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# SOLID WASTE MANAGEMENT STUDY FOR PULAU PINANG AND SEBERANG PERAI MUNICIPALITIES

## SUPPORTING REPORT

## VOLUME II

## PRELIMINARY DESIGN OF PANTAI ACHEH DISPOSAL SITE

AUGUST 1989

JAPAN INTERNATIONAL COOPERATION AGENCY

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## ABBREVIATION

| | | |
|---|---|---|
| ABC | : | Action Plan for a Beautiful and Clean Malaysia |
| BSDS | : | Bakau Street Disposal Site |
| BPTS | : | Balik Pulau Transfer Station |
| CIF | : | Cost, Insurance and Freight |
| DBKL | : | City Hall of Kuala Lumpur |
| DID | : | Drainage and Irrigation Department |
| DOE | : | Department of Environment |
| EIA | : | Environmental Impact Assessment |
| ENSEARCH | : | Environmental Management and Research Association of Malaysia |
| EPU | : | Economic Planning Unit |
| FTZIP | : | Free Trade Zone Incineration Plant |
| FTZTS | : | Free Trade Zone Transfer Station |
| GDP | : | Gross Domestic Product |
| IKU | : | Public Health Institute |
| JICA | : | Japan International Cooperation Agency |
| JKKK | : | Village Development and Security Committee |
| JMPDS | : | Jelutong Mole Previous Disposal Site |
| JMTS | : | Jelutong Mole Transfer Station |
| JPBD | : | Town and Country Planning Department |
| KEMAS | : | Community Development, Ministry of National and Rural Development |
| KMDS | : | Kuala Muda Disposal Site |
| LWL | : | Low Water Level |
| LA | : | Local Authority |
| M | : | Million |
| MC | : | Municipal Council |
| MMTS | : | Mak Mandin Transfer Station |
| MPPP | : | Majlis Perbandaran Pulau Pinang |
| MPSP | : | Majlis Perbandaran Seberang Perai |
| MOH | : | Ministry of Health |
| MHLG | : | Ministry of Housing and Local Government |
| M/P | : | Master Plan |
| MSWM | : | Municipal Solid Waste Management |
| NEB | : | National Electricity Board |
| NEP | : | New Economic Policy |
| PADS | : | Pantai Acheh Disposal Site |
| PBDS | : | Plan Burong Disposal Site |
| PDC | : | Penang Development Corporation |
| PERDA | : | Penang Rural Development Authority |
| PHA | : | Public Health Assistant |
| PHI | : | Public Health Inspector |
| PICIP | : | Prai Indusrial Complex Incineration Plant |
| PSD | : | Public Services Department, Prime Minister's Department |
| JKR/PWD | : | Public Works Department |
| PPC | : | Penang Port Commission |

| | | |
|---|---|---|
| PPC | : | Penang Port Commission |
| S/R | : | Suppoting Report |
| SWM | : | Solid Waste Management |
| SWMIS | : | Solid Waster Management Information System |
| TDC | : | Tourist Development Corporation |
| UDS | : | Urban Drainage System |
| USD | : | Urban Service Department |
| USM | : | University Sains Malaysia |

Volume II Preliminary Design of PADS in MPPP

CONTENTS

Page

Page

## List of Figures

Volume II.

# 1. Phased Improvement

## 1.1 Background of Phased Improvement

### (1) Design Principles Applied in the Master Plan

The design principles of sanitary landfill development and operation in the Master Plan are established so as to satisfy the following standards, guideline, etc.

a. DOE Standards

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

In Regulation 8, inland waters are divided into two areas, i.e. Standard-A catchment areas and Standard-B catchment areas. Standard-A areas are set for protection of water supply intakes for the purpose of human consumption including drinking.

Proposed Pantai Acheh diposal site is not located in the upperstream of water supply intakes. Therefore, Standard-B is applicable. The parameter limits of effluent in Standard-B are tabulated in Table 1.1-1.

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

c. Other aspects considered in the design

i. Social acceptability on noise, littering, landscape, odor, etc.

ii. Eco-system acceptability

iii. Operational acceptability

(2) Request for Phased Improvement

The realization of the sanitary landfill level, set up in the Master Plan is highly desirable in view of environmental preservation, social and operational acceptability. It is however, unavoidable to overcome the following financial difficulties in achieving the Master Plan targets.

a. Large capital investment

The capital investment on the development of Pantai Acheh sanitary landfill for Phase 1 is estimated to be very large for the Council, i.e. 18.5 million ringgit including cost of landfill equipment.
The Council however, has no financial source available for this development at present. It is therefore, necessary to obtain financial support from the Federal Government to materialize the development.

Table 1.1-1 Parameter Limits of Effluent of Standard B

| Parameter | Unit | Standard B |
|---|---|---|
| (i) Temperature | C | 40 |
| (ii) pH Value | — | 5.5-9.0 |
| (iii) BOD at 20 C | mg/l | 50 |
| (iv) COD | mg/l | 100 |
| (v) Suspended Solids | mg/l | 100 |
| (vi) Mercury | mg/l | 0.05 |
| (vii) Cadmium | mg/l | 0.02 |
| (viii) Chromium, Hexavalent | mg/l | 0.05 |
| (ix) Arsenic | mg/l | 0.10 |
| (x) Cyanide | mg/l | 0.10 |
| (xi) Lead | mg/l | 0.5 |
| (xii) Chromium, Trivalent | mg/l | 1.0 |
| (xiii) Copper | mg/l | 1.0 |
| (xiv) Manganese | mg/l | 1.0 |
| (xv) Nickel | mg/l | 1.0 |
| (xvi) Tin | mg/l | 1.0 |
| (xvii) Zinc | mg/l | 1.0 |
| (xviii) Boron | mg/l | 4.0 |
| (xix) Iron (Fe) | mg/l | 5.0 |
| (xx) Phenol | mg/l | 1.0 |
| (xxi) Free Chlorine | mg/l | 2.0 |
| (xxii) Sulphide | mg/l | 0.50 |
| (xxiii) Oil and Grease | mg/l | 10.0 |

b. Great increase of disposal cost

In case sanitary landfill of the Master Plan is introduced in MPPP, disposal cost, which includes depreciation and operation/maintenance costs will increase significantly as shown below.

| | 1987 | 1992 | 2005 |
|---|---|---|---|
| Annual Disposal Cost ($1,000) | 609 | 2,540 | 4,053 |
| Unit Disposal Cost ($/per ton) | 4.6 | 14.4 | 14.4 |

In view of the above, it should be emphasized that the realization of the planned sanitary landfill within the proposed time frame requires the satisfactory commitment on the improvements proposed by the Master Plan.

i. Reduction in collection and haulage cost

ii. Reduction in street/drain cleansing cost

iii. Increase in revenue from commercial waste collection and disposal fees.

In addition to the realization of the proposed improvement subjects, for the materialization of sanitary landfill, Federal, State and Local Governments have been discussing about financial problems faced by MPPP and MPSP.

Considering the magnitude of the project cost, it was requested the Malaysian side at the Technical Committee meeting that the Study Team should examine the possibility of the phased improvement of the Master Plan targets in order to mitigate the financial burden on MPPP.

## 1.2 Level of Sanitary Landfill Development and Operation

### (1) Presentation of Sanitary Landfill Level

In response to the request made by the Malaysian side at the Technical Committee meeting, the Study Team presented the following four levels of landfill development and operation from present landfill to the Master Plan target. (See Fig.1.2-1)

a. Level 1; Controlled Tipping (Present level)

i. Target

- Introduction of controlled tipping

ii. Level to be achieved

- Establishment of access to site
- Introduction of cover materials in order to prevent fire and to lessen blown waste and rank odor
- Introduction of inspection, control and operational recording system of incoming wastes

b. Level 2; Sanitary Landfill with a Bund and Daily Soile Covering

i. Target

- Introduction of sanitary landfill

ii. Level to be achieved

- Establishment of site boundary in order to distinguish the disposal site and to eliminate scavenging

- Execution of sufficient cover over waste disposed

- Establishment of disposal site by the construction of enclosing bund

- Introduction of divider between present landfill area and future landfill area

- Establishment of drainage system in order to divert stormwater and seepage from surrounding area and to reduce leachate

- Introduction of environmental protection facilities in order to lessen direct impact on surroundings such as buffer zone, litter control and gas removal facilities

- Introduction of semi-aerobic sanitary landfill by the installation of gas removal facilities

- Introduction of amenities for the staff

c. Level 3; Sanitary Landfill with Leachate Circulation

i. Target

- Establishment of leachate control

ii. Level to be achieved

- Establishment of leachate control by the installation of leachate collection, cycling and monitoring facilities

- Establishment of semi-aerobic sanitary landfill in order to facilitate the stabilization of waste disposed through the active decomposition in semi-aerobic condition

- Establishment of dust prevention system by introducing water sprinkling

d. Level 4; Sanitary Landfill with Leachate Treatment

i. Target

- Establishment of leachate treatment

ii. Level to be achieved

- Establishment of leachate treatment by the installation of oxidation pond

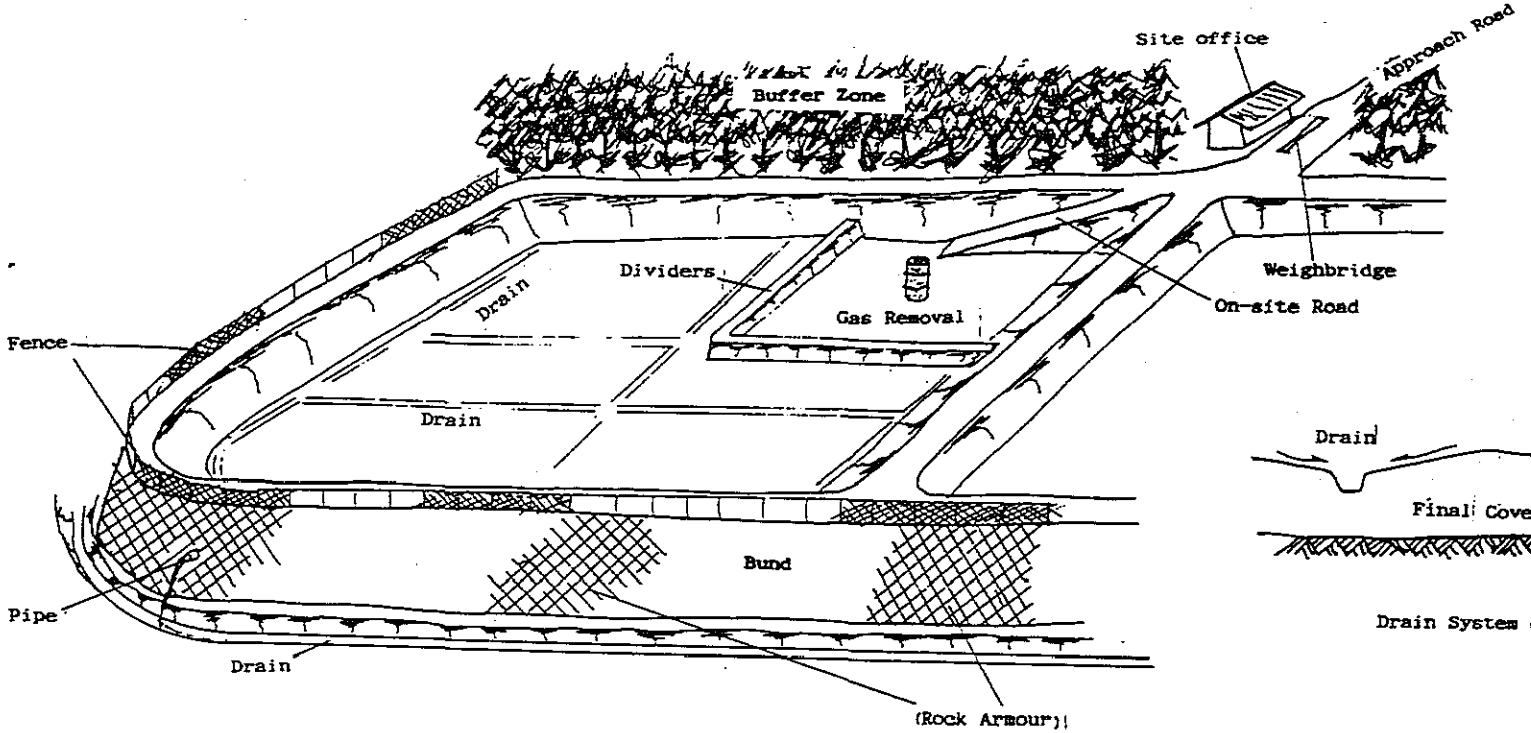
- Establishment of seepage control by the sealant(liner).

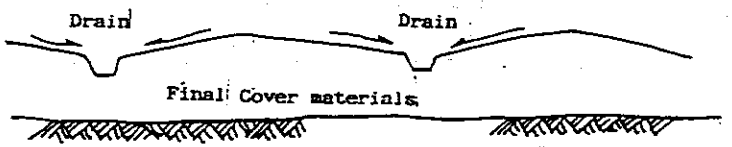
(2) Outline of Sanitary Landfill Development and Operation

The above mentioned level of sanitary landfill development and operation are described and tabulated in Table 1.2-1. The prospective levels of sanitary landfill development and operation in 2nd, 3rd and 4th level are illustrated in Fig.1.2-1, 1.2-2 and 1.2-3 respectively.

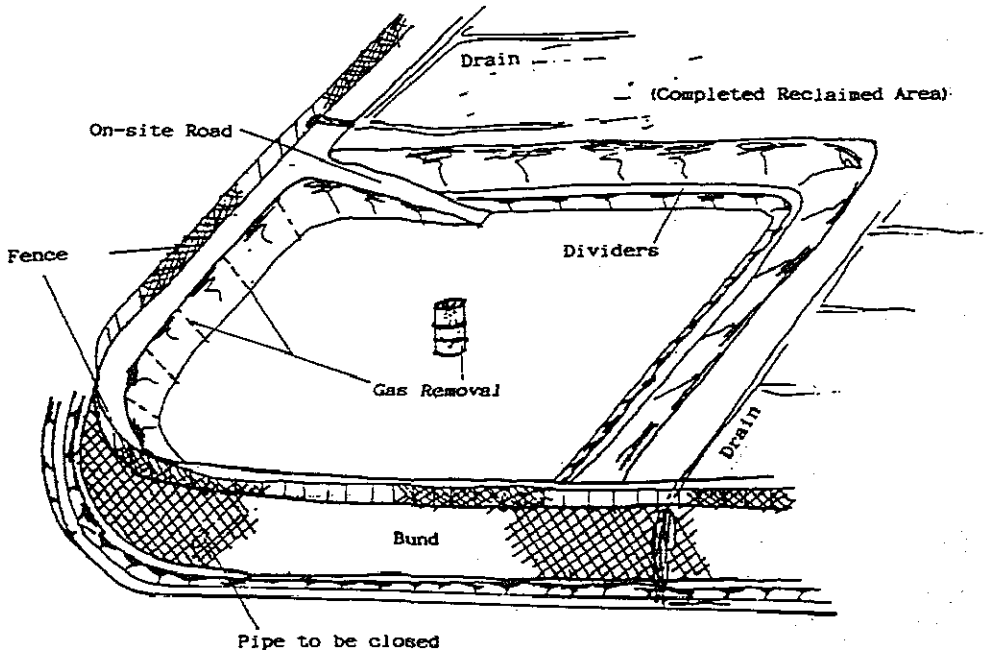
(3) Environmental Issues

A comparison on the environmental level to be achieved by each level of sanitary landfill development and operation is made and tabulated in Table 1.2-2.




Drain System of Completed Reclaimed Area



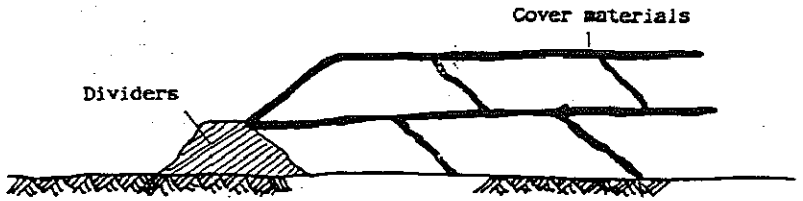




Fig. 1.2-1 Prospective Illustration of Sanitary, Landfill Development and Operation in Second Level

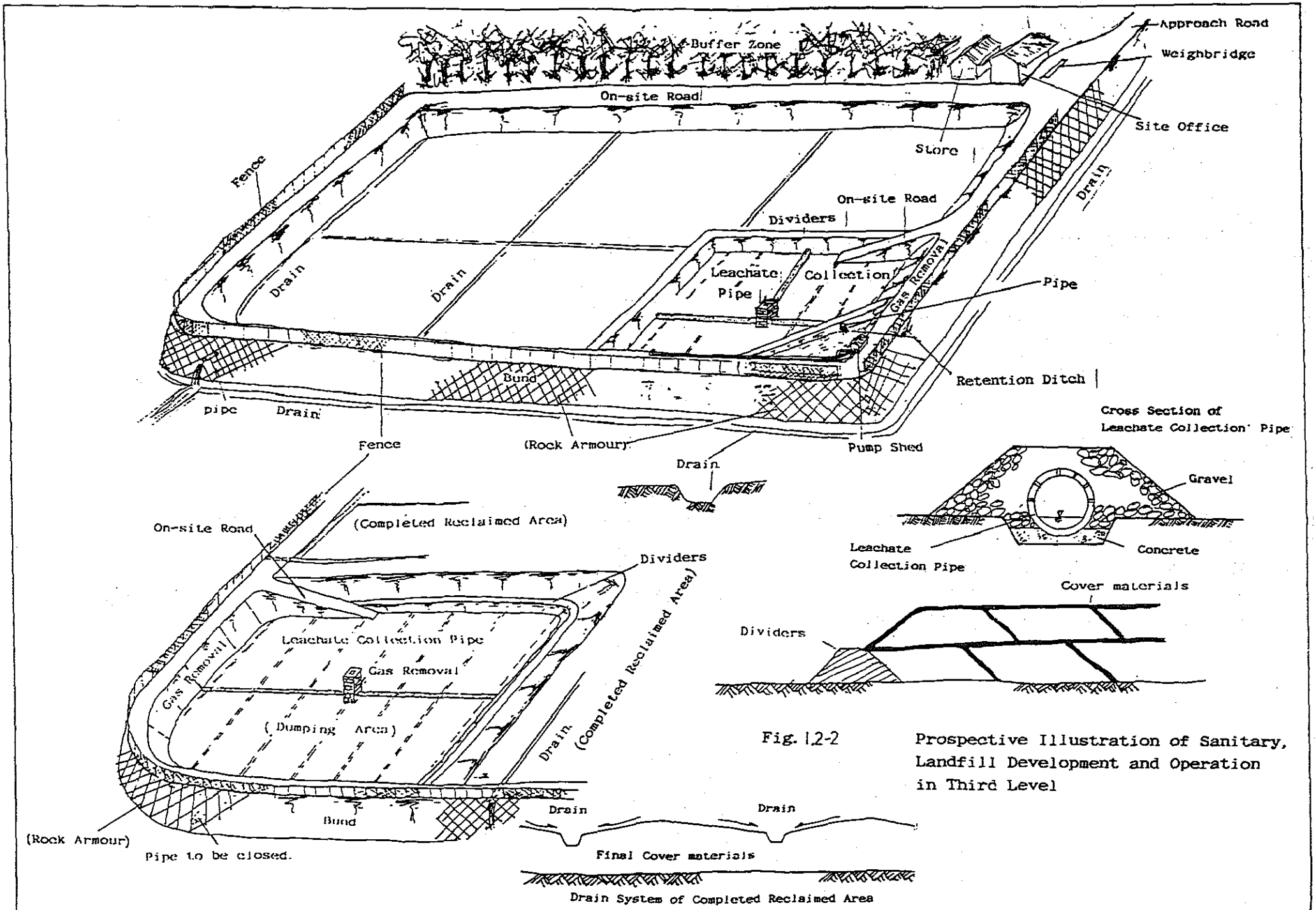



Fig. 12-2 Prospective Illustration of Sanitary, Landfill Development and Operation in Third Level

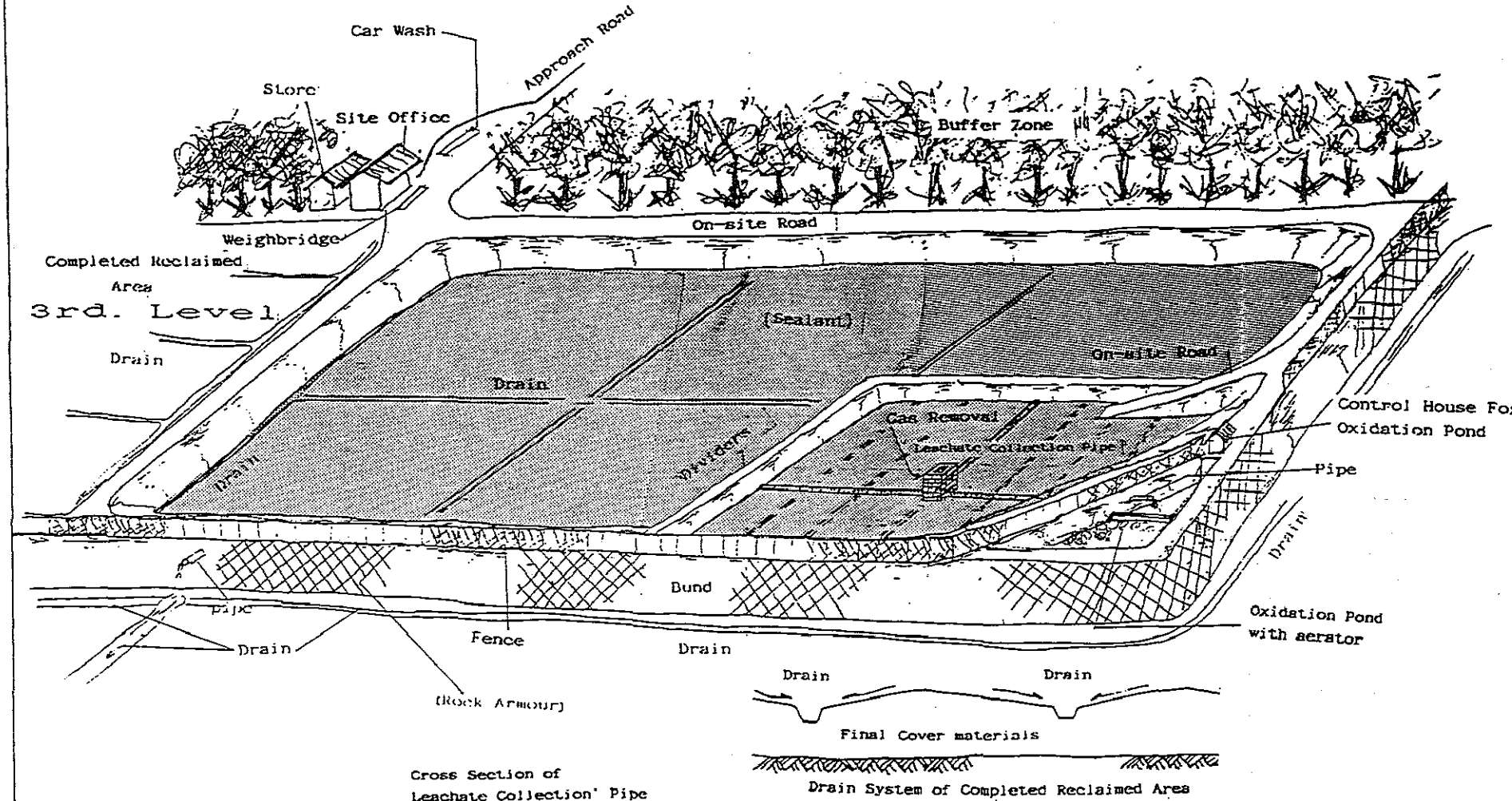



Fig. L2-3 Prospective Illustration of Sanitary, Landfill Development and Operation in Fourth Level

Table 1.2-1 Outline of Sanitary Landfill Development and Operation

| Items | Level of Sanitary Landfill | | | | Remarks |
|---|---|---|---|---|---|
| | 1st Level | 2nd Level | 3rd Level | 4th Level | |
| 1. Site Development Works | | | | | |
| 1.1 Main Facilities | | | | | |
| a. Enclosing Structure | | | | | |
| i. Enclosing Bund | | O | O | O | |
| ii. Divider | | ▲ | O | O | ▲ means that a bund is made of construction demolision and earth |
| b. Drainage System | | | | | |
| i. Surrounding Drain | | O | O | O | |
| ii. On-site Drain (Surface Water) | | O | O | O | The drain is for the site which is not used for landfill |
| iii. On-site Drain (Underground Springs) | | O | O | O | If necessary |
| iv. Drain for Reclaimed Area | | O | O | O | |
| c. Access | | | | | |
| i. Approach Road | O | O | O | O | |
| ii. On-site Road | O | O | O | O | |
| iii. Others | O | O | O | O | Improvement of existing road network for accessing to the site |

-con't

Note: O means the facility is necessary.

| Items | Level of Sanitary Landfill | | | | Remarks |
|---|---|---|---|---|---|
| | 1st Level | 2nd Level | 3rd Level | 4th Level | |
| 1-2 Environment Protection Facilities | | | | | |
| i. Buffer Zone | | ○ | ○ | ○ | |
| ii. Litter Control Facilities | | ▲ | ○ | ○ | Movable fence, etc. |
| iii. Gas Removal Facilities | | ▲ | ○ | ○ | |
| iv. Leachate Collection Facilities | | | ○ | ○ | |
| v. Leachate Cycling Facilities | | | ○ | ○ | |
| vi. Seepage Control Facilities | | | | ○ | |
| vii. Leachate Treatment Facilities | | | | ○ | |
| 1-3 Buildings and Accessories | | | | | |
| i. Site Office | ▲ | ▲ | ○ | ○ | |
| ii. Weigh Bridge | ○ | ○ | ○ | ○ | |
| iii. Storage Building | | | ○ | ○ | |
| iv. Safety Facilities | | ○ | ○ | ○ | Gate, fence lights, etc. |
| v. Fire Prevention Facilities | | ▲ | ○ | ○ | Watertank, extinguisher, etc. |
| vi. Monitoring Facilities | | | ○ | ○ | Monitoring well, etc. |
| vii. Car Wash | | | ○ | ○ | |

| Items | Level of Sanitary Landfill | | | | Remarks |
|---|---|---|---|---|---|
| | 1st Level | 2nd Level | 3rd Level | 4th Level | |
| 2. Equipment | | | | | |
| i. Landfill Equipment | O | O | O | O | |
| ii. Others | | | O | O | Water truck, Inspection Vehicles, etc. |
| 3. Operation and Maintenance | | | | | |
| 3-1 Operation | | | | | |
| a. Personnel | O | O | O | O | |
| b. Cover Material | ▲ | O | O | O | ▲ means insufficient operation |
| c. Utility | | | | | |
| i. Fuel | O | O | O | O | |
| ii. Water | | O | O | O | |
| iii. Electricity | | Nil | O | O | |
| d. Chemicals | | | | | |
| i. Insecticide | O | O | O | O | |
| ii. Monitoring Chemicals | | | O | O | |
| e. Others | | O | O | O | Devider, drain for reclaimed area, leachate collection pipes, etc. |

| Items | Level of Sanitary Landfill | | | | Remarks |
|---|---|---|---|---|---|
| | 1st Level | 2nd Level | 3rd Level | 4th Level | |
| 3-2 Maintenance | | | | | |
| i. Main Facilities | | O | O | O | |
| ii. Environment Protection Facilities | | O | O | O | |
| iii. Buildings and Accessories | O | O | O | O | |
| iv. Equipment | O | O | O | O | |

Table 1.2-2 Comparison of Environmental Level to be Achieved by Each Level of Sanitary Landfill Development and Operation

Cont./...

| Level / Items | Level of Sanitary Landfill Development and Operation | | | |
|---|---|---|---|---|
| | First Level | Second Level | Third Level | Fourth Level |
| 1. Landfill Structure | | | | |
| 1-1 Landfill structure | - Anaerobic Landfill | - Improved Anaerobic Sanitary Landfill | - Semi-aerobic Sanitary Landfill | - Semi-aerobic Sanitary Landfill |
| 1-2 Achieved Condition | - Leachate generated in solid waste layers is seldom drained but remained within, and always keeps landfill in an anaerobic state. Generally, the quality of leachate is not improved over a long time.<br>- Because of inactive decomposition of wastes, prompt stabilization of a landfill is not achievable. | - Through gas removal facilities, the quality of leachate is slightly improved as compared with the First Level. Almost all of the solid waste, however, is still kept in an anaerobic state.<br>- The rate of decomposition is also slightly improved. | - Leachate accumulated at landfill bottom is promptly discharged through drain pipes (leachate collection pipes). The pipes also permit the natural inflow of air.<br>- This structure facilitates the decomposition of solid waste because of semi-aerobic condition made by the drain pipes. The quality of leachate is much improved and generation of offensive odor is reduced further.<br>- Water content of solid wastes disposed is lower than the Second level. | - Same as the Third Level |
| 2. Leachate and It's Impacts on Surroundings | | | | |
| 2-1 Leachate Generation Amount | - Leachate is freely discharged out from both landfilling and reclaimed areas because enclosing structure is not set up.<br>- Rain water flows into the landfill from catchment area and it increases leachate amount. | - As for the reclaimed areas, surface water is drained and discharged out.<br>- Rain water from catchment area is diverted into surrounding drains.<br>- A divider limits the area for leachate generation to the working area.<br>- As mentioned above, since the area for leachate generation is limited, leachate amount is also limited to the precipitation on the certain area. | - Same as the Second Level | - Same as the Second Level |

| Items \ Level | Level of sanitary Landfill Development and Operation | | | |
|---|---|---|---|---|
| | First Level | Second Level | Third Level | Fourth Level |
| 2-2 Leachate Control Facilites | - None | - Enclosing bund and divider prevents direct discharge of leachate. | - In addition to the facilities for Second Level, there are leachate cycling and monitoring facilities.<br>- Leachate is discharged only during heavy rain from regulating pond. Leachate discharged is therefore, diluted. | - Same as Third Level except for effluent which is constantly treated and discharged from oxidation pond. |
| 2-3 Leachate Treatment Facilities | - None | - None | - Retention and regulating ponds may work as oxidation pond. | - Leachate is treated in an oxidation pond with aerator so as to satisfy the DOE effluent Standard B. |
| 2-4 Leachate Quality | - Amount of leachate is high and it's quality is worse than any other levels. Besides that, there shall be negligible improvement on the quality after a long period of time. | - Amount of leachate is limited because of bund and divider. However, the quality of leachate is not improved after a long period of time. | - Amount of leachate is limited as in Second Level.<br>- The quality of leachate is improved much faster than Second Level because of semi-aerobic landfill condition.<br>- Leachate cycling facilitates self purification of the wastes disposed.<br>- Since leachate is discharged only during heavy rain, it is therefore, diluted. | - Amount of leachate is limited as in Second Level.<br>- The quality of leachate to be discharged satisfies the DOE effluent Standard B ; i.e. BOD less than 50mg/l, COD less than 100mg/l, etc. |

| Items \ Level | Level of sanitary Landfill Development and Operation | | | |
|---|---|---|---|---|
| | First Level | Second Level | Third Level | Fourth Level |
| 2-5 Impacts by Leachate | | | | |
| a. Impacts on Underground Water | - The impacts are dependent on the permeability of bottom soil.<br>- If it is a permeable bottom soil, the impacts on underground water is very high because of high pressure head and large amount of leachate. | - The impacts are dependent on the permeability of bottom soil.<br>- The amount of leachate is less than First Level. However, the impacts are still high in the case of permeable bottom soil. | - The impacts are dependent on the permeability of bottom soil.<br>- Since amount and pressure of leachate is limited, permeance of leachate into underground water is reduced.<br>- The quality of leachate is better than Second Level. However, possibility of underground water contamination still exists. | - Sealant is laid so as to prevent underground water from leachate seepage.<br>- There is very little underground water contamination. |
| b. Impacts on Surface Water | - Because of free discharge of leachate from a landfill site, the impacts on to surrounding water area is very high. | - Discharge of leachate may occur when the divider is overflown and through seepage.<br>- Although leachate amount is limited, impacts on to surrounding water area is still high because of uncontrolled and unimproved leachate. | - Discharge of leachate is made only during heavy rain.<br>- Leachate can be monitored. In case leachate to be discharged would affect the surroundings, the construction of leachate treatment facility is encouraged. | - Effluent from landfill site satisfies the DOE Standard B. |
| 3. Others | | | | |
| 3-1 Vector control | - Great generation of flies, insects and rodents.<br>- Great crow gathering. | - Vector control is achieved and it is much improved compared to First Level. | - Same as Second Level. | - Same as Second Level. |
| 3-2 Odors and Gas Production | - Odors are constantly generated.<br>- Occational fires occur due to spontaneous ignition. | - It is much better than First Level.<br>- No occurance of fire | - Due to semi-aerobic landfill structure, it is better than Second Level. | - Same as Third Level. |
| 3-3 Others | - Litter of wastes and dust.<br>- Deterioration of landscape.<br>- Noise.<br>- Existence of scavengers. | - It is improved in all aspects. | - In addition to the condition achieved at Second Level, dust problem is improved by water sprinkler. | - Same as Third Level. |

## 1.3 Phased Improvement

### (1) Preliminary Estimates of Project Cost

After the selection of the most suitable alternative for the Master Plan, Pre-EIA and soil investigations were carried out on PADS. As a result, the following major aspects are realized regarding the development of PADS.

a. It is suggested by Pre-EIA that an effluence outlet from an retention pond should be set up in the sea (LWL should be deeper than 50cm.) out of the mangrove forest so as not to affect the fauna in the forest.

b. The result of soil investigation shows that there is more than 10m depth of marine clay layer that exists under the bottom of PADS. The permeability coefficient of marine clay is very low; i.e.10-6 to 10-7 cm/sec. This indicates that seepage control facilities at the bottom of PADS is not necessary.

Taking the above aspects into consideration, a preliminary estimate of the first Phase project cost is as follows.

- Second Level 5.3 million ringgit
- Third Level 6.1 million ringgit
- Fourth Level 13.8 million ringgit

However, this estimate has been based on the cost utilized in the Master Plan. Detailed estimates are shown in chapter 3.

### (2) Selection of Sanitary Landfill Level

A technical committee meeting was held on the 21st February 1989 in Kuala Lumpur to mainly discuss the draft Preliminary Environmental Impact Assessment (Pre-EIA) report for the project prepared by the University Sains Malaysia

(USM) incorporating the findings of JICA Study Team.

After much discussion on the subject, the committee decided that the 3rd level sanitary landfill was acceptable and that the 4th level would be introduced accordingly: for MPPP, it would be introduced from Phase 2.

The reasons are described as follows.

a. The USM Study Team presented the draft preliminary EIA report concerning the proposed disposal sites of Pantai Acheh. The Team concluded that the ecological and social impact from the implementation of the 3rd level sanitay landfill as prepared by the JICA Study Team would be minimum in light of the organic loading of predicted effuent and the mitigation measures to minimise the impact taken by the JICA Study Team.

b. Fourth level is set up to satisfy the design princples such as the DOE standards.
According to the financial evaluation, even if improvements in collection and cleansing works proposed by the Study Team are achieved, it seems to be difficult to materialize fourth level of landfill for the first phase project of PADS.

c. In case that the improvement to collection and cleansing works proposed are achieved it is financially feasible to execute third level for the first phase project of PADS.

d. There is no significant financial difference between second and third level of landfill. However, the environmental level to be achieved by each level of landfill will be significantly different.

e. In addition to the above, because of low permeability of bottom soil in PADS, there would be very little impacts on underground water.

f. Furthermore, leachate is able to be monitored. In case leachate to be discharged affects the surroundings, the construction of leachate treatment facility is encouraged.

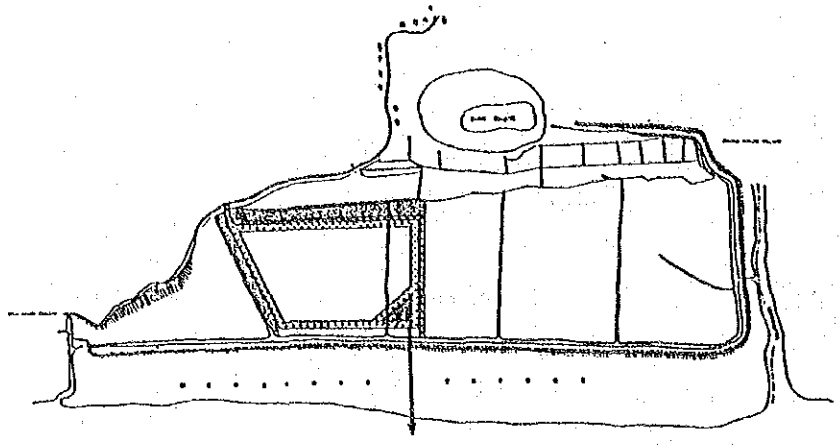
(3) Concept Plan of Proposed First Phase Project

a. Alternatives

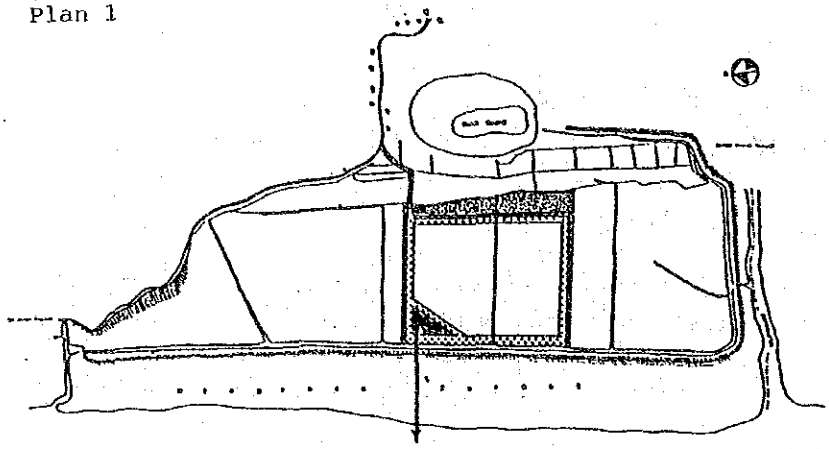
Prior to the preliminary design, a concept plan of the first phase project should be made to ensure efficient usage of the site up to year 2005. The basic conditions for the preparation of the concept plan are summarized as follows.

| Items | | PADS | Remarks |
|---|---|---|---|
| Area of Site | | 100ha | |
| Disposal volume (1000m3) | Phase I 1992-1996 | 1,544 | including cover soil |
| | Phase II & II 1997-2005 | 3,590 | including cover soil |
| Required Area for Phase I | | 25ha | |
| Level of Landfill | | 4 | |
| Construction Plan | | 2 stages | 1991 and 1996 |

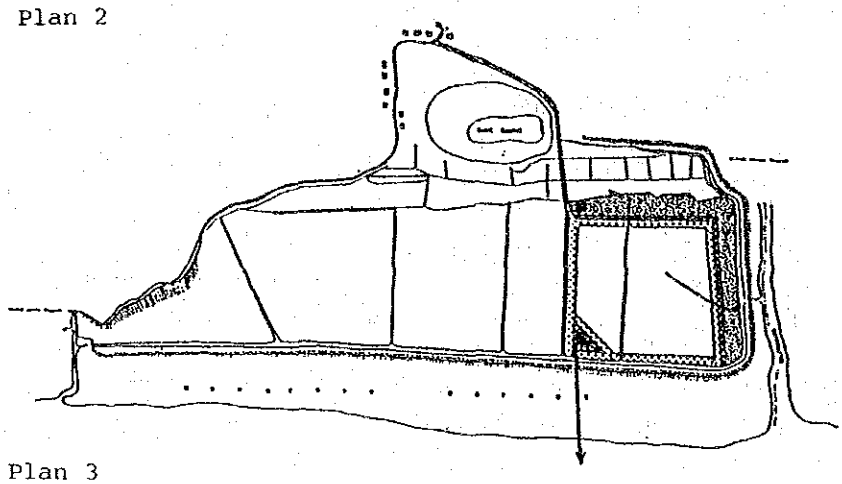
Based on the above mentioned planning conditions, the following alternatives of concept plans are proposed and are illustrated in Fig. 1.3-1.



Plan 1



Plan 2



Plan 3

LEGEND :

- Site Office
- Buffer Zone
- Bund
- Approach Road
- Drain
- Retention Pond
- Effluent Outlet

Fig.1.3-1 Concept Plan for First Phase Project of PADS

Plan 1

- Development and operation starts from the northern part of the site.

Plan 2

- Since it may be relatively easy to obtain neighbourhood consensus, development and operation starts from the center of the site.

- An approach road is planned to be constructed which passes across on private owned land.

Plan 3

- Development and operation starts from the southern part of the site.

- An approach road, which is the longest among the three plans, is planned to be constructed which across passes private owned land.

b. Comparison of Alternatives

Comparison of alternatives for concept plan is made and tabulated in Table 1.3-1.

c. Selection of Concept Plan

Based on the comparison, Plan 1 is selected as the concept plan for the first phase project of PADS. The reasons are summarized as follows.

i. It is not necessary to acquire new land for the development of the site. Since the site for PhaseI is rather far from residential area, and rather easy to obtain neighbourhood consensus.

Table 1.3-1 Comparison of Concept Plan for PADS First Phase Project

| Item | Plan 1 | Plan 2 | Plan 3 |
|---|---|---|---|
| ① Possibility of Land Acquisition | - Since all development necessary for the project are planned within the site, it is not necessary to acquire new land. | - In order to construct 250 meter length of approach road, it is necessary to acquire new land. | - In order to construct 900 meter of approach road, acquisition of new land is necessary. |
| ② Possibility of Getting Neighbouring Consensus | - An approach road is far from residential area. | - Beginning point of an approach road is located at the edge of residential area.<br>- Since northern and southern part of the site remains as it is at present and the site for phase I is far from residential area, getting neighbouring consensus is easy. | - Beginning point of an approach road is located at the edge of residential area.<br>- Since Kampong Sungai Pinang is situated adjoining to the site, it maynot be easy to obtain neighbouring |
| ③ Compatibility with Regional Development Plan | - A piece of land for housing project has been reclaimed in the north adjoining area<br>- In case of BukitKechilto be used as borrow pit for cover soil, the existing road to Kampong Pantai Acheh shall be used by haulage vehicles. | - In case that the borrow pit for cover soil is in Bukit Kechil, haulage vehicles can use the approach road. | - In case that borrow pit for cover soil is in Bukit Kechil, haulage vehicle can use the approach road. |
| ④ Economic Feasibility | - The shortest possible approach road is 100 meters long.<br>- The length of enclosing bund for phase IIandIII is shorter than Plan 2<br>- Rough estimation of site development cost is 1.2 (excluding landfill equipment) | - The approach road is 250 meter long.<br>The length of enclosing bund for phase IIandIII is the longest.<br>- Rough estimation of site development cost is 1.22 million ringgit. | - The approach road is 900 meter long.<br>The length of enclosing bund for phase IIandIII is shorter than Plan 2.<br>- Rough estimation of site development cost is 1.25 million ringgit. |
| ⑤ Environmental Acceptability | - Buffer zones are necessary at the northern and eastern areas.<br>- An oxidation pond is at the opposite and sea side of the reclaimed land<br>- Effluent outlet is furthest from a culture pond, being under construction in the southern part of Sungai Pinang. | - Buffer zone is necessary in the northern area.<br>- An oxidation pond is in the northern sea side<br>- Effluent outlet is positioned almost same as Plan 1. | - Buffer zones are necessary in the northern and southern areas.<br>- An oxidation pond is in the opposite and sea side of Kampong Sungai Pinang<br>- Effluent outlet is nearest to a culture pond, being under construction in the southern part of Sungai Pinang. |

ii. It is the most economical plan.

iii. Effluent outlet from retention pond is the furthest from a prawn culture pond, being under construction in the southern part of Sungai Pinang. The retention pond to be constructed in Phase I is able to be used as the oxidation pond in Phase II and III.

iv. Objections may come from the residents in Kampong Sungai Pinang in the Phase II and III project. Experience obtained from the first phase project can be utilized fully to face such objections.

(4) Phased Improvement

As mentioned above, the 3rd level sanitary landfill is selected for the First Phase of the PADS.

Furthermore, it is unrealistic from the financial viewpoint to construct all the facilities related to the PADS, which will cater for the disposal demand upto 2005, in Phase 1. Therefore, the master plan for the PADS will be implemented in the following two phases.
(cf. Fig. 1.3-2 and 1.3-2)

a. Phase 1

| | | |
|---|---|---|
| Level of Sanitary Landfill | ; | Third Level |
| Construction Completion Year | : | 1991 |
| Commencement Year of Landfill | : | January, 1992 Operation |
| Final Year of Landfill Operation | : | December, 1996 |
| Design Disposal | : | 560 tons/day in 1996 |
| Design Landfill Volume | : | 1.54 million m3 (total volume between 1992 and 1996 including covering soil) |
| Landfill Site Area | : | 25ha |
| Site Development Cost (including equipment) | : | 5.1 million ringgit |
| Unit Disposal Cost (excluding depreciation) | : | 4.8$/ton |

b. Phase 2 and 3

| | | |
|---|---|---|
| Level of Sanitary Landfill | ; | Fourth Level |
| Construction Completion Year | : | 1996 |
| Commencement Year of Landfill | : | January, 1997 Operation |
| Final Year of Landfill Operation | : | December, 2005 |
| Design Disposal | : | 770 tons/day |
| Design Landfill Volume | : | 3.59 million m3 (total volume between 1997 and 2005 including covering soil) |
| Landfill Site Area | : | 58ha |
| Site Development Cost (including equipment) | : | 11.0 million ringgit |
| Unit Development Cost (excluding depreciation) | : | 7.0$/ton |

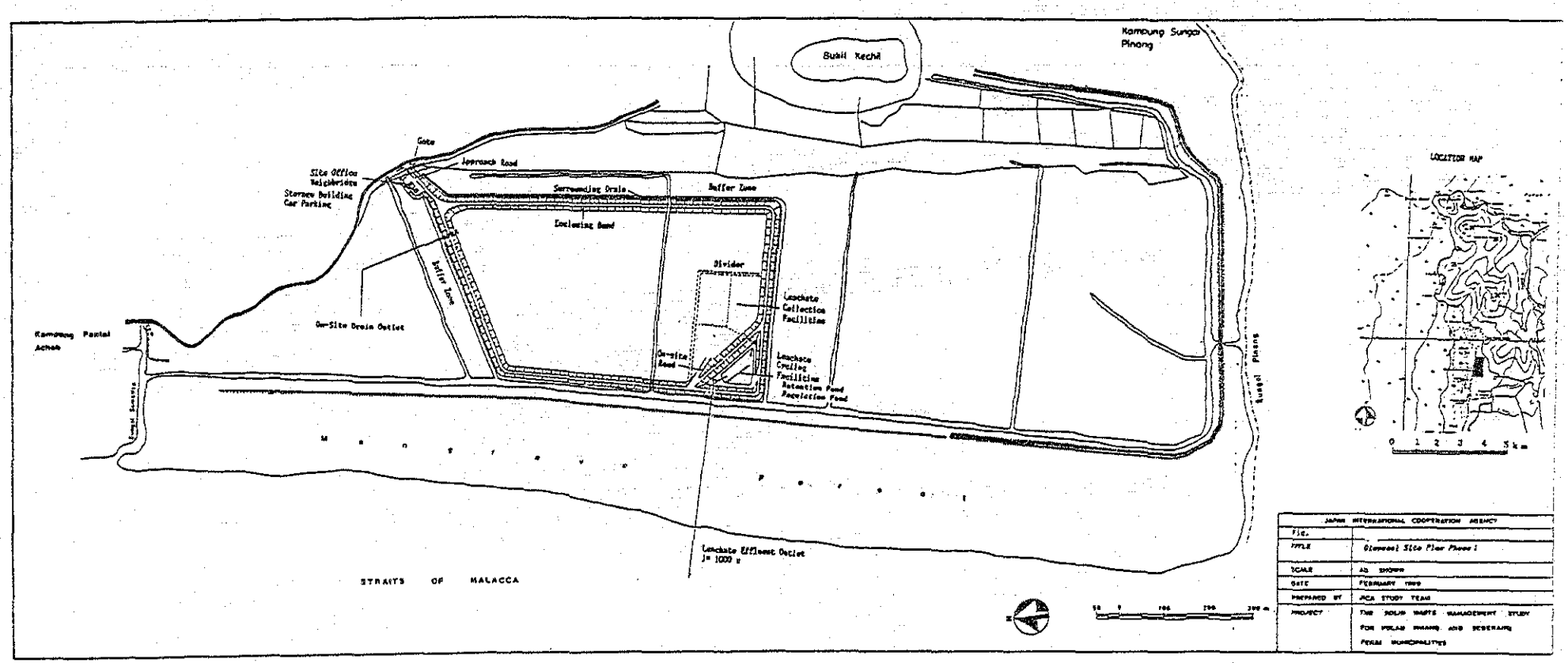



Fig. 1.3-2 First Phase Project of PADS

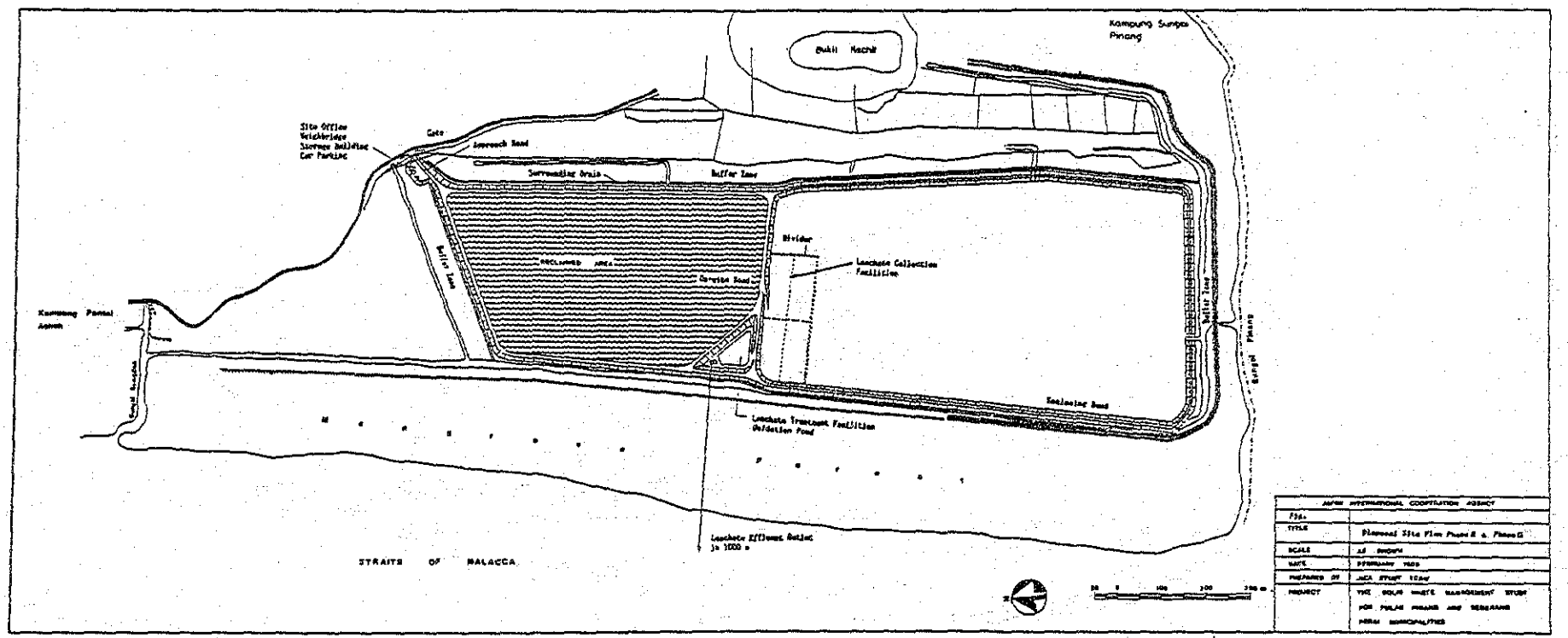



Fig. 1.3-3 Second and Third Phase Project of PADS

(5) Outline of the First Phase Project

Outline of the first phase project is summarized as follows:

a. Main facilities

i. Enclosing structure.

- Enclosing bund
- Divider

ii. Drainage system

- Surrounding drain
- On-site drain (surface water)
- On-site draing (underground springs)
- Drains for reclaimed area

iii. Access

- Approach road
- On-site road
- Improvement of existing bridge

b. Environmental protection facilities

- Buffer zone
- Litter control facilities
- Gas removal facilities
- Leachate collection facilities
- Seepage control facilities
- Leachate treatment facilities
- Effluent outlet
- Monitoring facilities

c. Building and accessories

- Site office
- Weigh bridge
- Garage and storage building
- Safety facilities
- Fire prevention facilities
- Car wash
- Utilities

d. Equipment

i. Landfill equipment

- Bulldozer
- Hydraulic excavator

ii. Others

- Water sprinkler truck
- Inspetion vehicle

## 2. Topographical Survey and Soil Investigation

### 2.1 Topographical Survey

(1) Survey works

The topographical survey works over the proposed Pantai Acheh disposal site was contracted out to a local survey company. The survey covered an area of 148 hectares of the site.

a. Methods of survey

i. Levelling

The Method of levelling used is spirit levelling. All spot levels of the survey site are based on the Survey Department Bench Mark BM 1356 emplaced on the grounds of the Sungei Pinang Police Station.

Chart Datum of Penang Port, the nearest Standard Port, is 1.42m below Lan Survey Datum.

ii. Traversing

The method of traversing used is EDM traversing. The coordinate system used is the Cassini Projection with the origin at Fort Cornwallis.

Connections were made to proven boundary marks from which the Cassini coordinates were derived. A loop traverse close was done for each network and where possible as a check another connection was done at the extreme end of the site.

iii. Tacheometry

For the purpose of spot heighting and picking up of topographic details such as houses, drains and bunds, the method of tacheometry was employed.

This entails the use of theodolite and levelling staff. Bearings and general numbers were read and from these the location and height of points were derived. All bearings are based on Cassini grid bearings.

b. Results of survey

The final plan is shown as attached maps JP/88/PG/22/PA/1, 2 & 3 at scale of 1:2000.

The coordinates and elevation of TBMs at Pantai Acheh are as follows.

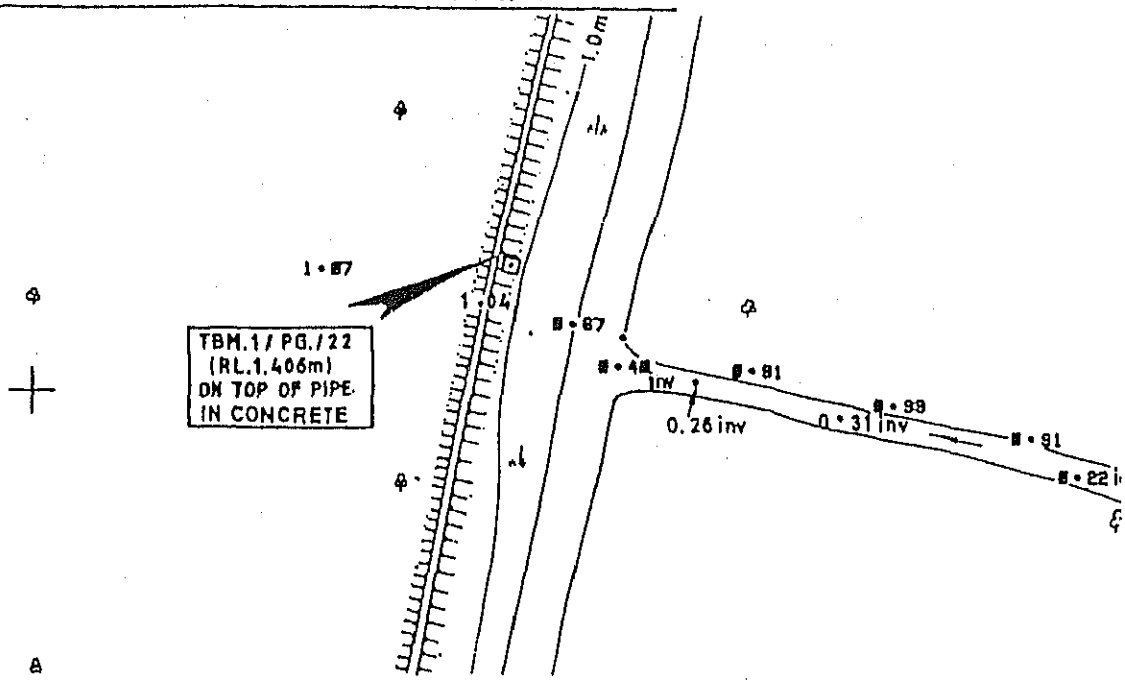
| TBM PG/22 | Coordinates | | Elevation |
|---|---|---|---|
| | N(m) | E(m) | (m) |
| No. 1 | -2164.46 | -16868.02 | 1.406 |
| No. 2 | -2647.69 | -16157.30 | 1.326 |

Note:-

Evaluation of TBM refers to the top of the pipe in concrete.

Location of TBMS are enclosed as in Fig 2.1-1 and 2.1-2. Network of traverse and traverse stations are shown in Fig. 2.1-3 and 2.1-4.

## LOCATION OF T.B.M,s No. 1/PG/22




REMARKS: ⊕..... Pipe in concrete ⊕..... Peg. ⊞..... Goverment Boundary Stone

## PHOTOGRAPH OF T.B.M,s

LEFT BANK RIGHT BANK

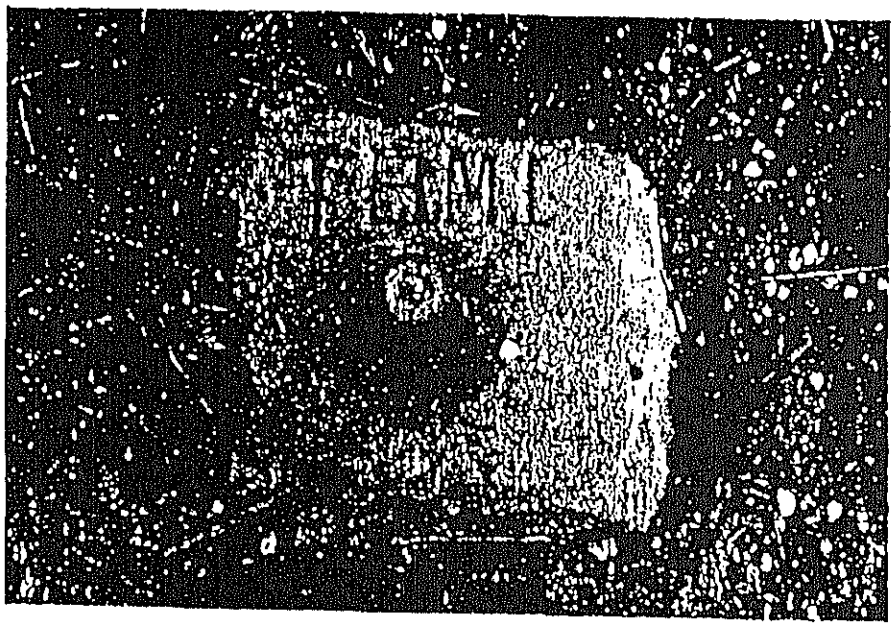
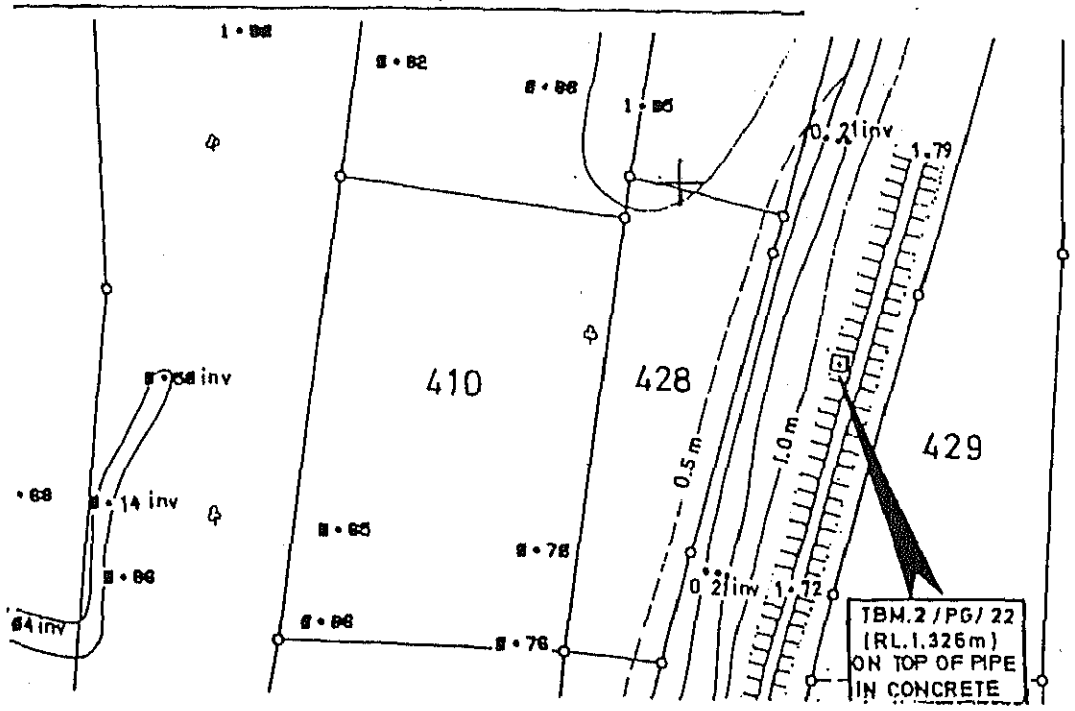


Fig.2.1-1 Location of TBM 1/PG/22

| REDUCED LEVEL OF T.B.M. | | REDUCED LEVEL OF T.B.M. | |
|---|---|---|---|
| H = 1.406 | m | H = - | m |
| G.H. = - | m | G.H. = - | m |

## LOCATION OF T.B.M,s No. 2/PG/22




REMARKS: ⊕..... Pipe in concrete ⊕..... Peg. ⊞..... Goverment Boundary Stone

## PHOTOGRAPH OF T.B.M,s

LEFT BANK RIGHT BANK

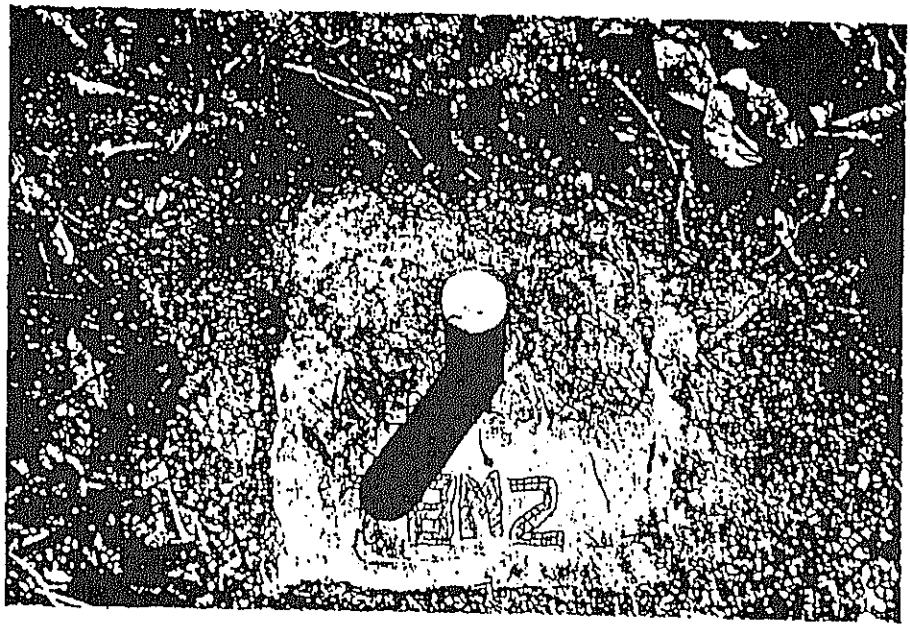


Fig.2.1-2 Location of TBM 2/PG 22

| REDUCED LEVEL OF T.B.M. | | REDUCED LEVEL OF T.B.M. | |
|---|---|---|---|
| H = 1.326 | m | H = - | m |
| G.H. = - | m | G.H. = - | m |

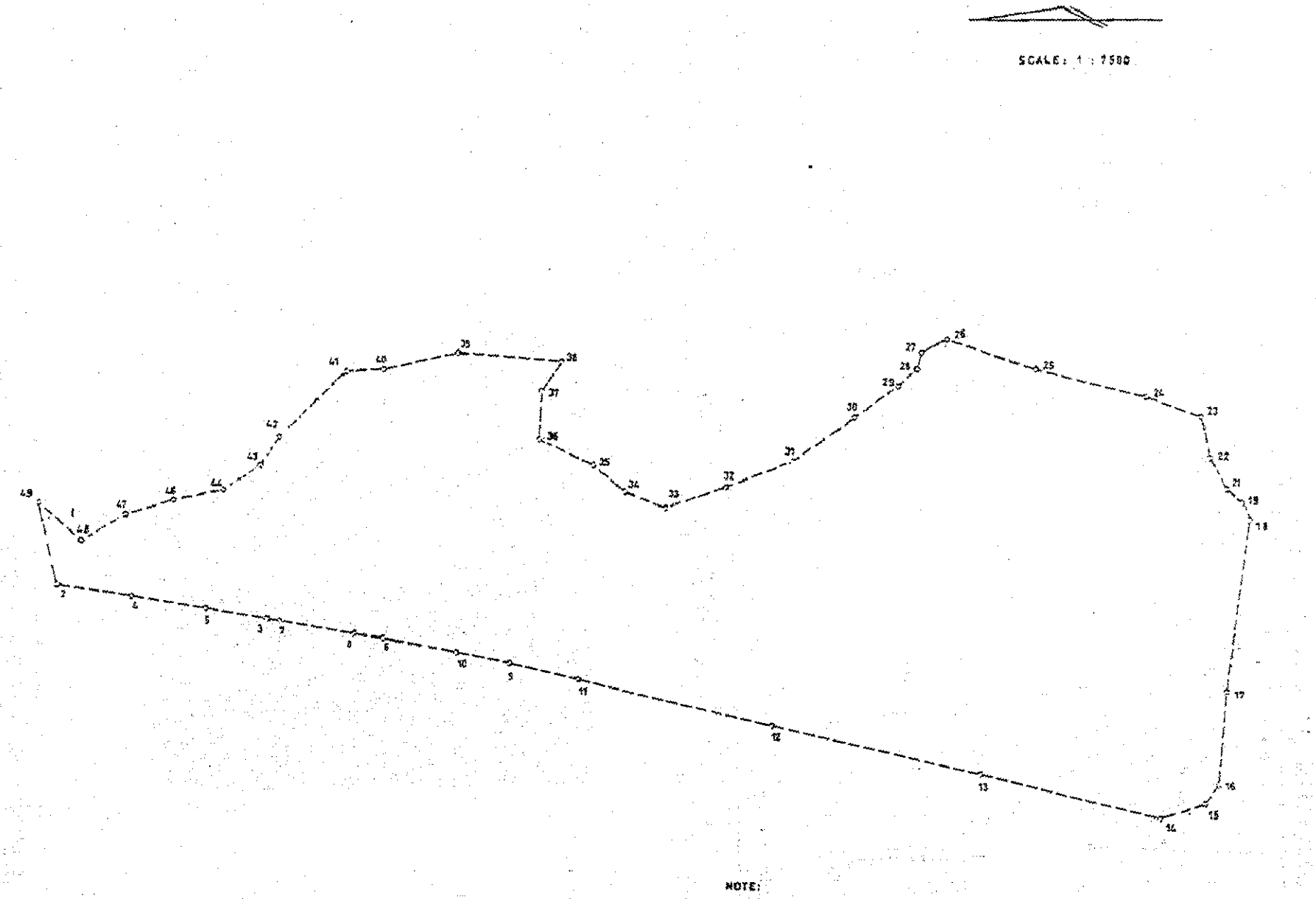



Fig.2.1-3 Network of Traverse at Pantai Acheh

PANTAI ACHEH

TRAVERSE STATIONS LISTING PROGRAM

| STATION | N | E | H |
|---|---|---|---|
| 1 | - 698.320 | -16534.088 | 1.941 |
| 2 | - 749.627 | -16606.203 | 1.590 |
| 3 | -1169.492 | -16671.222 | - |
| 4 | - 897.806 | -16629.150 | - |
| 5 | -1046.047 | -16652.106 | 1.601 |
| 6 | -1399.794 | -16708.409 | 1.579 |
| 7 | -1194.281 | -16675.225 | - |
| 8 | -1342.395 | -16699.141 | - |
| 9 | -1652.068 | -16756.266 | 1.296 |
| 10 | -1547.030 | -16736.340 | - |
| 11 | -1790.371 | -16787.476 | 1.531 |
| 12 | -2177.336 | -16873.954 | 1.591 |
| 13 | -2585.954 | -16961.948 | 1.285 |
| 14 | -2940.929 | -17044.517 | 1.525 |
| 15 | -3029.626 | -17015.469 | 1.442 |
| 16 | -3057.298 | -16977.656 | 1.469 |
| 17 | -3071.193 | -16799.676 | 1.496 |
| 18 | -3115.689 | -16460.801 | 1.881 |
| 19 | -3099.993 | -16426.226 | 1.651 |
| 21 | -3071.499 | -16401.755 | - |
| 22 | -3037.254 | -16339.515 | 1.623 |
| 23 | -3019.641 | -16259.180 | - |
| 24 | -2908.916 | -16221.025 | - |
| 25 | -2687.664 | -16166.042 | - |
| 26 | -2509.827 | -16109.487 | 1.637 |
| 27 | -2460.098 | -16135.362 | - |
| 28 | -2451.572 | -16169.014 | - |
| 29 | -2414.908 | -16203.160 | - |
| 30 | -2330.987 | -16265.682 | - |
| 31 | -2209.256 | -16354.197 | .850 |
| 32 | -2079.023 | -16406.587 | - |
| 33 | -1959.510 | -16448.283 | - |
| 34 | -1877.769 | -16418.491 | .816 |
| 35 | -1812.856 | -16365.518 | - |
| 36 | -1700.418 | -16315.588 | - |
| 37 | -1703.780 | -16220.223 | .842 |
| 38 | -1742.118 | -16159.364 | 2.157 |
| 39 | -1536.033 | -16145.625 | 1.785 |

Fig.2.1-4 Traverse Stations Listing Program

## 2.2 Soil Investigation

### (1) Soil investigation works

The soil investigation works were carried out by a local soil investigation company. The purpose of the investigation is to obtain subsoil information at the site for foundation design.

The scope of works included the following.

i. Boring of 2 deep boreholes (Their locations are shown in **Table 2.2-1**).

ii. Standard Penetration Test (SPT) and obtain disturbed and undisturbed samples for usual examination and laboratory testing.

iii. Perform various laboratory tests on the collected samples to determine and evaluate the engineering parameters of the subsoil.

iv. Perform various laboratory tests on the collected samples to determine and evaluate the engineering parameters of the subsoil.

The location of the boreholes are as follows.

**Table 2.2-1 Location of Boreholes in PADS**

| Pantai Acheh PTA | Coordinates | | Elevation |
|---|---|---|---|
| | N(m) | E(m) | (m) |
| No. 1 | -1635.39 | -16747.13 | 0.73 |
| No. 2 | -2526.01 | -16120.72 | 0.79 |

(2) Results of soil investigation

The following observation and results were gathered from the investigation carried out over Pantai Acheh site.

a) Visual observation

Visual observation of the soil samples from Borehole No. PTA-1 near the shoreline in the Pantai Acheh near the shoreline area has that marine silty clay penetrates to a depth of 18 meters below ground level. This silty clay is very soft and the N-value was only 3 blows at the depth of 18 meters.

The soil at Borehole No. PTA-2 in the inland consists of marine silty clay with fine sand and shell fragments partly to a depth of 12 meters. This is followed by medium to coarse sand or medium to coarese sandy silty clay. The N-value was 12 blows at the depth of 15 meters.

(b) Compilation of test results

The following figures and tables were extracted from the report on soil investigation over Pantai Acheh submitted by the contractor.

Fig.2.2-1: Pantai Acheh Soil Profile
Fig.2.2-2 Borehole PTA-1 log
Fig.2.2-3 Borehole PTA-2 log
Fig.2.2-4 Falling Head Permeability Test of Undisturbed Sample from PTA-1
Fig.2.2-5 Falling Head Permeability Test of Undisturbed Sample from PTA-2
Fig.2.2-6 Summary of Laboratory Test Results

## PANTAI ACHEH SUNGAI PINANG SITE

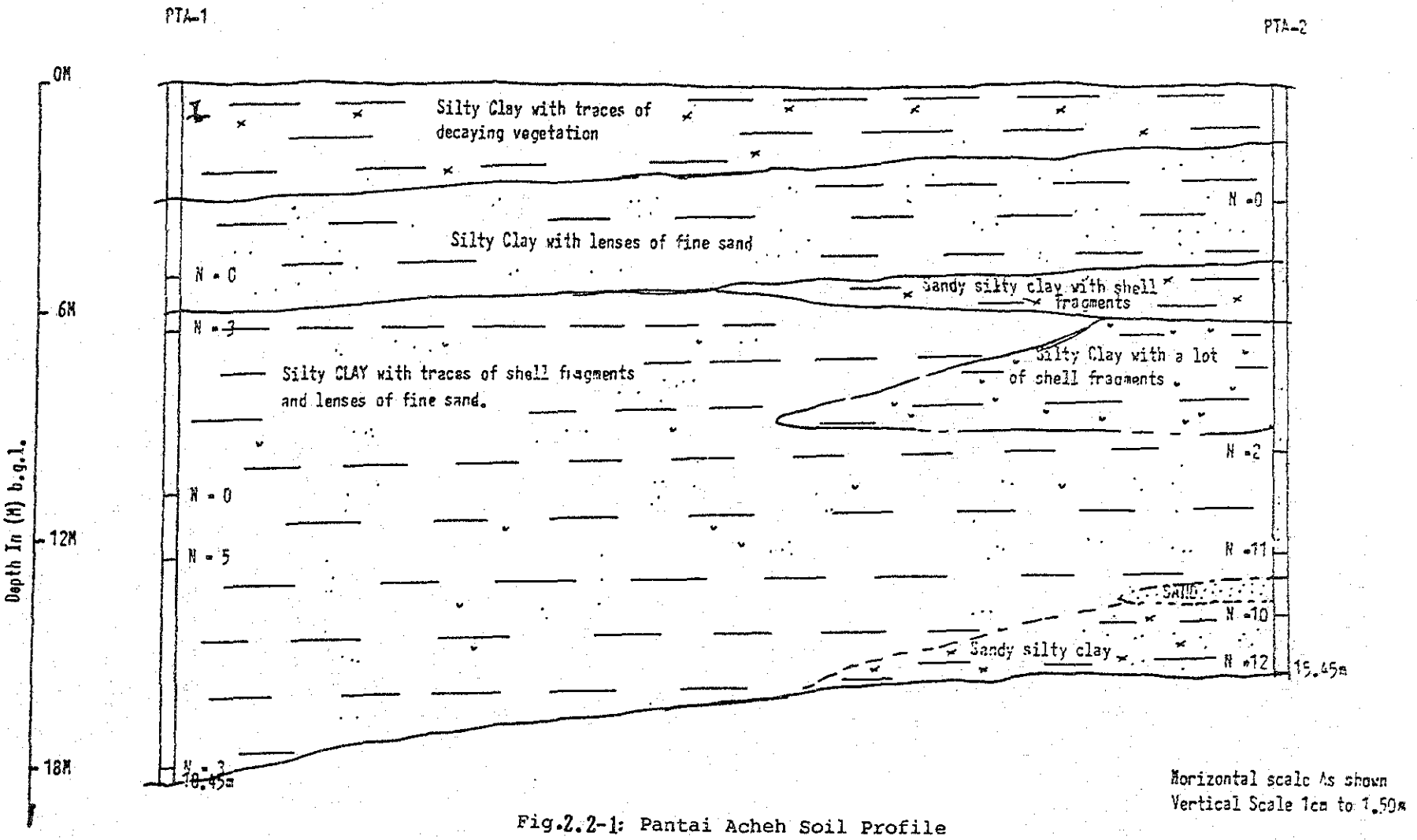



Fig.2.2-1: Pantai Acheh Soil Profile

**BOREHOLE No.** PTA 1
Sheet 1 of 3

Type of boring ..... Percussion
Type of rig ..... KSI 200
Dia of boring ..... 156 mm
Casing details .....

Feature . Soil Investigation Works For The Solid Waste Management Study For Pulau Pinang And Seberang Prai Municipalities.
Location .....
Ground level:

| Date & (Time) | Depth of boring & (casing) | Ground Water | Samples & Tests: Depth (m) | Sample | Test | Strata: Legend | Depth (m) | Reduced Level (m) | Thickness (m) | Description |
|---|---|---|---|---|---|---|---|---|---|---|
| 29-11-88 (8:00) | | | 0.00 to | D1 | | | | | | Very Soft Grey silty CLAY with traces of decaying roots. |
| | | | 1.50 to | UD1 | | | | | | |
| | | | 2.00 | D2 | | | | | | |
| | | | 3.00 to | UD2 | | | 3.00 | | 3.00 | |
| | | | 3.50 | D3 | | | | | | Very Soft Dark grey silty CLAY. |
| | | | 3.50 | D4 | N=0 (Weight of Hammer) | | | | | |
| | | | 4.95 | | | | | | | |
| | | | 6.00 to | UD3 | | | 6.00 | | 3.00 | |
| | | | 6.45 | D5 | | | | | | Very Soft Dark grey silty CLAY with traces of shell fragments. |
| | | | 7.50 to | UD4 | | | | | | |
| | | | | | | | 8.00 | | | |

- Small disturbed sample
- Large disturbed sample
- Undisturbed sample
- Standard penetration test
- Water sample
- Drill core sample
- Vane test
- Field permeability test
- m Moisture content (%)

**Remarks**

Fig.2.2-2 Borehole PTA-1 log

Contractor . 29-11-88.....
Date started . 30-11-88.....
Date finished .....

Scale: 1 div. : 10cm

Logged by .....
Checked by: .....
Date: .....

Fig. No. .....

**BOREHOLE No.** PTA 1
Sheet 2 of 3

Type of boring ..... Percussion
Type of rig ..... MST 200
Dia of boring ..... 156. mm
Casing details .....

Feature ..... Soil Investigation Works For The Solid Waste Management Study For Pulau Pinang And Seberang Prai Municipalities.
Location .....
Ground level:

| Date & (Time) | Depth of boring & (casing) | Ground Water | Samples & Tests: Depth (m) | Sample | Test | Strata: Legend | Depth (m) | Reduced Level (m) | Thickness (m) | Description |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | D6 | | | | | | |
| | | | 9.00 to 9.50 | UD5 | | | | | | Very Soft Dark grey silty CLAY with traces of shell fragments. |
| | | | | D7 | | | | | | |
| | | | 10.50 to 10.95 | D8 (Weight of Hammer) | N=0 | | 10.50 | | 4.50 | |
| | | | | D9 | | | | | | Very Soft Dark grey silty CLAY. |
| | | | 12.00 to 12.60 | UD6 | N=5 | | 12.00 | | 1.50 | |
| | | | | D10 | | | | | | |
| | | | 13.50 to 13.95 | D11 | N=2 | | | | | Soft Dark grey silty CLAY. |
| | | | | D12 | | | | | | |
| | | | 15.00 to 15.45 | D13 | N=3 | | | | | |
| | | | | | | | 16.00 | | | |

- Small disturbed sample
- Large disturbed sample
- Undisturbed sample
- Standard penetration test
- Water sample
- Drill core sample
- Vane test
- Field permeability test
- Moisture content (%)

Remarks

Contractor ..... Geotechnique (M)
Date started ..... 29-11-88
Date finished ..... 30-11-88

Scale: 1 div. : 10cm
Logged by .....
Checked by: .....
Date: .....
Fig. No.

**BOREHOLE No.** PIA 1
Sheet 3 of 3

Type of boring ..... Percussion .....
Type of rig ..... HSI 200 .....
Dia of boring ..... 156mm .....
Casing details .....

Feature Soil Investigation Works For The Solid
Location Waste Management Study For Pulau Pinang
And Seberang Prai Municipalities.....
Ground level:

| Date & (Time) | Depth of boring & (casing) | Ground Water | Samples & Tests: Depth | Sample | Test | Strata: Legend | Depth | Reduced Level | Thickness | Description |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | m | | | | m | m | m | |
| | | | 16.50 to 17.00 | U37 (Weight of Hammer) | | | | | | Soft Dark grey silty CLAY. |
| | | | 18.00 to 18.45 | D14 | N=3 | | 18.45 | | 6.45 | |
| 30-11-88 (8:00) | | 0.8m ▲ | | | | | | | | - End Of Borehole - |

Small disturbed sample
Large disturbed sample
Undisturbed sample
Standard penetration test
Water sample
Drill core sample
Vane test
Field permeability test
Moisture content (%)

Remarks ▲ Water Sample collected at 18.45 m.

Contractor Geotechnique (M)
Date started 29-11-88
Date finished 30-11-88

Scale: 1 div. : 10cm
Logged by .....
Checked by: .....
Date: .....
Fig. No.

**BOREHOLE No.** PTA 2
Sheet 1 of 2

Type of boring ..... Percussion .....
Type of rig ..... MSI 200 .....
Dia of boring ..... 156 mm .....
Casing details .....

Feature ..... Soil Investigation Works for the Solid .....
Location Waste Management Study For Pulau Pinang .....
And Seberang Prai Municipalities.
Ground level:

| Date & (Time) | Depth of boring & (casing) | Ground Water | Samples & Tests: Depth | Sample | Test | Strata: Legend | Depth | Reduced Level | Thickness | Description |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | m | | | | m | m | m | |
| 29-11-88 (11:30) | | | 0.00 to | | | | | | | Soft Dark grey silty CLAY with traces of decaying vegetation at top. |
| | | | 1.50 to | UD1 | | | 1.50 | | 1.50 | |
| | | | 2.00 | D2 | | | | | | Soft Dark grey silty CLAY with lenses of fine sand. |
| | | | 3.00 to | D3 | N=0 (Weight of Hammer) | | | | | |
| | | | 3.45 | | | | | | | |
| | | | 4.50 to | UD2 | | | 4.50 | | 3.00 | |
| (12:00) | | 0.45m | 5.00 | | | | | | | Top: Soft Dark grey silty CLAY with lenses of fine sand. |
| (13:00) | | 1.22 m | | D4 | | | | | | Bottom: Soft Grey medium to coarse sandy silty CLAY with a lot of shell fragments. |
| | | | 6.00 to | D5 | N=2 | | 6.00 | | 1.50 | |
| | | | 6.45 | | | | | | | Soft Grey silty CLAY with a lot of shell fragments. |
| | | | 7.50 to | D6 | N=3 | | | | | |
| | | | 7.95 | | | | 8.00 | | | |

- Small disturbed sample
- Large disturbed sample
- Undisturbed sample
- Standard penetration test
- Water sample
- Drill core sample
- Vane test
- Field permeability test
- m Moisture content (%)

Remarks

Fig.2.2-3 Borehole PTA-2 log

Contractor Geotechnique (M)
Date started 29-11-88
Date finished 30-11-88

Scale: 1 div. : 10cm
Logged by .....
Checked by: .....
Date: .....
Fig. No.

**BOREHOLE No.** BH 2
Sheet 2 of 2

Type of boring ..... Percussion
Type of rig ..... KGL 200
Dia of boring ..... 156mm
Casing details .....

Feature Soil Investigation Works For The Solid
Location Waste Management Study For Pulau Pinang
And Seberang Prai Municipalities.
Ground level:

| Date & (Time) | Depth of boring & (casing) | Ground Water | Samples & Tests: Depth | Sample | Test | Strata: Legend | Depth | Reduced Level | Thickness | Description |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | m | | | | m | m | m | |
| | | | | | | | | | | Soft Grey silty CLAY with a lot of shell fragments. |
| | | | 9.00 to | | N=2 | | 9.00 | | 9.00 | |
| | | | 9.60 | UD3 | | | | | | |
| | | | | D7 | | | | | | Soft Grey silty CLAY with lenses of fine sand. |
| | | | 10.50 to | | | | | | | |
| | | | 11.00 | UD4 | | | | | | |
| | | | 12.00 to | | N=11 | | 12.00 | | 3.00 | |
| | | | 12.45 | D8 | | | | | | Top: 15 Soft Grey silty CLAY with lenses of fine sand. Bottom: 30 Compact Grey medium to coarse SAND. |
| | | | | D9 | | | | | | |
| | | | 13.50 to | | N=10 | | 13.50 | | 1.50 | |
| | | | 13.95 | D10 | | | | | | Stiff Grey medium to coarse sandy silty CLAY. |
| | | | 15.00 to | | N=12 | | | | | |
| | | | 15.45 | D11 | | | 15.45 | | 1.95 | |
| (16:35) | | | | | | | | | | - End Of Borehole - |

- Small disturbed sample
- Large disturbed sample
- Undisturbed sample
- Standard penetration test
- Water sample
- Drill core sample
- Vane test
- Field permeability test
- m Moisture content (%)

Remarks ▲ Water Sample collected at 15.45 m.

Contractor Geotechnique (M)
Date started 29-11-88
Date finished 30-11-88

Scale: 1 div. : 10cm
Logged by .....
Checked by: .....
Date: .....
Fig. No.

## FALLING HEAD PERMEABILITY TEST

Project : Soil Investigation Works For The Solid Waste Management Study For Pulau Pinang And Seberang Prai Municipalities

Sample No. & Depth : PTA-1/UD3 (6m to 6.45m) Sample Condition : Undisturbed

| | | | |
|---|---|---|---|
| Weight of Empty Mould | (gm) | : | 2013 |
| Weight of Mould + Wet Soil | (gm) | : | 3614 |
| ϕ of Mould | (cm) | : | 10.20 |
| Length of Sample (L) | (cm) | : | 11.90 |
| Initial Moisture Content | (%) | : | 61.7 |
| Final Moisture Content | (%) | : | 62.01 |
| ϕ of Standpipe | (cm) | : | 1.40 |
| Sectional Area of Standpipe = $\frac{D^2}{4}(a)$ | ($cm^2$) | : | 1.54 |
| Volume of Mould | ($cm^3$) | : | 972.38 |
| Cross Sectional Area of Sample (A) | ($cm^2$) | : | 81.71 |
| Wet Density | ($Mg/m^3$) | : | 1.65 |
| Dry Density | ($Mg/m^3$) | : | 1.02 |

| Date | Time on Clock | Time Elapsed | Height (cm) | |
|---|---|---|---|---|
| 5/12/88 | 5:08 | | 97.8 Saturation | |
| 6/12/88 | 9:10 | | 80.0 Saturation | |
| | 10:27 | | 79.0 Saturation | |
| | 11:52 | | 78.0 Saturation | |
| | 12:31 | | 77.5 Saturation | |
| | 1:38 | | 76.7 Saturation | |
| | 3:09 | | 75.5 Saturation | |
| | 4:11 | | 74.7 Saturation | |
| 7/12/88 | (t1) 8:53 | | 62.0 | h1 |
| | 10:16 | | 61.1 | |
| | 11:16 | | 60.4 | |
| | 12:16 | | 59.7 | |
| | 2:06 | 90,480 seconds | 58.7 | |
| | 2:16 | | 58.6 | |
| | 3:16 | | 58.1 | |
| | 4:35 | | 57.0 | |
| 8/12/88 | (t2) 10:01 | | 46.4 | h2 |

Fig. 2.2-4 Falling Head Permeability Test of Undisturbed Sample from PTA-1

Sample No. & Depth : PTA-1/UD3 (6.00 - 6.45m)

$$K = \frac{2.3026\ aL}{A(t2 - t1)} \log_{10} \frac{h1}{h2}$$

$K_{29^o} = 7.2 \times 10^{-7}$ cm/sec.

$K_{20} = 5.90 \times 10^{-7}$ cm/sec.

Remarks : Initial K = $7.39 \times 10^{-7}$ cm/sec.

t2 - t1 = 90,490 seconds

A = 81.71

h1 = 62.0

h2 = 46.4

a = 1.54

FALLING HEAD PERMEABILITY TEST

Project : Soil Investigation Works For The Solid Waste Management Study For Pulau Pinang And Seberang Prai Municipalities

Sample No. & Depth : PTA-2/UD2 (4.5m to 5m) Sample Condition : Undisturbed

| | | | |
|---|---|---|---|
| Weight of Empty Mould | (gm) | : | 7406 |
| Weight of Mould + Wet Soil | (gm) | : | 7881 |
| ϕ of Mould | (cm) | : | 5.08 |
| Length of Sample (L) | (cm) | : | 11.90 |
| Initial Moisture Content | (%) | : | 27.21 |
| Final Moisture Content | (%) | : | 29.1 |
| ϕ of Standpipe | (cm) | : | 1.27 |
| Sectional Area of Standpipe = $\frac{\pi D^2}{4}$ (a) | ($cm^2$) | : | 1.267 |
| Volume of Mould | ($cm^3$) | : | 241.193 |
| Cross Sectional Area of Sample (A) | ($cm^2$) | : | 20.27 |
| Wet Density | ($Mg/m^3$) | : | 1.97 |
| Dry Density | ($Mg/m^3$) | : | 1.55 |

| Date | Time on Clock | Time Elapsed | Height (cm) | |
|---|---|---|---|---|
| 6/12/88 | 11:47 | | 93.5 Saturation | |
| | 12:31 | | 91.0 Saturation | |
| | 1:38 | | 87.8 Saturation | |
| | 3:09 | | 83.9 Saturation | |
| | 4:11 | | 81.5 Saturation | |
| 7/12/88 | (t1) 8:52 | | 50.1 | h1 |
| | 10:16 | | 48.1 | |
| | 11.16 | | 46.6 | |
| | 12:16 | 26,820 seconds | 45.3 | |
| | 2:07 | | 42.6 | |
| | 2:16 | | 42.5 | |
| | 3:16 | | 41.0 | |
| | (t2) 4:35 | | 39.3 | h2 |
| 8/12/88 | 10:01 | | 62.2 | |
| | 11:18 | | 60.3 | |

Fig.2.2-5 Falling Head Permeability Test of Undisturbed Sample from PTA-2

Sample No. & Depth : PTA-2/UD2 (4.50 - 5.00m)

$$K = \frac{2.3026\ aL}{A(t2 - t1)} \log 10 \frac{h1}{h2}$$

$K_{20^\circ} = 6.73 \times 10^{-6}$ cm/sec.

$K_{20} = 5.50 \times 10^{-6}$ cm/sec.

t2 - t1 = 26,820 seconds

A = 20.27

h1 = 50.1

h2 = 39.3

a = 1.267

Remarks : Initial K = $6.45 \times 10^{-6}$ cm/sec.

## SUMMARY OF LABORATORY TEST RESULTS

Soil Investigation Works For The Solid Waste Management Study For Pulau Pinang And Seberang Prai Municipalities - 40/037/88

**GEOTECHNIQUE (M) SDN. BHD.**

| BOREHOLE No. | SAMPLE No. | DEPTH (M) FROM | DEPTH (M) TO | NATURAL MOISTURE CONTENT % | BULK DENSITY $Mg/m^3$ | DRY DENSITY $Mg/m^3$ | SPECIFIC GRAVITY | ATTERBERG LIMITS % LIQUID LIMIT | ATTERBERG LIMITS % PLASTIC LIMIT | ATTERBERG LIMITS % PLASTIC INDEX | UNCONFINED COMPRESSION STRENGTH $kN/m^2$ | TRIAXIAL COMPRESSION TEST APPARENT COHESION $kN/m^2$ | TRIAXIAL COMPRESSION TEST ANGLE OF SHEARING RESISTANCE $\phi$ | VOID RATIO e | COEFFICIENT OF PERMEABILITY K CM/SEC. | CONSOLIDATION TEST PRE-COMPRESSION LOAD $kN/m^2$ | CONSOLIDATION TEST COMPRESSION INDEX Cc | COMPACTION TEST OPTIMUM MOISTURE CONTENT % | COMPACTION TEST MAXIMUM DRY DENSITY $Mg/m^3$ | PARTICLE SIZE DISTRIBUTION % GRAVEL > 2 mm. | PARTICLE SIZE DISTRIBUTION % SAND 0.06 - 2 mm. | PARTICLE SIZE DISTRIBUTION % SILT/CLAY < 0.06 mm. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PTA-1 | UD1 | 1.50 | 2.00* | | | | 2.43 | 74 | 40 | 34 | 2.8 | | | | | | | | | 1 | ? | 52/45 |
| | UD2 | 3.00 | 3.50 | 114.9 | | | 2.64 | 55 | 29 | 26 | | | | | | | | | | 1 | 8 | 50/41 |
| | UD3 | 6.00 | 6.45 | 66.6 | 1.58 | 0.95 | 2.47 | 47 | 23 | 24 | | 4.5 | 0.8 | | | | | | | 1 | 13 | 54/32 |
| | UD5 | 9.00 | 9.50 | | | | 2.62 | 45 | 21 | 24 | 16.8 | | | | | | | | | 10 | 19 | 51/21 |
| | UD6 | 12.00 | 12.60 | 82.2 | 1.52 | 0.83 | 2.54 | 64 | 31 | 33 | | 10.0 | 2.0 | | | | | | | 0 | 1 | 46/53 |
| | UD7 | 16.50 | 17.00 | 112.7 | 1.41 | 0.66 | 2.50 | 86 | 44 | 42 | | 14.0 | 1.2 | | | | | | | 1 | ? | 52/45 |
| | D14 | 18.00 | 18.45 | 106.0 | | | 2.35 | 91 | 41 | 50 | | | | | | | | | | 1 | 1 | 30/59 |
| | | | | | | | | | | | | | | | | | | | | | | |
| PTA-2 | UD1 | 1.50 | 2.00 | | | | 2.58 | 38 | 21 | 17 | 3.3 | | | | | | | | | 3 | 27 | 48/27 |
| | D3 | 3.00 | 3.45 | 144.4 | | | | 76 | 40 | 36 | | | | | | | | | | | | |
| | UD2 | 4.50 | 5.00 | | | | 2.61 | 44 | 24 | 20 | 7.6 | | | | | | | | | 22 | 29 | 31/18 |

Fig. 2.2-6 Summary of Laboratory Test Results

## SUMMARY OF LABORATORY TEST RESULTS

Soil Investigation Works for The Solid Waste Management Study for Pulau Pinang And Seberang Prai Municipalities - MJ/032/88

**GEOTECHNIQUE (M) SDN. BHD.**

| BOREHOLE No. | SAMPLE No. | DEPTH (M) | | NATURAL MOISTURE CONTENT % | BULK DENSITY Mg/m³ | DRY DENSITY Mg/m³ | SPECIFIC GRAVITY | ATTERBERG LIMITS % | | | UNCONFINED COMPRESSION STRENGTH kN/m² | TRIAXIAL COMPRESSION TEST | | VOID RATIO e | COEFFICIENT OF PERMEABILITY K CM/SEC. | CONSOLIDATION TEST | | COMPACTION TEST | | PARTICLE SIZE DISTRIBUTION % | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FROM | TO | | | | | LIQUID LIMIT | PLASTIC LIMIT | PLASTIC INDEX | | APPARENT COHESION kN/m² | ANGLE OF SHEARING RESISTANCE ϕ | | | PRE-COMPRESSION LOAD kN/m² | COMPRESSION INDEX Cc. | OPTIMUM MOISTURE CONTENT % | MAXIMUM DRY DENSITY Mg/m³ | GRAVEL > 2 mm. | SAND 0.06 - 2 mm. | SILT/CLAY < 0.06 mm. |
| PTA-2 | D5 | 6.00 | 6.45 | 50.0 | | | | | | | | | | | | | | | | | | |
| | UD3 | 9.00 | 9.60 | 126.5 | 1.40 | 0.62 | 2.50 | 94 | 38 | 56 | | 7.0 | 4.1 | | | | | | | 1 | 4 | 33/43 |
| | UD4 | 10.50 | 11.00 | 104.2 | 1.43 | 0.70 | 2.47 | 79 | 38 | 41 | | 5.0 | 2.7 | | | | | | | 4 | 6 | 40/50 |
| | D8 | 12.00 | 12.45 | | | | 2.67 | | | | | | | | | | | | | 20 | 72 | 8 |
| | D10 | 13.50 | 13.95 | 16.0 | | | 2.56 | 26 | 13 | 13 | | | | | | | | | | 15 | 61 | 8/16 |
| | D11 | 15.00 | 15.45 | 12.7 | | | 2.65 | | | | | | | | | | | | | 17 | 57 | 6/20 |
| | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | |

# 3 Preliminary Design of PADS

## 3.1 Planning Conditions

### 3.1.1 Basic Principals

The final disposal site composes the ultimate termination point of accumulated waste, resulting in a land reclamation site by means of landfill. Accordingly, upon consideration of the necessary functions of a final disposal site, the basic principals for the execution of the preliminary designs regarding Phase I of the project have been conceived of and are arranged in the following.

(1) An adequate landfill volume exists
Within the areas selected as final disposal sites, the guarantee of landfill volume in Phase III (2005) and the smooth derivation from the landfill design of Phase I are considered.

(2) The design appropriately pertains to the topography, geology and surrounding environment.

(3) The wastes disposed of at the site are to be harmless and stablized quickly.

(4) During and after completion of the filling, the area does not become a pollution outbreak source.

(5) During and after completion of the filling, safety from disaster is guaranteed.

(6) The completed site will be of a configuration harmonious with the surrounding environment.

(7) Throughout and after completion of the filling, the operation and maintenance expenses will be kept low.

### 3.1.2 Designed Landfill Volume

(1) Conditions for Estimation

a. Landfill periods: 1992 - 1996 (Phase I)
1997 - 2005 (Phase II & III)

b. Unit weight of wastes disposed: 0.8 ton/m3
(after compaction)

c. Covering materials 30% of the waste volume performed everyday

(2) Desinged Landfill Volume

The designed landfill volumes for the Kuala Muda and Pulau Burong disposal sites within Phase I, II and III are listed below.

Table 3.1-1 Designed Landfill Volume

| Item | Unit | Phase I | Phase II & III | Remarks |
|---|---|---|---|---|
| Disposal Amount | t/day | 560 | 770 | Phase I 1996<br>Phase II&III 2005 |
| Cumulative Disposal Amount Total | 1000t | 950 | 3,159 | |
| Cumulative Disposal Volume | 1000m3 | 1,188 | 3,949 | 0.8 ton/$m^3$ |
| Cumulative Covering Material | 1000m3 | 356 | 1,186 | 30% of the above volume |
| Designed Landfill Volume | 1000m3 | 1,544 | 5,134 | |

### 3.1.3 Topography and Geology

(1) Topography

a. Topography

The final disposal site at Pantai Acheh is situated between PenangRiver and Pantai Acheh fishing village. Along the coast, to the inland side is the Mangrove Forest. The D.I.D separated the area by the construction of a drain and bund. The elevation of the area is an average 0.5m and is a low marsh. Also, as the sea is still very shallow at a distance from the shore, at low tide the water line recedes 1km.

b. Geology

The geology is pricipally marine clay accumulated layers where very thin layers of gravel and sand are accumulated hoizoritally. The geological inspection was done by boring and the following is the derived profile.

Table 3.1-2 Characteristics of Marine Clay

| Items | Unit | PADS |
|---|---|---|
| Natural Moisture Content | % | 80 - 100 |
| Bulk Density | $ton/m^3$ | 1.5 - 1.6 |
| Specific gravity | | 2.4 - 2.6 |
| Atterberg limit | | |
| - Plastic limit | % | 25 - 40 |
| - Liquid limit | % | 47 - 70 |
| Permeability coefficient | cm/sec | $10^{-6}$ - $10^{-7}$ |

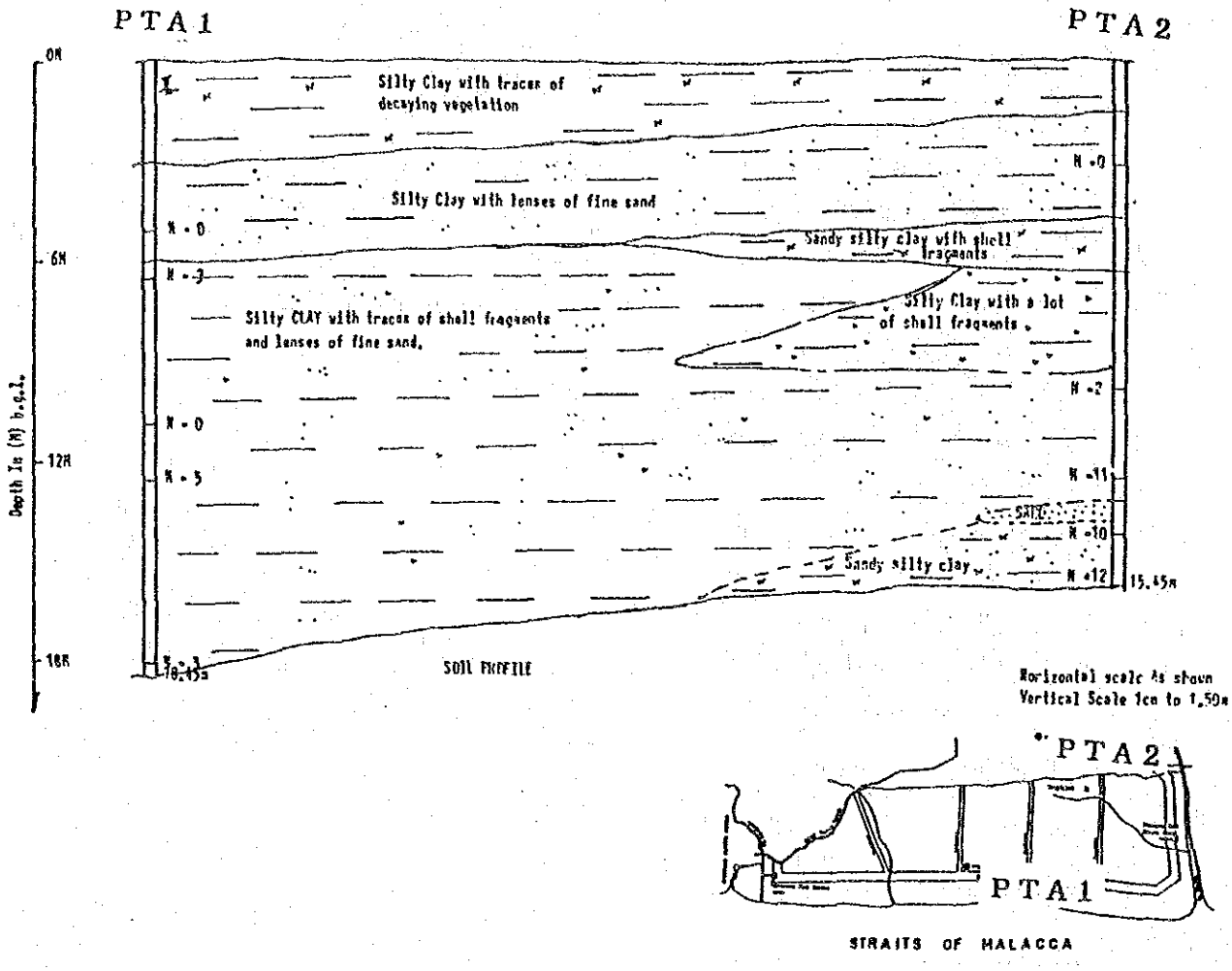



Fig. 3.1-1 PADS Geological Profile

## 3.2 Facility Design

### 3.2.1 Facility Lay-out

(1) Design principals

The design principals for the facility lay-out are as follows.

a. The design is to smoothen the execution and transitions in the work from Phase I through to Phase III.

b. Regarding the surrounding land use conditions, the consideration is that each facility cast no bad effects on the local area.

c. The on-site roads/or landfill flow are to be uncomplicated and harmonious.

d. The administration facilities are to be erected near the entrance to the disposal site for full supervision of the waste collection vehicles.

e. Each type of facility is to not be decentralized but placed near administration facilities, making maintenance operation easy.

f. The leachate cycling facilities are to be placed as far away as possible from residential areas.

(2) Types of facilities

a. Main Facilities

i. Enclosing structure .... Enclosing bund/divider

ii. Drainage system .....Surrounding drain/onsite drain (surface)/on-site drain (underground)/ drain for reclaimed area.

iii. Access ..... Approach road/on-site road/improvement of existing road.

b. Environmental protection facilities

i. Buffer zone

ii. Litter control facilities

iii. Gas removal facilities

iv. Leachate collection facilities

v. Leachate cycling facilities

vi. Leachate effluence facilities

vii. Monitoring facilities

c. Building and accessories

i. Site office

ii. Weigh bridge

iii. Storage building

iv. Safety facilities ..... Gates/fences/street lights

v. Fire prevention facilities .... Water tank, extinguisher,

vi. Other ..... Parking lot/greenery/car wash, etc.

(3) Lay-out design

The lay-out of the main facilities is as follows.

a. Approach road

An approach road is planned in order to regulate the site. The sight distance of the intersection of the existing road is to be adequate.

The slope is to be gentle, matching that of the existing road.

b. Buffer zone

The buffer zone is established inland and of a 50m width and filled with the Mangrove Forest. It is to exist between the reclaimed area adjacent to the landfill site.

c. Surrounding drain

A bund of 5m height is designed to be placed inside the buffer zone along the land in use for an assured 25ha landfill site.

d. Retention pond

This is to be placed at a distance from the reclamation area,

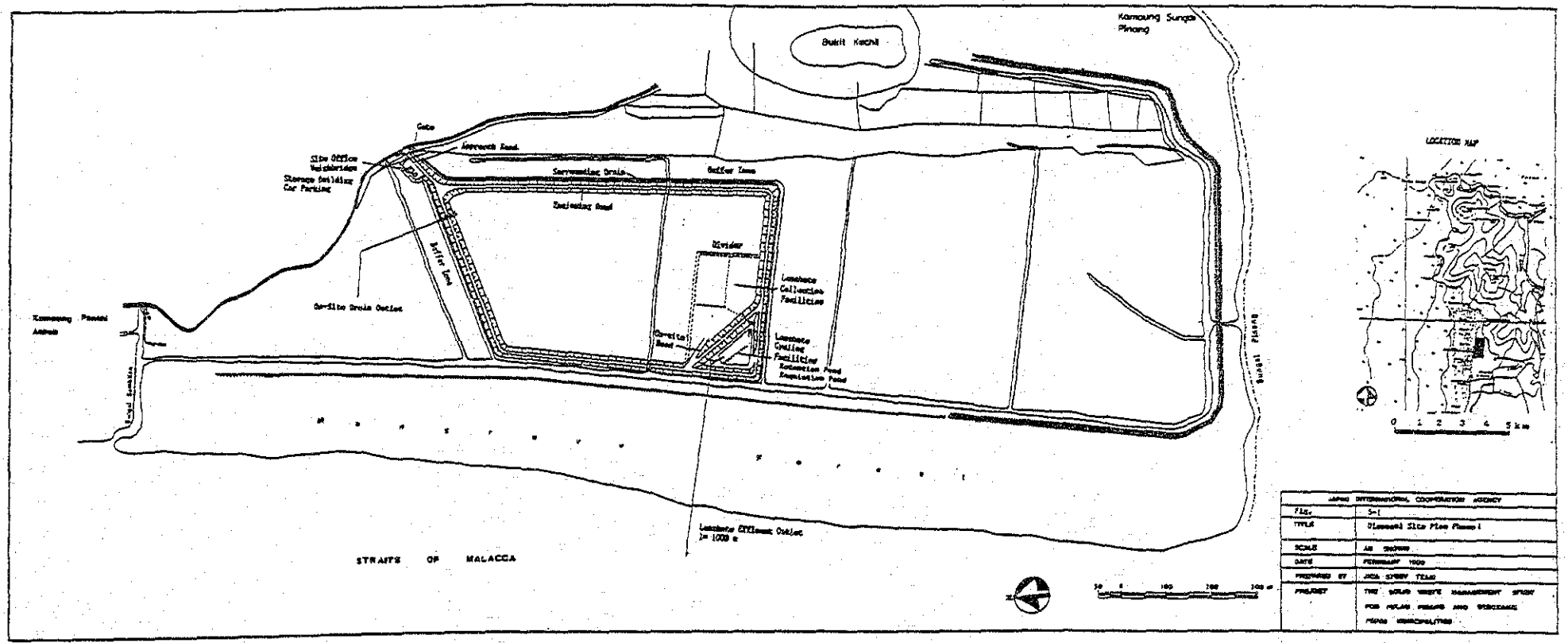



Fig. 3.2-1 The Lay-out of the Major Facilities for PADS

### 3.2.2 Main Facilities

At the final disposal site, as basic facilities for landfill disposal, the principal goals for the main facilities are the guarantee of landfill volume and the reduction of leachate.

(1) Enclosing structures

a. Enclosing bund

Because the disposal site is located on flat land in order to carry out sanitary landfill, enclosing the landfill site will be a bund for the prevention of rain water invasion and the guarantee of the designed landfill volume.

Earth construction is applied to the bund structure based on,

i. topography (marsh),
ii. ground (soft ground),
iii. construction characteristics, and
iv. economic characteristics.

The landfill height and bund height are calculated based on the results from the study on the

i. designed landfill volume
(The target year for the master plan is 2005)
ii. site area ; 100ha
iii. facilities site (bund, facilities for inspection and administration, buffer zone etc.),
iv. bund foundation soil,
v. settlement,
vi. covering materials, and
vii. tide and waves.

The results show the landfill height at 6.6m and the bund height at 5m. The bund top functioning as the on-site road and the disposal site administration road is of a 5m width and a gravel pavement.

As for the bund, a typical cross section shown in Fig. 3.2-2, follows a land sliding analysis and the settlement study, based on geological investigation data.

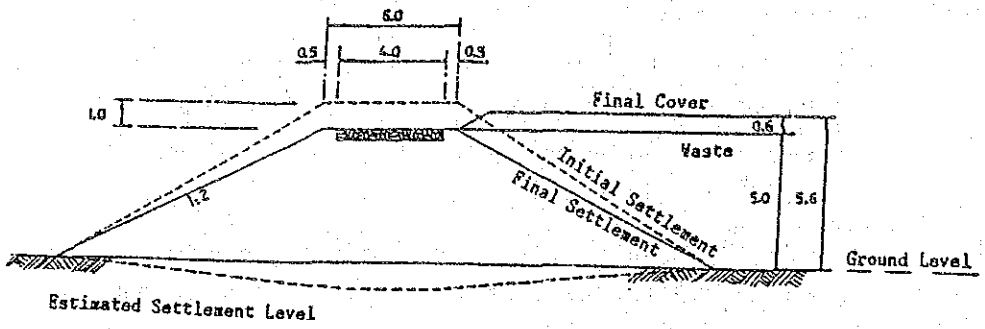



Fig. 3.2-2 Typical Cross Section of Enclosing Bund

Within the preliminary designs, by the typical cross section of enclosing bund required in the master plan, the designed landfill volume up until 1996 of Phase I is assured. The Phase I necessary landfill site is for KMDS, 10ha and for PBDS, 11ha.

The soil parameter employing the land sliding analysis is shown in the following table.

Table 3.2-1 Soil Parameter Table

| Earth Layer | Unit Weight | Cohesion | Angle of Internal Friction |
|---|---|---|---|
| | $r$ ($t/m^3$) | $c$ ($t/m^2$) | $\phi$ (Degree) |
| Foundation | 1.5 | 1.5 | 0 |
| Bund | 1.6 | 2.0 | 30 |
| Waste Layer | 1.0 | 1.5 | 30 |

And, the groundwater level is the same as that of the earth's surface.

b. Divider

Generally, the divider inside the enclosing bund is established based on the following goals.

i. Landfill Work ..... By limiting the area for landfilling, efficient equipment and landfill operation are assured.

ii. Waste conditions ..... The types of waste are separated for landfill purposes.

iii. Leachate Measure ..... The rainwater and spring water from non-landfill areas are eliminated thus allowing for smaller scale leachate cycling facilities.

iv. Facility Construction ..... Leachate collection facilities are prepared in a stepby-step procedure.

Since waste to be disposed of is not reduced in volume due to non-intermediate treatment facilities such as incinerators, the landfill volume is huge. The major purpose of a divider is explaind in iii. reduction of leachate quantity.

For the maintenance operation for the divider,

- Bund deformation ..... Differential settlement
- Bund water isolation ..... Impermeable soil have been considered, with the bund height at 1.5m. The site soil permeability coefficient of $10^{-6}$ - $10^{-7}$ cm/sec is suitable for the the divider construction. However, as this is a marsh, the construction is carried out using imported soil.

The 1996 yearly landfill area is calculated at 5.0ha for site, after considering the bund height and final covering materials.

Consequently, in order to find the average leachate volume, for the site in rainy season the area of a divider is determined at 2.0ha, in dry season at 3.0ha.

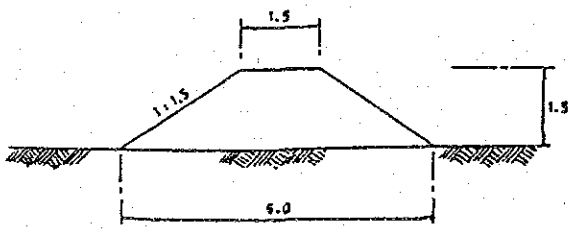



Fig. 3.2-3 Typical Cross Section of Divider

(2) Drainage System

a. General

When waste comes in contact with rainwater, following waste decomposition, there is elution of many produced contaminants/or there is suspension resulting in the formation of leachate.

Because leachate contaminates the surrounding area, the target for drainage system is the reduction of leachate volume. The principal purposes for the systems are listed below.

i. Elimination of rainwater from the water inflow from outside the landfill site.

ii. Elimination of inflowing spring water from side surfaces/or underground.

iii. Elimination of rainwater from the non-landfill site partitioned-off by the divider within the enclosing bund.

iv. Elimination of rainwater from the completed landfill site.

As a disaster prevention measure, the drainage discharges outside the disposal site.

b. Design Conditions

The conditions for the design of economical systems for the effectiveness of the above purposes are as follows.

i. The drainage system design is based on the "Urban Drainage Design Standards and Procedures for Peninsular Malaysia"

ii. Discharge Design;

Table 3.2-2 Discharge Design

| Drain | Return Period (year) | Daily Rain-fall (mm/day) | Rainfall Intensity (mm/hr) | Runoff Coeff-icient | Discharge (m3/sec/ha) | Remarks |
|---|---|---|---|---|---|---|
| Surrounding Drain | 2 to 5 yrs. | 100<br>125 | 65<br>80 | 0.35<br>0.35 | 0.064<br>0.078 | Rainfall duration is one hour |
| On-site Drain * | 0.5 | 60 | 30 | 1.0 | 0.167 | Rainfall duration is 30min. |
| Drain for Reclaimed Area | 0.5 | 60 | 30 | 0.9 | 0.150 | - ditto - |

* The on-site drain for underground water will be constructed if necessary.

c. Drain

i. Surrounding drain

The drain will be installed outside of the enclosing bund, joining the existing drain.

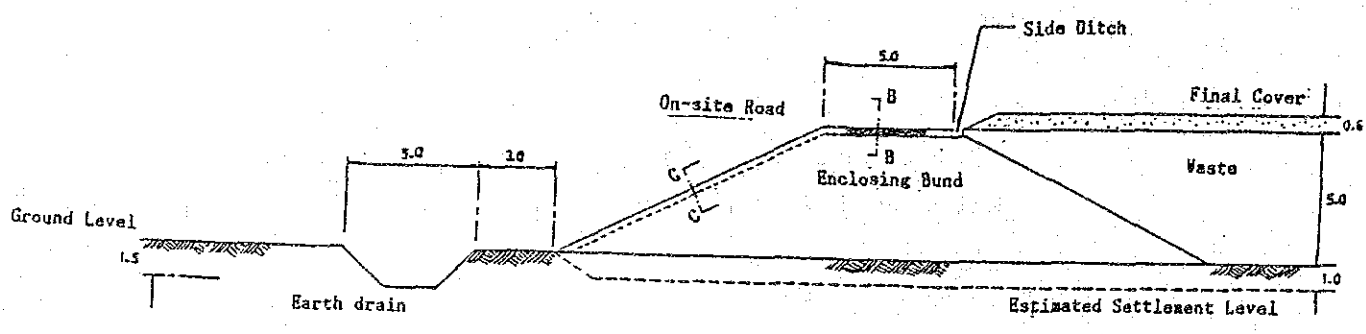



Fig. 3.2-4 Typical Cross Section of Surrounding Drain

ii.On-site drain (surface)

1) Since the ground is composed of marine clay, unlined drains are installed.
2) The drainage from the inside of the landfill area to the outside the bund is discharged naturally following the tidal fluctuations. (cf. Fig. 3.2-5)

iii. Drain for reclaimed area

1) This drain is established after the completion of final covering of material.
2) The lining of the unlined drain is marine clay.
3) The slope of the drain is less than 2%.
4) Rainwater is discharged outside the enclosing bund.

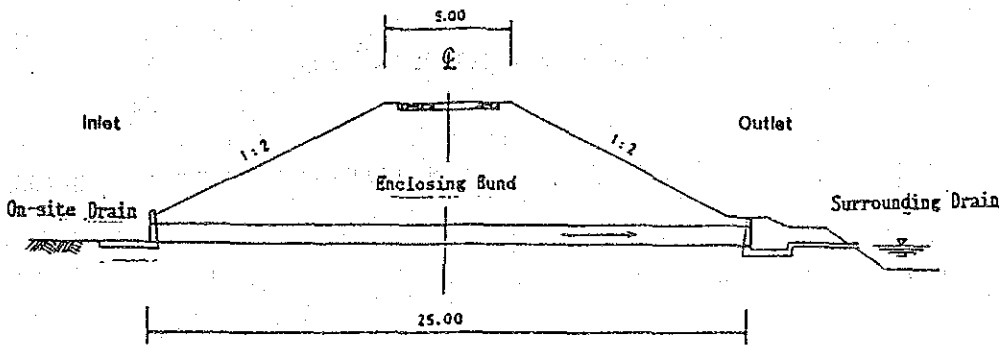



Fig. 3.2-5 Drain Outlet Profile

(3) Access

a. Approach road

This road is to harmonize the entrance of the collection vehicle from the public road to the disposal site.

i. An approach road from the public road into the disposal site will be established.

ii. The road will be wide encough for two-way traffic with a carriageway of 6m.

iii. The road will be asphalt-paved.

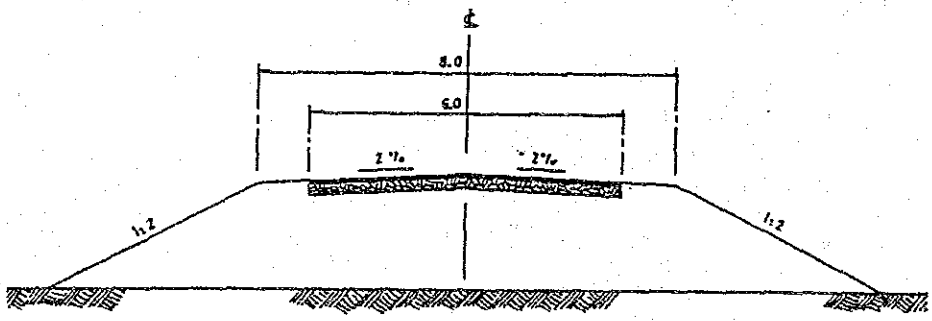



Fig. 3.2-6 Typical Cross Section of Approach Road

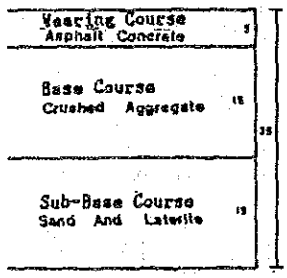



Fig. 3.2-7 Detail of Pavement for Approach Road

b. On-site road

The on-site road includes the road on the top of the bund and the road which joins the bund and working face. The road on the top of the bund also represents the inspection and administration road of the disposal site.

i. The road width is to be 5m.

ii. 4m of the road is paved with gravel at a thickness of 30cm.

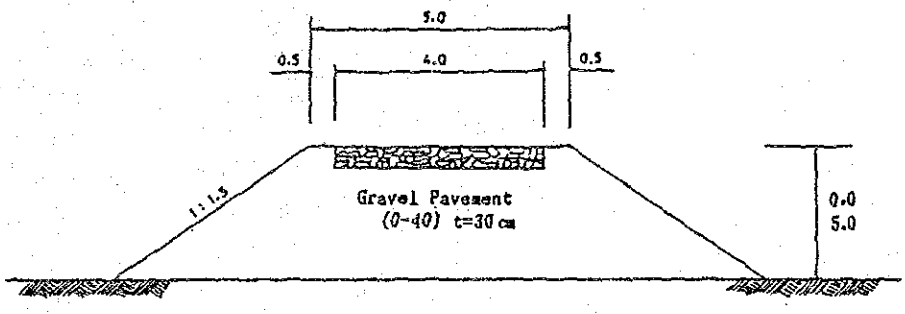



Fig. 3.2-8 Typical Cross Section of On-site Road

c. Reconstruction of the Existing Bridge

Because the espacity of the bridge in the Kampung Bukit Kechil vicenity is not great enough for heavy vehecles, it will be reconstructed.

| | |
|---|---|
| width | 6m |
| length | 13m |

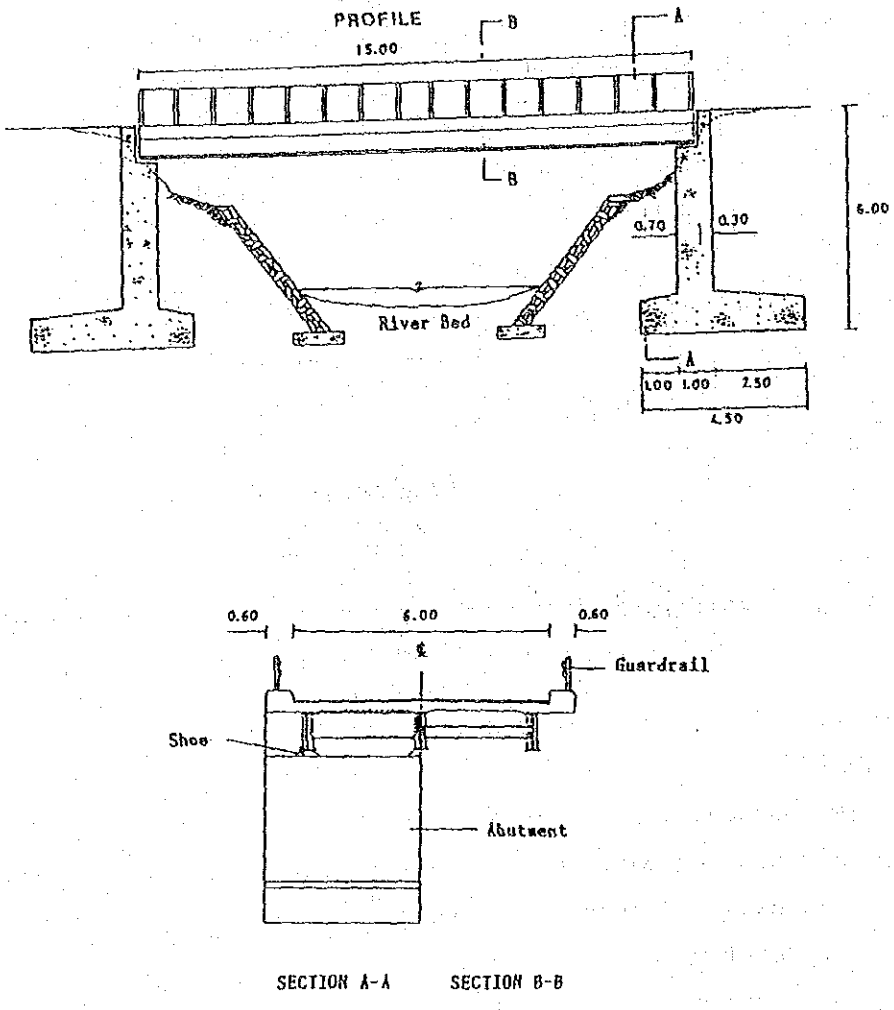



Fig. 3.2-9 Reconstruction Bridge

### 3.2.3 Environmental Protection Facilities

The facilities are for the prevention of primary and secondary pollution outbreak during and after completion of landfill operations.

(1) Buffer zone

This will be constructed between the disposal site and the residential area for essentially the following purposes.

- To hide the site from direct view
- To reduce the noise and vibrations emitted during landfilling.
- To reduce odors.
- To balance the site with the natural surroundings in a harmonious fashion.

The buffer zone is hoped to occupy quite a bit of space. However, since this would result in a reduction in landfill volume, the zone is set at a 50m width.

For forestry and for environmental protection for the planned housing development, this will expand to a 50m width outside of the enclosing bund containing, as is, the Mangrove Forest.

(2) Litter control facilities

Litter control within the landfill site follows the same measure as is taken for disaster and pest control, wherein principally the covering material acts as the main agent. Nonetheless, there looms the inevitability of litter scattering during the landfill oparations before the covering material has been placed. As a means of prevention, a movable fence to catch flying litter will be put up.

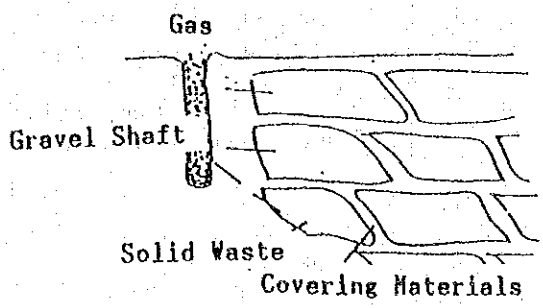
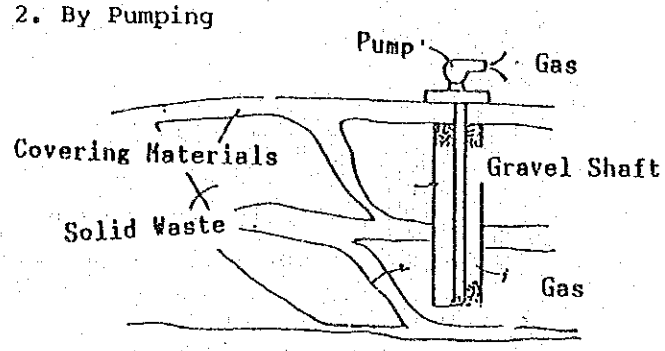
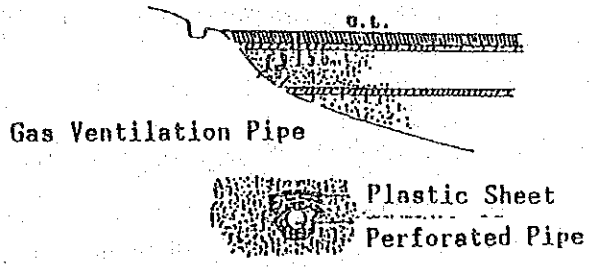
(3) Gas removal facilities

For the organic matters present during landfilling operations, decomposition occurs by loamy microbes and results in the production of water, gas and inorganic clorines. If the landfill structure houses aerobic matters, this gives rise to aerobic bacterial activety. If the decomposition is early, carbon dioxide, water, ammonia etc. are produced, without a problem. On one hand, if the structure houses anarobic matters, this gives rise to anaerobic bacteria, which slow decomposition, thus odors and combustable gas, such as methane, carbon dioxide, hydrogen sulfide and ammonia, are emitted, badly affecting the environment.

Generally, as for the outbreak of gas in landfill sites, gushing and exhaust are common at the weak points on the boundary surface between landfill sites and surrounding structures. Disaster prevention measures, which are represented by gas removal facilities are necessary at points where gas unexpectedly gushes and thus produces fires, odors etc.

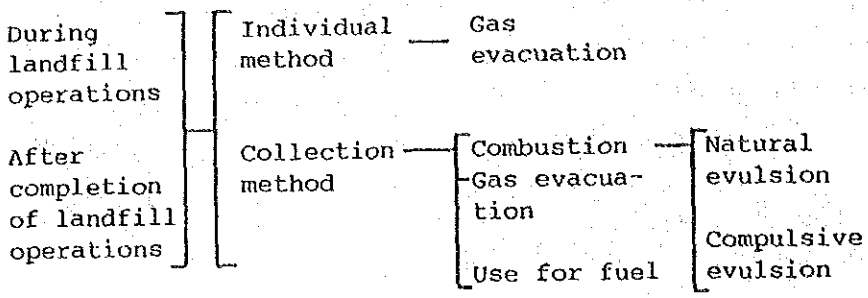
As for gas removal facilities, as shown below, there are three types under consideration : by evacuation, by pumping and by ventilation. Within these designs, the most economical gas remmoval facility, the one by evacuation, has been selected.

Table 3.2-3 Characteristics of Types of Gas Removal Facilities

| | |
|---|---|
| 1. By Evacuation<br>  <br> | By excavating a shaft in the vertical direction and filling it with gravel, the gas is expelled. |
| 2. By Pumping<br>  <br> | By excavating a well and installing a pump, the gas enters the well and is expelled. |
| 3. By Ventilation<br>  <br> | By installing pipe in the horizontal direction and embedding it with gravel, the gas is expelled by forced ventilation. |

For these gas removal facilities, joined with the leachate collection facilities, the function of the expansion of the aerobic range within the landfill is expected.

Gas removal facilities by evacuation are set-up as follows.



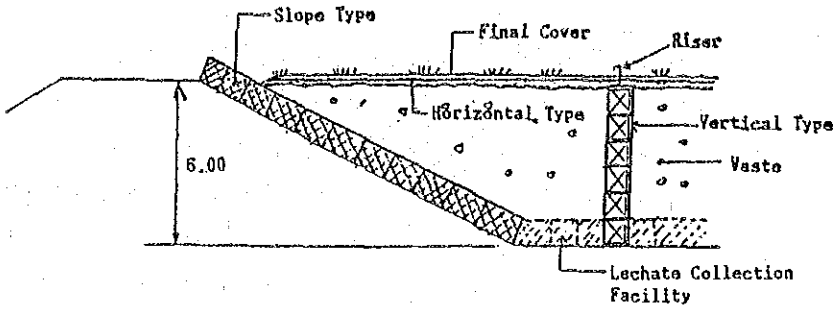

The waste characteristics, stratum thickness and operational conditions for the design conditins of the gas removal facilities by evacuation are the following.

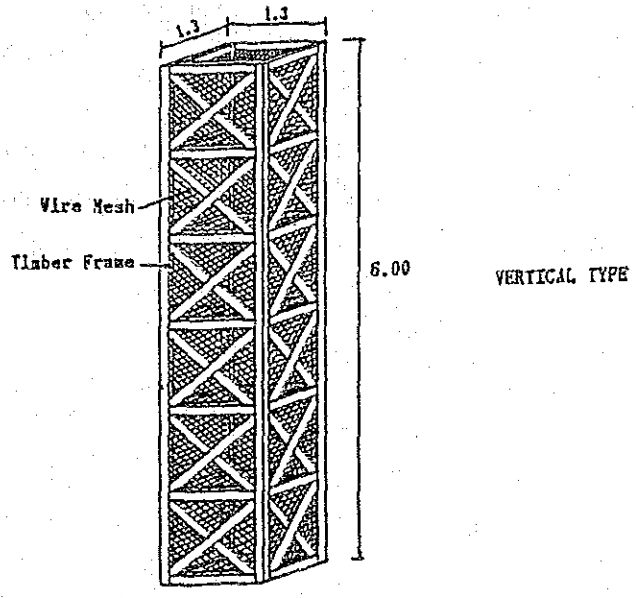
1) waste type .... garbage
2) landfill layer thickness ..... approx. 6.6m
3) operational conditions ..... the landfill site area at 25ha at site the divider will occupy 2-3ha.

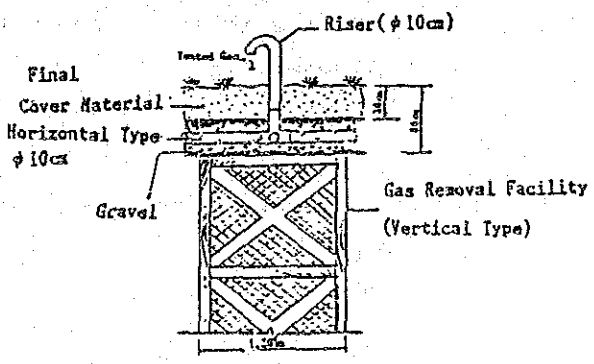
Based on the above conditions, during landfilling operations the individual gas evacuation method is followed and after the completion of landfill, from the point of view of safety and control, the collective gas evacuation method is followed by connecting individual vertical shafts with horizontal shaft.

An outline of the gas removal facilities is shown in Fig. 3.2-10.

The completed landfill site gas removal facilities have been designed at 3-4 positions per hectare. As for disaster prevention measures, the gas removal facilities make prevention quite possible. However, the covering material is the most important factor, as it is necessary to not leave waste exposed over a long term.



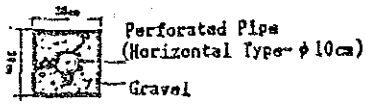




Fig. 3.2-10 Gas Removal Facilities by Evacuation

(4) Leachate collection facilities

a. General

Their purpose is to collect the rainwater contaminated by waste, the water within waste as well as decomposed polluted water and send it to the leachate control facilities. At the same time, they play a shield-like role for the prevention of deterioration of the surrounding areas by the permeation or discharge of contaminated water. Moreover, depending on the joining of the leachate collection facilities to the gas removal facilities, it is also possible to expand the aerobic area within the landfill layer.

As for the leachate collection facilities, depending on h e topography, the configuration of the landfill and the structures, there are many combinations considered. The functions are classified below.

i. Horizontal leachate collection

Leachate collection which doesn't allow for leachate to rest in the landfill site is based on a downflowing, natural type of collection . The facilities will be established at the bottom of the landfill site.

ii. Vertical leachate collection

The landfill layer is thick thus suggesting that the time it takes for leachate to reach the bottom of the landfill site for collection is long. In this case, a vertical leachate collection facility will also be established.

iii. Leachate drain pipe

This is to discharge the leachate collected by the site's inner facilities to the outside of the site.

The landfill depth is 6.1m and not very profound. However, the slope and the vertical gas removal facilities will be used as a substitute for the vertical leachate collection facilities.

As leachate collection facilities, a drain lined with rubble is provided. However, due to soft ground, unequal settlement is expected, thus a rubble-lined drain which responds to the functuations in the soil will be constructed. As is usual, the gabion method will be employed.

b. Preliminary design

i. Design flow

The purpose of these facilities is

1) for leachate conveyance to leachate cycling facilities
2) to reduce the leachate head (pressure) in the landfill
3) for the expansion of the aerobic area in the landfill layer by their (leachate collection facilities) connection to the gas removal facilities

The following is a flowchart on the design of the leachate collection facilites.

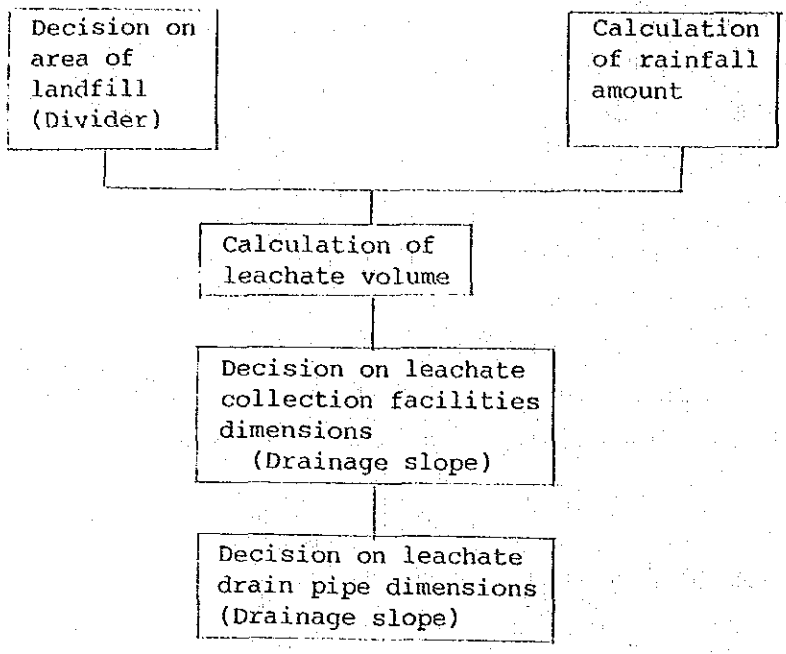



Fig. 3.2-11 Design flowchart of Leachate Collection Facilities

ii. Area of landfill site

The study on the area done in relation to the divider is described as follows:

| | | |
|---|---|---|
| Rainy season | (Jul.-Nov.) | 2.0ha |
| Dry season | (Dec.-Jun.) | 3.0ha |

iii. Record on rainfall and evaporation

Table 3.2-4 Daily Average Rainfall and Evaporation

Penang International Airport

| Category | Month | | | | | | | | | | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | |
| 1. monthly average rainfall amount(mm) | 69.6 | 93.3 | 104.7 | 213.7 | 240.0 | 170.0 | 207.9 | 235.3 | 341.4 | 379.9 | 246.0 | 106.9 | 1951 1985 |
| 2. daily average rainfall amount(mm) | 2.2 | 3.3 | 4.5 | 7.1 | 7.7 | 5.7 | 6.7 | 7.6 | 11.4 | 12.3 | 8.2 | 3.4 | |
| 3. daily average Evaporation amount(mm) | 3.5 | 3.6 | 3.4 | 3.1 | 2.8 | 2.8 | 2.6 | 2.4 | 2.4 | 2.4 | 2.4 | 3.0 | 1983 1987 |
| 4. monthly average defference (mm) (2-3) | - | - | 1.1 | 4.0 | 4.9 | 2.9 | 4.0 | 5.2 | 9.0 | 9.9 | 5.8 | 0.4 | |

Note: - For surface water evaporation, the steppe coefficient of 0.75 was employed

iv. Calculation of leachate volume

The calculation method using a rational formula is shown below.

(Leachate Volume Calculation formula)

$$Q = 1/1000\ (C_1 * A_1 + C_2 * A_2) I$$

$$(A = A_1 + A_2 + A_3)$$

Notes:

Q ; leachate volume ($m^3$/day)

A : landfill site catchment area total($m^2$)

$A_1$: $(A_1-A_2-A_3)$ ($m^2$), area where there is no direct elimination of surface flow ($m^2$) (principally, the area of the divider where landfilling is conducted)

$A_2$: area of completed landfill where surface flow is directly eliminated ($m^2$)

$A_3$: area of non-filled side where rainwater is directly eliminated ($m^2$)

$C_1$: $A_1$ divider leachate generation ratio

$C_1$= 0.4 - 0.7 standard value is 0.5

$C_2$: $A_2$ divider leachate generation ratio

I : largest monthly average rainfall amount

Daily conversion value (mm/day) - Daily average evapo ration amount(mm/day)

At the time of leachate volume calculation, in the completed reclaimed area, after 1 year has elapsed, due to the completion of final the covering of material and of an adequate drainage system, it is expected that the rainwater will entirely discharge outside the area.

Table 3.2-5 Leachate Volume by Season

| Season | $A_1$ (ha) | $A_2$ (ha) | I (mm/day) | Q ($m^3$/day) |
|---|---|---|---|---|
| rainy season | 2.0 | 3.0 | 9.9 | 188 |
| dry season | 3.0 | 2.0 | 4.9 | 103 |

v. Decision on dimensions of leachate collection facilities For the leachate collection facilities, not only the effects of collection but also of ventilation are considered, thus allowing for an ample margin of flow capacity. As collection facilities, gabions are constructed of which the dimensions are shown in the below figure.

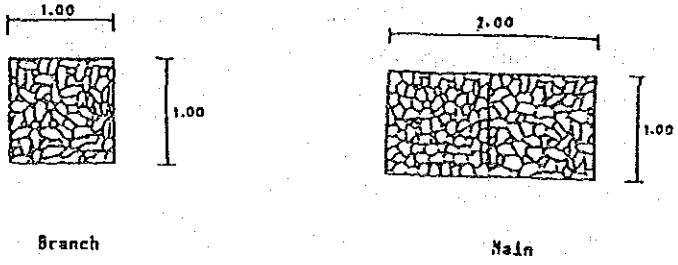



Fig. 3.2-12 Leachate Collection Facility Dimensions

The seepage movement of leachate is calculated using the Darcy Formula. As for the leachate seepage, voids formed by rubble which speed up the flow are abundant thus resulting in turbulent flow as opposed to laminar flow. Accordingly, in both principal and branch drains single lines of gabions will be placed.

$Q = VA = KA\ (\Delta h/\Delta \ell)^n$

Q : discharge ($m^3$/sec) 0.0022

A : flow area ($m^2$)

K : permeability coefficient (m/s) 0.1m/s

l : permeable layer length (m) $\Delta \ell\ /\Delta h = 0.002$

h : loss by friction

n : turbulency coefficient 1/2

* $A = Q/K(\Delta h/\Delta \ell)^n = 0.50m^2$

Accordingly, to protect 1/3 below of the water depth, the main leachate collection, gabion will be arranged in 2 lines and the branch in 1 line.

vi. Drain pipe dimensions

The dimensions of the drain pipe shown below are to clarify the collection and ventilation effectivity. At the transition into leachate collection facilities, the drainage pipe will be placed inside the gabions in order to convey leachate.

$$A = \frac{\pi}{4} D^2 \times \frac{1}{3} - \left(\frac{D}{2} \cos 60^\circ \times \frac{D}{2} \sin 60^\circ \times 2\right) \times \frac{1}{2}$$

$$= D^2 \left(\frac{\pi}{12} - \frac{\sqrt{3}}{16}\right) = 0.1535D^2$$

$S = \pi D/3 \qquad R = 0.1466D$

$$V = \frac{1}{n} R^{2/3} I^{1/2} = \frac{1}{n}(0.1466D)^{2/3} I^{1/2}$$

$Q = AV$

- Design conditions

  Discharge ($m^3$/Sec); 0.00218

  Slope (I) 1/500

  Roughness coefficient; n=0.015(concrete pipe)

- Calculation results

  Pipe Diameter & Flow Capacity

| D(m) | A(m) | V(m/sec) | Q($m^3$/sec) |
|---|---|---|---|
| 0.1 | 0.00154 | 0.18 | 0.00027 |
| 0.2 | 0.00614 | 0.28 | 0.00174 |
| 0.25 | 0.00959 | 0.33 | 0.00315 |
| 0.3 | 0.01382 | 0.37 | 0.00513 |

Accordingly,the pipe diameter at both KMDS and PBDS is decided as 0.30m. At the transition,in order for the drain pipe to easily collect enough leachate, the pipe is perforated across the top half in areas.

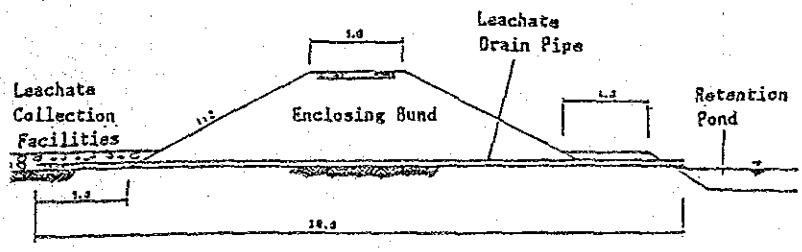



Fig. 3.2-13 Leachate Drain Pipe Profile

(5) Leachate cycling facilities

Leachate discharge into the surface and underground flow is a pollution source for the surrounding environment. The leachate volume is determined in relation to the water supply within the landfill site (rainfall, surface water and spring water). For leachate treatment facilities to meet the Malaysian governmental effluence quality standards requires vast financial resources which could be considered a pecuniary difficultly. With leachate monitoring as a principal objective, based on the effective use of the landfill site structures, the leachate cycling facilities, with the expectation of leachate level control, will be designed.

a. Design flowchart

The design flowchart for leachate cycling facilities is shown in Fig. 3.2-14.

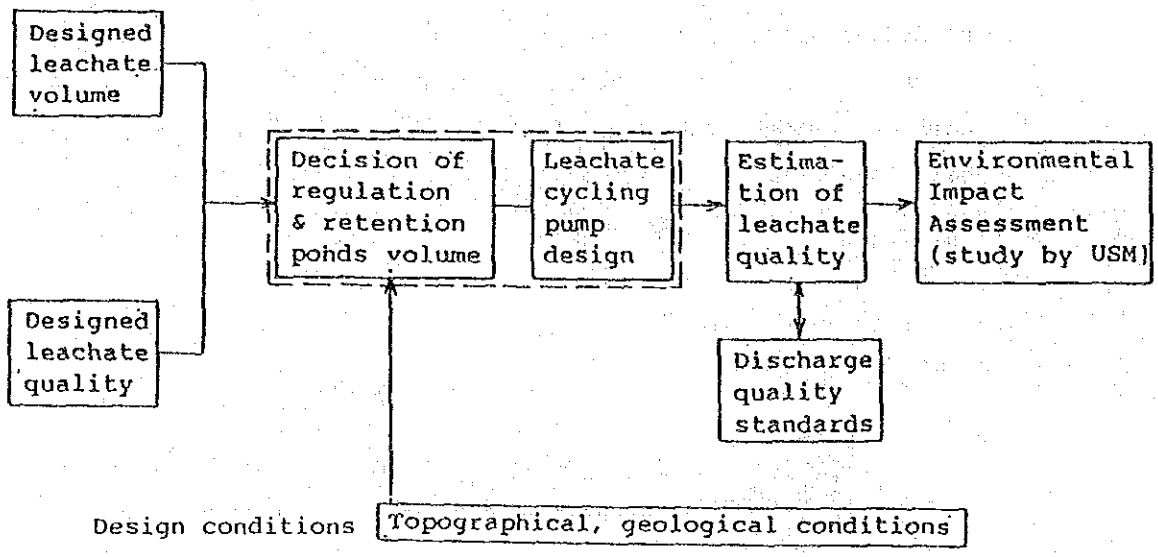



Fig. 3.2-14 Leachate Cycling Facilities Design Flowchart

b. Design conditions

i. Designed leachate volume

The leachate generation volume estimation, based on the

study done on the leachate collection facilities, shows that of PADS at88 $m^3$/day.

ii. Leachate quality estimation

1) Generation mechanism of leachate

The soild waste to be disposed of at the disposal site consist of,

- construction demolition waste
- glass
- metal
- plastic
- others

Organic substances such as

- garbage (food wastes)
- trees and grass
- paper
- others

Leachate contains pollutants which are the result of rain water passing through soild waste layers and the matter retained in solid waste. The leachate consists of solutions of inorganic substances. The generation mechanism of leachate is summarized and illustrated in Fig. 2.3-15.

Decomposition of organic substances highly depends on,

- Physical and chemical conditions of waste such as types of waste, waste components, water content of waste, temperature, PH, oxygen supply, etc.
- Biological conditions such as symbiosis of micro-organisms, adaptation of them, etc.

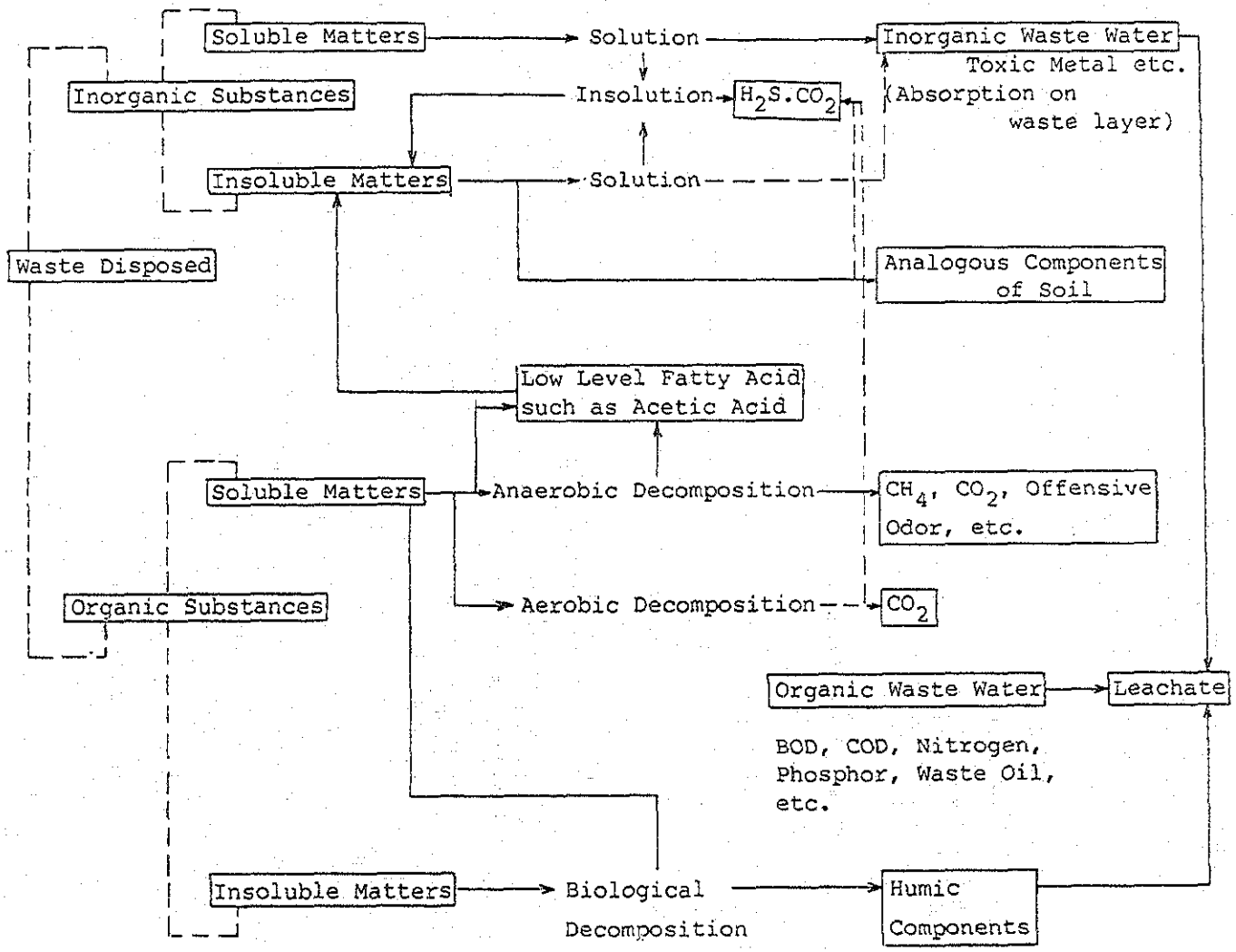



Fig. 3.2-15 Generation Mechanism of Leachate

Thus, the quality of leachate reflects the above indefinable factors.

Furthermore, the quality of leachate improves greatly because of the large amount of precipitation and long stabilization period.

As clearly described in this section, the estimation of leachate quality is very difficult. According to the actual research data in Japan, the quality of leachate at the beginning of landfilling operations, ranges as follows,

BOD ; 2,000 - 40,000 mg/1
COD ; 1,000 - 40,000 mg/1
$NH_3$-N; 500 - 1,000 mg/1

2) Prediction of leachate quality

The inquiries to DOE, UPM and WHO reveal that no investigation has been done on the leachate quality in Malaysia but only on some underground water quality near the dumping sites.

Therefore, the prediction on the leachate quality in PADS, KMDS and PBDS is based on that acquired in Japan. The conditional differences in between Malaysia and Japan are,

- waste quality
- precipitation and its intensity
- temperature
- landfill height
- landfill operation such as level of compaction, existence of water etc.

Considering the above mentioned aspects, the main points for the prediction on leachate quality in PADS, are summarized as follows.

- The heavy and strong intensity of precipitation in Penang State may dilute leachate making it cleaner, compared with that of Japan
- Depth of landfill is shallower than in Japan. This makes the landfill more aerobic in condition.(the depth of landfill in Japan may be more than 30 to 40m in some cases)
- Compared with Japan, the high, uniform temperatures in Malaysia causes more rapid decomposition of waste. Therefore, the stabilization of waste is achieved more rapidly.

3) Water quality establishment methods

Of the methods outlined below, the most widely used in present cases are 1. and 2..

1. To conduct a survey on actual leachate discharge after landfilling operations.

2. To refer to other survey results on similar conditions at other disposal sites.

3. To predict the water density at the landfill site diluted by rainwater, by referring to contaminated water in waste pits.

4. Although there are many undetermined elements, to assure the volume and decompostion process of the water inflow and outflow and of organic carbon within waste, based on results from inspection, and estimate the water quality density by an accumulation formula.

As for the estimation methods for similar cases at other disposal sites, the following formulas are offered.

$$CA = (SA \times HA \times \alpha A)/(S'A \times NA \times VA)$$

$$CB = (SB \times HB \times \alpha B)/(S'B \times NB \times VB)$$

Here,

S : landfill site area ($m^2$)

S': catchment area ($m^2$)

H : landfill layer thickness (m)

N : landfilling operations period (year)

V : yearly leachate volume ($m^3$/ year)

$\alpha$ : total BOD discharge volume from $1m^3$ of landfill waste

C : average BOD density

A and B refer to the numerical values at sites A and B. $\alpha A/VA$ and $\alpha B/VB$ are estimated coefficients by waste type and climate where BOD compares with leachate volume and where climate is represented by rainfall amount. Accordingly, the Malaysian and Japanese values of rainfall amount are the following.

| | Japan | Penang |
|---|---|---|
| Yearly average rainfall amount (mm) | 1,600 | 2,400 |

In this case, site A is the disposal site in Japan. Site B, PADS, can be estimated, using the following formula.

$$CB = CA \times \frac{(SA/SB)(HA/HB)}{(S'A/S'B)(NA/NB)} \times \frac{1600}{2400}$$

Here, general leachate quality for facility design in Japan is tabulated in Table 3.2-6.

Table 3.2-6 Standard Leachate Quality in Japan

| Item | Waste (Garbage) | Incinerated Ash |
|---|---|---|
| BOD | 1200 mg/l | 250 mg/l |
| SS | 300 mg/l | 300 mg/l |
| COD | 480 mg/l | 100 mg/l |
| $NH_3$-N (T-N) | 480 mg/l | 100 mg/l |
| PH | Where decomposed organic materials are abundant, acidification occurs | Where flamable volume is low, alcalization occurs |
| No. of colifor groups | Can exceed $3000/cm_3$ | |
| F2 | F2 : Normally 10ppm<br>H2 : Normally traces (unknown) | |
| Other Heavy metals | too dangerous to observe | |
| Color | Brown to yellow | |
| elution | can exceed | |
| remaining material after | 1000mg/l | |

Note: 1) landfill structure ; semi-aerobic landfill
2) landfilling period; 5 years
landfill thickness; 4 m
3) flammable ash volume; 8%

Source: Study on the Leachate Treatment System Development for Landfills, 1979 by Japan Waste Management Association

In Japan, for COD measurement, ($KM_nO_4$) is used. In Malaysia, ($K_2Cr_2O_7$) is used. There is a difference of a 3 times greater value for Malaysia. Using the above mentioned formula, the following are the measured leachate qualities for PADS.

| | |
|---|---|
| BOD | 1,300 mg/l |
| COD | 1,500 mg/l |

As for heavy metals within leachate, from the observation data during landfilling operations at municipal disposal sites in Japan, $H_g$ and Cd were hardly found. The reason is that waste disposed of was municipal and not industrial and also by covering operations, soil adsorption occurred. However, Fe and Mn, in anaerobic conditins where liquidation was known, were found. However, within this design, heavy metal treatment is not considered necessary.

a. Leachate cycling facilities design

These facilities consist of:

- regulation pond and retention pond
- leachate cycling pump and pit

i. *Regulation pond*

This is to hold leachate temporarily. Because the volume fluctuates depending on rainfall, the pond is to be big enough to hold 10 days' volume of the largest monthly rainfall.

Table 3.2-7 Regulation Pond Area

| Item | PADS |
|---|---|
| leachate volume ($m^3$/day) | 188 |
| necessary capacity ($m^3$) | 1880 |
| water depth (m) | 1.0 |
| pond area ($m^2$) | 1880 |

By operating the regulation pond gate, leachate diluted by rainfall is discharged into the retention pond.

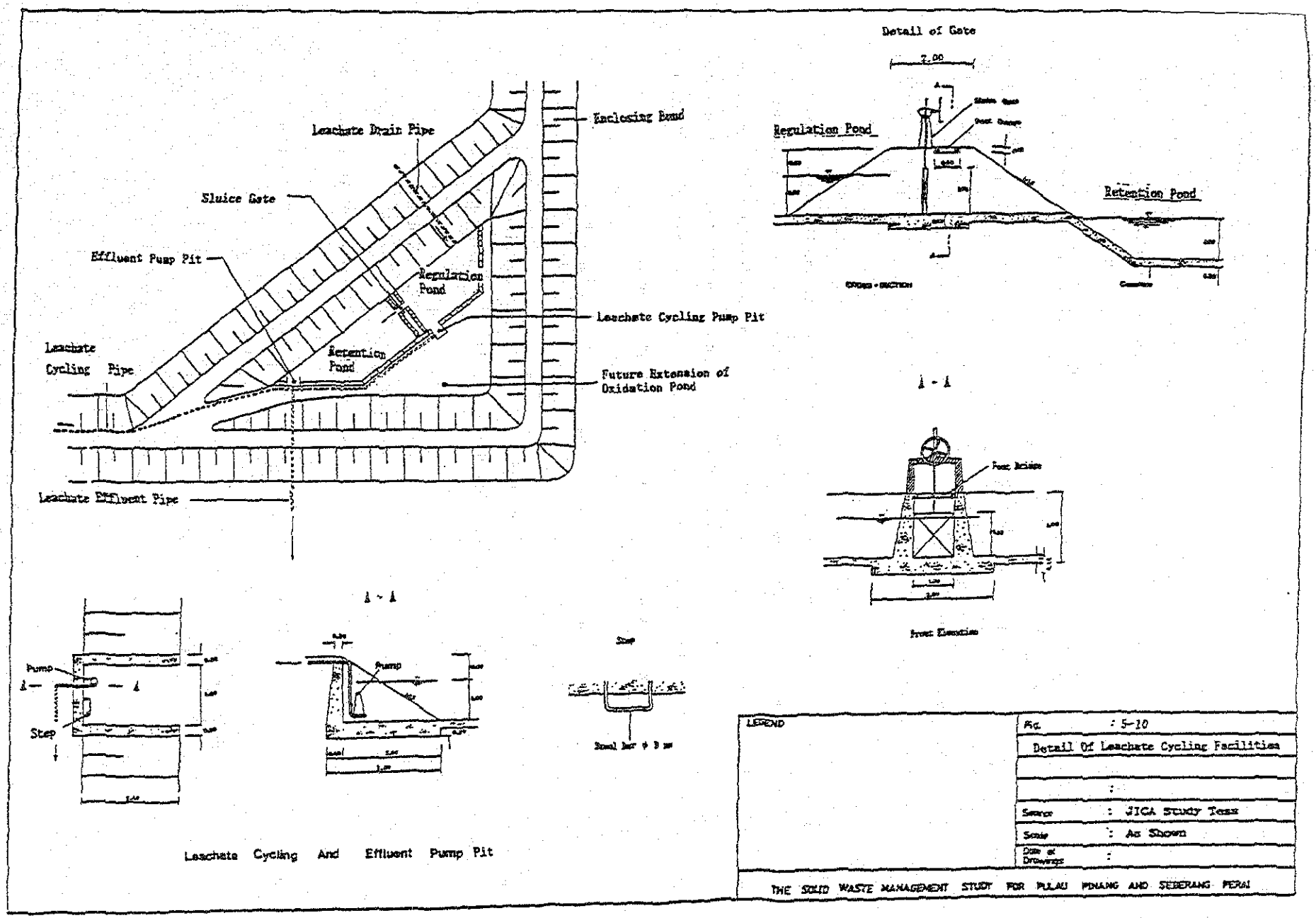
ii. Retention Pond

The capacity of the retention pond is the same as for the regulation pond.

iii. Leachate cycling pump

The pump partially purifies the leachate in the regulation pond which, before entering the retention pond, is continuously cycled back to the landfill area.

It takes 10 hours to cycle back to the landfill area one day's volume of leachate. The length of the cycling pipe is 500m with a 15m head water. The design is for an immersed pump with mouth diameter of 50mm and generating power of 57.5kw.




Leachate Cycling And Effluent Pump Pit

Fig. 3.2-16 Leachate Cycling Facilities

b. Effluent standard

According to the DOE, an effluence standard is established for Malaysia. The disposal site is located in the ocean area. Accordingly, the effluence standard is within standard B. The standard value of principal items is shown below.

| | standard B |
|---|---|
| PH | 5.5 - 9.0 |
| BOD | 50mg/l at 20°C |
| COD | 100mg/l |

c. Effluence leachate quality estimation

i. The system of partial purification of the leachate cycling facilities

To actively partially purify the leachate by bacterial material within the landfill area joined by gas removal facilities. Oxygen supply is provided and aerobic reproductive expansion is measured. Leachate, by leachate cycling facilities, in being cycled back again and again to the landfill site, is partially purified.

ii. Leachate quality estimation

Estimation on leachate quality after cycling is difficult because data on leachate quality from other sites is inexistant.

Leachate is diluted by 20% by direct rainfall into the regulation and retention ponds. Leachate is further purified through cycling where the BOD content is improved by 20%.

The value after dilution and purification of leachate in terms of BOD and COD are as follows.

| | |
|---|---|
| BOD | 40% |
| COD | 20% |

Then, the estimated final leachate quality is as below.

| | |
|---|---|
| BOD | 800 mg/l |
| COD | 1200 mg/l |

(6) Leachate effluence facilities

The effluence outlet is situated where, even at low tide, there is guarantee of water depth.

a. Design conditions

Designed effluence volume; $1880m^3$

Effluence time ; discharge every 5 days, in operation 10hrs. a day

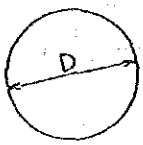
Velocity in pipe ; approx, 1m/sec (to avoid sedimentation)

b. Pipeline design

i. Pipe diameter

The velocity of sending leachate, in order to avoid sedimentations is desgined and guaranteed to be over 1m/s.

Pipe Profile




$$A = \frac{\pi}{4}D^2$$

$$Q = AV$$

$$A = \frac{Q}{V} \qquad D = 2\sqrt{\frac{Q}{\pi V}}$$

A : flow area of pipe (m2)

V : velocity (m/sec)

Q : leachate effluence volume (m3)

D : diameter (m)

The leachate sending pipe is

$Q = 1880 / (5 \times 10 \times 60^2) = 0.01044 m3/s$

Accordingly, the pipe diameter is

$$D = 2\sqrt{\frac{0.001044}{1 \times 3.1416}} = 0.115 = 0.15m$$

ii. Pipeline

Following these conditions,

- shallowness of ocean (0 m to 1 m),
- soft ground (marine clay) and
- fishery activity,

the pipeline is installed 1m under the seabed.

A system of flags, for example, to warn fishers, etc., of the placed pipe below will be established.

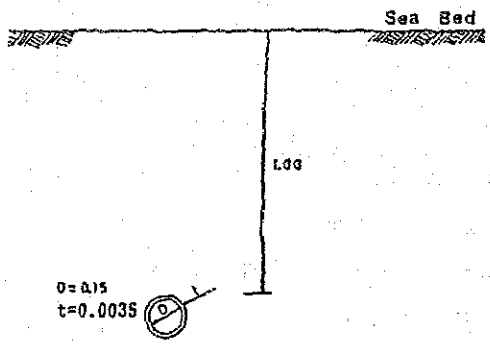



Fig. 3.2-17 Typical Cross Section of Pipline Setting Out

c. Effluence outlet

If the outlet is placed in the sea it risks being clogged by inflowing sand. Thus, the outlet is designed to be placed above sea level where it is independent from the tides. The effluence outlet structure is shown in the following.

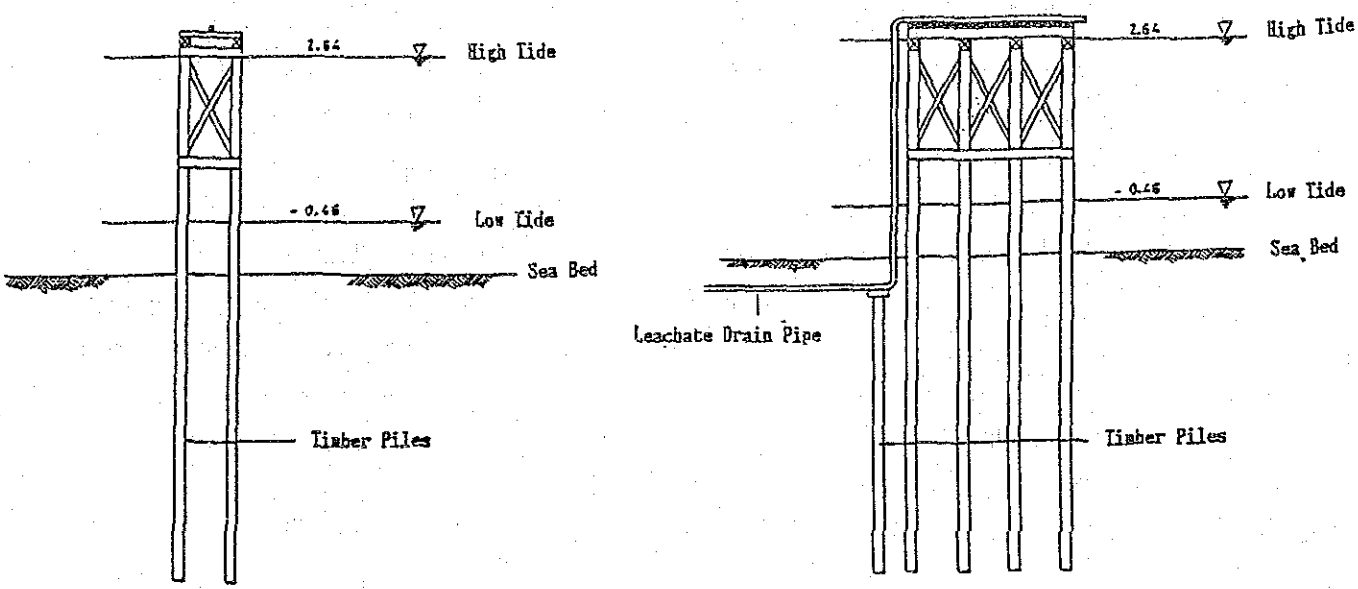



Fig. 3.2-18 Profile of Effluence Outlet

d. Leachate effluence pump

i. Leachate effluence volume

$$Q=188m^3/day \times 1/24 \times 1/60^2 = 0.00218m^3/s = 131 \ /min.$$

ii. Pump head

Head loss (H) is calculated by the Darcy formula.

$$H = f\frac{LV^2}{D2}(m)$$

| | |
|---|---|
| L: pipeline length (m) | 1,000 |
| D: pipeline diameter (m) | 0.10 |
| V: flow velocity (m/s) | 1.0 |
| g: acceleration of gravity (m/s) | 9.8 |
| f: head loss coefficient | 0.035 |

$$H : 0.035x1000/0.10 \times 1.0^2/2x9.8 = 17.9m$$

Considering the head loss is caused by bends, the entry, expansion, contraction, branching, and the valve and pipe end.

The total head loss is 20m.

Total pump head = total head loss + actual head

The design calls for an immersed pump, with diameter of 40mm for generating power of 57.5kw for the PADS.

(7) Monitoring Facilities

The monitoring facilities are to be monitoring wells constructed at both disposal sites in order to monitor groundwater quality.

### 3.2.4 Building and Accessories

(1) Site office

This will be established for the weighing of waste and for the administration of the disposal site. The principal functions will be carried out in the spaces categorized below.

- weighing office
- administration office
- operator's break room
- guard's room
- shower room
- kitchen
- lavatory
- storage room

This structure will be constructed by the SRC (Steel reinforced concrete).

(2) Weighbridge

Incoming waste must be weighed for proper operations within the disposal site. The covering material will be kept in balance with the landfill design. Records on weighing of waste are necessary data in determining the fees for incoming individual waste and future disposal siteplanning. The calculation conditions for the number of necessary weighbridges to be constructed are the following,

- Collection vehicles (vehicle/day); 148 vehicles for the PADS in 1996
- peak ratio ; 15%
- procedure time ; weighing time (3 min.)

Two weighbridges are to be constructed at the site, the weigh-bridge bridge consists of a load-cell type a 4-point support system, a digital counter (separated from the main body), an underground system and has a weighing capacity up to 30 tons.

(3) Fire prevention facilities

A fire extinguisher and reserve water pond are to be assured for the site office and other facilities for the prevention of fire.

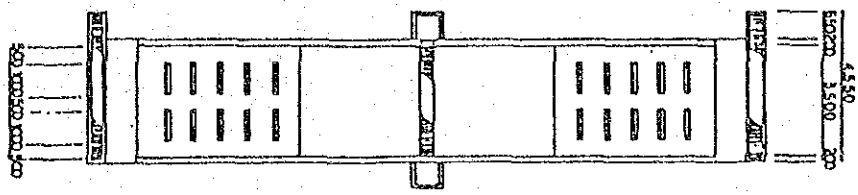
(4) Storage building

A storage building is to be constructed at each disposal site for the housing and repair of landfill equipment and materials.

(5) Others

In order to prevent anyone from illegally entering the site, a gate and fence are to be constructed. Flashlights will also be provided for the guard. A parking lot will be constructed for visitors and the staff. In order to prevent dirtying of public roads by collection vehicles, a car wash should be provided.

PLAN



CROSS SECTION

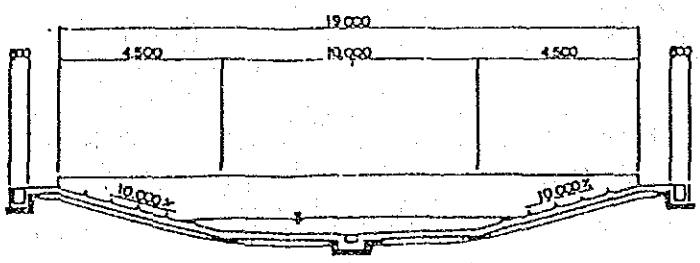



Fig. 3.2-19 Car Wash

## 3.3 Operation and Maintenance Plan

### 3.3.1 Landfill Plan

(1) Basic Policy

The following basic policy is sustained for preparation of landfill plan.

a. Solid wastes are spread and compacted sufficiently.

b. The scattering of solid wastes is minimized.

c. The diffusion of offensive ordor is minimized.

d. Stabilization of wastes as early as possible is arranged.

Compaction of solid wastes is necessary for lengthening the service life of the landfill site, which also is helpful in lessening settlement after completion of landfill. Furthermore, the prevention of scattering of solid wastes and diffusion of offensive odor is required in order to conserve the surrounding environment. For ultimate use of the completed landfill site, early stabilization is necessary for landfill purposes.

(2) Landfill Structure

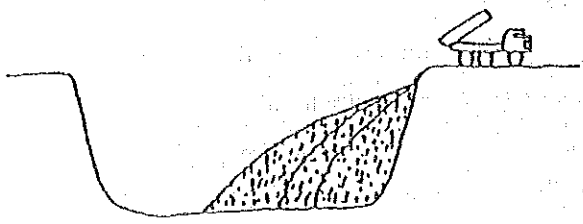
Regarding landfill structuring, the semi-aerobic landfill method is selected. The reasons are listed below.

a. for rapid stabilization of waste
b. for the reduction of leachate
c. for the reduction of odors and gas
d. because the cost is only a bit higher than that of modified anaerobic sanitary landfill.
e. because leachate monitoring is possible

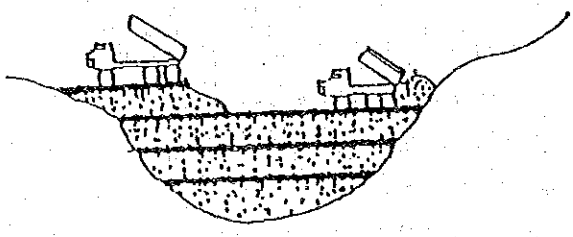
(3) Landfill method

The landfill method includes an open dumping, a sandwich and a cell method. The open dumping method has coventionally been carried out at many dumping site in Malaysia but, by this method, a highly-compacted landfill cannot be expected, nor can be prevented the scattering of waste, the generation of offensive odor or the breeding of vectors and insects.

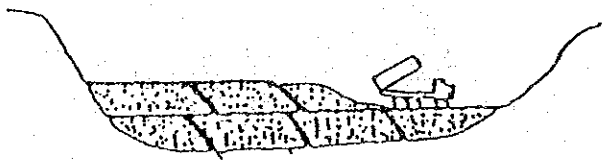
The sandwich method is applied by landfilling solid wastes horizontally, and covering the ground with soil, by which to form different layers. Where the landfill site is narrow, this method is effective, but if the site is wide, solid wastes are left uncovered for a couple days, resulting in unfavourable offensive odor and so on. The cell method is applied by laying soil on solid waste every day. Through this method a highly-compacted landfill can be expected and it is considered possible to prevent scattering of solid waste thus, generation of offensive odor and the breeding of vectors and insects. Since the landfill site is wide at the PADS, compared with the landfill volume, if the sandwich method is applied, the exposure time period of solid waste could possibly be long. Therefore, the cell method should be applied.



Open Dumping Method



Sandwith Method



Cell Method

Fig. 3.3-1 Land Fill Method

(4) Covering Materials

In order to conduct landfilling by the cell method, covering materials are to be supplied in a stabilized manner in balance with the landfill disposal.

a. Objectives for covering materials

i. to prevent gas leakage

ii. to prevent disaster

iii. to prevent the scattering of waste

iv. to support vehicle flow

b. Covering material amount

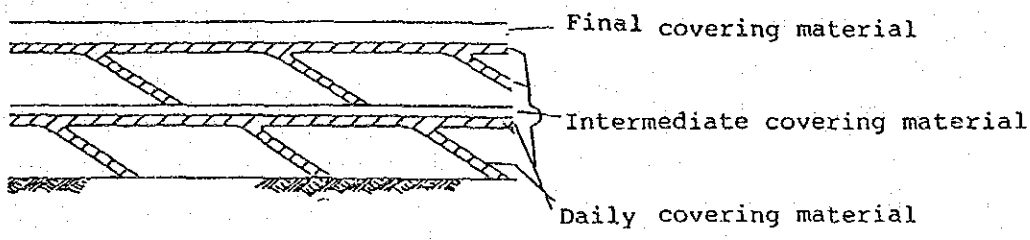



Fig. 3.3-2 Covering by Cell Method

| | |
|---|---|
| Daily covering material | 20cm thick |
| Intermediate covering material | 30cm thick |
| Final covering material | 60cm thick |

In 1996, the landfill volume is estimated to reach, at the PADS, 815$m^3$/day.

The study on covering material is conducted using the estimated PADS volume and shown as follows.

Daily covering material $(17.5 \times 13.5 + 17.5 \times 21.5\sqrt{10}) \times 0.2 = 76.6m^3$

Intermediate covering material

$$17.5^2 \times 0.30 \times 1/2 = 45.9m^3$$

Final covering material $17.5^2 \times 0.60 \times 1/2 = 91.9m^3$

$214.4m^3$

Accordingly, the covering material will be placed in a 30% ratio to the disposal volume of waste.

c. Guarantee of covering material

As for the quality of the covering material

Daily covering material; sandy soil for good ventilation

Intermediate and final covering material;
clayey silt of a small permeability coefficient, and for good vegetation in final covering.

The covering material will be procured basically from the adjacent Bukit Kechil.

(5) Landfill equipment plan

a. Planning conditions

Judging from topographical and geological conditions as well as the quality of solid waste, it is essential to consider the following conditions to prepare the landfill equipment plan.

i. Equipment should be of a type which functions even over poor ground.

ii. The landfill material consists of combustibles and non-combustibles, some of which necessitate crushing. Therefore, equipment with a certain capacity for crushing is required.

iii. Since a large amount of garbage will be disposed of at the site, it is essential to carry out covering every day.

iv. Not only for the ultimate use of the completed site, but also for the preservation of sanitary conditions as well as the lengthening of the life span of the disposal site, equipment with a high capacity for compaction is necessary. The content of the work concerning each type of landfill equipment at the site is shown in Table 3.3-1.

Table 3.3-1 Content of the Work for Landfill Equipment

| Waste Handling | Cover Material Handling | Other |
|---|---|---|
| Pushing (moving) | excavation | leveling (site access road & unloading site |
| Crushing | loading, hauling, spreading and leveling | site maintenance |
| compaction | compaction | |

The features of each type of equipment necessary for the above are indicated in Table 3.3-2.

Table 3.3-2 Comparison of Landfill Equipment Performance

| Machine type | Waste Handling | | | Soil Covering | | |
|---|---|---|---|---|---|---|
| | Leveling | Compacting | Trenching | Leveling | Compacting | Trenching |
| Crawler-dozer (Bulldozer) | Excellent | Good | Fair | Excellent | Good | Poor |
| Crawler-loader (Tractor shovel) | Good | Good | Excellent | Good | Good | Poor |
| Wheel-dozer | Excellent | Good | Fair | Good | Good | Poor |
| Wheel-loader | Good | Good | Fair | Good | Good | Poor |
| Scrape-dozer (Scraper) | Poor | Poor | Good | Excellent | Poor | Poor |
| Power shovel | Poor | Poor | Excellent | Fair | Poor | Poor |
| Landfill compactor | Excellent | Excellent | Poor | Good | Excellent | Poor |

b. Equipment selection

The following equipment is selected for efficient operation and maintenance of landfill.

i. Bulldozer

For leveling and compaction of covering material, a bulldozer excells in leveling and compaction of waste and covering material and has various other uses. For example, it can be used in maintenance of the facilities, the enclosing bund and the on-site road. Considering that the area over which the bulldozer will be operating is soft ground, a bulldozer for swamp use and a 21-ton class weight should be selected.

ii. Back hoe (Hydraulic excavator)

For drain excavation, a back hoe is inferior in loading capacity to a crawler-loader, but is excellent in excavation.

c. Selection of number of equipment

i. Bulldozer (21-ton class)

The equipment needs to be capable of handling 240m$^3$ of landfill in 8hrs. per day. According to the 1996 daily landfill estimations, 3 vehicles will be necessary for the estimated 560m$^3$.

ii. Back hoe (Hydraulic excavator)

For principally drain excavation, one will be necessary.

(6) Landfill operations

The landfill operations are outlined in the following.

a. The waste is filled in places directed to the driver by the staff.

b. The dumped waste is spread and crushed by a bulldozer into a flat horizontal layer for sufficient compaction.

c. After the completion of landfill operations, the covering operations will be performed on a daily basis by the cell method.

d. Intermediate covering material will be laid on the first layer of landfill when it has extended as far as the divider.

e. A second layer of landfill will be laid on the the first layer in the same manner, extending to the divider.

f. Final covering material will be laid on top of the second layer of landfill.

g. A divider, gas removal facilities and leachate removal facilities will be constructed in the adjacent area for the next landfill operations.

(7) Landfill plan

This is summanized in the following.

a. Divider

The divider should be constructed on a small scale during the rainy season (July - Nov.) and on a large scale during the dry season (Dec. - June) following the increase and decrease of leachate. The divider should always be constructed directly adjacent to the soon-to-be completed landfill area.

b. Construction work

Private contractors will perform the construction of the following.

- divider
- leachate collection facilities
- gas removal facilities
- on-site road
- site ditch

c. Configuration of completed landfill area

To insure the immediate discharge of rainwater on the completed area, the following work will be completed by the MPPP.

- leveling
- temporary drain construction
  - main ..... concrete lined
  - branch .... unlined

d. Procurement of covering material

The covering material will be procured by a bidding process involving selected suppliers.

### 3.3.2 Facilities Maintenance

(1) On-site maintenance

In order to execute landfilling in a safe, sanitary and effective manner, the final disposal site facilities must be kept in the best condition by proper maintenance.

a. On-site and approach roads

The on-site roads in the final disposal site are to be constructed following the landfill operation. The on-site road is to be paved with gravel and compacted and the approach road with asphalt to avoid any problems for vehicles.

b. Fire prevention measures

The conceivable cause of fire at the final disposal site can be the ignition and explosion of combustible gases such as methane, the spontaneous combustion of combustibles by the effect of lens on glass waste, the ignition and explosion of fuels for landfill equipment and so on. Although the method of burning combustible gases such as methane can be applied, it should not be the policy to install spontaneous combustion equipment for gas because the gas removal facility to be installed at the disposal site is cabable of removing enough generated gas. Spontaneous combustion caused by the effect of lens on glass waste should be prevented by timely covering of materials.

c. Sanitation control

Rodents, flies, mosquitoes, vectors and birds very often swarm at the final disposal site, which causes a problem to be tackled. Therefore, it is essential to work out a measure to prevent breeding of vectors, insects and so forth as mcuh as possible. The most effective measure is to carry out daily covering of materials by the cell method, and it is important to prohibit solid wastes from being exposed and standing water from being produced. Only when absolutely necessary should insecticides be used and only very sparsely.

A conceivable cause of offensive odor is solid wastes themselves and decomposition of wastes after landfilling. The odor caused by anaerobic fermentation is said to be more offensive than that caused by aerobic fermentation because of volume and quality of generated gas. An effective measure is to throughly cover organic solid waste, which is the cause of offensive odor, and to keep the inside of the landfill site in a good aerobic state by immediately draining rain water.

d. Waste scattering prevention

A fence will prevent waste from scattering outside the site, In addition, scattered waste within the site will be constantly checked and collected.

e. On-site maintenance (equipment)

The following is necessary equipment for effective on-site maintenance.

- disaster prevention .... water sprinkler truck
- on-site patrol ..... inspection vehicle

(2) Main facilities maintenance

At the final disposal site, the main facilities are the bund structure, drainage facilities and the leachate collection facilities. These facilities must be maintained in top condition as one breakdown could effect all of them, resulting in mass damage.

a. The bund must be checked for any breaks or holes.

b. The drainage system should be constantly checked and cleaned out as it can be stopped up by sand, leaves, weeds and other objects.

c. The leachate volume should be checked daily. In case of sudden increase or decrease, the leachate collection facilities could become stopped up and cause leachate to discharge outside the landfill site. Also, the existence of spring water in the landfill site should be investigated.

(3) Equipment Maintenance

In order to perform maintenance for effective operatations, if during periodic investigation problems are discovered, they should be analyzed and equipment should be repaired by only skilled engineers. Necessary spare parts should be kept in stock.

(4) Hygiene and safety control

a. Hygiene control

As the final disposal site operations are outdoors, dust, odors, landfill gas and other things can badly affect the staff working in this already tenuous environment. Hygiene control, as well as safety control, are assured by grasping the working conditions and improving certain aspects when necessary. Periodic health check-ups are performed and medicine is given for any possible accident. In addition, the staff will possess full knowledge of hospital location and access in case of any emergency.

b. Safety control

Methane outbreak and fuels for landfill equipment should strictly be controlled, and, in order to prevent fire caused by carelessly thrown cigarettes, a measure such as a no-smoking rule should be taken at the landfill site. In addition to the above various measures, it is planned to purchase a water sprinkler truck equipped with a fire-fighting pump for emergencies. of course, the staff will be well educated on disaster prevention.

### 3.3.3 Personnel Plan

(1) Organization structure

This is the following

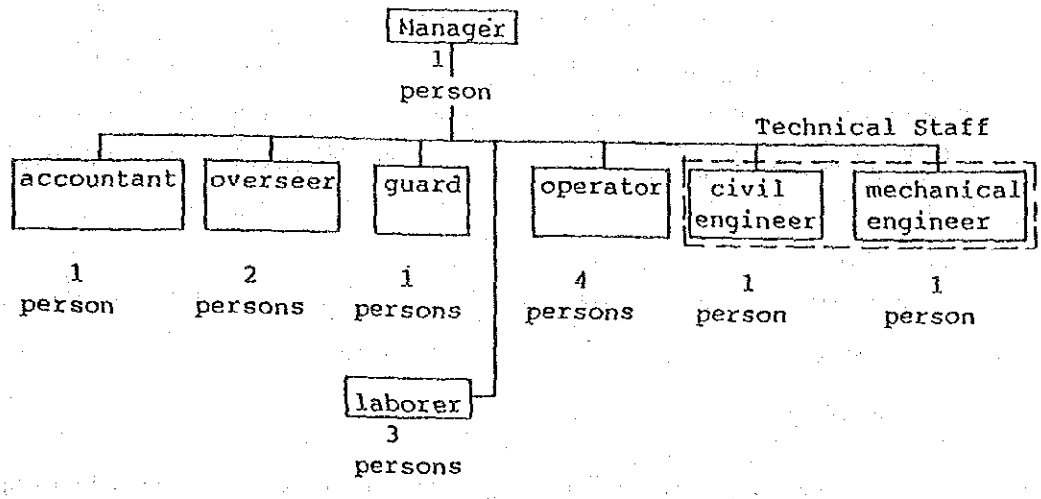



Fig. 3.3-3 Organization Structure

(2) Personnel

a. Manager --- 1 person

Representative of the final disposal site who controls the entire structure and manages the work of the entire staff.

b. Accountant --- 1 person

Work includes the whole phase of accounting work at the disposal site, including calculation of fee on direct-hauled waste.

c. Overseer --- 2 persons

Work includes weighing and inspection of hauled waste and daily patrol of disposal site facilities.

d. Guard --- 1 person

Their work covers supervision for illegal entry and dumping, as well as night-time patrol.

e. Operator --- 4 persons

Work includes levelling and compaction of hauled solid waste. Leveling and compaction of covering materials, driving of the water sprinkler truck for fire prevention, construction and maintenance of site access road and maintenance of gas removal facility, as well as daily maintenance of equipment, and excavation of reclaimed area drainage.

f. Civil engineer --- 1 person

Work includes preparation and supervision of the landfill plan and especially calculations of required covering materials, safety control of landfilling operations of required covering materials, planning and supervision of construction work tendering, guidance for maintenance and repair of on-site and approach road, as well as examination of environmental conservation measures, and planning of drainage for reclaimed areas which will be excavated by the operator.

g. Mechanical engineer --- 1 person
Their work includes maintenance and repair work of equipment and leachate monitoring.

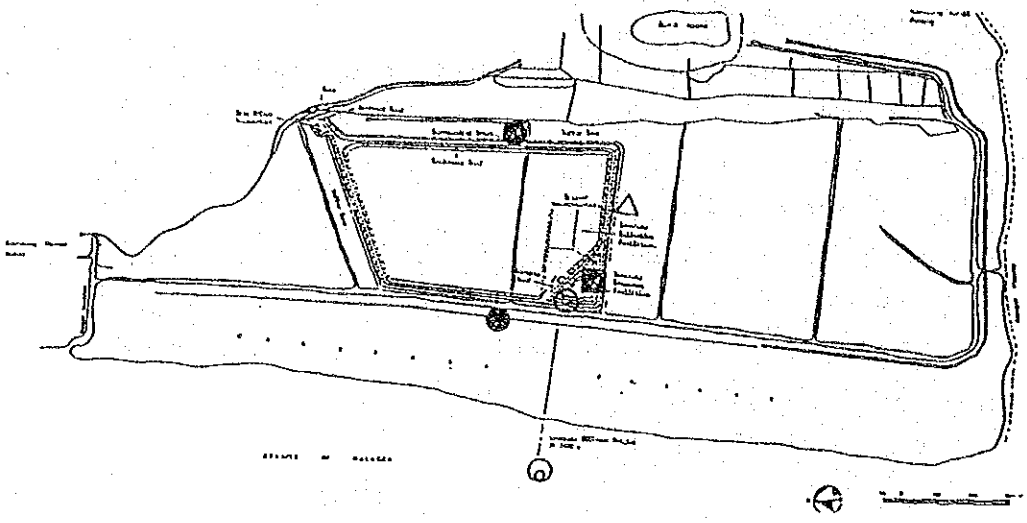
h. Laborer --- 3 persons
Work covers guidance for collection vehicles, maintenance of gas removal facility, fire prevention control as well as other necessary work for operations at the disposal site, and drain cleaning out.

### 3.3.4 Environmental Monitoring

In the process of carrying out landfill work, they should prepare a monitoring (or supervision) plan, which includes water quality inspection and scattering of solid wastes, in order to conserve the enivironmental conditions of the final disposal site.

(1) Water quality monitoring
The following monitoring methods shall be effected for ample control.

a. monitoring of groundwater by monitoring well,
b. monitoring of surrounding drain surface water,
c. monitoring of regulation pond leachate,
d. monitoring of leachate at the effluence pump and at the effluence outlet.



LEGEND
- Monitoring Well
- △ Surface Water Sampling
- ■ Leachate Sampling
- ○ Effluence Sampling

Fig. 3.3-4 Location of Water Monitoring System

(2) Waste monitoring

a. Monitoring of direct-hauled waste by the private sector, in particular, checking of unacceptable industrial waste by refering to the scheduled waste inventory list, by the D.O.E survey on industrial toxic waste,

b. Monitoring of scattered waste outside the site,

c. Monitoring of illegal dumping.

Based on the results from the above tested monitoring, the following counter measures will be taken in the event of any problem.

i. Deterioration of leachate quality

On a short term scale, the discharge of leachate will be stopped and will be kept cycling for partial purification.

On the long term scale, an oxidation will be constructed.

ii. Toxic waste appearance

If the level of toxins exceeds the limits according to the D.O.E standards, as in the above i., discharge will be stopped and toxins will be chemically treated by coagulation settling.

iii. Fluctuation in leachate volume

Fluctuation is due to leachate collection facilities breakdown, insufficient drainage of the reclaimed area or main facilities breakdown. Accordingly, equipment relating to this should be inspected.

## 3.4 Ultimate Use

### 3.4.1 Basic Conditions on Ultimate Use

The following are basic considerations necessary for ultimate use of completed landfill sites.

- problems related to settlement
- problems related to gas generation
- maintenance of completed landfills

(1) Settlement

Settlement of the landfill is dependent on the dept of the fill, composition of wastes, compaction of the material, moisture content, and other factors. Studies have indicated that approximately 90 percent of the ultimate settlement will occur in the first 5 years. The final 10 percent will occur over a much longer period.

Settlement is classified into the following two types:

- settlement of refuse layers
- settlement of soft sub-soil layers

a. Settlement of refuse layer

Settlement of refuse layer is caused by two factors namely;

- compaction
- decomposition

Compaction is caused by surcharge such as upper layer and vehicle weight. The amount of settlement by compaction varies according to materials and water content.

Little information is available on the decomposition of buried material in a sanitary landfill. It is extremely difficult to predict the time required for complete decomposition. Many items, particularly paper, have been found unchanged in landfill that had been completed 15 to 25 years previous. The rate of decomposition is primarily dependent upon the moisture content and generally takes place at a very slow rate.

b. Settlement of soft sub-soil layer

Settlement of soft sub-soil layer is classified into the following.

- immediate settlement
- settlement by consolidation

The amount of settlement depends on the following factors;

- characteristics of sub-soil
- depth of sub-soil layers
- weight of surcharge

Based on the soil data obtained by soil testing, the amount of settlement on both the KMDS and PBDS is calculated as 50cm.

(2) Gas Generation

Decomposition of the wastes will result in the production of gases, principally methane, carbon dioxide, nitrogen, hydrogen, and hydrogen sulfide. The rate of gas production will usually reach a peak within the first 2 years and then slowly taper off. Methane gas causes the most concern because of its explosive character.

A counter measure for gas generation is construction of gas removal facilities such as installation of perforated pipes and gravel.

(3) Maintenance

Completed landfill generally require maintenance because of differential settlement. Maintenance consists primarily of resloping the surface to maintain good drainage and filling in small depressions that result fron uneven settlement.