.5	9.0	14.5	4.0	37.5	48.0	8.5	7.5	

* Total landfill volume includes covering material which is 30% of it.
** As for Kuala Muda site, the site is divided into two.
One is in lagoon and the other is inland.

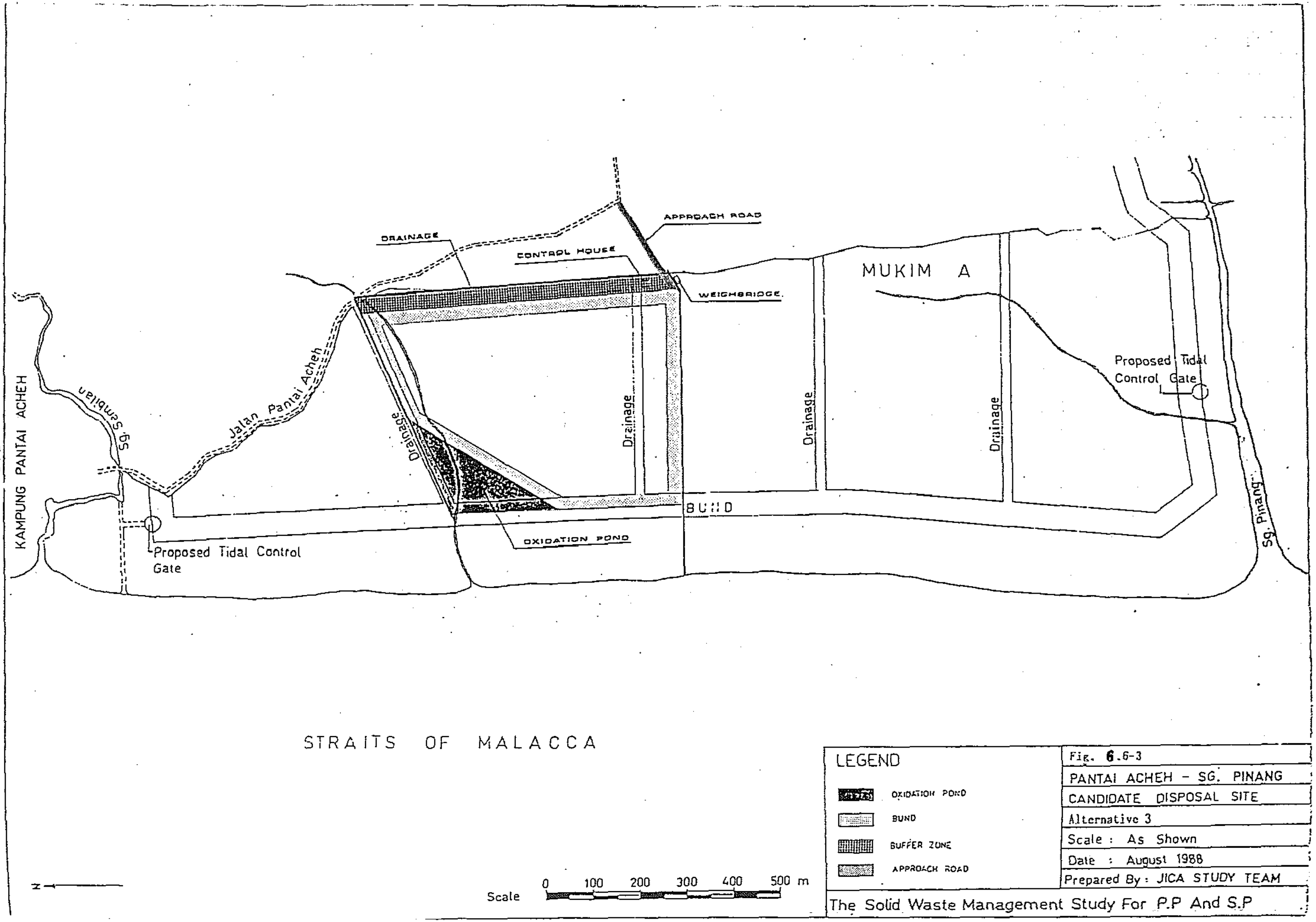


LEGEND

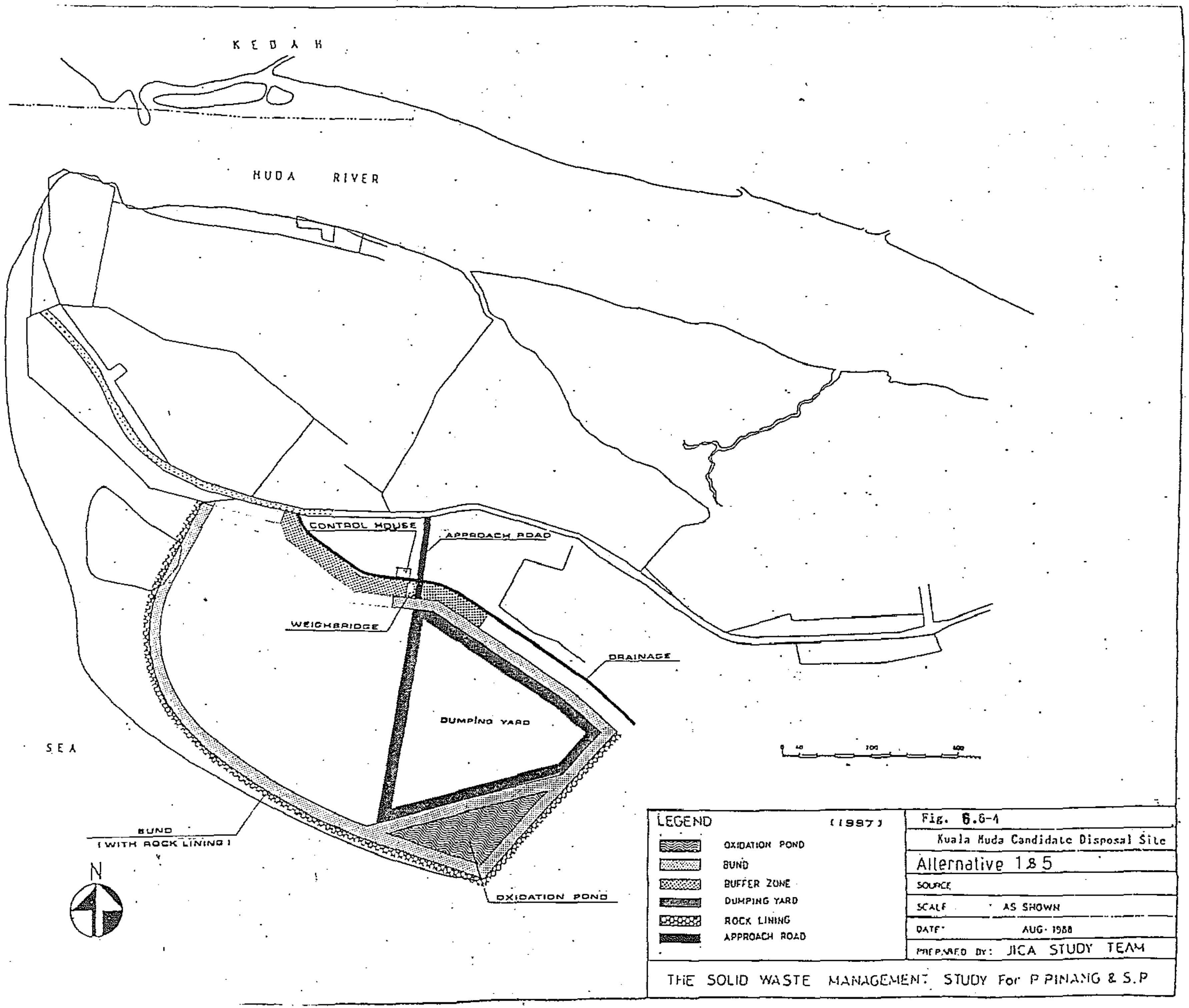
- OXIDATION POND
- BUND
- BUFFER ZONE
- APPROACH ROAD

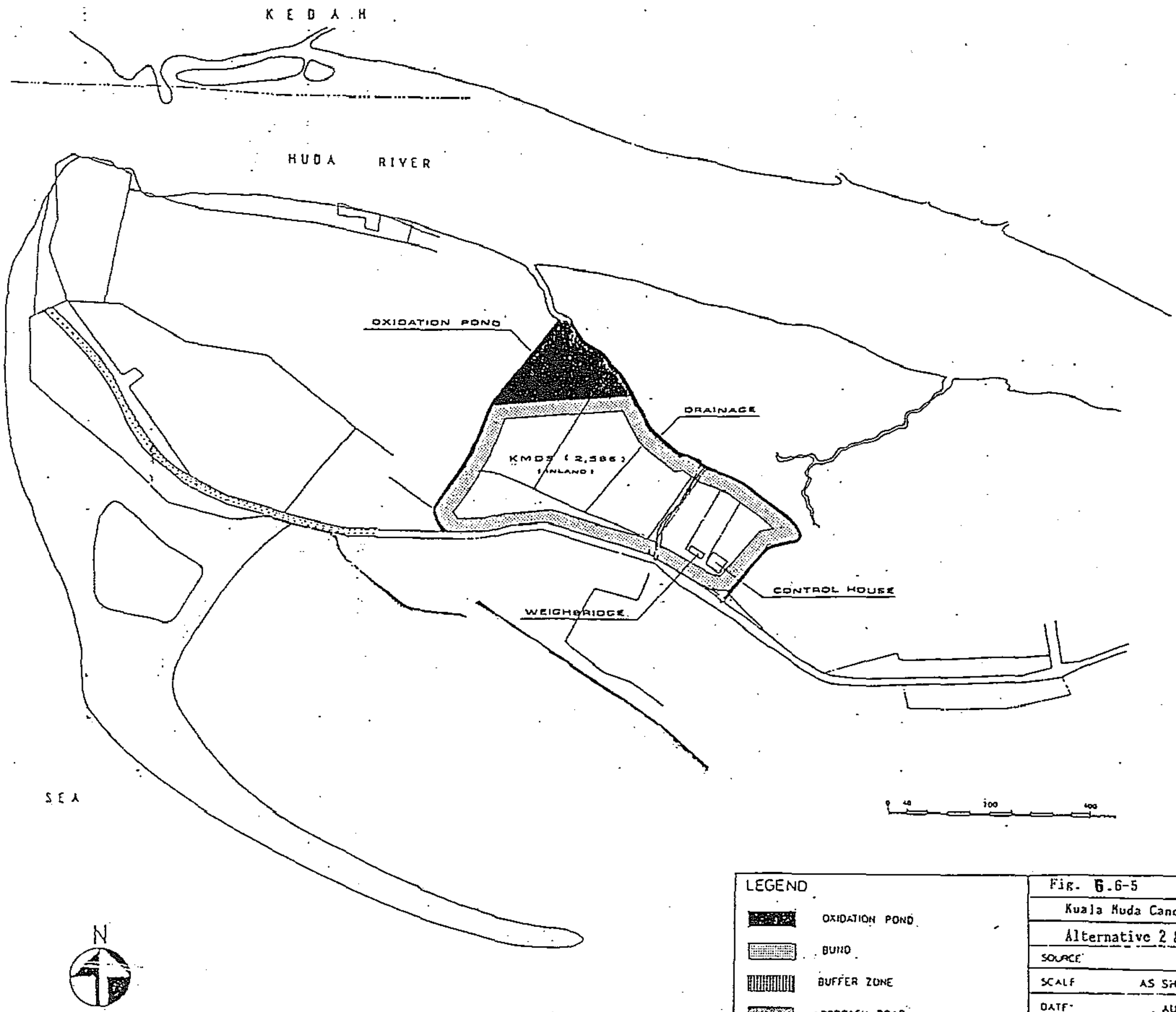
Fig. 6.6-2
PANTAI ACHEH - SG. PINANG
CANDIDATE DISPOSAL SITE
Alternative 1 & 2
Scale : As Shown
Date : August 1988
Prepared By : JICA STUDY TEAM

The Solid Waste Management Study For P.P And S.P



KAMPUNG PANTAI ACHEH
Sg. Sembilan
Jalan Pantai Acheh
Proposed Tidal Control Gate
DRAINAGE
CONTROL HOUSE
APPROACH ROAD
WEIGHBRIDGE.
Drainage
Drainage
Drainage
Drainage
MUKIM A
Proposed Tidal Control Gate
BUND
OXIDATION POND
Sg. Pinang
STRAITS OF MALACCA
N
Scale
0
100
200
300
400
500 m
LEGEND
OXIDATION POND
BUND
BUFFER ZONE
APPROACH ROAD
Fig. 6.6-3
PANTAI ACHEH - SG. PINANG
CANDIDATE DISPOSAL SITE
Alternative 3
Scale : As Shown
Date : August 1988
Prepared By : JICA STUDY TEAM
The Solid Waste Management Study For P.P And S.P

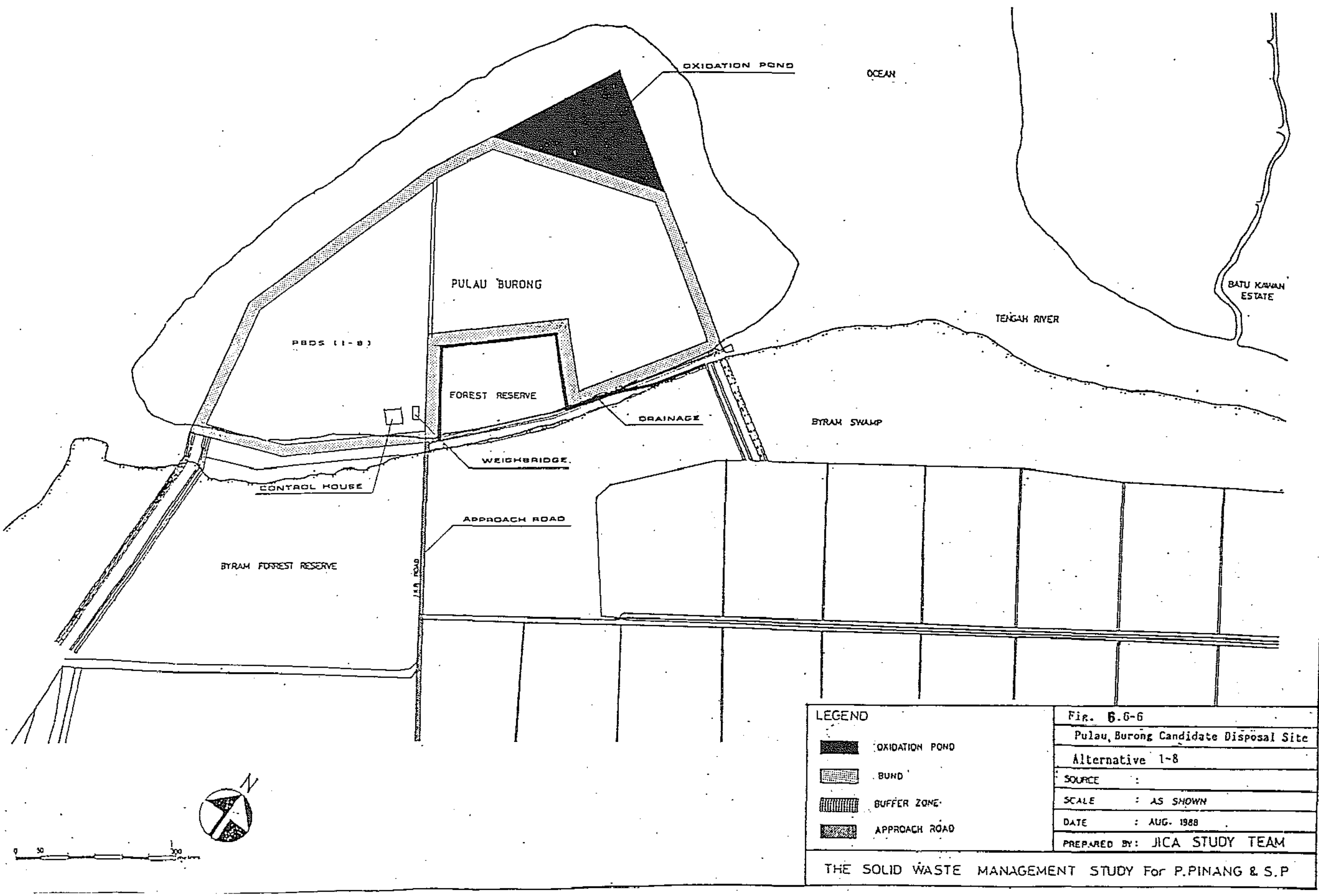

KEDAH
HUDA RIVER
SEA
CONTROL HOUSE
APPROACH ROAD
WEIGHBRIDGE
DRAINAGE
DUMPING YARD
OXIDATION POND
BUND (WITH ROCK LINING)
N
0 40 200 400
LEGEND (1997)
OXIDATION POND
BUND
BUFFER ZONE
DUMPING YARD
ROCK LINING
APPROACH ROAD
Fig. 6.6-4
Kuala Muda Candidate Disposal Site
Alternative 1&5
SOURCE
SCALE AS SHOWN
DATE AUG. 1988
PREPARED BY: JICA STUDY TEAM
THE SOLID WASTE MANAGEMENT STUDY For P PINANG & S.P



LEGEND
OXIDATION POND
BUND
BUFFER ZONE
APPROACH ROAD

Fig. 6.6-5
Kuala Muda Candidate Disposal Site
Alternative 2 & 8
SOURCE
SCALE AS SHOWN
DATE AUG. 1988
PREPARED BY JICA STUDY TEAM

THE SOLID WASTE MANAGEMENT STUDY For P PINANG & S.P


OXIDATION POND
OCEAN
BATU KAWAN ESTATE
TENGAH RIVER
PULAU BURONG
PBDS (1-8)
FOREST RESERVE
DRAINAGE
BYRAM SWAMP
WEIGHBRIDGE
CONTROL HOUSE
APPROACH ROAD
BYRAM FORREST RESERVE
N
0
50
100
LEGEND
OXIDATION POND
BUND
BUFFER ZONE
APPROACH ROAD
Fig. 6.6-6
Pulau, Burong Candidate Disposal Site
Alternative 1-8
SOURCE :
SCALE : AS SHOWN
DATE : AUG. 1988
PREPARED BY: JICA STUDY TEAM
THE SOLID WASTE MANAGEMENT STUDY For P.PINANG & S.P

Subsequently, the effective disposal area comes from the subtraction of areas required for the above-mentioned three facilities from the available land area.

④ Landfill volume for waste

Based on the effective area, landfill volume for wastes is calculated in the following manners;

- Each mount is 5m in height.
- Volume for cover materials is 30% of total landfill capacity.
- Based on the above-mentioned assumption, landfill volume of the first mount is calculated.
- Subsequently, landfill volume of the second mount is calculated based on the 10% reduced area of the effective disposal area for the first mount.
- The landfill volume of the succeeding mount is calculated by the same manner above-mentioned.

⑤ Required height for disposal by year 2005

In order to find out reclaimed height for final disposal by the year 2005, required height is calculated based on total disposal volume.

ii. Design of facilities

The facilities which are needed to be preliminarily designed at this stage are as follows;

- Site preparation works
- Access
- Enclosing structures
- Environmental prevention measures
- Leachate collection and treatment
- Drainage and ground water protection
- Gas removal
- Administration and inspection
- Basic utilities

The considerations for the design of the above-mentioned facilities at this stage is described below.

① Site preparation works

Cleaning works of the site such as clearing, and grubbing.

② Access

Paved all-weather access roads to landfill site and on-site roads to unloading area are considered.

③ Enclosing structures

Bund and embankment are considered.

④ Environmental prevention measures

Buffer zone, fence, gate and car wash are considered.

⑤ Leachate collection and treatment

Leachate collection pipe and oxidation pond for leachate treatment are considered.

⑥ Drainage and groundwater protection

Installation of drainage canals to divert surface water runoff and sealants by clay are considered.

⑦ Gas removal

Gas removal facilities are considered.

⑧ Administration and inspection

Building including employee facilities and weighbridge are considered.

d. Operation and maintenance plan

The considerations for the operation and maintenance plan at this stage is described below.

① Operation plan

Basically, usual practice is 7 days/week and 7 hours/day.

Neither co-disposal of sludges nor the recovery of gas is considered.

Cover materials are considered to be imported at this stage and examination of availability of cover materials at the site will be studied at the feasibility study stage.

② Personnel requirements

Personnel required for the operation of the site is considered.

③ Equipment requirements for landfill

Based on the peak disposal amount per day, which includes cover materials, landfill equipment requirements are calculated.

e. Calculation of bill of quantity

Based on the design of landfill, operation and maintenance plan, bill of quantity of each site for each alternative is calculated.

g. Cost Estimation

After the calculation of bill of quantity, cost estimation is done based on construction price data collected.

(3) Outline of Each Disposal Sites

Based on the preliminary design, the outline of each disposal site is summarized and tabulated in Table 6.6-4.

Table 6.6-4. Outline of Each Disposal Site

I T E M S	Unit	DISPOSAL SITE AND ALTERNATIVES											R E M A R K S
		P A D S		K M D S		P B D S							
		1&2	3	1,4&5 Sea*	2 & 6 Inland*	1	2	3	4&5	6	7	8	
1 Civil & Mechanical Work													
Cleaning	ha	74.0	24.0		18.0	35.0	35.0	28.3	35.0	35.0	35.0	35.0	
Buffer Zone	m	2200	1000	1000									
Bund (Sea Coast)	m			1800									
Bund (Inland)	m	4200	1900	1400	2000	3000	3000	2800	3000	3000	3000	3000	
Bund (Inland) >2 Step	m	2600			1300	2200	5500		13000	14000	1700	1100	
Drainage	m	10000	2000	4500	2100	3500	3300	3000	8900	11000	3100	2700	
Access road (New)	m	200	200	200	1500								W=6 m Asphalt Pavement
Access road (Pavement Only)	m					1200	1200	1200	1200	1200	1200	1200	W=6 m Asphalt Pavement
On-site road	m	10000	2000	4500	2100	3500	3300	3000	8900	11000	3100	2700	W=6 m Gravel Pavement (t=0.3m)
Seapage Control (Inland)	ha	63.5	20.0	40.0	12.2	27.3	27.3	21.0	27.3	27.3	27.3	27.3	Clay (t=0.50 m)
Leachate collection pipe	m	10000	2000	4500	2100	3500	3300	3000	8900	11000	3100	2700	
Others	LS	1	1	1	1	1	1	1	1	1	1	1	Gas Removal, Fence, Gate and Car wash etc.
Weighbridge	No.	3	1	1	1	1	1	1	4	1	1	1	
Building	No.	1	1	1	1	1	1	1	1	1	1	1	
Oxidation Pond	No.	1	1	1	1	1	1	1	1	1	1	1	With Aerator
2 Equipment													
Tractor (Crawler)	No.	8	3	4	2	4	6	3	11	13	4	4	
Water truck	No.	1	1	1	1	1	1	1	1	1	1	1	
3 Operation & Maintenance													
i Personnel	No.	23	9	14	9	17	14	9	29	25	11	11	
Manager	No.	1	1	1	1	1	2	1	1	1	1	1	
Technician	No.	3	1	2	1	2	2	1	4	3	1	1	
Overseer	No.	6	2	2	2	6	6	2	6	2	2	2	
Operator	No.	8	3	4	3	4	1	3	11	13	4	4	
Laborer	No.	5	2	5	2	4	3	2	7	6	3	3	
ii Utility													
Water	1000m3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	
Electricity	Mwh	2630	2630	2630	2630	2630	2630	2630	2630	2630	2630	2630	
Fuel	1000 l	90	34	45	22	45	67	34	123	146	45	45	
iii Cover Materials	1000m3	105	22	43	17	50	76	24	116	181	45	40	
iv Maintenance													
Aerator for Oxidation Pond	No.	1	1	1	1	1	1	1	1	1	1	1	
Tractor (Crawler)	No.	8	3	4	2	4	6	3	11	13	4	4	
Water truck	No.	1	1	1	1	1	1	1	1	1	1	1	

* As for Kuala Muda site, the site is two. One is in lagoon and the other is inland.