CHAPTER 4 SITE CONDITIONS

4.1 Nam Son Landfill Site

4.1.1 Meteorological Condition

The site area is located in the northern area of Vietnam, and belongs to the tropical monsoon climate zone. There are four seasons like Japan; Spring (February – April), Summer (May – July), Autumn (August – November), Winter (November – January). The seasonal difference in temperature is not as large as in Japan.

(1) Temperature

Yearly average temperature is 23.4°C. In the past, the highest recorded temperature was 42.8°C in May 1926 and lowest temperature was 2.7°C in December 1955.

There is no meteorological observation base in Nam Son area. Therefore the following data of Hanoi will be used as basis for the project plan and design.

- Average temperature 23.4° C, Maximum 42° C, Minimum 4° C.
- For the average monthly atmospheric temperature, the maximum 29.9° C of July and the minimum 15.3° C of January.
- Average precipitation is 1,690 mm/year.

(2) Precipitation

The precipitation varies greatly by seasons. Rainy season is from May to October and dry season is from November to April. Rainfall in rainy season often accounts for 75-85% of the total annual rainfall. The lowest rainfall is usually in December, January, and February. In the past, the highest total annual rainfall was 2038.6 mm. The highest total monthly rainfall was 422 mm. The highest daily rainfall was 277.6 mm. Annual average rainfall is 1690 mm and annual average evaporation is 938 mm.

(3) Wind

There is usually a northeast wind during the dry season and a southeast wind during the rainy season in the area. Average wind velocity ranges from 1 to 4 m/second in winter and from 1.2 to 3.5 m/second in summer.

4.1.2 Topographic Conditions

The planned site is located 50 km north of the city center of Hanoi, 3 km southwest from the nearest point of the Provincial Road No 35, and about 2 km west of Cong river.

(1) Overview of Surface Conditions

The project area is located in a valley surrounded by low range of hills of 29.5 m to 66 m in elevation. There is a lake called Phu Thinh with area of 4 ha and small ditch crossing. Land use of this area is classified into following types:

- Rice fields
- Cultivated Fields for crops and vegetables
- Residential area
- Lake and rivers
- Cemetery

On the basis of the elevation and the terrain surface formation, the topography of the area can be classified into the following types :

- *Erosion* type : this terrain type appears mainly in the study area surrounding the survey location. The soil and rock that form this terrain type is Triat sediment of Na Khuat (T2NK) formation. Its petrography components are clay schist mixed with sandstone of green, reddish brown and yellowish brown color.
- *Accumulation* type : this type appears almost everywhere in the area. Impure clay of reddish brown, yellowish brown, and whitish gray color is predominant for this type.

The topography in the area is segmented. Its elevation varies from 8 m to 66 m.

(2) Configurations

Main configurations are follows:

- *Hills on the boundary* : There are three hills on the northern border, two on the southern, and one on the both eastern and western borders. These hills separate the area from the surrounding river and ditches, and form a basin involving Lake Phu Thinh.
- *Lake Phu Thinh* : This lake is located at the center of the area. The water of this lake is normally used for irrigation. Depth of the lake is about 2 m.
- *Channels* : There is a small channel flowing through the project area, from the south to the north. This channel will be relocated to the edge of the dike for Landfill Phase 1 site.

4.1.3 Geological Conditions

There exist small channels, a lake and small ponds at the project area and its surroundings. Most of these ponds and canals often get dry or shallow during the dry season. No signs of floods are seen in this area.

(1) Overview of Geological Conditions

Based on the topographic and geological survey, the formation of the area is composed of sediments of Na Khuat (T2NK). The sediments of the Na Khuat formation are those belonging to the Mau Son (T3 Kms) formation.

(2) Stratum and Physical Properties

The project site is located in the northern part of Soc Son Suburban District. Its petrography composition from the bottom to the top is as follows :

- *Bottom layer* : sandstone, clay schist of light green, light violet, and brownish red color, in some parts mixed with big size sandstone or small size grit.
- *Middle layer* : mainly reddish brown and yellowish brown clay schist mixed with sandstone.
- *Top layer* : clay schist mixed with green and light red sandstone.

The thickness of this part ranges from 750m to 800m.

Based on the boring and survey results for the depth of 20m, the stratum in the survey area can be divided into the following layers in top-to-bottom order :

1) Layer No.1

Covering soil compositions : brown, grayish brown, and reddish brown impure clay. The consistency ranges from stiff plastic to hard. The structure is porous. This layer appears in all bore holes with its thickness between 0.2m to 1.0m.

2) Layer No.2

Mixture of reddish brown, yellowish brown and whitish gray clay and gravel. Consistency is semi-hard and hard. A thin layer of impure clay is mixed in this layer. This layer exists in all bore holes. Its thickness varies from 2.4m to 10.2m.

3) Layer No. 3

Mixture of mixed clay of yellowish brown, whitish gray, reddish brown color and gravel. Consistency ranges from stiff plastic to hard. This layer appears in all boreholes with its thickness ranging from 3.5m to 10.4m.

4) Layer No. 4

Weathered schist in violet brown, yellowish brown and pinkish brown. This layer exists in almost all bore holes. The thickness of this layer has not yet been defined. The depth of the layer varies from 8.6m to 13.4m.

(3) Hydrogeological Features

The survey results show that the ground of the site area for Nam Son landfill has 4 layers. The first one is a thin and porous layer of soil with high deformity and weak bearing capacity. This layer does not have adequate capacity to hold leachate and landfill gas. Layers numbers 2, 3, 4 are of good soil quality with low deformity and small permeability; coefficients ranging from 2×10^{-5} to 3.8×10^{-6} cm/s. The second and third layers have adequate capacity to hold leachate and gases. They have a thickness sufficient for meeting the existing regulation, but not enough for satisfying the newly proposed standards (not yet enforced). The fourth layer has enough capacity and thickness for meeting the existing regulation, but it is located very deep and not enough for the proposed standards.

In the project area, the groundwater is shallow which runs 1.6m to 7.2m from the ground surface. Therefore, this groundwater layer is very sensitive target for probable pollution by leachate from the waste layer. Water appears in cracks in weathered clay with a small volume.

4.1.4 Socioeconomic Conditions

(1) Population and socioeconomic environment in Soc Son district

Soc Son District, with an area of 31,466.9 ha, has the population of 211,186 at the end of 1995. The population density is 6.7 persons per ha. The density is the smallest among all the 12 districts under HPC. Administratively, Soc Son District is divided into 25 villages and one town. The population is mainly concentrated in the plain area and population density is low in the mountain area, i.e. Bac Son, Nam Son, Hong Ky, and Trung Gia.

In Soc Son, agriculture is the basic livelihood. The area of agricultural land is about 700 m^2 per inhabitant all over the district. Agricultural production generally depends heavily on the irrigation. There is a total of 125 km of irrigation channels in this district.

There are some people engaged in small scale manufacturing industry including handicrafts, mechanical work, construction material production, food processing. However, the output of these industries is very small compared to the agricultural production.

Changes in population structure have been quite small during the last few years.

(2) Socioeconomic Conditions of the Project area

The landfill sites (Phases 1 and 2) are located in a part of the following communes:

- Phase 1: Nam Son and Bac Son commune.
- Phase 2: Nam Son, Hong Ky and Bac Son Commune.

The three communes, Son Son, Bac Son, and Hong Ky, are among the poorest communes in Soc Son District. There are no commune offices, and only an army regiment is located near the site.

The major income of the residents comes from agricultural work. Due to the poor soil and insufficient irrigation, crop harvest is usually once a year except for rice crop harvest twice a year in some areas. Rice production contributes about 50% of total income. Subsidiary crops are grown in upper land. The major subsidiary crops are sweet potatoes, potatoes, cassava, sugar cane, and corn. Vegetables are also planted to send to Hanoi. Incomes from these products account for 20% of the total. The residents also plant fruit trees, raise cattle, poultry and feed fish for sale. Income from these supplementary products may account for 30 % of total income of households.

Estimation of annual income per capita of residents in the districts is no more than 100 US dollar. Although the income is low, the life in the area is not so hard because of self-sufficient economy.

(3) Infrastructure and Existing Structures in the Area

The project area is served by a 6 kv line and a 6kv/380v electric transformer. Most residents use electricity for daily activities. Route 35 starting from National Route 3 crosses the area. Route 35 is an asphalt paved road. In the area, there are inter-village roads without pavement.

In the area, there is no piped water supply system, and rain and wastewater drain according to the natural topography.

In Nam Son commune there is a historic site Doan temple. There is also a Christian church. At a distance of 5 km from the project area, there is Giong temple for a legendary hero of Vietnam, who defeated the Yin army of China.

(4) Education, Culture, Health and Other Public Services in The Project Area

In the area, there are preschool, primary school and secondary schools. Most children go to school. However, there are no engineers or college graduate experts working in the area. Some experts living in Nam Son commune work in other communes or in other cities.

There is a medical station for health care. No doctors stay at the station, only medical interns work for the station. Patients who get serious disease are taken to district or central hospitals.

Cultural activities and entertainment are rarely organized. There are no cultural centers, cinemas, theaters, or clubs.

4.2 Transfer Station Sites

4.2.1 Overview

Of the 10 candidate locations, HPC and the JICA Study Team have selected Dong Ngac and Duc Giang as sites for waste transfer station.

The Dong Ngac site is located in the Tu Liem district, west of old town area, and very close to the Thang Long bridge. The Duc Giang site is located in Gia Lam district, close to the Duong river. Both sites are agricultural fields. There are no houses inside those two sites. However, the following number of houses exist along candidate access roads:

- 45 houses at Duc Giang.
- 189 houses at Dong Ngac (including houses of some companies).

At two sites, there are some farming lots separated with boundaries. Each lot belongs to a family. The lands of road, canal, ponds, and drainage belong to the Government. The land and farming lots along roads, and bridges (inside Right-of-way) belong to the Government.

(1) Dong Ngac Site

This site is located on the west side of the southern access road for the Thang Long bridge. The surroundings are the factories, shops, houses, agricultural fields and roads. The dominant wind direction is from southeast in summer and from northeast in winter. Distance between the site and a residential area located north of the site is long enough that waste odor problems would not be serious.

But the road facing the site is very crowded now because it is used as an access/bypass road to Thang Long bridge. The careful access road plan and the traffic control will be needed if the site is used as a transfer station.

(2) Duc Giang Site

This site is located between the southern bank of the Duong river and Route No.1. The surroundings are factories, houses, railway, and agricultural fields. The future land use plan shows that this site is developed as industrial zone and amusement parks. It seems there will be no serious problems for the residents.

The access road from Route No.1 crosses the railway. Structure of this crossing is poor.

4.2.2 Topographic Conditions

(1) Dong Ngac

There are no roads planned within the site. Two access roads to the site run under two bridges:

- Thang Long Railway bridge:
  a. Width: 30.5 m
  b. Height: 7.5 m – 8.8 m
- Thang Long Car bridge:
  a. Width: 30 m
  b. Height: 9.5 m

There are no restricted construction area near the bridge bents, but future access road should have certain distance from the bents so as not to narrow drivers' view.

There is one small bridge (Vanh Khuyen Bridge) in an access road that crosses the main drainage canal. Dimensions of the bridge are 4.5m x 6.2m. The waterway runs from west to east.

Preliminary planned access road goes under:

- Telephone line 5.2m above the ground
- Electric line 8.0m and 6.7m above the ground

(2) Duc Giang

There is no roads planned within this site. The newly designed Highway 1A is 4 km from the exiting road to the east.

- There is no bridge over access road to the site.
- Preliminary planned access road have to cross the Railway Hanoi- Lang Son.
- This access road runs under:
  - High-voltage electric line 13.95 m above the ground
  - Telephone line 4.0 m above the ground
  - Electric line 5.5 m above the ground
- There is a temple of Thanh Am village along the access road to the site.

- Within and near-by the site there are 18 culverts.

4.2.3 Socioeconomic Conditions

(1) Agricultural Activity

There are 367 farming lots and 7 ponds in the Duc Giang area. There are 174 farming lots in the Dong Ngac area.

(2) Farming Season

There are three main farming seasons as shown below:

- From February to May: grow rice. Harvest of 150 to 200 kg rice per "sao" (360 sqm) for this season.
- From June to November: grow rice. Harvest of 120 to 200 kg rice per 'sao" (360 sqm) for this season.
- From November to January is subseason, growing maize, or bean. Average yield of 50 (bean) or 80 (maize) kg per "sao" (360 sqm) for this sub-season. (This sub-season does not exist in Dong Ngac area).
  There is also one fish farming season per year. 1 "sao" (360 sqm) of pond yields 16 to 43 kg fish per year.

(3) Income of the Residents

Income of farmers depends on the area and number of farming. Prices of crops are as follows:

- Rice: 2300 VND per kg.
- Maize: 2000 VND per kg.
- Bean: 6000 VND per kg.
- Fish: 10000 VND per kg.

CHAPTER 5 PLANNING CONDITIONS

5.1 Planning Conditions for Nam Son Landfill Phase 2

(1) Objective

The objective of the planned landfill is to dispose of all collected waste excluding hazardous waste in a sanitary, environmentally sound, and cost effective manner.

(2) Site Location

The planned site is located in Nam Son Commune, Soc Son Suburban district in Hanoi City and is about 50 km from the center of Hanoi (See Figure 3.1.1).

(3) Site Boundary and Area

Approximately 73.5 ha of land are prepared as the total landfill area at Nam Son. In which, area of 13.5 ha is for the Landfill Phase 1 which has been put in a partial operation since May 1999. The remaining 60 ha approximately is for the Landfill Phase 2 which is the area for this study. The site maps are shown in Figure 5.1.1 and 5.1.2.

(4) Regulations and Standard to be Applied

The proposed landfill will satisfy all the relevant Vietnamese laws, regulations, standards and guidelines, which are listed in Section 7.2.6. In addition, all the documents and drawings prepared for the Phase 1 will be taken into consideration as reference.

(5) Type of Waste to be Accepted

The planned landfill site will accept the following types of waste:

- Household waste
- Street waste
- Commercial and industrial waste excluding hazardous waste
- Non-hazardous residues from waste treatment facilities such as medical waste treatment, industrial waste treatment and composting.
- Mud from ditches with appropriate water contains according to Vietnamese regulations.

Residue of hazardous waste and hospital waste generated after treatment (Item 4 above) will be disposed of in an area separated from other landfill area within the Phase 2 site. The following types of waste will not be accepted:

- Night soil sludge

- Hazardous waste including hazardous hospital waste and hazardous industrial waste

Soil waste and demolition waste are acceptable. However, in order to prolong the life of the landfill, these types of waste should be transported to Lam Du landfill.

(6) Commencement of Operation

The commencement of operation will be in 2004.

(7) Post Closure Land Use of Site

Post closure land use of site will be planned according to Vietnamese regulation.

(8) Use Period

The planned site will be used until it is full. There are no special administrative or social conditions that affect the use period. It is estimated that use period of the planned site may be about 14 years under normal conditions of landfill operation.

(9) Project Organization

- Agency responsible for implementing the project: TUPWS
- Agency responsible for financing the project: HPC
- Operating organization of landfill: URENCO
- Users of landfill:
  a. URENCO
  b. Urenco of Soc Son suburban district
  c. Enterprises or persons who pay fees and permitted by HPC

(10) Resettlement

HPC will make all necessary arrangements for resettlement of local residents living in or near the planned site.

(11) Distance between the Landfill Site and Local Residents

No local residents will live in areas within the stipulated distance by Vietnamese regulations from the boundary of the planned site.

(12) Major Facilities

Major facilities are as follows:

- Surrounding embankment (waste retaining structure)
- Section embankment
- Leachate collection and treatment facility (liner, leachate collection pipes,

biological treatment facility: oxidation pond)

- Gas exhaust pipes
- Drainage
- Onsite roads
- Heavy equipment (such as bulldozers) and other equipment for landfill operation
- Garage for heavy equipment (Some maintenance equipment will be provided.)
- Car wash facility for waste transport vehicles
- Gate and fence
- Lighting system for landfill operation and security
- Fire fighting equipment

The following facilities will be provided during Phase 1 site construction, and therefore, their costs are not included in the Phase 2 project cost.

- Administrative office
- Truck scale (if design capacity satisfied the proposed maximum vehicle load)
- Electricity and water supply

(13) Landfill Method

The following methods will be applied:

- Cell method
- Push up operation
- Daily application of cover soil

(14) Incoming Waste Amount

Projected incoming waste amounts are shown in Figure 6.2.1 and Table 6.2.2. At the time of commencement of operation of the planned landfill, the planned site will receive an average of 1,386 ton/day of waste.

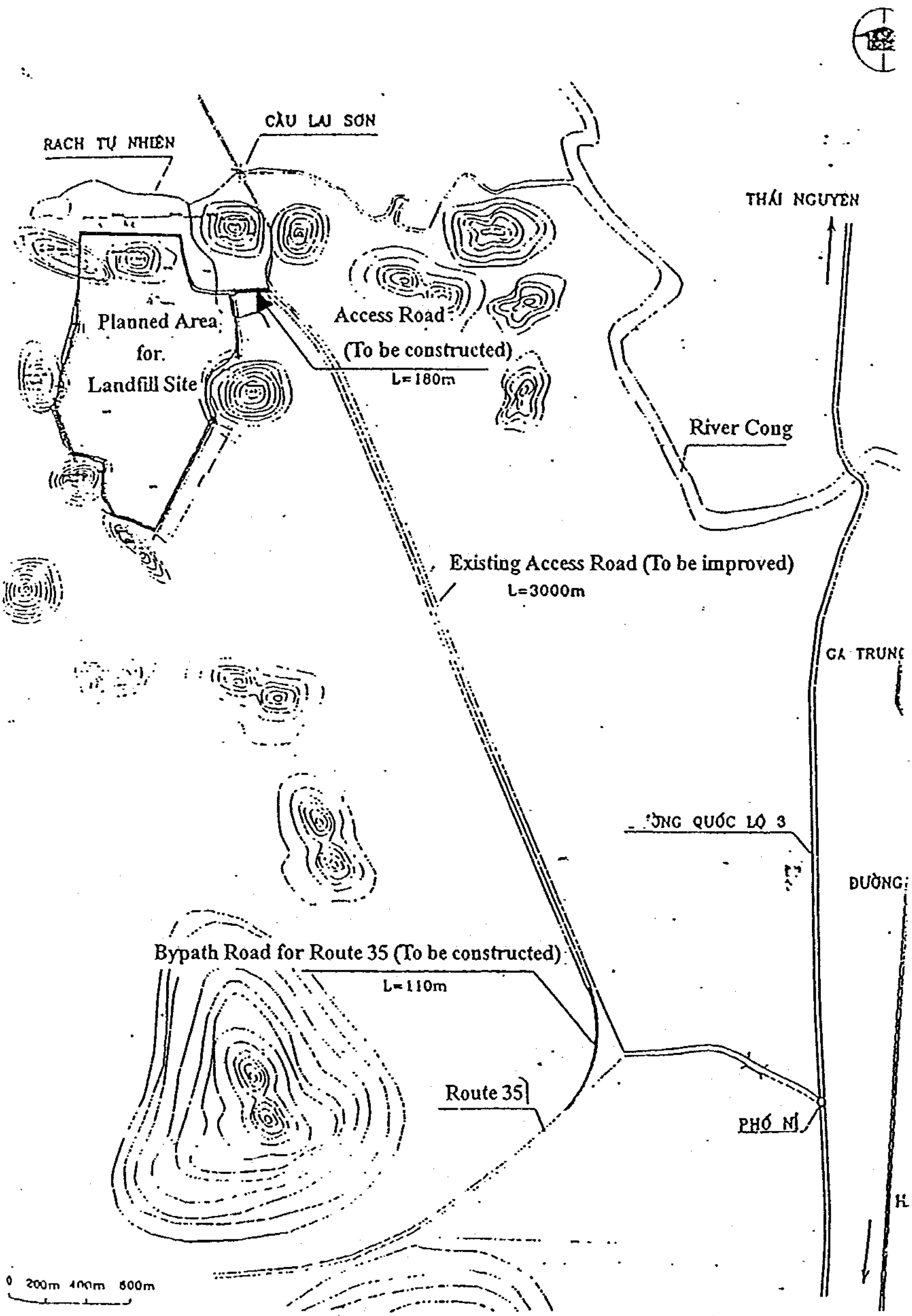


Fig.5.1.1 Nam Son Landfill Site Map (1/2)

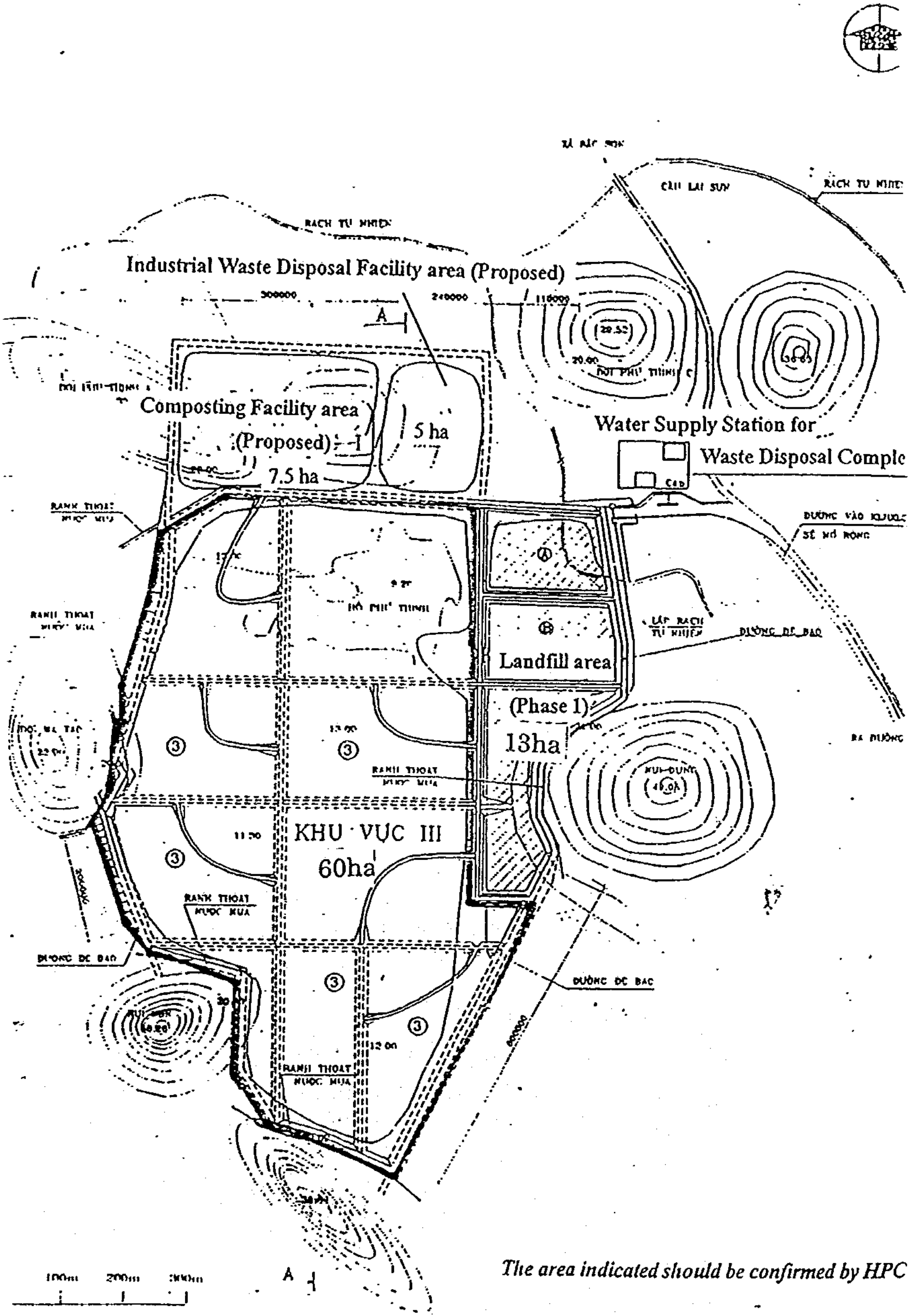


Fig.5.1.2 Nam Son Landfill Site Map (2/2)

5.2 Planning Conditions for the Transfer System

(1) Introduction

The objective of the proposed waste transfer system for Hanoi city is to minimize cost of transport of waste from waste generation areas to the Nam Son landfill, which is about 50 km north of Hanoi city center. The Nam Son site has been selected by the Hanoi People's Committee (HPC) as the only disposal site available currently in HPC jurisdiction area after using up the existing Tay Mo landfill site. The construction of a part (about 1.2 ha) of the Phase 1 area (13.5 ha) was completed, and URENCO started using the site in June 1999, but suspended the use in September 1999. When HPC finishes construction of some more landfill area, URENCO would resume using Nam Son site.

(2) Project Component

Proposed transfer system will consist of the following three elements:

- Transfer station(s) with relevant facilities
- Large vehicles to transport waste from the transfer stations to the Nam Son Landfill Site.
- Upgrading of the Route 35 (about 17 km) leading to Nam Son

(3) Location and Area

The planned transfer station will have an area of 5 ha, and will be located in Dong Ngac.

(4) Final Disposal Site

The final disposal will be Nam Son Landfill Phase 2. It is planned that the Landfill Phase 2 site will be open simultaneously when the transfer system will be in operation.

(5) Route of the Secondary Transport Vehicles

The route from the transfer station to the final disposal site will be as follows:

Dong Ngac transfer station – South Thang Long Highway – Thang Long bridge – North Thang Long highway – Route 2 – Route 35 – Bac Son Road – Nam Son Landfill

(6) Road Conditions

It is assumed that the roads on this route will be good enough for allowing the use of 25 ton GVW trucks with dimension of 2.5 m wide, 12 m long, and 3.6 m high by the time of commencement of the operation.

(7) Type of Waste to be Accepted at Transfer Stations

The following types of waste will be accepted at the planned transfer stations:

a) household waste
b) street waste
c) commercial and industrial waste excluding hazardous waste

The following types of waste will not be accepted at the transfer stations:

a) construction waste and soil waste
b) hazardous waste
c) night soil or night soil sludge

(8) Commencement of Operation

Operation of the planned transfer system will start on 1st January 2004.

(9) Owner, Operator, and User of Transfer System

a) Owner: HPC
b) Organization responsible for planning of the transfer system: Chief Architect Office and Department of Transport and Public Works (TUPWS) of HPC
c) Organization responsible for construction and procurement: TUPWS of HPC
d) Operator of the facility and equipment: URENCO
e) Organizations which can bring waste to the transfer stations
    - URENCO (main user)
    - Enterprises or persons who pay fees and permitted by HPC

(10) Operational and Environmental Principles

a) All incoming solid waste will be transferred within 24 hours.
b) Transfer facilities and area will be covered by a building structure.
c) All area where solid waste contacts ground (floor) will be paved.
d) Deodorization system will be provided to control odor if necessary.
e) URENCO will bring collected waste to the transfer stations 7 days a week, 365 days a year/

(11) Capacity of Transfer System

The planned transfer system will be have a capacity of transferring 1,600 ton/day of waste for 365 days a year, equivalent to an estimated incoming waste amount in 2006 (1,586 ton/day). HPC will procure all additional equipment and facilities that will be required to meet future demand.

CHAPTER 6 CURRENT AND FUTURE WASTE FLOW AND QUALITY

6.1 Waste Quantity

6.1.1 Current Waste Quantity

(1) Collection

Based on the household waste generation survey conducted by the JICA Study Team from October - December, 1998, it is estimated that Tay Mo landfill site received 1,050 ton/day of solid waste on average during the survey period (see the technical note below), and 1,060 ton/day of waste in the beginning of 1999. Of 1,060 ton/day of waste, it is estimated that URENCO transported 1,017 ton/day of waste. Two suburban districts of Tu Liem and Thanh Tri transported 30 ton/day, and industrial enterprises transported 13 ton/day.

Another landfill, Lam Du landfill managed also by URENCO received about 300 ton/day of demolition waste and soil waste on average in the beginning of 1999.

Technical Note:

The average daily quantity of 1,050 ton/day was derived from the URENCO's truck scale data for four separate weeks recorded at the entrance of Tay Mo landfill site. Weekly averages of the waste collection quantity of those four weeks are as follows:

a.	Average of 7 days from 19 – 25 October 1998:	1,019 ton/day
b.	Average of 7 days from 26 Oct. – 1 Nov. 1998:	963 ton/day
c.	Average of 7 days from 24 – 30 November 1998:	1,101 ton/day
d.	Average of 7 days from 8 – 14 December 1998:	1,118 ton/day
e.	Average of the above 4 weeks:	1,050 ton/day

A summary table as well as the 4-weeks data used for the estimation are shown in Tables 6.1.3 – 6.1.8 Those table also show number of daily round trips made by collection trucks.

(2) Generation

According to URENCO, it collected 75 % of waste generated in the 7 urban districts in the beginning of 1998. Based on this information and other assumptions explained later, it is estimated that the generation amount of solid waste excluding demolition waste and soil waste is 1,319 ton/day in the beginning of 1999. Generation amount of demolition waste and soil waste is estimated to be about 400 ton/day.

Projection of waste generation and target collection in the urban district of Hanoi is shown in Table 6.1.1.

6.1.2 Waste Amounts Received at Transfer Station and Nam Son Landfill Phase 2

Waste amounts received at the planned Dong Ngac transfer station and Nam Son Landfill Phase 2 during the project period are shown in Table 6.1.1

Dong Ngac transfer station and Nam Son Landfill Phase 2 will receive the following solid waste. The amount indicated in parenthesis are those received at time of commencement of operation in 2004.

1. Solid waste directly transported to Dong Ngac	(1,304 ton/day)
2. Residue of compost (Cau Dien)	(62 ton/day)
3. Residue of hospital waste incineration (Cau Dien)	(1 ton/day)
4. Waste transported by enterprises (non-URENCO)	(19 ton/day)
5. Waste transported by sub urban districts of Tu Liem and Thanh Tri	(0 ton/day)
6. Total amount received at Dong Ngac transfer station (1+2+3+4+5)	**(1,386 ton/day)**
7. Waste transported by sub urban districts of Soc Son	(57 ton/day)
8. Residue of industrial waste treatment facility to be located in Nam Son solid waste management complex (This residue will be directly taken to Nam Son landfill)	(20 ton/day)
9. Total amount received at Nam Son Landfill Phase 2 (6+7+8)	**(1,464 ton/day)**

At the time of commencement of operation in 2004, Dong Ngac transfer station will receive solid waste of 1,386 ton/day, and Nam Son Landfill Phase 2 will receive 1,464 ton/day of solid waste. These amounts have been estimated based on 1) the waste amount surveys conducted by the JICA Study Team in 1998 and 2) assumptions shown in the following section. It is estimated that Nam Son Phase 2 landfill has the capacity of receiving about 10 million ton of solid waste. Waste amount to be received at the planned Dong Ngac transfer station and Nam Son landfill site are shown in Table 6.1.2

6.1.3 Assumptions Used for Estimation of Future Waste Quantity

(1) Assumptions on Users of Dong Ngac transfer station and Nam Son Landfill Phase 2

Users of the planned Dong Ngac transfer station and Nam Son Landfill Phase 2 are as follows:

a) URENCO
b) Soc Son District

c) Operator of industrial waste treatment facilities

d) Enterprises (industrial waste generators) accepted by HPC

(2) Assumptions of New Facilities for Waste Treatment

It is assumed that URENCO will start operation of new compost plant, hospital incinerator, and industrial waste treatment according to the following plan and schedule.

Assumptions of New Facilities for Waste Treatment

Type of Facility	Year of Commencement of Operation	Waste Receiving Capacity	Amount of Residue
1. Compost plant financed by Spanish ODA	2001	137 ton/day	62 ton/day
2. Hospital incineration installed in Cau Dien	1999	3.4 ton/day	1 ton/day
3. Industrial waste treatment facility	2001	50 ton/day	20 ton/day

The Study Team considers that the large scale compost production in Nam Son Solid Waste Management Complex proposed by an American company will not be feasible, and therefore is not considered in planning the capacity of Nam Son Landfill Phase 2.

(3) Assumptions on Future Waste Generation Quantity

It is assumed that increases in future waste generation is co-related to the economic growth, which reflects both per capita income increase and population increase. The project growth rates of waste generation are shown in the following table.

Projected Growth Rates of Waste Generation

Period	Annual Growth Rate of Waste Generation	Remark
1998 – 2005	5.04 %	Hanoi GRP growth rate 7.2 % x 0.7
2006 – 2010	4.86 %	Hanoi GRP growth rate 8.1 % x 0.6
2011 – 2020	3.65 %	Hanoi GRP growth rate 7.3 % x 0.5

Note: Source of the above shown Hanoi GRP (grow regional product) is those of low case shown in the Interim Report Part 2 Section 3.1.4.

These growth rates of waste generation are quite high compared to those experienced in many cities of other Asian countries.

The coefficients ranging from 0.7 to 0.5 used in this table are assumed mainly considering the historical experience in Japan, which exhibited a coefficient of 0.7 during the period 1965 – 1985.

(4) Assumptions on Future Waste Collection Quantity

The following assumptions are used.

a) URENCO's collection amount will increase by 8%/year until the rate of collection relative to generation reaches 95%. (See note below.)
b) URENCO's collection rate will continue to be 95% once it reached 95%.
c) Collection amount of Soc Son District will increase by 5%/year from 1998 to 2020.
d) Collection amount of private enterprises (mainly industrial waste generators) will increase by 8%/year from 1998 to 2020.

Note: During the period from the beginning of 1995 to mid 1998, URENCO's collection quantity increased by 60%, annual growth being 14%/year on average. A main reason for such rapid growth is attributable to the rapid expansion of the collection service coverage, which has been led, by the expansion of urban areas.

6.1.4 Waste Flow

Current waste flow (beginning of 1999) and the future waste flow (at time of commencement of the planned facilities in 2004) are shown in Figures 6.1.1 and 6.1.2, respectively.

Table 6.1.1 Projection of Waste Generation and Proposed URENCO's Collection Target in the Urban Districts of Hanoi

Unit: ton/day

Year	Demolition waste & soil waste			Other solid waste			Total Solid Waste		
	Generation	Collection by URENCO	Target coverage	Generation	Collection by URENCO	Target Coverage	Generation	Collection by URENCO	Target Coverage
a	b	c	d	e	f	g	h	i	j
			c/b*100			f/e*100	b+e	c+f	i/h*100
1997	353	257	73%	1,195	872	73%	1,548	1,129	73%
1998	370	278	75%	1,256	942	75%	1,626	1,219	75%
1999	389	300	77%	1,319	1,017	77%	1,708	1,317	77%
2000	409	324	79%	1,385	1,098	79%	1,794	1,422	79%
2001	429	350	82%	1,455	1,186	82%	1,884	1,536	82%
2002	451	378	84%	1,528	1,281	84%	1,979	1,659	84%
2003	474	408	86%	1,605	1,384	86%	2,079	1,792	86%
2004	**497**	**441**	**89%**	**1,686**	**1,494**	**89%**	**2,184**	**1,935**	**89%**
2005	523	476	91%	1,771	1,614	91%	2,294	2,090	91%
2006	548	514	94%	1,857	1,743	94%	2,405	2,257	94%
2007	575	546	95%	1,948	1,850	95%	2,522	2,396	95%
2008	602	572	95%	2,042	1,940	95%	2,645	2,513	95%
2009	632	600	95%	2,142	2,035	95%	2,773	2,635	95%
2010	662	629	95%	2,246	2,133	95%	2,908	2,763	95%
2011	687	652	95%	2,328	2,211	95%	3,014	2,864	95%
2012	712	676	95%	2,413	2,292	95%	3,124	2,968	95%
2013	738	701	95%	2,501	2,376	95%	3,238	3,077	95%
2014	765	726	95%	2,592	2,462	95%	3,357	3,189	95%
2015	793	753	95%	2,687	2,552	95%	3,479	3,305	95%
2016	821	780	95%	2,785	2,645	95%	3,606	3,426	95%
2017	851	809	95%	2,886	2,742	95%	3,738	3,551	95%
2018	883	838	95%	2,992	2,842	95%	3,874	3,681	95%
2019	915	869	95%	3,101	2,946	95%	4,016	3,815	95%
2020	948	901	95%	3,214	3,053	95%	4,162	3,954	95%

Table 6.1.2 Projection of Waste Quantity to be Received at the Planned Transfer Stations and Nam Son Landfill Sites

	7 Urban Districts Area																	
				WASTE TRANSPORTED by URENCO			WASTE RECEIVED AT TRANSFER STATIONS						RECEIVED AT NAM SON LANDFILL				Waste Receive at Nam Son Landfill Phase 2 Site	
YEAR	WASTE GENERATED at Beginning of the Year	WASTE COLLECTED by URENCO at Beginning of the Year (b+c+d+e)	Collection Coverage (c/b)	Cau Dien New Compost Plant	Cau Dien Hospital Waste Treatment Facility	Nam Son Industrial Treatment Facility	Directly to Transfer Stations (c-e-f-g)	Residue of Compost	Residue of Hospital Waste	Collected by Private Enterpises	Collected by Tu Liem & Thanh Tri Districts	Received at Dong Ngac (h+i+j+k+l)	Subtotal (h+i+j+k+l)	Collected by Soc Son District	Residue of Industrial Waste Treatment	Total (n+o+p)	Annual Quantity	Cummulative Quantity
a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s
1,998	1256	942	75%	0	0	0	942	0	0	12	29	0	982	0	0	0	0	0
1,999	1319	1017	77%	0	3	0	1,014	0	1	13	30	0	1,058	0	0	0	0	0
2,000	1385	1098	79%	0	3	0	1,095	0	1	14	32	0	1,142	47	0	47	0	0
2,001	1455	1186	82%	137	3	50	996	62	1	15	33	0	1,107	50	20	70	0	0
2,002	1528	1281	84%	137	3	50	1,091	62	1	16	35	0	1,205	52	20	72	0	0
2,003	1605	1384	86%	137	3	50	1,194	62	1	18	0	0	1,274	55	20	75	0	0
2,004	1686	1494	89%	137	3	50	1,304	62	1	19	0	1,386	1,386	57	20	1,464	535,766	535,766
2,005	1771	1614	91%	137	3	50	1,424	62	1	21	0	1,507	1,507	60	20	1,588	579,541	1,115,307
2,006	1857	1743	94%	137	6	100	1,500	62	2	22	0	1,586	1,586	63	40	1,690	616,689	1,731,996
2,007	1948	1850	95%	137	6	100	1,607	62	2	24	0	1,695	1,695	66	40	1,802	657,706	2,389,702
2,008	2042	1940	95%	137	6	100	1,697	62	2	26	0	1,787	1,787	70	40	1,897	694,343	3,084,044
2,009	2142	2035	95%	137	6	100	1,792	62	2	28	0	1,884	1,884	73	40	1,997	728,898	3,812,942
2,010	2246	2133	95%	137	6	100	1,890	62	2	30	0	1,985	1,985	77	40	2,102	767,147	4,580,089
2,011	2328	2211	95%	137	12	150	1,912	62	4	33	0	2,011	2,011	81	60	2,152	785,450	5,365,539
2,012	2413	2292	95%	137	12	150	1,993	62	4	35	0	2,094	2,094	85	60	2,239	819,581	6,185,120
2,013	2501	2376	95%	137	12	150	2,077	62	4	38	0	2,181	2,181	89	60	2,330	850,459	7,035,579
2,014	2592	2462	95%	137	12	150	2,163	62	4	41	0	2,271	2,271	94	60	2,424	884,851	7,920,430
2,015	2687	2552	95%	137	12	150	2,253	62	4	45	0	2,364	2,364	98	60	2,522	920,568	8,840,999
2,016	2785	2645	95%	137	18	200	2,290	62	6	48	0	2,407	2,407	103	80	2,590	947,845	9,788,844
2,017	2886	2742	95%	137	18	200	2,387	62	6	52	0	2,507	2,507	108	80	2,695	983,787	10,772,630
2,018	2992	2842	95%	137	18	200	2,487	62	6	56	0	2,611	2,611	114	80	2,805	1,023,811	11,796,441
2,019	3101	2946	95%	137	18	200	2,591	62	6	61	0	2,719	2,719	119	80	2,919	1,065,389	12,861,830
2,020	3214	3053	95%	137	18	200	2,698	62	6	65	0	2,832	2,832	125	80	3,037	1,111,621	13,973,452

Note:

1. It is assumed that waste amount collected by Tu Liem, Thanh Tri, and Soc Son districts will increase by 5 % per year.
2. It is assumed that waste amount collected by private companies will increase by 8 % per year.
3. It is assumed that Tu Liem and Thanh Tri districts will open their own landfill sites in 2003 respectively.
4. Cumulative solid waste amount to be disposed at Nam Son Phase 2 Landfill site during 13 years from 2004 - 2016 will be 10,000,000 ton.

Table 6.1.3 Summary of Truck Scale Data on Waste Collection Amounts in Hanoi

(Unit: ton/day)

	7 days for 19-25 Oct.1998	7 days for 26 Oct-1 Nov.1998	7 days for 24-30 Nov.1998	7 days for 14-Aug Dec.1998	Average of 4 Weeks
A. URENCO (Exclude Item D)					
1st Shift	214	201	204	251	218
2nd Shift	749	728	855	827	790
Subtotal	964	929	1059	1079	1008
B. Collection by Non-URENCO					
1st Shift	33	20	31	28	28
2nd Shift	23	14	11	11	15
Subtotal	56	34	42	39	43
C. Total of A & B					
1st Shift	247	221	235	279	245
2ndShift	772	742	866	838	805
Total	1019	963	1101	1118	1050
D. Soil/Demolition Waste					
1st Shift	258	294	233	294	270
2nd Shift	0	34	0	87	30
Subtotal	258	328	233	381	300
E. Grand Total (C+D)					
1st Shift	505	515	468	573	515
2nd Shift	772	776	866	925	835
Total	1278	1290	1334	1499	1350

Note on the Truck scale recording hours:
1st shift: 07:00 - 19:00
2nd shift: 19:00 - 07:00 (Actually, there were almost no trucks coming between 02:00 - 07:00.

Table 6.1.4 Summary of Truck Scale Data on Waste Collection Trips in Hanoi

(Unit: Number of trips)

	7 days for 19-25 Oct.1998	7 days for 26 Oct-1 Nov.1998	7 days for 24-30 Nov.1998	7 days for 14-Aug Dec.1998	Average of 4 Weeks
A. URENCO (Exclude Item D)					
1st Shift	69	70	61	76	69
2nd Shift	193	193	197	196	195
Subtotal	262	263	258	272	264
B. Non-URENCO					
1st Shift	7	7	8	12	9
2nd Shift	4	4	3	3	4
Subtotal	11	11	11	15	12
C. Total of A & B					
1st Shift	76	77	69	88	78
2nd Shift	197	197	200	199	198
Total	273	274	269	287	276
D. Soil/Demolition Waste (Not included in the transfer plan)					
1st Shift	41	45	35	44	41
2nd Shift	0	5	0	13	5
Subtotal	41	50	35	57	46
E. Total (C+D)					0
1st Shift	117	122	104	132	119
2nd Shift	197	202	200	212	203
Grand Total	314	324	304	344	322

Note on the Truck scale recording hours:
1st shift: 07:00 - 19:00
2nd shift: 19:00 - 07:00 (Actually, there were almost no trucks coming between 02:00 - 07:00.

Table 6.1.5 Daily Waste Collection Amounts Recorded during 19 - 25 October 1998

	19-Oct Monday	20-Oct Tuesday	21-Oct Wednesday	22-Oct Thursday	23-Oct Friday	24-Oct Saturday	25-Oct Sunday	7 days Average(kg)	7days Average(ton)
A. General Waste									
1st Shift	267575	208060	229105	217715	181935	195600	201015	214429	214
2nd Shift	799265	756510	775120	753620	740420	737385	682210	749219	749
Subtotal	1066840	964570	1004225	971335	922355	932985	883225	963648	964
B. Collection by Non-URENCO									
1st Shift	52870	36550	63220	27550	21200	15220	11320	32561	33
2nd Shift	28770	39200	35110	6390	10550	22410	20060	23213	23
Subtotal	81640	75750	98330	33940	31750	37630	31380	55774	56
C. Soil/Demolition Waste									
1st Shift	236160	266680	229295	257580	250125	242245	326375	258351	258
2nd Shift	0	0	0	0	0	0	0	0	0
Subtotal	236160	266680	229295	257580	250125	242245	326375	258351	258
D. Total (A+B+C)									
1st Shift	556605	511290	521620	502845	453260	453065	538710	505342	505
2nd Shift	828035	795710	810230	760010	750970	759795	702270	772431	772
Total	1384640	1307000	1331850	1262855	1204230	1212860	1240980	1277774	1278

Trips

	19-Oct Monday	20-Oct Tuesday	21-Oct Wednesday	22-Oct Thursday	23-Oct Friday	24-Oct Saturday	25-Oct Sunday	7 days Average
A. General Waste								
1st Shift	72	66	68	74	65	71	67	69
2nd Shift	193	194	194	200	194	191	187	193
Subtotal	265	260	262	274	259	262	254	262
B. Non-URENCO								
1st Shift	7	8	7	10	8	9	3	7
2nd Shift	3	4	4	2	4	5	4	4
Subtotal	10	12	11	12	12	14	7	11
C. Soil/Demolition Waste								
1st Shift	40	42	35	41	40	42	50	41
2nd Shift	0	0	0	0	0	0	0	0
Subtotal	40	42	35	41	40	42	50	41
D. Total (A+B+C)								
1st Shift	119	116	110	125	113	122	120	118
2nd Shift	196	198	198	202	198	196	191	197
Total	315	314	308	327	311	318	311	315

Table 6.1.6 Daily Waste Collection Amounts Recorded during 26 October - 1 November 1998

	26-Oct Monday	27-Oct Tuesday	28-Oct Wednesday	29-Oct Thursday	30-Oct Friday	31-Oct Saturday	1-Nov Sunday	7 days Average (kg)	7days Average (ton)
A. General Waste									
1st Shift	206895	181930	191585	210865	199210	207765	208030	200897	201
2nd Shift	727800	763693	738115	524195	773520	778825	790495	728092	728
Subtotal	934695	945623	929700	735060	972730	986590	998525	928989	929
B. Collection by Non-URENCO									
1st Shift	20220	19810	15590	19030	21230	22860	18170	19559	20
2nd Shift	11060	23040	11060	15380	15290	13060	9270	14023	14
Subtotal	31280	42850	26650	34410	36520	35920	27440	33581	34
C. Soil/Demolition Waste									
1st Shift	323555	356675	463805	333555	247970	181550	151890	294143	294
2nd Shift	0	176045	59525	0	0	0	0	33653	34
Subtotal	323555	532720	523330	333555	247970	181550	151890	327796	328
D. Total (A+B+C)									
1st Shift	550670	558415	670980	563450	468410	412175	378090	514599	515
2nd Shift	738860	962778	808700	539575	788810	791885	799765	775768	776
Total	1289530	1521193	1479680	1103025	1257220	1204060	1177855	1290366	1290

Trips

	26-Oct Monday	27-Oct Tuesday	28-Oct. Wednesday	29-Oct. Thursday	30-Oct Friday	31-Oct Saturday	1-Nov Sunday	7 days Average
A. General Waste								
1st Shift	68	65	68	73	73	70	73	70
2nd Shift	194	196	193	191	190	192	195	193
Subtotal	262	261	261	264	263	262	268	263
B. Non-URENCO								
1st Shift	7	12	8	5	7	5	5	7
2nd Shift	4	4	4	4	4	3	2	4
Subtotal	11	16	12	9	11	8	7	11
C. Soil/Demolition Waste								
1st Shift	51	53	69	51	38	28	23	45
2nd Shift	0	27	9	0	0	0	0	5
Subtotal	51	80	78	51	38	28	23	50
D. Total (A+B+C)								
1st Shift	126	130	145	129	118	103	101	122
2nd Shift	198	227	206	195	194	195	197	202
Total	324	357	351	324	312	298	298	323

Table 6.1.7 Daily Waste Collection Amounts Recorded during 24 - 30 November 1998

	30-Nov Monday	24-Nov Tuesday	25-Nov Wednesday	26-Nov Thursdday	27-Nov Friday	28-Nov Saturday	29-Nov Sunday	7 days Average(kg)	7days Average(t)
A. General Waste									
1st Shift	211,030	178,545	183,849	172,585	201,190	241,320	240,385	204,129	204
2nd Shift	883,810	848,295	828,710	838,115	838,635	846,895	898,365	854,689	855
Subtotal	1,094,840	1,026,840	1,012,559	1,010,700	1,039,825	1,088,215	1,138,750	1,058,818	1,059
B. Collection by Non-URENCO									
1st Shift	30,050	38,940	52,790	20,455	19,990	33,761	21,430	31,059	31
2nd Shift	14,840	9,110	14,160	11,260	10,520	8,060	11,080	11,290	11
Subtotal	44,890	48,050	66,950	31,715	30,510	41,821	32,510	42,349	42
C. Soil/Demolition Waste									
1st Shift	249,740	204,140	237,920	255,735	201,350	221,745	257,850	232,640	233
2nd Shift	0	0	0	0	0	0	0	0	0
Subtotal	249,740	204,140	237,920	255,735	201,350	221,745	257,850	232,640	233
D. Total (A+B+C)									
1st Shift	490,820	421,625	474,559	448,775	422,530	496,826	519,665	467,829	468
2nd Shift	898,650	857,405	842,870	849,375	849,155	854,955	909,445	865,979	866
Total	1,389,470	1,279,030	1,317,429	1,298,150	1,271,685	1,351,781	1,429,110	1,333,808	1,334

Trips

	30-Nov Sunday	24-Nov Monday	25-Nov Tuesday	26-Nov Wednesday	27-Nov Thursday	28-Nov Friday	28-Nov Saturday	7 days Average(kg)	7days Average(t)
A. General Waste									
1st Shift	59	56	58	54	60	66	74	61	
2nd Shift	198	199	197	195	196	197	196	197	
Subtotal	257	255	255	249	256	263	270	258	
B. Non-URENCO									
1st Shift	9	9	10	5	6	12	6	8	
2nd Shift	4	2	4	3	3	2	3	3	
Subtotal	13	11	14	8	9	14	9	11	
C. Soil/Demolition Waste									
1st Shift	39	32	36	38	29	34	39	35	
2nd Shift	0	0	0	0	0	0	0	0	
Subtotal	39	32	36	38	29	34	39	35	
D. Total (A+B+C)									
1st Shift	107	97	104	97	95	112	119	104	
2nd Shift	202	201	201	198	199	199	199	200	
Total	309	298	305	295	294	311	318	304	

Table 6.1.8 Daily Waste Collection Amounts Recorded during 14 - 20 December 1998

	14-Dec. Monday	8-Dec Tuesday	9-Dec Wednesday	10-Dec Thursday	11-Dec Friday	12-Dec Saturday	13-Dec Sunday	7 days Average(kg)	7days Average(t)
A. General Waste									
1st Shift	179,775	255,075	200,360	175,070	186,105	186,675	575,520	251,226	251
2nd Shift	792,685	852,145	824,745	837,605	843,400	788,860	852,230	827,381	827
Subtotal	972,460	1,107,220	1,025,105	1,012,675	1,029,505	975,535	1,427,750	1,078,607	1,079
B. Collection by Non-URENCO									
1st Shift	26,920	43,015	22,480	37,320	20,070	23,320	24,000	28,161	28
2nd Shift	10,310	11,700	14,440	12,780	11,130	8,050	9,220	11,090	11
Subtotal	37,230	54,715	36,920	50,100	31,200	31,370	33,220	39,251	39
C. Soil/Demolition Waste									
1st Shift	280,835	296,370	274,575	260,685	256,250	339,070	349,410	293,885	294
2nd Shift	154,615	0	64,620	138,805	153,964	49,165	47,250	86,917	87
Subtotal	435,450	296,370	339,195	399,490	410,214	388,235	396,660	380,802	381
D. Total (A+B+C)									
1st Shift	487,530	594,460	497,415	473,075	462,425	549,065	948,930	573,271	573
2nd Shift	957,610	863,845	903,805	989,190	1,008,494	846,075	908,700	925,388	925
Total	1,445,140	1,458,305	1,401,220	1,462,265	1,470,919	1,395,140	1,857,630	1,498,660	1,499

Trips

	14-Dec Monday	8-Dec Tuesday	9-Dec Wednesday	10-Dec Thursday	11-Dec Friday	12-Dec Saturday	13-Dec Sunday	7 days Average(tr.)
A. General Waste								
1st Shift	57	74	58	56	58	56	175	76
2nd Shift	197	202	195	199	195	190	195	196
Subtotal	254	276	253	255	253	246	370	272
B. Non-URENCO								
1st Shift	12	14	12	16	9	13	7	12
2nd Shift	3	3	4	4	4	2	2	3
Subtotal	15	17	16	20	13	15	9	15
C. Soil/Demolition Waste								
1st Shift	42	42	42	39	40	50	54	44
2nd Shift	23	0	9	21	24	7	7	13
Subtotal	65	42	51	60	64	57	61	57
D. Total (A+B+C)								
1st Shift	111	130	112	111	107	119	236	132
2nd Shift	223	205	208	224	223	199	204	212
Total	334	335	320	335	330	318	440	345

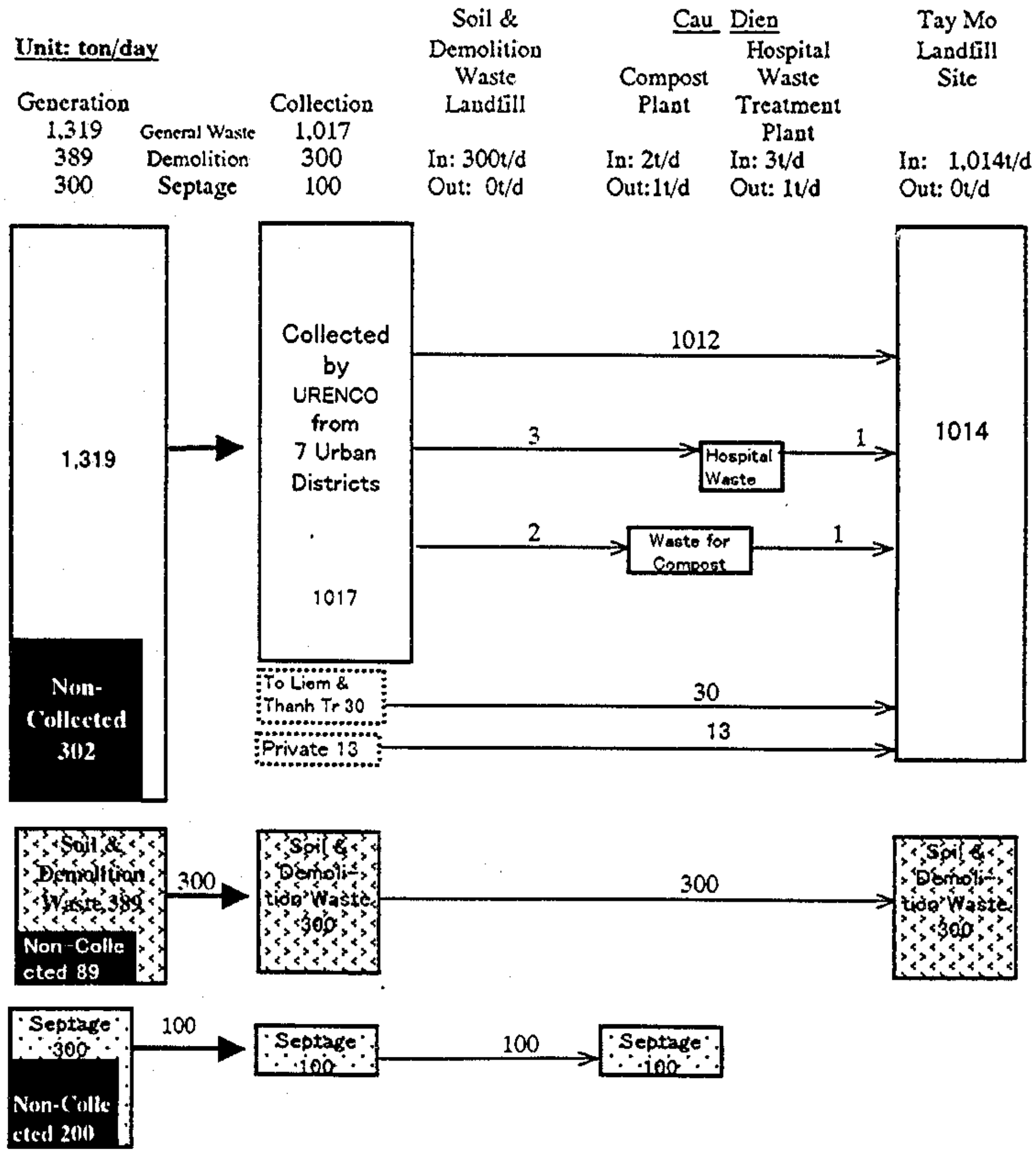
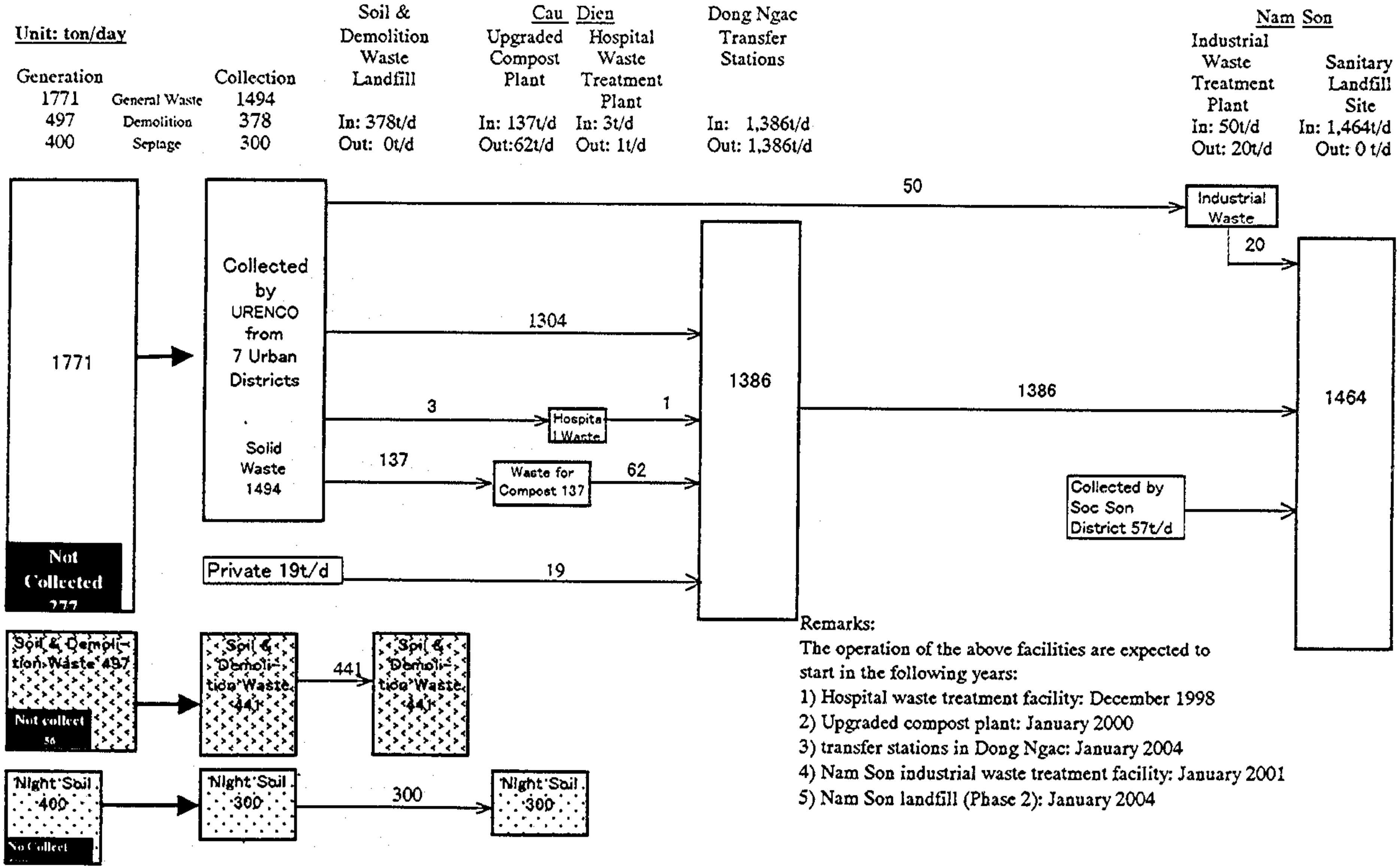


Figure 6.1.1 Waste Flow in the Beginning of 1999 in 7 Urban Districts of Hanoi



Remarks:

The operation of the above facilities are expected to start in the following years:

1) Hospital waste treatment facility: December 1998
2) Upgraded compost plant: January 2000
3) transfer stations in Dong Ngac: January 2004
4) Nam Son industrial waste treatment facility: January 2001
5) Nam Son landfill (Phase 2): January 2004

Figure 6.1.2 Waste Flow in the Beginning of 2004 in the Urban Hanoi

6.2 Waste Quality

6.2.1 Current Waste Quality

Waste quality analysis mentioned below was conducted by JICA Study Team during the first work in Vietnam with the purpose of studying the current waste composition for waste management plan.

- Physical composition analysis on wet base and estimation of bulk density
- Physical composition analysis on dry base
- Chemical composition analysis of the three components, i.e., water content, ash content and combustible content
- Chemical composition analysis of the six elements, i.e., C, H, O, N, Cl, and sulfa

The data resulting from the physical composition survey is most crucial information for planning the transfer station and final disposal site. As the following table shows, six samples were prepared and analyzed. Of the six samples, three samples, M1, M2 and M3, were household waste samples collected through the household waste generation survey, and the remaining three, M4, M5, M6 samples, were general domestic waste collected by URENCO trucks.

Title

Sample No.	Sample Source	Remarks
Sample M1	20 bags from area A	Dong Da District (Governmental house)
Sample M2	20 bags from area B	Hoan Kiem & Tay Ho (Private house)
Sample M3	20 bags from area C	Gia Lam District
Sample M4	Truck No. 51-04	Open Truck
Sample M5	Truck No. 70-67	Open Truck
Sample M6	Truck No. 95-34	Small Compactor

Sample M1 is typical waste generated by people living in governmental houses, and M2 is of private house. It is considered that income level of people living in private houses is higher. Sample M3 was collected from houses in suburban area.

The reason why three samples were taken from collection vehicles is that the result will show the typical waste composition dumped into the landfill containing not only household waste but also street waste, market waste, and others.

Two types of waste collection vehicles were selected to know the difference in bulk density of waste collected by these vehicles.

Samples M1, M2, and M3 were taken and analyzed for the physical composition analysis on wet base on 28 August and analyzed for other physical and chemical analysis later. Samples M4, M5, and M6 were taken on 8 September at Tay Mo landfill site.

The procedure for physical composition analysis of the samples followed the guideline of "Procedural Manual for Municipal Solid Waste Composition Analyzing" – British Columbia, Canada – 1991 that is very similar procedure applied in Japan. Collected wastes were sorted into the following categories.

a) Organic waste
b) Paper
c) Plastics, rubbers
d) Bricks, stones
e) Timber, rags
f) Bones, shells
g) Metal, tin cans
h) Glass
i) Others

One sample was prepared using waste contained in 20 plastic bags. Weights of respective samples were as follows. M1: 37.0 kg, M2: 33,0 kg and M3: 32.6 kg. Bulk density was measured by using 50-liter plastic bucket which was filled with sample waste. Sampling quantity of M4 was 17.3 kg, M5 was 18.4 kg and M6 was 16.3 kg and bulk density was measured by using 90% of 50-liter bucket because total volume was not enough for full bucket capacity. Since the truck scale at Tay Mo was not working at the time of sampling, loaded waste weights were measured by another truck scale at a private company. Loading quantity of the sample waste in each vehicle were 3,835 kg of M4, 4,540 kg of M5 and 2,160 of M6. Loading space capacity of open truck for samples M4 and M5 was 8.2 m^3 and small compactor for sample M6 was 4.4 m^3. Bulk density in the car was calculated with practical loading quantity and loading space capacity.

The result of wet-base physical analysis, which shows the physical composition ratio of each sample, is shown in the following table. The components of samples M1, M2, and M3 contain high percentage of the category of "Bricks, stones" that are mostly cinders and coal residues from cooking activities except for "Kitchen waste" and "Sand and Dust". The components of samples M5 and M6, especially M6 contain high percentage of the category of "Kitchen wastes" that contain organic matter such as leaves and market.

Moisture contents ratio of samples M4, M5, and M6 from collecting vehicles are higher than others generated from household.

According to the pre-feasibility report for Nam Son Waste treatment complex by Hanoi TUPWS or the document "Solid Waste Management in Hanoi" prepared by

URENCO, the composition of domestic waste that consists of household waste and market waste except street waste was analyzed by URENCO themselves as below.

Comparing the waste composition information between URENCO and Study Team, there are some small differences but the result of the waste quality analysis by the Study Team shows typical waste composition in Hanoi. One possibility of the differences can be the difference of sampling sources. URENCO data is from domestic waste that might consist of household waste and market waste, sample M1- M3 are from only household waste and sample M4-M6 waste collected from city area mixed together with household waste, market waste and street waste.

The reason why the content ratio of plastic has increased is that plastic bags or packages have been used much more than before.

For designing the waste treatment facility or the transfer station in the pre-feasibility study, the waste composition data of sample M4-M6 are used because they indicate current practical composition of the waste collected and hauled to the disposal site.

Table 6.2.2 graphically show average waste composition of samples M4-M6.

Table 6.2.1 Solid Waste Composition Ratio on Wet Base

(Unit: %)

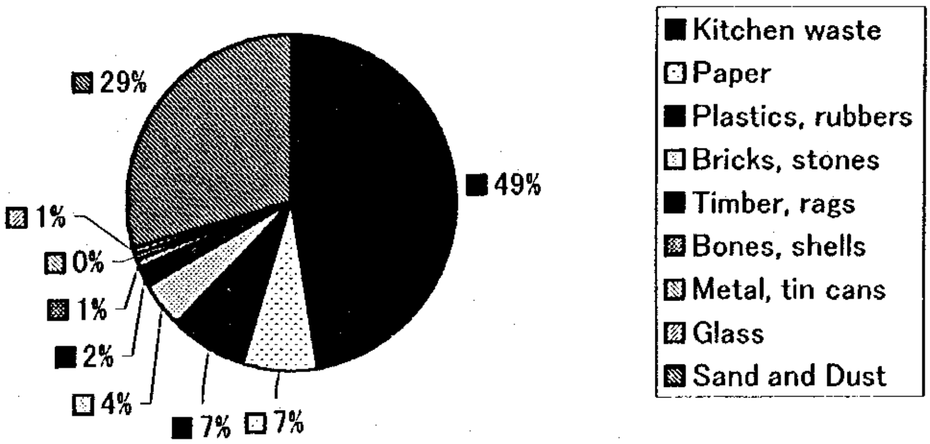
Types of Waste	M1	M2	M3	Ave.	M4	M5	M6	Ave.	Total Ave.
Bulk Density in Car [kg/m^3]	-	-	-	-	487.6	425.2	505.3	-	-
Bulk Density [kg/m^3]	380.0	368.0	378.0	375.3	384.4	408.9	362.2	385.2	380.3
Kitchen waste	39.50	30.60	37.70	36.45	34.90	42.40	67.50	47.51	41.98
Paper	3.20	4.10	2.40	3.25	11.50	5.40	4.90	7.28	5.27
Plastics, rubbers	6.70	9.60	4.10	6.90	9.80	6.50	6.10	7.47	7.19
Bricks, stones	14.60	7.30	5.20	9.36	4.60	7.00	1.20	4.41	6.89
Timber, rags	1.30	1.20	2.10	1.58	1.70	2.70	1.20	1.92	1.75
Bones, shells	1.10	1.50	2.10	1.58	1.20	1.20	0.60	0.96	1.27
Metal, tin cans	1.10	0.60	0.60	0.79	0.70	0.60	0	0.38	0.59
Glass	1.90	4.8	0.30	2.07	1.70	0.60	0	0.77	1.42
Sand and Dust	30.60	40.30	45.50	38.03	34.10	33.60	18.50	29.31	33.67
Moisture Content	38.8%	34.9%	36.9%	36.9%	43.0%	40.4%	46.6%	43.3%	40.1%

Table 6.2.2 Solid Waste Composition Comparison

(Unit: %)

URENCO Study (1994)	
Types of Waste	
Bulk Density	416
Organic waste	50.27
Paper	2.72
Plastics, rubber	0.71
Bricks, Clay	7.43
Wood, linen	6.27
Bone, shells	1.06
Metal parts	1.02
Glassware	0.31
Fine fraction	30.21
Moisture Content	67%

JICA Team Study			
M1–M 3 Ave.	M4-M 6 Ave.	Total Ave.	Types of Waste
375.3	385.2	380.3	Bulk Density
36.45	47.51	41.98	Kitchen waste
3.25	7.28	5.27	Paper
6.90	7.47	7.19	Plastics, rubbers
9.36	4.41	6.89	Bricks, stones
1.58	1.92	1.75	Timber, rags
1.58	0.96	1.27	Bones, shells
0.79	0.38	0.59	Metal, tin cans
2.07	0.77	1.42	Glass
38.03	29.31	33.67	Sand and Dust
36.9%	43.3%	40.1%	Moisture Content



CHAPTER 7 PLAN FOR NAM SON LANDFILL PHASE 2

7.1 Objective of the Project

The major objective of Nam Son Landfill Phase 2 project is to develop a final disposal site that has the capacity to dispose of all collected waste in sanitary and environmentally sound and cost effective manner.

Another objective of this project is to serve as a national model case of large-scale sanitary landfill in Vietnam.

7.2 Planning and Design Policy

7.2.1 Site Selection

The site location in Nam Son for this project had been determined by Hanoi Peoples Committee (HPC) as the result of intensive study of candidate sites. Construction of the Landfill Phase 1 with area of 13.5 ha in Nam Son has been already started and put in operation since the middle of May 1999 with 1.2 ha to receive the waste from Hanoi Urban. The existing Tay Mo landfill is closing soon but still accepting some portion of the total waste.

Thus, there is no choice for the Study Team to re-consider the alternative locations for this project.

7.2.2 Site Boundary and Area

Approximately 73.5 ha of land are prepared as the total landfill area at Nam Son. In which, the area of 13.5 ha is for the Landfill Phase 1.

According to the topographical investigation for the project conducted by the Study Team in December 1998, the area of the Landfill Phase 2 was measured as 59.44 ha including Phu Trinh Lake area based on the latest landfill zoning plan.

Thus, the area for the project is assumed to be 59.44 ha for this study.

7.2.3 Waste Acceptance

The wastes disposed of into the Landfill Phase 2 should be non-hazardous municipal solid waste, in principle. It will accept treated residual from hospital waste incinerator in Cau Dien or industrial waste treatment facilities in Nam Son Waste Treatment Complex. In addition, the Landfill Phase 2 should have a small section if necessary for hazardous municipal waste such as electric cell and batteries which contain some heavy metals that cause negative environmental impacts, even though currently there is no mandatory source separation system of such toxic matter in Hanoi. Acceptable waste is listed below.

- Non-hazardous municipal solid waste from the transfer station
- Industrial waste treatment residual with no hazardous substance
- Hospital waste incinerator residual (Ash)

7.2.4 Incoming Waste Quantity Control

Incoming waste quantity should be controlled through measuring the quantity with the electric weigh-bridge. The weigh-bridge will be installed at the initial stage of the Landfill Phase 1 and will be used continuously for the Phase 2 operation period. In case the original weigh-bridge will not have enough loading capacity for the large transportation vehicle with 35 tons load used in future, it should be replaced to another appropriate one.

The administration office will have to control not only quantity of incoming wastes but also types of wastes and particular dumping place for each waste for the traceability.

7.2.5 Environmental Pollution Control

Nam Son Landfill Phase 2 should be designed, constructed and operated with proper facilities which can control the environmental pollution to meet the related environmental standards.

An EIA report for this project prepared by the Study Team recommends that some mitigation measures listed in Table 7.2.1 are necessary to control environmental impacts during the landfill operation. Especially the EIA report proposes an appropriate and cost-effective leachate treatment system for prevention of the aquatic environment. Prevention of fires that could be caused either naturally or artificially is important for workers health and atmospheric environment. Currently, fires often occur at the existing Tay Mo landfill site.

Besides these recommendations by the EIA report, cover soil operation and surrounding fence are needed in order to prevent generation of rats and crows that damage the neighboring environment.

7.2.6 Satisfaction of Related Regulations and Standards

Nam Son Landfill Phase 2 should satisfy the following Vietnamese regulations and environmental standards.

Regulations and its guidance regarding urban landfill in Vietnam is contained in TC9423 prepared by Ministry of Construction are as follows:

- Regulation on designing, constructing, operating and controlling urban landfill site
- Interpretation (guiding the implementation) on the regulation on designing, constructing, operating and controlling urban landfill site

Limitations of parameters and concentration of pollution materials in surface, underground water, air are given in the following Vietnamese standards on design regulations and environment.

- TCVN 5937-1995 on allowed limit value of basic parameters of surrounding air
- TCVN 5938-1995 on allowed limit value of parameters and concentration of hazardous substances in ambient value
- TCVN 5942-1995 on allowed limit value of parameters and concentration of pollution materials in surface water
- TCVN 5944-1995 on allowed limit value of parameters and concentration of pollution materials in underground water
- TCVN 5945-1995 on industrial wastewater - limit value of parameters and concentration of pollution materials
- TCVN 5949-1998 on allowed limit value of basic parameters of noise level in public and residential area

7.2.7 Liner Facilities

The bottom and walls of landfill site should have good impermeable layer, which is either natural or artificial, to prevent leachate leaking into soil layer and underground water source under the bottom, and leaking through the walls, which may cause pollution for surface water.

Because of the natural geological condition in Nam Son, the liner facilities that consist of penetration protection clay layer and synthetic flexible membrane liner should be equipped on the bottom and inside slope of landfill site.

7.2.8 Leachate Control

Leachate control system that consists of leachate collection facilities and leachate treatment facilities should be provided for the project to control the leachate quality below the environmental standard.

Leachate collection facility is the effective system for semi-aerobic sanitary landfill since it can not only remove the leachate from waste layer, but also collect and exhaust the gas from waste layer, and supply the air into waste layer.

The leachate generated from a landfill site will vary in volume and composition depending on the age of the site and stages of biodegradation reached. Because of the changes in leachate composition with time, the leachate control systems should adapt to these changes. Leachate treatment is required to remove any contaminating components of the leachate and bring it to a standard whereby it can be discharged to Cong River. Generally a range of potentially polluting components are, for example, pH, concentration of organic material, ammonium and nitrate, suspended solids and metal content.

For the Landfill Phase 2, it is recommended that the combined system with biological treatment process with forced aeration equipment and physical treatment process such as coagulating sedimentation should be prepared. HPC is planning to use the anaerobic treatment process to treat the leachate from the Landfill Phase 1. This anaerobic treatment system has been only experimented with at the laboratory level and there is no practical treatment experience. If the result of the Phase 1 will satisfy the water quality standard, this anaerobic system is also considered as an alternative option for the leachate treatment facilities of the Landfill Phase 2.

If heavy metal is likely to be contained in collected waste in future because of increasing consumption of electric cell, car battery or other materials that contain heavy metal, a physical/chemical treatment process will be necessary to treat them.

The leachate treatment facility will be operated for 10 – 30 years even after closing the landfill site because leachate is generated even after the closure.

7.2.9 Gas Control

Gas control facility should be installed to comply with the Vietnamese regulation that stipulates all sanitary landfill sites must have a gas controlling system to prevent fire, explosion, and to protect the environment in the landfill ground and the surrounding areas.

Gas ventilation mechanism is very effective for not only collecting and exhausting the landfill gas such as CH_4, CO_2, and NH_3, but also natural air circulation within waste layer for effective semi-aerobic sanitary landfill.

CH_4 gas recovering facility is not considered for the project because the demand of the CH_4 gas or electricity generated from the gas generator will not be so high around the area for the near future, and this facility costs a lot.

7.2.10 Environmental Monitoring

Environmental monitoring should be carried out during landfill operation period and post-closure period. Monitoring parameters include landfill gas, underground water and surface water, odor, and settlement.

Monitoring of underground water is useful to evaluate possible pollution risks. Monitoring of landfill gas is necessity to know the gas density and explosion risks, especially for site workers safety. Settlement monitoring is useful to watch the level of stability of waste in order to plan post-closure land use.

7.2.11 Operation Method

The solid waste must be sufficiently compacted so as to stabilize the landfill foundation and prolong use period of landfill

The cell method is recommended for the project in view of large area of the Landfill Phase 2, and fill-up method is recommended for bedding and compaction. A layer of cover soil should be systematically placed on waste dumped every day.

7.2.12 Locally Manageable Operation

All proposed facilities are those that can be managed by Hanoi City and its employees. Construction and operation of the Landfill Phase 2 will give earning opportunity to local people who live in neighboring villages.

7.2.13 Site Work Environment

Sanitary and good working conditions, which are necessary for modern landfill site, have been taken into consideration in designing site facilities. Sanitary facilities and amenities such as toilets, showers, lockers, rest rooms will be provided. Daily cover soil will help to keep the site sanitary. Administration building will have office room and meeting room with air conditioning and telephone line. Cars will be provided for site inspection.

7.2.14 Ultimate Land Use

The landfill site will be used for some other purposes such as green park or sports field to increase real estate values in future after closure of the landfill according to the Vietnamese regulation.

Table 7.2.1 Proposed Major Mitigation Measures in EIA

Control Target	Major Mitigation Measures Proposed in the EIA
Aquatic Environmental Pollution	- Good impermeable liner and a collection system for leachate with imported HDPE sheet - The treated water quality shall meet required class A quality standard at discharge point to Cong River complying with TCVN 5945-1995
Atmospheric Environmental Pollution	- Adequate installation of gas collection and monitoring systems
Risk of Fires or Explosion and Labor Safety	- Special safety training for site workers dealing with gas and first aid - Sign boards, security fence and suitable equipment of gas vent

7.3 Expected Duration and Capacity of the Landfill

The waste receiving capacity of a landfill depends on size (area) and height of landfill, as well as other design and natural conditions. Concerning the height of landfill, we have studied two cases. The first case is to set landfill height at 20 m from the bottom of the landfill (or 26+ from the sea level) as in the case of the Phase 1 design. The second case sets the height at 30 m (or 36+ from the sea level) using some area of Phase 1 higher than its original top level which is 26+ m. Landfill capacity is expected to be about 8.2 million m^3 for the first case, and for the second case it is to be about 12.4 million m^3.

Expected use period of the landfill is approximately 10.2 years for the first case, and 15.1 years for the second case. Duration of the second case is 4.9 years or 48 % longer than the first case. The second case is more economical than the first case. The Study Team recommends the second case.

The Study Team recommends also that a part of Phase 1 should have 30 m height of landfill. There is a few different ways of making the landfill height 30 m for Phase 1. For example, it is possible to apply 20 m height of landfill for both Phases 1 and 2 first, then go back to Phase 1 site for additional 10 m. An alternative is to fill Phase 1 to the height of 30 m before start using Phase 2 site. The latter method may be applicable if the construction of Phase 2 is delayed.

It is estimated that Landfill Phase 2 can receive about 10.9 million ton with the landfill height of 30 m. Assumptions and calculations are shown below.

1. The height of Nam Son Landfill Phase 2

   The height of Nam Son Landfill Phase 2 will be planned to be 30 m which means the top level is about 36 m above sea level.

   When the level of Phase 2 landfill area reaches the same level of Phase 1 which is planned at about 26 m above sea level, the waste also will be dumped on some part of Phase 1 area.

   As the result of this plan, finally about 12,400,000 m^3 of landfill capacity will be expected including the volume for cover soil (see Figure 7.4.4).

2. Bulk density (Specific weight) of the waste

   Bulk density of the waste will be increased as time being like follows.

   1) Original domestic waste (When the waste is dumped on the ground before tamping)

      <u>**385 kg/m^3**</u> (source: JICA study interim report (I/R) vol.3 Table 5.3.2)

2) Tamped waste (When the waste is tamped before daily cover soil)

<u>670 kg/m³</u> (according to some references or study reports, it is expected that the waste will be tamped with 600 – 900 kg/m³ in Europe and USA. In Japan, it is about 800 – 1,000 kg/m³ after 5 years because landfills are usually constructed in mountain area with higher waste layers. If push-up filling method and tamping 5-6 times to every 60 cm of waste layer each, a larger bulk density can be expected. But considering the practical situation in Vietnam with heavy rain season, it would be difficult for heavy equipment like bulldozer to tamp the waste layer with push-up methods perfectly because the bottom area usually is covered by rainwater. Therefore, a larger bulk density is not expected.)

3) Settled waste (When the landfill is filled up with the waste)

<u>850 kg/m³</u> (according to the survey report of old landfill sites 10 years after their closing in Tokyo, Japan which had buried the non-treated (non-incinerated) waste such as organic waste for 10 years, the bulk density of buried waste was 700 – 1,000 kg/m³. Therefore in this study, the middle point of this range which is 850 kg/m³ will be adopted at the time when the landfill is full on the average.)

3. Volume decreasing ratio by decomposition

In this study, it is considered that 20% of total buried waste will be decreased by decomposition to gas or leachate.

According the survey by Tokyo Metropolitan Government that had measured the decreasing ratio of the organic waste which settled into a large-scale experiment vessel for 10 years, 23.4 – 29.4% of such organic matter was decreased by decomposition.

Considering the deference of climate and environmental condition, it is expected that more organic matter will decompose in Vietnam. Therefore it is assumed that 30% of organic matter will be decreased by decomposition.

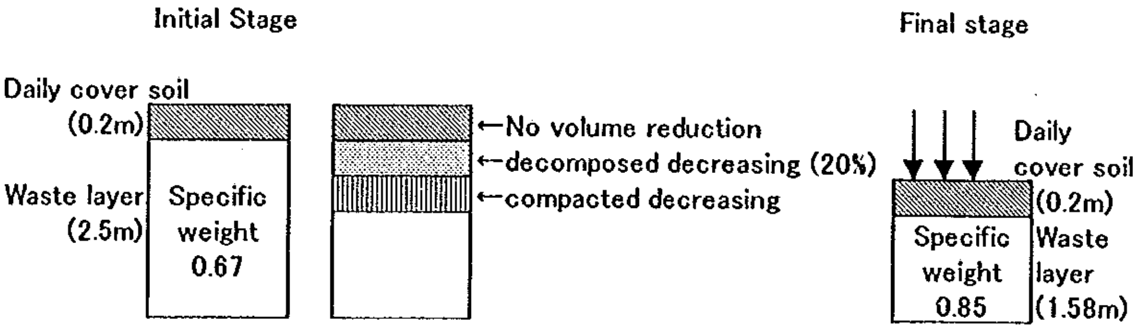
According to the waste quality survey carried by the JICA Study Team, there is 57.67% of organic matter in Hanoi domestic waste which are "kitchen waste", "paper", timber & rags" and "bone & shell". It means about 20% of total waste will be decreased by decomposition.

$57.67 \times 0.3 = 17.03 \rightarrow 20\%$

4. Cover Soil Volume

For daily operation, 20cm thickness of daily cover soil will be covered onto the tamped waste layer which reaches 2.5m thickness.

For intermediate and final cover soil operation, the thickness of these soil will be 60cm.



5. Expected duration of landfill site

a) Landfill height: 30m(from the bottom to top)

Expected capacity: 12,367,239 m^3 (see I/R, vol.3, Figure 7.7.4(p. 7-28))

b) Expected number of waste layers

(30m − 0.6m) / (0.2m + 1.58m) = 16.5

As above equality shows, there are about 16 waste layers formed in the landfill.

Therefore, intermediate cover soil layer will be done for each 4 daily waste layers which means there will be 3 intermediate layers with the thickness of 0.6m and 1 final cover soil layer with the same thickness.

So, total thickness of cover soil is calculated as follows.

Daily cover soil + Intermediate cover soil + Final cover soil

= 0.2 x (16-3-1) + 0.6 x 3 + 0.6 = 4.8m

c) Expected cover soil volume

Cover soil will be covered on all exposed waste surfaces including slope face.

The soil volume for slope face is assumed 10% of the cover soil for flat face.

Thus, total cover soil volume is expected as follows.

Total cover soil volume = 12,367,239 m^3 x 4.8/30 x (1+0.1) = 2,176,63 m^3

d) Expected buried waste volume

The waste volume to be buried in the landfill area is calculated as follows.

Total waste volume in the landfill = 12,367,239m^3 - 2,176,634m^3 = 10,190,605m^3

Cover soil volume / Landfill capacity = 17.6% (by volume)

Cover soil / Settled waste volume = 21.4% (by volume)

e) Expected total accepted waste volume

The total accepted waste volume for the Landfill Phase 2 is calculated as follows.

Buried waste volume in the landfill = 10,190,605 m^3

Bulk density is assumed as 0.85 t/m^3, which means,

10,190,605m^3 x 0.85 = 8,662,014 tons

Considering the decreased volume by decomposition that is assumed as 20% of initially buried waste.

8,662,014 tons / 0.8 = 10,827,517,5 tons

f) Expected duration of the Landfill Phase 2 proposed by JICA Study Team

According to the waste generation and collection quantity estimation by JICA Study Team (see, I/R, vol.3, Table 5.2.2), the landfill will be full by about January 2018 if operation will be started from January 2004. Duration is expected about 14 years and 1 month.

A large-scale composting project by American company as 100% foreign investment in Nam Son Solid Waste Treatment Complex by HPC it is currently being considered. The treatment capacity on input waste basis is planned to be 250,000 tons per year. If this project is carried out in future, usage life of the landfill will last longer than 15 years.

Table 7.3.1 Life estimation of Nam Son Landfill (filling up to +26 m: depth=20 m)

YEAR	Annual Received Quantity (Ton)	After Biodegraded Quantity (Ton)	Settled Bulk Density (t/m3)	Annual Calculated Volume (m3)	Cover Soil Volume (m3)	Annual Total Volume (m3)	Accumulation (m3)	Landfill Height (m)	Effective Volume (m3)	Cumlative Waste Quantity (ton)
	a	b	c	d	e	f	g	h	h	i
		a x 0.8	0.85	b/c	c*0.214	c+d			8,230,000−f	
									8,230,000	
2004	535,766	428,613	0.85	504,250	107,910	612,160	612,160	1.5	7,617,840	535,766
2005	579,541	463,633	0.85	545,451	116,726	662,177	1,274,337	3.1	6,955,663	1,115,307
2006	616,689	493,351	0.85	580,413	124,208	704,621	1,978,958	4.8	6,251,042	1,731,996
2007	657,706	526,164	0.85	619,017	132,470	751,487	2,730,445	6.6	5,499,555	2,389,702
2008	694,343	555,474	0.85	653,499	139,849	793,348	3,523,793	8.6	4,706,207	3,084,044
2009	728,898	583,118	0.85	686,021	146,809	832,830	4,356,623	10.6	3,873,377	3,812,942
2010	767,147	613,718	0.85	722,021	154,512	876,533	5,233,156	12.7	2,996,844	4,580,089
2011	785,450	628,360	0.85	739,247	158,199	897,446	6,130,602	14.9	2,099,398	5,365,539
2012	819,581	655,665	0.85	771,370	165,073	936,444	7,067,045	17.2	1,162,955	6,185,120
2013	850,459	680,367	0.85	800,432	171,292	971,725	8,038,770	19.5	191,230	7,035,579
March 2014	167,366	133,892	0.85	157,521	33,709	191,230	8,230,000	20.0	0	7,202,945
									Close	

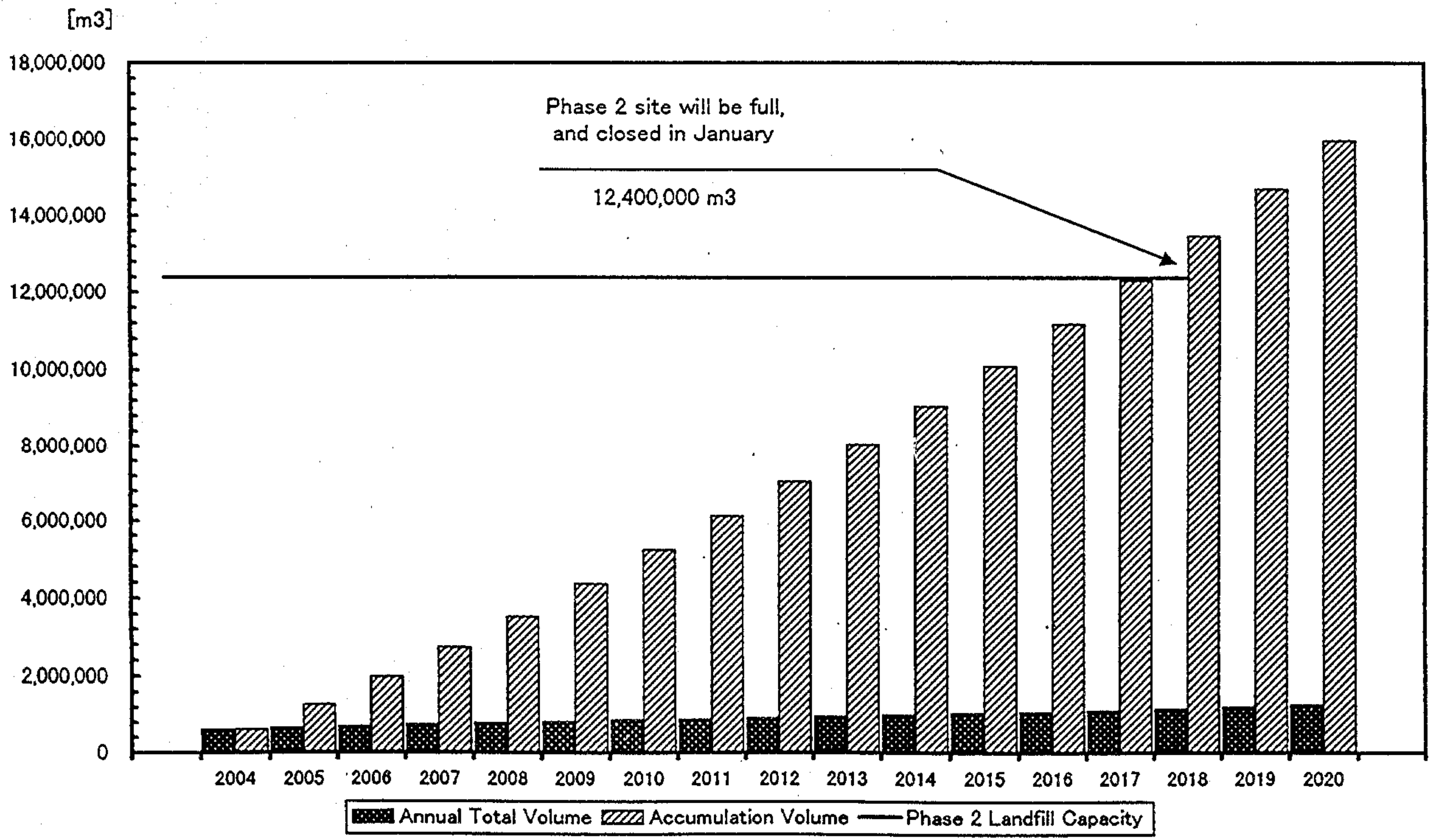
7,202,945

Table 7.3.2 Life estimation of Nam Son Landfill (filling up to +36 m using some area of Phase 1: depth=30 m Recommended)

YEAR	Annual Received Quantity (Ton)	After Biodegraded Quantity (Ton)	Settled Bulk Density (t/m3)	Annual Calculated Volume (m3)	Cover Soil Volume (m3)	Annual Total Volume (m3)	Accumulation (m3)	Calculated Landfill Height (m)	Effective Landfill Volume (m3)	Cumulative Waste Quantity (ton)
	a	b	c	d	e	f	g	h	h	I
		a x 0.8	0.85	b/c	d*0.214	d+e			12,400,000−f	
									12,400,000	
2004	535,766	428,613	0.85	504,250	107,910	612,160	612,160	1.5	11,787,840	535,766
2005	579,541	463,633	0.85	545,451	116,726	662,177	1,274,337	3.1	11,125,663	1,115,307
2006	616,689	493,351	0.85	580,413	124,208	704,621	1,978,958	4.8	10,421,042	1,731,996
2007	657,706	526,164	0.85	619,017	132,470	751,487	2,730,445	6.6	9,669,555	2,389,702
2008	694,343	555,474	0.85	653,499	139,849	793,348	3,523,793	8.5	8,876,207	3,084,044
2009	728,898	583,118	0.85	686,021	146,809	832,830	4,356,623	10.5	8,043,377	3,812,942
2010	767,147	613,718	0.85	722,021	154,512	876,533	5,233,156	12.7	7,166,844	4,580,089
2011	785,450	628,360	0.85	739,247	158,199	897,446	6,130,602	14.8	6,269,398	5,365,539
2012	819,581	655,665	0.85	771,370	165,073	936,444	7,067,045	17.1	5,332,955	6,185,120
2013	850,459	680,367	0.85	800,432	171,292	971,725	8,038,770	19.4	4,361,230	7,035,579
2014	884,851	707,881	0.85	832,801	178,219	1,011,020	9,049,790	21.9	3,350,210	7,920,430
2015	920,568	736,455	0.85	866,417	185,413	1,051,831	10,101,621	24.4	2,298,379	8,840,999
2016	947,845	758,276	0.85	892,089	190,907	1,082,996	11,184,617	27.1	1,215,383	9,788,844
2017	983,787	787,029	0.85	925,917	198,146	1,124,063	12,308,681	29.8	91,319	10,772,630
January 2018	79,923	63,939	0.85	75,222	16,097	91,319	12,400,000	30.0	0	10,852,554
									Close	

10,852,554

Fig. 7.3.1 Annual Disposal Volumc and Landfill Operation Period



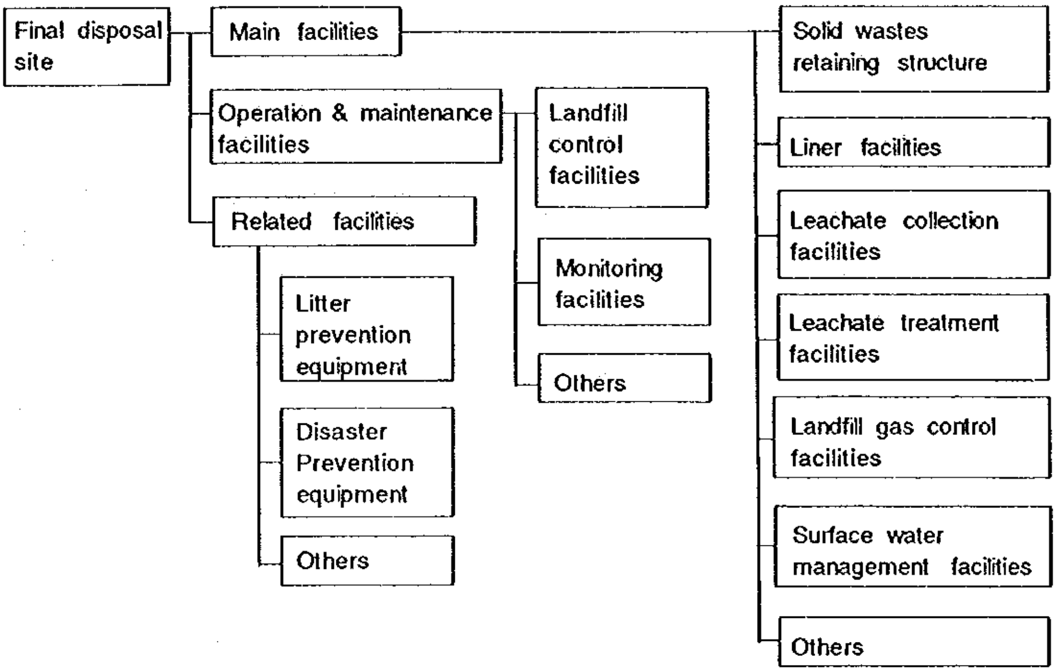
7.4 Facility and Equipment Plan

7.4.1 Type of Facilities

The facilities for Nam Son Landfill Phase 2 mainly consist of the following components.

a) Main facilities
b) Operation & management facilities
c) Related facilities

The following figure shows components of the landfill facilities.



Planned Landfill Facilities for Nam Son Landfill Phase 2

Major specifications of the facilities are shown in Sections 7.4.2, 7.4.3, and 7.4.4.

7.4.2 Main Facilities

(1) Solid Waste Retaining Structure

Structures of retaining facilities are constructed to prevent landfilled wastes from overflowing, collapse of working face and to ensure the landfilled wastes are stored safely. In many cases, these structures also prevent discharge and seepage of effluent from the landfill.

Generally a landfill structure is constructed to store waste, not water. However, in the event of an abnormal rainfall, temporary retention of rainwater inside the landfill can be expected. So, it is required to store water safely too.

The retaining facility must be able to sufficiently carry out these functions.

a) Store the designed landfill volume
b) Prevent collapse of working face and overflow waste
c) Prevent leachate discharge and seepage from landfill site
d) Retain rainwater temporary inside the landfill site safety
e) Retain waste safely during the landfilling process as well as after completion

The retaining facility for the Landfill Phase 2 will be a round embankment. The top of the embankment is at the height +15 m with the width of 8.5 m same as the Phase 1. The slope of the round embankment will be 1:2 on both inside and outside.

Separating embankment between each compartment inside the landfill which runs in the direction of east and west will be designed 8.5 m wide, +15.0 m high, and with the slope of 1:1 same as the Phase 1. Separating embankment which runs in the direction of north and south in the landfill will have the slope of 1:1.5 because trucks will run on this embankment for waste dumping.

After filling up to +15 m in the whole landfill area, another surrounding embankment of 5 m height will be constructed and waste will be filled up inside. At the final stage of Nam Son Landfill operation, the top level of landfill will be +36 m with the surrounding slope consisted of three 5 m embankments and two 3 m embankments with total 16 m of waste layer filling from the primary embankment level which is +15 m. Figure 7.4.1 shows the standard cross section of embankment. Accompanied with progress of the Landfill Phase 2 operation, waste will be also buried, to the level of +36 m, in the phase 1 area which would have been filled up to +26.0 m during the Phase 1 operation.

Width of the surrounding road and onsite road is 6.5 m and pavement is of the local standard road class III. Standard cross section of these roads is given in Figure 7.4.2.

This kind of very large landfill site should be divided into several compartments. These compartments can accept the different types of waste at the same time, for example, one compartment for domestic waste and the other for industrial waste.

The Phase 2 site will have 9 compartments and one of them will be prepared for treated industrial waste residues of small quantity.

Figure 7.4.3 shows land reclamation plan of the Phase 2 before dumping waste. Figure 7.4.4 shows a plan of Nam Son Landfill of both the phase 1 and the phase 2 at the time of completion of landfill. Figure 7.4.5 and Figure 7.4.6 shows standard cross section plan.

For certain kinds of sites a strip of dike or a big belt of soil is necessary to support the heap of waste. Therefore, these dikes must be compacted by heavy equipment.

It is recommended that construction work of the Phase 2 should be divided into at least two stages for economical reasons.

(2) Liner facility

Liner facility is planned and implemented in the sanitary landfill to prevent pollution of public water area or underground water by leachate and to mitigate adverse impacts of such pollution on the surrounding area. It is also to prevent increase in leachate volume caused by the influx of underground water into the landfill.

Liner facility should be selected based on the location conditions of the sanitary landfill system. Under certain conditions, partial function of the liner facility is sufficient.

It is important to plan and design liner facility with a high level of suitability based on topographical and subterranean characteristics. A common design concept is to have a design which does not allow the discharge of leachate from the landfill into the outside area by utilizing the characteristic of the topography of the landfill site and distribution pattern of permeability of the ground layer as well as characteristics of groundwater.

Run-off and discharged water collection facilities complement the function of liner facility. The former removes rainfall from the landfill area and thereby controls the volume of leachate generated. The latter drains away the discharged water quickly. Therefore, the ability of these facilities to enhance the function of the liner facility should be considered at the design stage.

Coefficient of permeability of the bottom layer is a very important factor to judge the necessity of liner facilities for landfill site. The Vietnamese regulation says that it is not necessary to provide artificial liner facility in case the coefficient is in the order of 10^{-5}cm/sec. Japanese design guideline for landfill site also says that the liner facility must be installed in case the bottom layer does not have enough impermeable condition. The required coefficient should be less than 10^{-5}cm/second and its thickness should be more than 5 m.

JICA Study Team conducted a geological survey for the site. The result of in-situ permeability test from two-boring survey, which was carried out during the first local study period, indicates the coefficient of permeability ranges from 8.54×10^{-5}

to 1.5 x 10^{-6} cm/sec with thickness of 6.8-8.3 m. Drilling of three more bore-holes was planned to be carried out during the second study in Vietnam. However, at this stage final resettlement agreement between the potentially affected residents and HPC was not completed, and the drilling was unavoidably cancelled. According to another geological survey report conducted by Hanoi City for the pre-feasibility study of Nam Son waste complex and feasibility study of Nam Son Landfill Phase 1, penetrating coefficient was measured 2.0 x 10^{-5}~3.8 x 10^{-6} cm/s with thickness of 5-11 m. These results of penetrating coefficient level are close to the above-mentioned borderline to determine the liner system installation. Thus, it is recommended that artificial liner facility, synthetic flexible membrane liner, should be laid on that natural clay layer in order to prevent seepage to natural environment. A 1.5 mm thick of HDPE sheet is recommended for synthetic flexible membrane liner.

Proposed landfill area which has the height from +6.5 m to +14.00 m, has to be excavated 1-4 m to create a slope for collecting leachate so the thickness of clay and mix clay layers is decreased greatly and the thickness is not the same in the whole area. It is recommended that the thickness of natural clay layer should be required to be at least 1.5 m in the whole area. Including some area which has natural clay layer with less than 1.5 m thickness, whole landfill bottom area should be excavated more than 1.5 m deeper than designed bottom level and excavated original clay layer should be replaced artificially with well tamping. Well tamping should be done each 50 cm thickness of replaced clay layer and piled up to 1.5 m thickness.

The groundwork before laying of sheet liners, involves generally removes angular stones and pointed objects, sufficiently compact and finish up flat and smooth. An undulating surface can easily become the cause of damage to the sheet liner. If appropriate groundwork cannot be achieved due to high cost, it is better to insert a layer of non-fabric blanket between the sheet liner and the groundwork.

It may be necessary to apply a layer of soil cement on a slope in order to strengthen its compaction effect. Some kind of soil cement method is effective to make an artificial impermeable layer mixing with original soil as good liner facility.

Groundwater drainage facility such as underdrain must be installed to counteract backwater pressure due to groundwater or spring water.

Standard cross section of the Landfill Phase 2 is shown in Figure 7.4.7.

(3) Leachate Collection Facility

The purpose of leachate collection facility is to quickly send seepage water and leachate from the landfilled layers to the leachate treatment facility. The leachate volume generated in a landfill should be kept at a minimum level. If it can be removed immediately to the leachate treatment facility, there will be no trapped water in the landfill. Therefore water pressure acting on the liner facility and landfilled waste retaining facility will be reduced. That is, the leachate collection facility can be considered as a very important facility influencing the selection of liner facility. These three facilities are closely inter-related and in principle they are designed as the so-called "Remove Leachate Quickly From Landfill" type of facility.

In the case of semi-aerobic landfill type, the leachate collection facility can also double up as gas vent.

The components of a leachate collection facility depend on the landfill type and structure. Generally, they can be classified as below.

- Leachate Collection Facility
  - Collection Pipe
    - Bottom Pipe
      - Trunk Line
      - Branch Line
    - Inclined Pipe
    - Vertical Pipe
  - Leachate Retention Pit / Leachate Control Pond. Valve (facility for extractiong leachate)
  - Reticulation Pipe (facility for transporting leachate)

Components of Leachate Collection Facility

Bottom pipe and vertical pipe will be equipped for the Landfill Phase 2. Bottom pipe is that ducting placed on the bottom of landfill for leachate collection and comprises trunk and branch lines installed at a gradient to enable drainage using natural flow potential. Vertical pipe is placed vertically in the landfill. They are extended vertically as landfilling continues. The bottom end of the vertical pipe is connected with a bottom pipe and it can serve as a gas vent.

There are three types of piping pattern, straight-line pattern, herringbone pattern, and ladder pattern, depending on the topography of the landfill site and landfill method. The ladder pattern will be used for this project because it is commonly used on flat landfill site where it is difficult to achieve the required crossfall.

It is desirable to install more than one line of pipes in order to secure the function of discharging leachate from the landfill. Collection pipes should also be installed at mid-level if the landfilled layer is too thick.

The layout of bottom collection pipes must be located based on consideration given to the permeability of landfilled waste and buffer sand layer on the sheet liner, size and topography of landfill site. Furthermore, if it is a semi-aerobic sanitary landfill structure, then the ability of the leachate collection facility to act as an aerator is also an important criterion. In general, spacing between the bottom collection pipes would depend on the catchment area and whether it is a sectioned or separated landfill. In this project, intervals of collection pipes will be 20 – 100 m.

The type of material for collection pipes is to be chosen to ensure that it has sufficient structural strength to accommodate the varying depth to which it might be buried and also that it is anti-corrosive to the leachate. Generally, perforated concrete pipes or those made of synthetic polymer are commonly used as collection pipes. Hard PVC pipe is recommended for this project. Also these pipes must be able to withstand the load of wastes and waste trucks without being flattened.

The filter material is the material used to cover the surrounding of the collection pipes in order to ensure its functionality. Pebbles and gravel of 50 mm to 150 mm diameter are suitable and normally used as filter material. It is not really desirable to apply a layer of sand or buffer blanket over the filter material because their pores can be easily clogged up.

The bottom piping are perforated pipes or packed gravel which are buried together with filter material to prevent clogging. In order to prevent deterioration of the function of filter material, the thickness of the filter layer should be more than 50 cm from the ground level (or above the protective earth cover for the sheet liner). The functioning of the collection pipes can be enhanced if proper filter material is chosen in the beginning.

The width of filter material should be preferably be more than three times the diameter of the pipe in order to ensure its functionality and to reduce the direct vertical loading on the collection pipe. In the presence of sheet liner, care must be taken to ensure that the gravels and pebbles do not touch the sheet liner directly. A protective layer of buffer blanket, sand or earth cover can be applied between them.

Figure 7.4.8 shows the typical design examples of bottom collection pipe for the project.

The diameter size and slope of collection pipes is 600 mm with 0.5% for trunk line, 400 mm with 0.5% for branch line and 200 mm with 1% for sub-branch line. Detail diameter calculation is necessary considering the actual rainfall intensity in Hanoi area.

Figure 7.4.9 shows layout plan of leachate collection facility.

(4) Leachate Treatment Facility

The purpose and function of a leachate treatment facility at the landfill site is to purify the leachate collected so that the leachate, when discharged, will not pollute the surrounding water bodies or underground water.

Since the volume and quality of leachate fluctuate with the rainfall, quality of landfilled waste, landfill type, etc., the following should be considered for stable leachate treatment.

1) Selection of appropriate leachate treatment process

A rational leachate treatment process should be selected with the quality of leachate and discharged water as part of the conditions to be considered when designing the facility.

Leachate quality is determined by the quality of landfilled waste, the landfill type, etc., while the quality of the discharged water is subject to the regulations or the condition of water usage in the area where leachate is discharged.

2) Countermeasures for leachate quality fluctuations

The leachate is usually highly concentrated during the early stages of landfilling but as time passes, the concentration drops. Leachate at the early stages can be easily treated biologically but it becomes more difficult to treat later on. Therefore, careful consideration like the original typical leachate quality assumed during the design stage must be given when selecting leachate treatment method.

Maintenance and operation measures will become important at the later stages of landfilling. The leachate that is difficult to treat biologically has to be either reduced in volume or treated by a physical-chemical based system.

3) Countermeasures for leachate volume fluctuations

Basically, volume of leachate changes with the amount of rainfall but there is a limit to the treatment capacity of the facilities. Thus, in order to operate the facilities at a constant level throughout the year, leachate volume control facilities are required. However, the cost effectiveness and feasibility of the leachate volume control and treatment facilities may be questionable in areas with heavy rainfall since their capacities are liable to be very large depending on the adopted design storm recurrence interval.

Therefore, it is desirable to consider countermeasures to channel out rainwater or to prevent rainwater seepage into the landfilled layers by using section landfill or separate landfill or an appropriate selection of the cover soil so as to reduce the leachate volume as much as possible.

Leachate must be treated and meet the standard from Vietnamese regulation TCVN 5945 – 1995 shown in Table 7.4.1 through the biological and physical treatment process before discharging into the surface river.

In addition to the leachate treatment facility for the Landfill Phase 1 with 400 m^3/d capacity, another independent treatment facilities will be designed and installed for the Phase 2. Treatment method for the Phase 2 is the combined system with an aeration pond and precipitation pond. Typical treatment flow is shown in Figure 7.4.10. An activated aeration is the simple process of introducing large volumes of air into a leachate lagoon, either using diffusers or mechanical aerators, to promote more rapid aerobic decomposition of the organic constituents of the leachate. The addition of air avoids the possibility of insufficient oxygen becoming a limit to the rate of aerobic microbial activity. The sludge from this process will be removed from the pond and stored in the landfill area separated from the waste dumping area. EM will be added to the sludge for reducing odor and promoting the bio-decomposition. The sludge will become compost. Leachate is passed to the sedimentation process to remove heavier, suspended particles. A further refinement is to add a flocculation stage before sedimentation to remove lighter organic and mineral suspended particles. This is achieved by adding a flocculation agent to the leachate to induce the fine particles to coalesce into larger ones and then either sink to the bottom or rise to the surface for subsequent removal. Mixing the leachate and additives such as lime, 1,300–1,500 mg/l, will be continued for at least 30 minutes and then flocculated for more than 5 hours. Sludge from this process is also removed to the landfill area. H_2O_2 can be also effective for oxidation of leachate. In the canal after retention pond to Cong River, wet land system with aquatic vegetation will be effective for clarification.

If the leachate treatment facility for the Phase 1 which consists of an anaerobic biological treatment tank (UASB) can satisfy the environmental standard practically, this system can be an alternative method for the Phase 2.

The average leachate generation volume of the Phase 2 is estimated to be 900-1300 m^3/day using water balance calculation method with the climate data such as precipitation and evaporation. Thus in the Phase 2 project, the capacity for the leachate treatment is determined to be 1200 m^3/day.

The capacity of leachate treatment facility is fixed but the volume fluctuates mainly with the amount of rainfall. Therefore, it is necessary to have an overflow control facility for stable operation of the leachate treatment facility. This leachate control facility should have the following capabilities.

- Measures to cope with sudden increases in leachate due to heavy rain.
- Ensure a constant leachate quality
- Leachate storage during suspension of leachate treatment facilities for repair and maintenance of facilities and instruments.

Thus in this project, approximately 125,000 m^3 of leachate adjusting pond will be provided.

Some part of leachate from the treatment process of both aeration and precipitation will be re-circulated to the waste layer in the landfill. Leachate treatment involves the re-circulation of collected leachate back through the landfill to encourage more decomposition of some of its soluble organic compounds by the bacteria present in the landfill. Other than through evaporation and use of the absorptive capacity of landfilled wastes, this method does not reduce the leachate volume for treatment. The re-circulation method can be either by an above ground spray over an area of the landfill where filling has finished or has reached an intermediate level, or by injection below the surface of the landfill into horizontal perforated pipes or a porous gravel layer. Figure 7.4.10a and 10b shows typical structure for re-circulation bed.

(5) Landfill Gas Treatment Facility

Semi-aerobic sanitary landfill system is more effective for early decomposition and stabilization of buried waste rather than generation and recovery of CH_4 rich gas under anaerobic condition.

Organic substances in landfilled wastes generate various kinds of gas in accordance with the decay, decomposition and stabilization by the micro-organisms.

The decomposition process varies due to the micro-organisms involved. They are generally divided into aerobic decomposition by the action of micro-organisms that need oxygen and anaerobic decomposition by the action of micro-organism that do not need oxygen.

It is actually not able to keep whole landfill layer in anaerobic state on landfill site. It is, therefore, not avoidable to practically leave them in anaerobic state.

In anaerobic decomposition, methane (CH_4), carbon dioxide (CO_2), ammonia (NH_3) are generated with a very small amount of hydrogensulfide (H_2S), methyl sulphide $(CH_3)_2S$. methyl mercaptan (CH_3 SH).

It is necessary to treat the gas appropriately because it can have some undesired effects like withering of living trees, obstruction to compaction, spread of wastes and cover material and also cause fire and explosion.

A gas treatment facility must be able to remove the gas generated within the landfill layers. It should have gas venting pipes, and in the case the gas is released into the atmosphere, appropriate final treatment facilities must also be considered so as to prevent air pollution.

A gas treatment facility must be constructed at the same pace as the landfill operation advances. This is unlike other treatment facilities or those to be used at sites after a landfill is completed.

For the Landfill Phase 2, vertical gas vent pipes will be installed connecting with leachate collection pipes at the bottom with cylinder type or square type gabion made of timber log.

Gas collecting system must ensure the design guide from the Vietnamese regulation:

The distance between the gas collecting facilities is 70-100m. The facilities must attain the following parameters:

- Diameter or square side of the gabion varies between 0.4-1.2m
- Depth of the pipe will correspond to the thickness of the buried waste layer
- The gas vent pipe is made of PVC having 150 mm diameter with holes drilled mound then covered with a gravel, stony layer.

The place where gas are released must be arranged at the end of the wind direction, in airy places without obstacles which may make gas accumulated.

Figure 7.4.11 shows the standard figure of vertical gas vent.

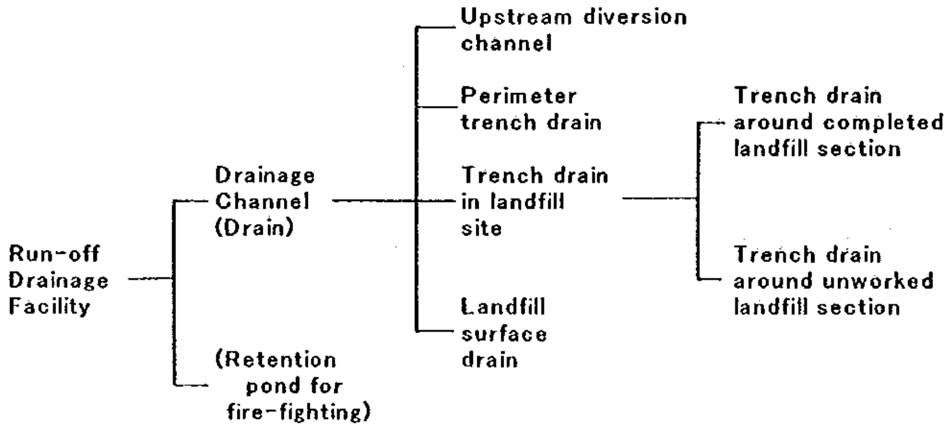
(6) Surface Water Management Facility

It is normal that depending on the topography of landfill site a larger or smaller part of the rainfall from the landfill site and its surrounding area will flow into the landfill. The rainfall volume is much higher than the amount of leachate normally generated within the landfill. If this rainwater were to seep into the landfill, the leachate treatment facility must then be not only capable of treating large amount of leachate but also capable of handling fluctuating leachate volume and quality. In order to avoid such a situation, the run-off on the surrounding area needs to be separated from leachate by constructing surface water management facility. The amount of run-off on the surrounding area and its portion flowing into the landfill are dependent on the topography and condition of environmental disruption.

Rainfalls in the empty area of the landfill before waste dumping are not polluted by wastes. It can be separated from leachate and at the same time to reduce leachate volume by digging trench drains along the section embankments. In addition, the construction of surface drains on the final cover of the completed landfill will remove the run-off and function to control leachate quickly.

One should not only think of the surface water management facility as solely to reduce the loading on the leachate treatment facility, but it is also necessary to prepare an overall drainage plan for the landfill site.

Surface water management facility can be classified in the following way from the standpoints of serving to reduce leachate volume through removal of rainwater and being part of the overall drainage network in the sanitary landfill system



Components of Run-Off Drainage Facility

The perimeter drain is constructed around the landfill site before the commencement of landfilling operation. It collects rainfall in the surrounding area and functions to prevent the run-off from seeping into the landfill. The catchment area for design discharged volume should be established so that the drain would be able to handle run-off from the surface of the final cover upon completion of landfilling

After application of the final cover soil, landfill surface drains are installed to drain off surface run-off. They are laid out to give the most efficient run-off drainage. Surface drain is dug on the required slope on the fully compacted final cover layer.

Subsidence of ground is greatest soon after completion of landfill. Therefore, in the beginning, it is better to adopt a simple type such as an open ditch land with sheet liner.

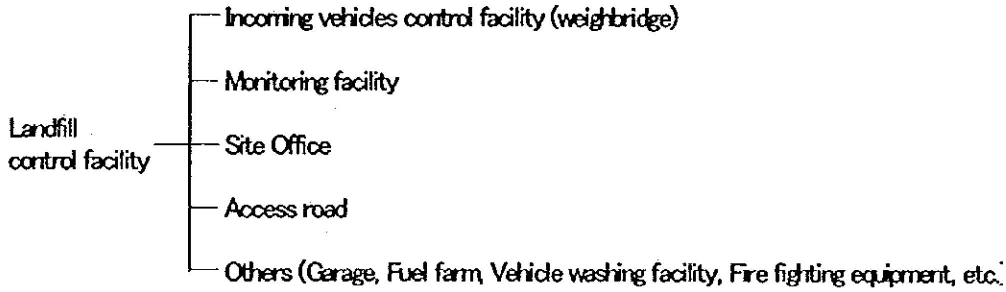
In the phase 2 project surface water collection ditch with reinforced concrete U-drain will be constructed along the outside of the surrounding embankment.

7.4.3 Operation and Maintenance Facilities

(1) Landfill Control Facilities

For proper management of sanitary landfill system, facilities to control operations and monitoring, a site office and access roads, etc., will be provided when necessary.

Control facilities include the site office to that records and controls the quality and volume of landfilled waste, landfill vehicles used for landfill operations, fuel storage tanks, places for washing those vehicles, monitoring facilities, roads for management, etc., as shown below.



Components of Run-Off Drainage Facility

Landfilled wastes must be checked for smooth operations as well as to prevent land pollution due to inclusion of harmful substances. Therefore, the type, structure, quality, etc. of the solid waste must be carefully checked.

It is proposed that weighbridge for weighing and recording the landfill site that is installed for Phase 1 will be used for Phase 2 continuously. However, in case the loading capacity of it is not enough to weigh the large scale transporting truck that is approximately 35 tons used for Phase 2 when a transfer station is constructed, new bigger weighbridge need to be installed instead of the primary one.

A site office constructed in Phase 1 stage will be also used continuously during the Phase 2's operation period. Some additional rooms will be constructed when necessary due to increases of truckload and landfill quantity.

The same access road will be also used during the operation of Phase 1 and the Phase 2.

(2) Monitoring Facilities

Monitoring facilities will be installed for the proper control of the sanitary landfill system to monitor the landfilled waste, leachate, underground water, discharged water, gas, bad water, etc., which are generated at the landfill site.

Monitoring the landfilled waste layers during or after the landfill operation will check the changes in the solid waste component, traces and measures the amount of settlement in the landfilled layers. The data obtained can be used for designing future leachate treatment plants or planning post-closure land use, etc.

The environment will be monitored during and after landfilling operations.

The more data collected or analyzed, the better for future planning of landfill. Therefore it is important that data on solid waste component, leachate, underground water, gas, bad odors, etc., be regularly collected.

Especially in this project, several monitoring wells for monitoring underground water will be provided outside the landfill site.

7.4.4 Related Facilities

The related facilities are necessary for the effective management and operation of the landfill site. Related facilities should include the following.

(1) Approach Roads

Approach roads or access roads for effective delivery of wastes or building materials into the landfill site.

In the beginning stage of the Landfill Phase 2 surrounding and separating embankment will have such road on its top. Also two approach roads in each compartment will be constructed for effective vehicle flow.

(2) Liter Prevention Facilities

To prevent solid waste from flowing out of the landfill site, cover soil should be applied as soon as waste is dumped. Littering prevention fence should be provided wherever necessary. The height should be about 3 to 4 times that of the perimeter fencing. To cope with strong winds or seasonal winds, trees must be planted to act as wind breakers.

(3) Notice sign Boards, Doors/Gates, etc.

Notice sign board, door/gate built in Phase 1 will be used continuously during the whole landfilling operation. Notice sign board must clearly indicate names of the site and responsible organization.

Fences will be also built along the surrounding embankment to prevent illegal trespassing. Other notice sign boards will be also hung on the fence.

(4) Fire Prevention Facilities

Fire prevention facilities must always be available to prevent fire from spreading out on the landfill site.

Fires on landfill sites usually spread out because of the generation of methane gas. To prevent outbreaks of fires, it is advisable that gases generated must be removed with gas vent pipes as fast as possible and dumped waste be covered with soil.

Firebreaks must be built around the landfill area. Fire extinguishers, water, sand, etc. must be made available always. Bulldozers, water spraying trucks, etc. will also be fully provided. In the sanitary landfill system, it would be better if the cover soil itself is fire-proof. Stock of cover soil must be made available to extinguish fires. Dump trucks, dozer shovels, etc. will be used when necessary.

Table 7.4.1 Industrial wastewater TCVN 5945 - 1995

Limit value of parameters and maximum allowable concentration of pollutants

N^0	Parameter and substance	Unit	Limitation value		
			A	B	C
1	Temperature	^0C	40	40	45
2	pH value		6 ÷ 9	5,5 ÷ 9	5 ÷ 9
3	BOD_5 (20^0C)	Mg/l	20	50	100
4	COD	Mg/l	50	100	400
5	Suspended solids	Mg/l	50	100	200
6	Arsenic	Mg/l	0,05	0,1	0,5
7	Cadimium	Mg/l	0,01	0,02	0,5
8	Lead	Mg/l	0,1	0,5	1
9	Residual Chloride	Mg/l	1	2	2
10	Chromium (VI)	Mg/l	0,05	0,1	0,5
11	Chromium (III)	Mg/l	0,2	1	2
12	Mineral oil and fat	Mg/l	0	1	5
13	Animal-vegetable fat and oil	Mg/l	5	10	30
14	Cooper	Mg/l	0,2	1	5
15	Zinc	Mg/l	1	2	5
16	Manganese	Mg/l	0,2	1	5
17	Nickel	Mg/l	0,2	1	2
18	Organic phosphorus	Mg/l	0,2	0,5	1
19	Total phosphorus	Mg/l	4	6	8
20	Iron	Mg/l	1	5	10
21	Tetrachlorethylene	Mg/l	0,02	0,1	0,1
22	Tin	Mg/l	0,2	1	5
23	Mercury	Mg/l	0,005	0,005	0,01
24	Total nitrogen	Mg/l	30	60	60
25	Trichlorethylene	Mg/l	0,05	0,3	0,3
26	Ammonia (as N)	Mg/l	0,1	1	10
27	Fluoride	Mg/l	1	2	5
28	Phenol	Mg/l	0,001	0,05	1
29	Sulfide	Mg/l	0,2	0,5	1
30	Cyanide	Mg/l	0,05	0,1	0,2
31	Coliform	MPN/100ml	5000	10000	-
32	Gross alpha activity	Bq/l	0,1	0,1	-
33	Gross beta activity	Bq/l	1,0	1,0	-

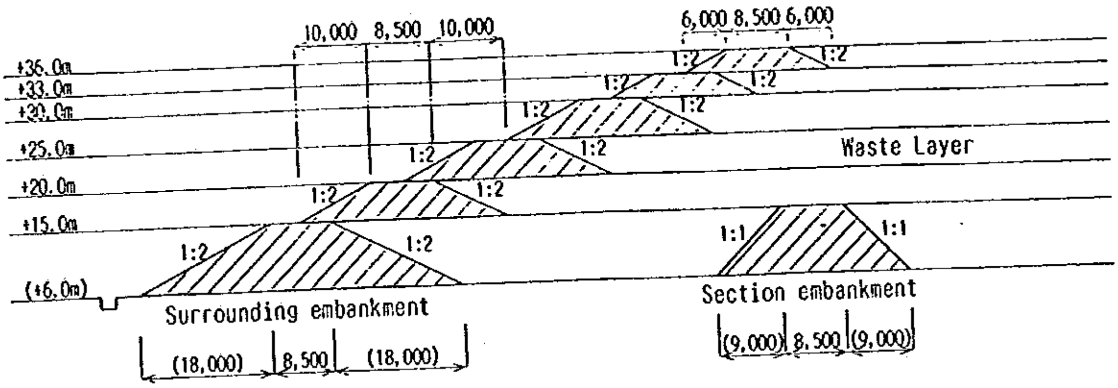


Fig. 7.4.1 Standard cross section of embankment

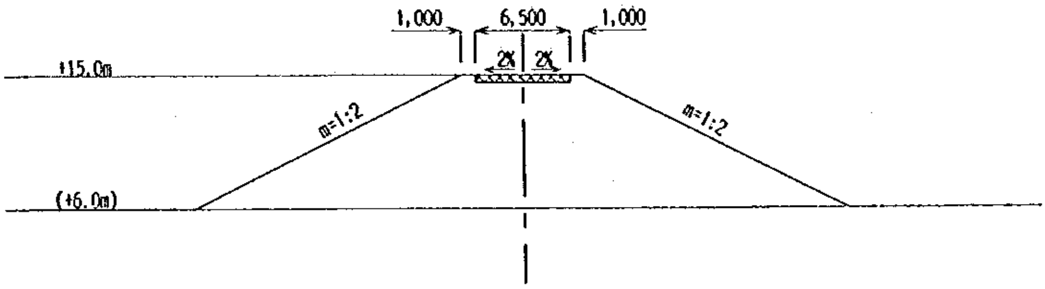


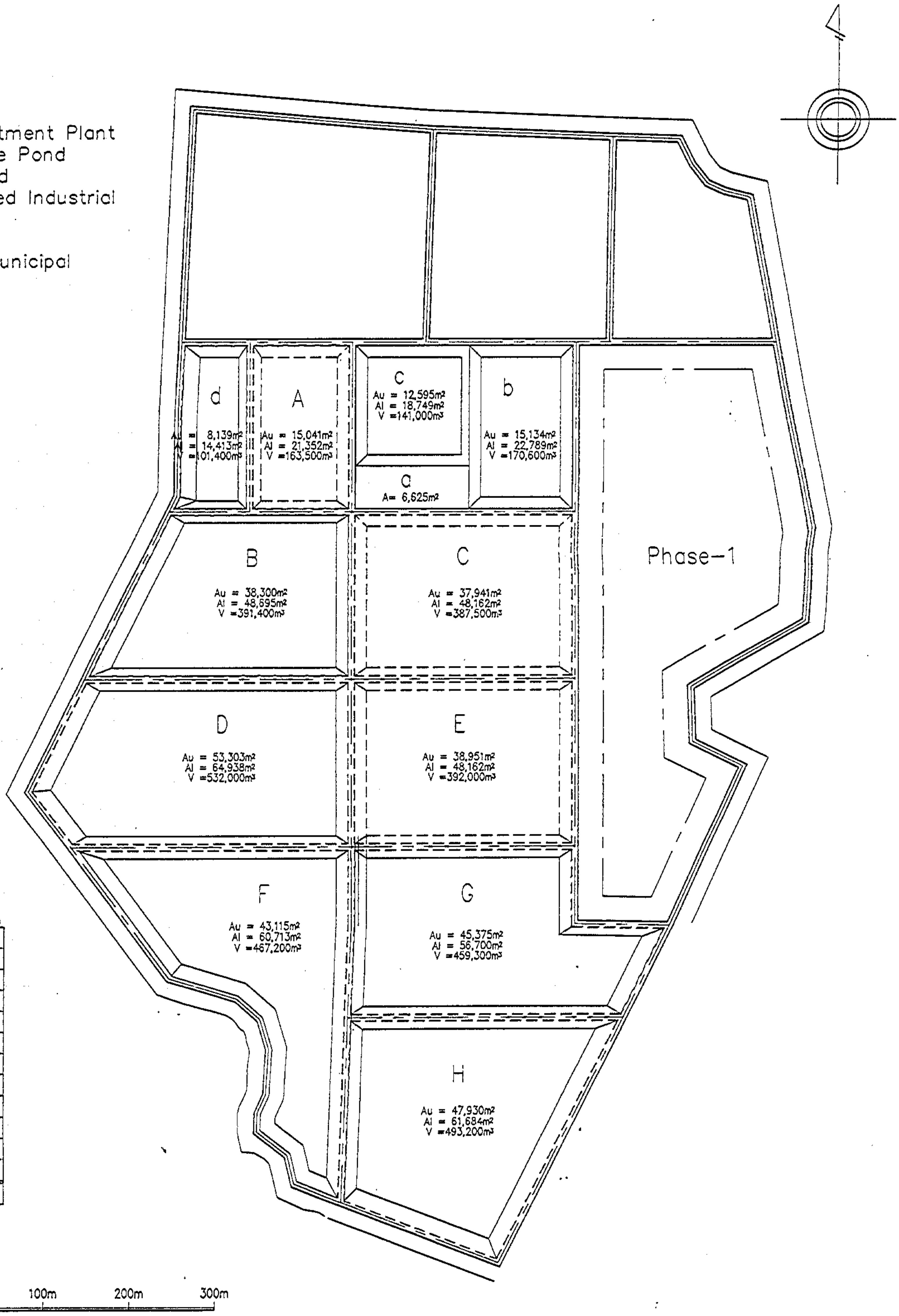
Fig. 7.4.2 Standard cross section of surrounding embankment with road

Fig.7.4.3 Land Reclamation Plan of Phase 2

S=1:5000

a: Area for Leachate Treatment Plant
b: Discharge Water Storage Pond
c: Leachate Adjasting Pond
d: Compartment for Treated Industrial Waste

A~H: Compartments for Municipal Solid Waste



Compartment Capacity

Bottom to +15.0m High

	V
A	163,500
B	391,400
C	387,500
D	532,000
E	392,000
F	467,200
G	459,300
H	493,200
Sub-Total	3,286,100
d	101,400
Total	3,387,500

Fig.7.4.4 Completed Plan of Nam Son Landfill

S=1:5000

Level	Area (m^2)	Vol. (m^3)
15.0	458,839	
20.0	434,883	2,234,305
25.0	434,883	2,174,415
25.0*	461,009	
30.0	419,972	2,202,453
33.0	392,369	1,218,512
36.0	374,334	1,150,055
Bottom to+15.0		3,387,500
Total		12,367,239

* including a part of Phase 1

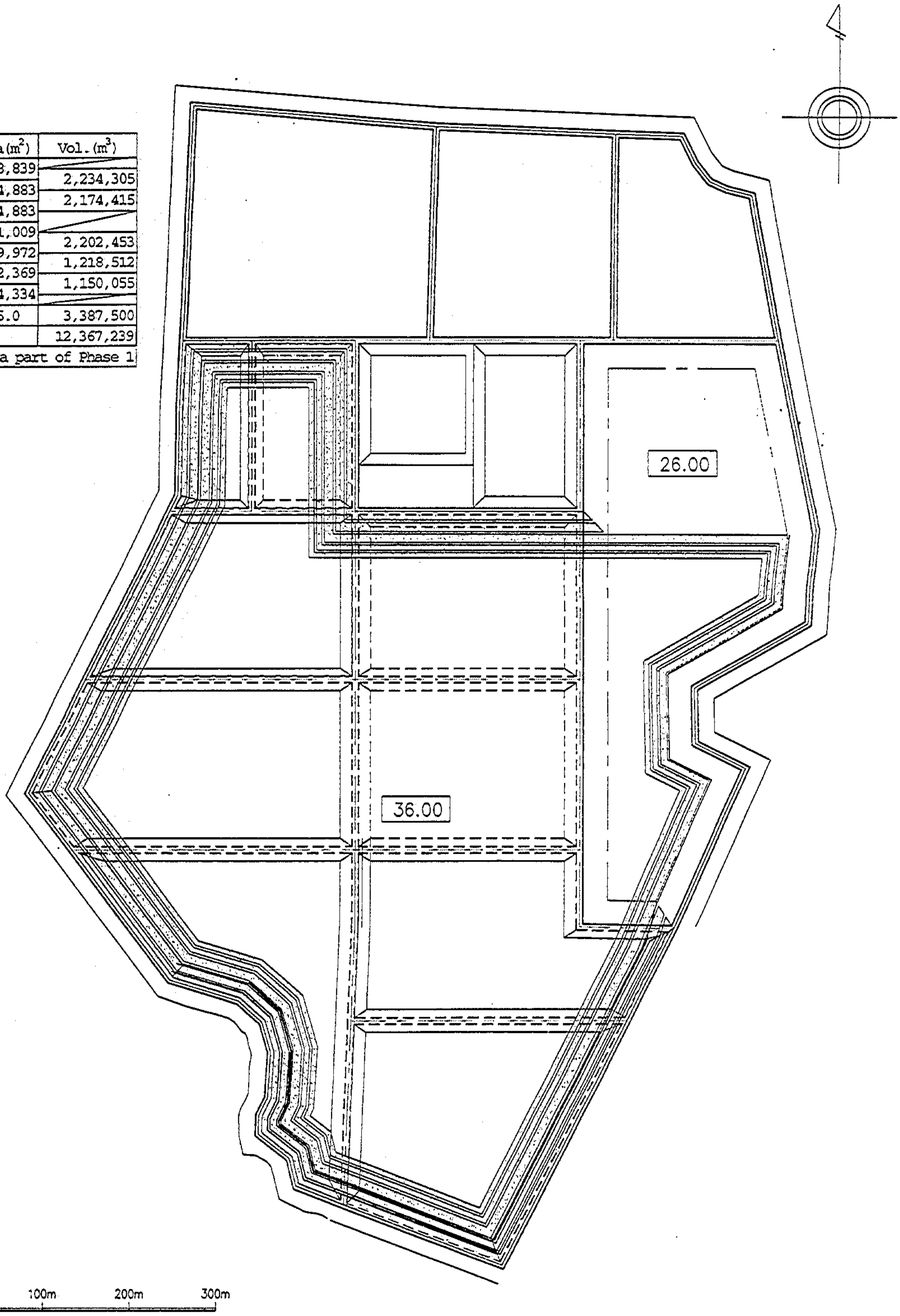


Fig.7.4.5 Standard Cross Section Plan(Land Reclamation)

S=1: 2000

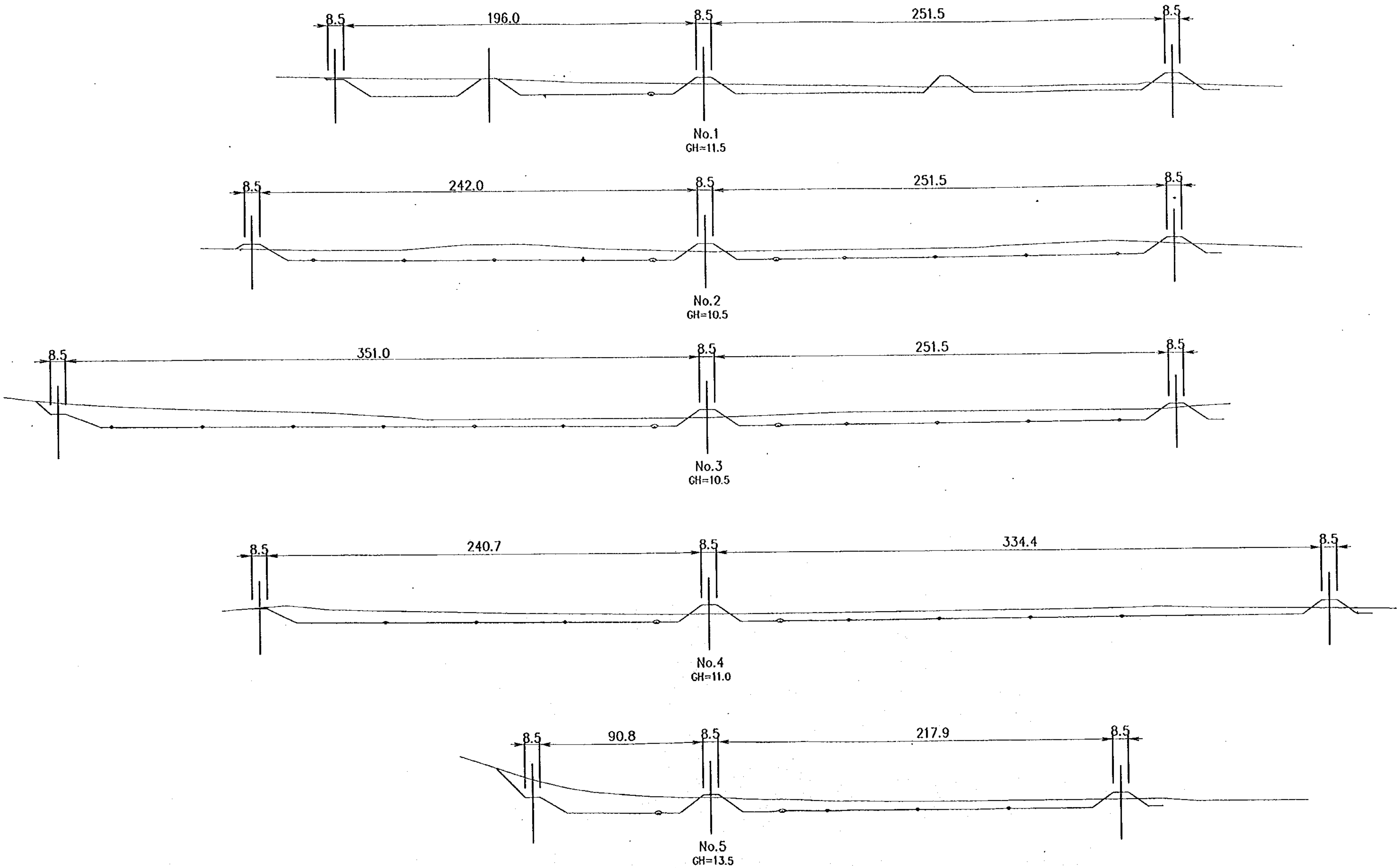
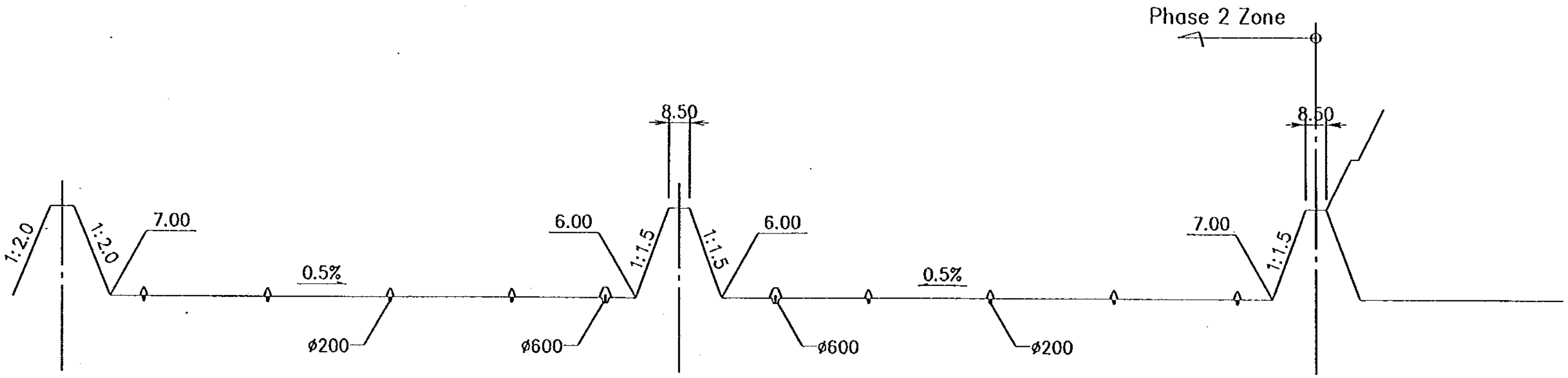
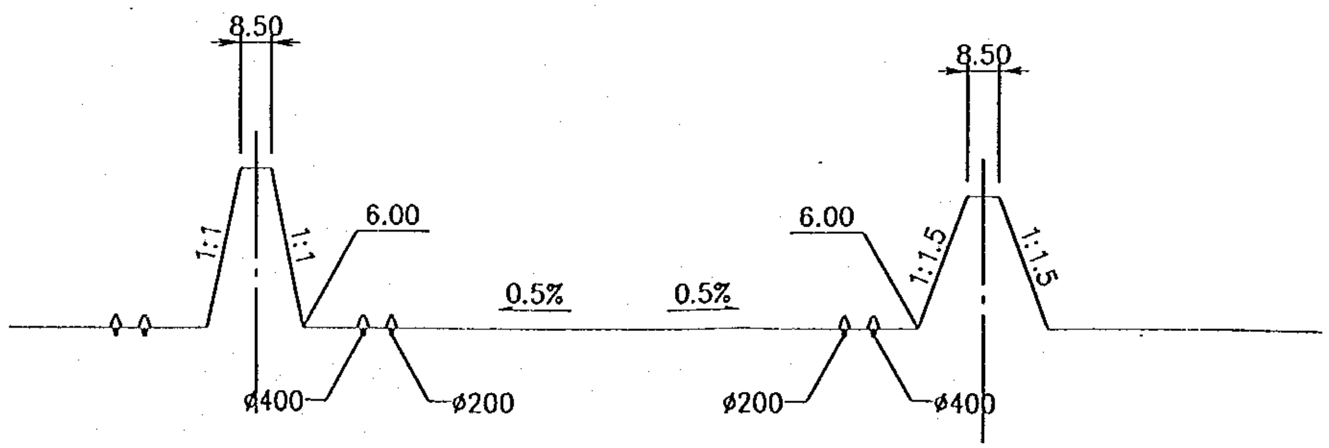


Fig.7.4.6 Standard Cross Section Plan (Land Reclamation)

V=1: 500
H=1: 2000



A—A



B—B

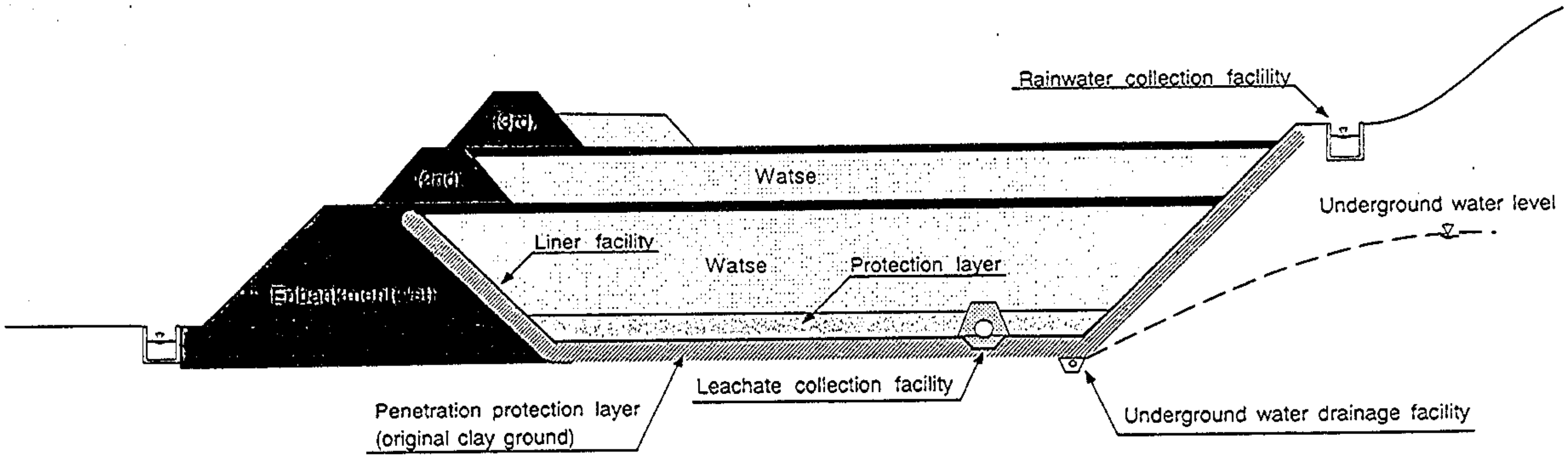
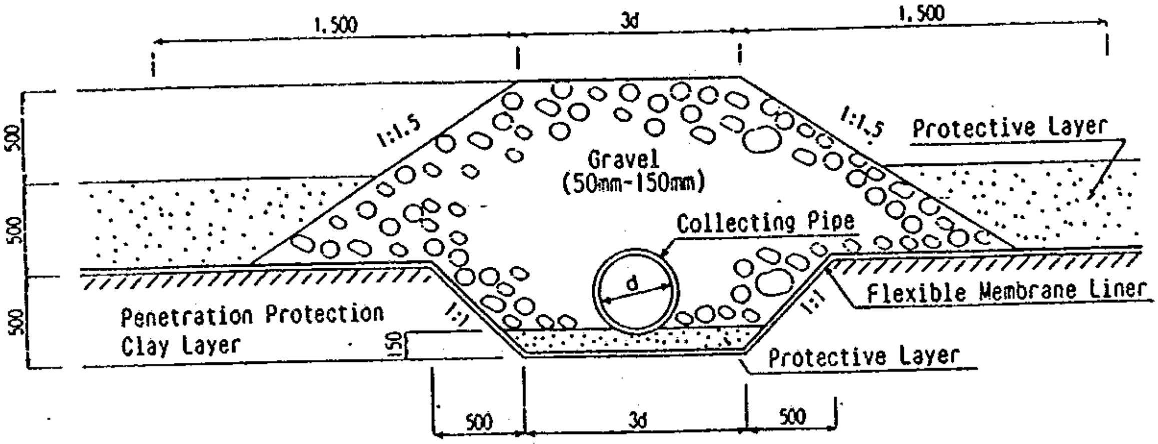


Fig. 7.4.7 Standard cross section of Nam Son Landfill site phase 2



	d (mm)
Trunk Line	600
Branch Line	400
Sub-branch Line	200

Fig. 7.4.8 Cross section of leachate collection pipe

Fig.7.4.9 Layout Plan of Leachate Collection Pipe and Gas Vent Pipe
[FINAL DISPOSAL SITE–PHASE2]

S=1:5000

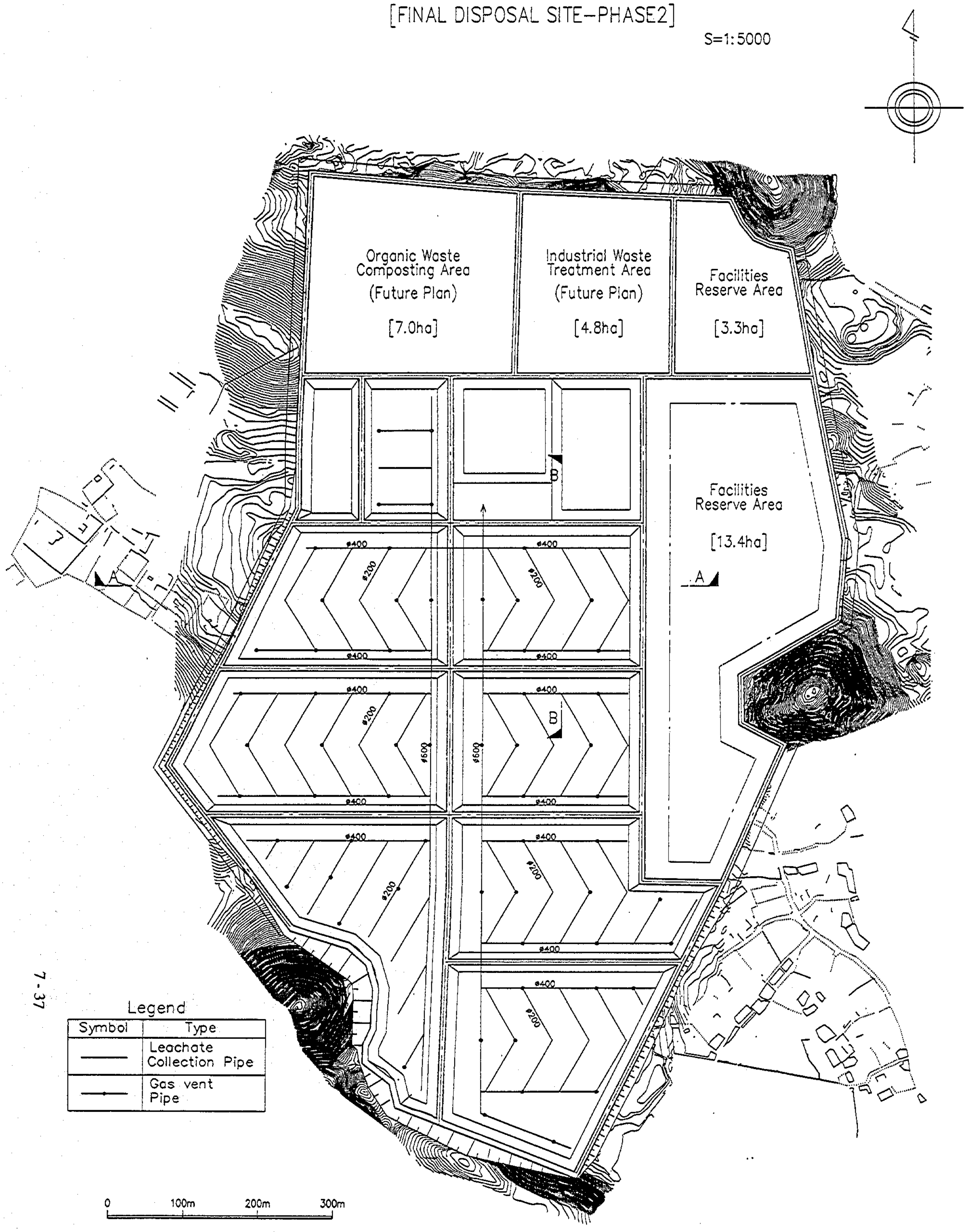
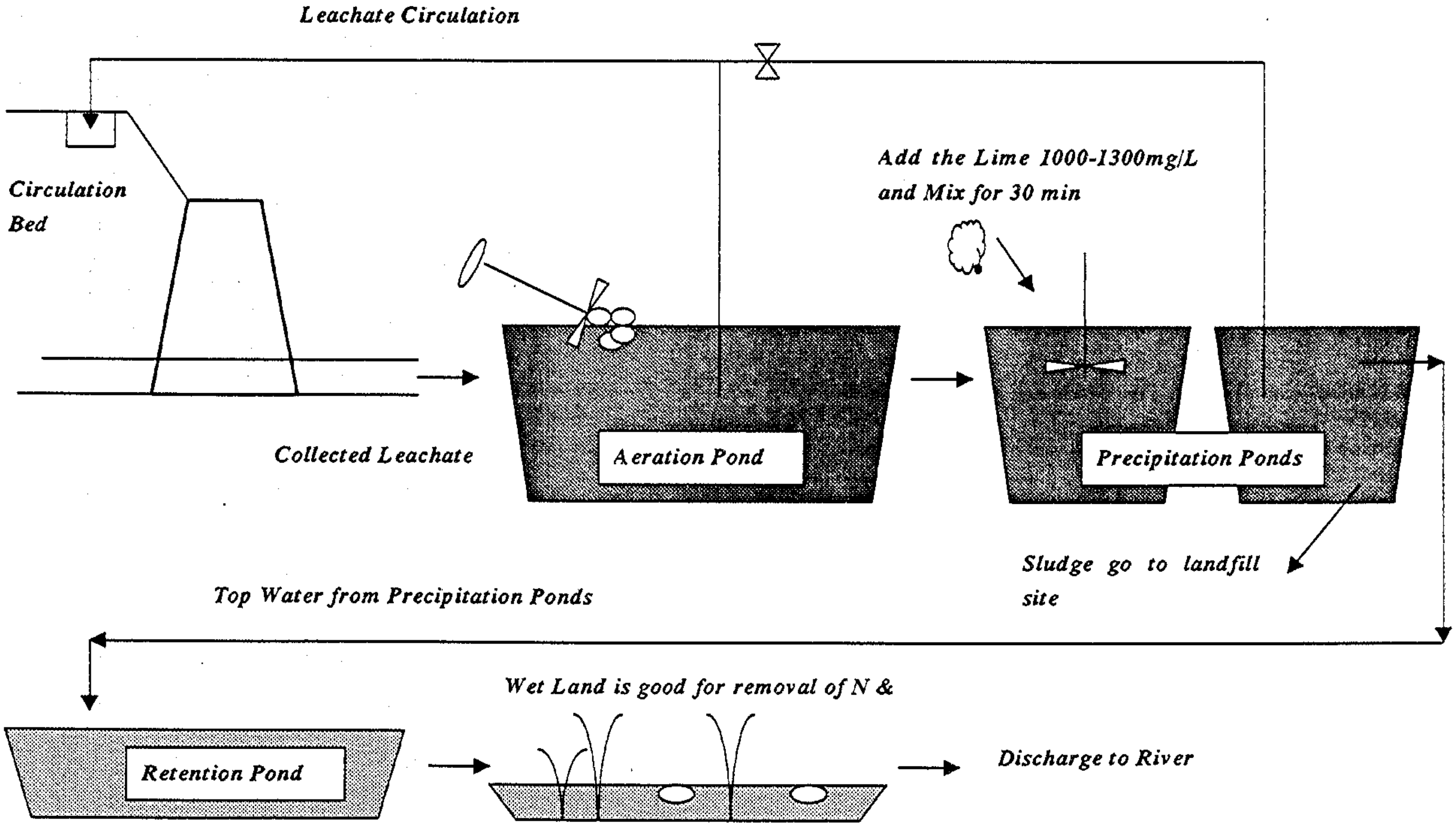


Figure 7.4.10 Typical Leachate Treatment Flow for the phase 2



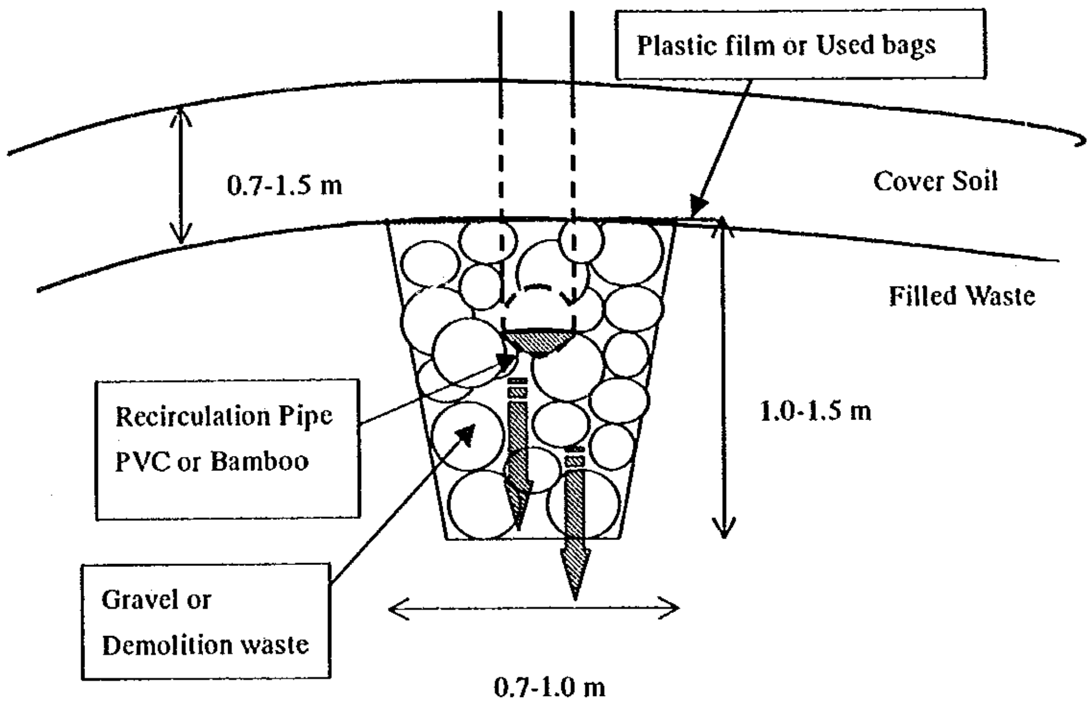


Figure 7.4.10a Cross-section of Re-circulation Bed with Pipe

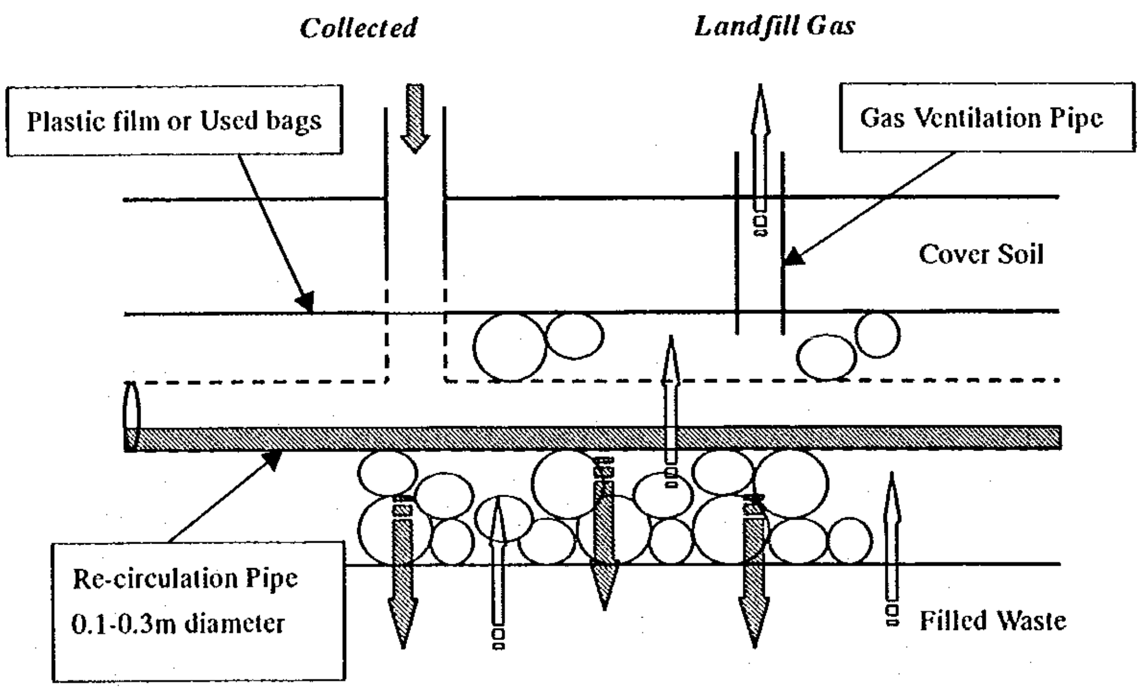


Figure 7.4.10b Profile of Re-circulation Bed with Pipe

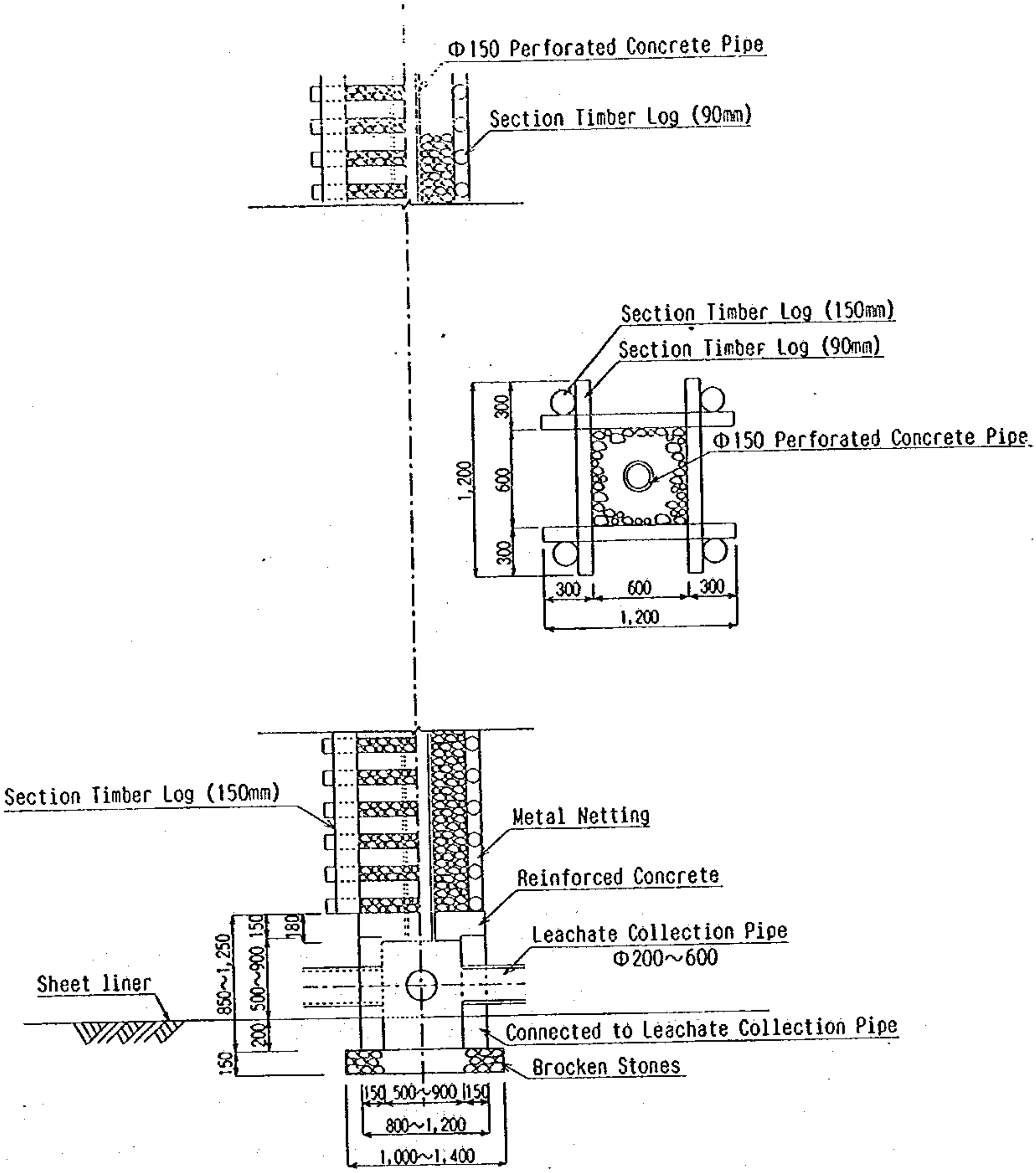


Fig. 7.4.11 Vertical Gas Vent (Used simultaneously as vertical drainage pipe)