7.5 Plan for Landfill Operation and Site Management

The landfill operation includes a whole series of works such as the delivery of solid wastes into the landfill site, spreading, mixing, final cover soil, and all those related temporary measures.

The solid waste is placed within the landfill site so as not to cause environmental problems in the sanitary landfill system. Stabilization of the landfill layer must also be promoted. At the same time, it would also be important that effective and economic solid waste disposal within a limited landfill space be considered. Natural conditions such as the surrounding environment, geography of the landfill site, weather, the type and amount of solid waste generated per day, financial and technical aspects, etc. have to be considered before proceeding with the landfilling works,

There is a close relationship between factors affecting the landfilling operation and the functions of the sanitary landfill system. Landfilling operation should not only depend on the natural instincts and experiences of the supervisor of operations, decisions of the works should also be based on results of surveys on the technical and economic aspects.

7.5.1 Landfill Methods

The method and order of landfilling must be carefully selected so as to improve stabilization of the landfill, create a physically strong foundation, improve the usability of the completed landfill site, etc. At the same time, proper landfill equipment must be used to sufficiently compact the landfilled waste. To improve the potential usage of the completed landfill site, separate landfill methods should also be used when necessary. Data on the amount and type of landfilled solid waste, their changes with time must also be noted for future reference or for maintenance of the landfill site.

The solid waste must be sufficiently compacted so as to stabilize the landfill foundation and prolong use period of landfill. A layer of cover soil must be systematically placed after landfilling each layer of solid waste. This one-day's completed fill including the cover soil is called a cell. The daily cover soil should be prepared and supplied by selection of suitable construction waste.

The thickness of the waste layer depends on the kind of waste to be buried. Each garbage layer must be tamped 5-6 times by tampers. After each day or when the height of the garbage hillock reaches 2-2.5m, the garbage layer must be covered with earth or similar material. According to the Vietnamese regulation, the minimum thickness of the covering layer is between 10-15cm depending on the kind of garbage to be buried, and 20 – 30cm thickness is recommended for organic waste. Thus to keep the daily condition of the landfill sanitary, it is proposed that the thickness of daily cover soil should be 20 cm on each 2.5 m of daily waste layer.

Covering material is earth with clay content of 30% or sand, clinker or gravel having grain size of less than 1cm. After covering with a waterproof layer, the last covering layer of the landfill ground should be fertile earth having the minimum thickness of 60cm over which trees will be planted.

The cell method is recommended for sanitary landfill in view of large area of landfill, and push-up method is recommended for bedding and compaction. Covering with soil should be daily applied.

The cell method has a cell of solid waste topped with a layer of cover soil and is the most popular method today. The size of each cell is determined by the amount of solid waste used per day. Since each cell is an independent landfill area, each cell acts as a firebreaker. It also prevents the solid waste from being scattered, emission of bad odors and harmful vectors from breeding. The disadvantage is that gas generation and water flow within the landfill will be hindered.

There are some types for waste spreading and compaction such as "Push Down" or "Push Up" a slope by a bulldozer of a loader or "Mounting Up" method.

In the case of pushing the solid waste down the slope, it is difficult to apply pressure on a waste layer, and to spread the solid waste into a uniform thickness. The bottom part of the slope tends to be thicker. Mixing and compaction is also difficult. On the other hand, it is easier to make a uniform landfill layer when it is pushed up a slope. Compaction is also easier. Therefore, when the compaction layer has to be stabilized as soon as possible, then the push up method is preferred.

The method is shown in Figures 7.5.1 - 7.5.4.

7.5.2 Landfill Equipment

Landfill equipment should be selected after considerations given to the land structure, size, landfill method, solid waste type used in the sanitary landfill system. Landfill machines can be classified according to their functions into 1) equipment to spread and compact a landfill layer of uniform thickness, 2) digging equipment, cover soil spreading equipment, and 3) other machines required for smooth landfill operations.

Examples of heavy equipment are shown in Figure 7.5.5.

Some heavy equipment is required for bedding and compaction of waste and cover material in the Phase 2 project. Bulldozer and excavator with wide caterpillars, dump truck to move for cover material from stock yard to landfill site will be required for the planned sanitary landfill operation judging from amount of waste and cover material to be handled. Specifications of each equipment are as follows.

- Bulldozer Class 15 t/unit, Capability: 45 m^3/hr/unit (for spreading and compaction)
- Excavator Class 1.0 m^3, Capability: 60 m^3/hr/unit (for excavation and loading)
- Dump truck Class 11 t, Capability 25 m^3/hr/unit (L=1 km)

At the initial stage of the Landfill Phase 2 operation which will start in 2004, the following assumptions are used for calculating required number of heavy equipment.

Waste to be handled: 2,783 m^3/day (1,015,670 m^3/year (*1))

(*1) equal to 535,766 tons with an average specific weight between 0.385 of initially dumped and 0.67 of daily tamped waste)

Cover soil to be applied: 296 m^3/day (107,910 m^3/year)

Operation hours: 16 hours per day with two shifts for bulldozer

8 hours per day for excavator and dump truck

Equipment condition: All necessary equipment is newly procured

- Bulldozer For Waste and Cover soil
  (2,783 m^3 +296 m^3)/ (45 m^3/hour x 16 hour/day) = 4.3 → 5
- Excavator For Cover soil 296 m^3 / (60 m^3/hour x 8 hour/day) = 0.6 → 1
- Dump truck For Cover soil 296 m^3 / (25 m^3/hour x 8 hour/day) = 1.5 → 2

Besides these heavy equipment, a small-size pick-up truck will be necessary for site management from the initial stage.

Additional heavy equipment should be provided as incoming waste increases.

Number of heavy equipment is estimated in the following table.

Number of heavy equipment

Equipment	2004	2007	2009	2010	2014	2017	2018	Total
Bulldozer	5	1	-	1	1+(5)	(1)	1	9 (5)
Excavator	1	-	-	-	1+(1)	-	-	2 (1)
Dump Truck	2	-	1	-	(2)	-	-	3 (2)
Pick-up Truck	1	-	-	-	(1)	-	-	1 (1)

1) Equipment will be purchased within the previous year.
2) As an usage life of equipment is assumed 10 years, initial purchased equipment will be replaced in 2014.

7.5.3 Environmental monitoring

(1) Recommendations by the EIA Study

According to the EIA report for this project, environmental monitoring program, especially for water and air quality control, is proposed to be carried out as follows.

The systematic establishment of the environment monitoring points as well as the program for environment quality supervision in the project area should comply with the natural conditions such as meteorology, hydrology, hydro- geology and the current state of the environment quality.

The contents of the program for monitoring the environment quality in the landfill area at the Solid Waste Treatment Complex in Nam Son include:

- Air environment monitoring
- Water environment monitoring (Underground and surface water)

The environment quality control must be carried out in accordance with the following laws and principles and technical specification:

- Law on the environment and others relevant documents of Vietnam.
- The 1995 Vietnam standards for environment.
- The process for the solid waste management.
- The current state of the regional environment quality.

(2) Air Quality Monitoring (landfill gas)

The contents, locations and frequency of the air quality monitoring are indicated in Table 7.5.1.

Gas exhaust pipes are used for gas monitoring. Temperature, volume and component analysis show organic material condition of waste and ground air condition. If density of CH_4 is high, the site manager should instruct "No smoking on the site". After closure of the site, gas volume will decrease and component will become increasingly similar to the original air. When methane gas density become less than 1.5%, the site can be used carefully for other purpose.

(3) Water Quality Monitoring

1) Surface water

Surface water monitoring program should be carried out at the following monitoring points:

- Inside the Solid Waste Treatment Complex in Nam Son: Four monitoring points in the Phu Thinh Lake behind the leachate treatment facility.

- Outside the Solid Waste Treatment Complex in Nam Son: Water samples will be collected from several ponds, lake, channels, and the Cong River. Three samples are planned to be collected from ponds, lake, and channels. The proposed monitoring points for water samples collection in the Cong River into which treated leachate water is discharged are as follows:
  - One sample at discharge point.
  - One sample in the upstream (500 m from discharge).
  - One sample in the downstream (1000 m from discharge).

The total surface water samples outside the Solid Waste Treatment Complex are six samples. The total surface water samples intended for the inside and outside the waste treatment complex are ten samples. Table 7.5.2 shows the program for the surface water monitoring.

2) Groundwater

The program for groundwater monitoring is indicated in the Table 7.5.3.

Groundwater quality analysis is useful to know whether or not contamination by leachate has occurred and degree of contamination. This monitoring should be carried out at least once per month by using monitoring wells located at the upper and lower groundwater stream of the site, the result should be publicly available. If monitoring results show that contamination has occurred by leachate, the municipality should carry out appropriate surveys and take countermeasures. If local people use the same aquifer as shallow well, the municipality should consider construction of a piped water supply system.

In addition to the monitoring of the air environment and water quality at the landfill, it's necessary to have the following.

(4) Settlement

When final soil covering for the site is completed, settlement boards should be installed at appropriate places and periodical measurements are necessary to know the waste organic material conditions and to estimate the future settlement. The settlement will decrease year by year. It will take over 20 years before the settlement stops completely. The municipality should consider the land use according to the stability of the ground.

(5) Odor

Odor generated from waste organic material is a serious problem to local people. Daily soil covering can prevent the generation of odor. Imperfect covering sometimes causes odor problems. Therefore, the municipality should carry out odor analysis periodically.

(6) Leachate

Leachate analysis is also one of the most important source of information to understand organic material condition in waste. BOD & COD should be monitored. Level of BOD and COD will decrease year by year. When density level become as low as natural surface water, we can know the site has become stable and stop the leachate treatment.

The environmental monitoring should also include or be accompanied with the following activities:

- Surveys and interviews with the public community should be conducted once or twice a year so as to regulates the plan for collection and transport of waste in each phase.
- Supervise waste carrying activities, and repair and upgrade the access road and in- site roads.
- Supervise the activities of the employees and scavengers in order to provide them with protection equipment when necessary.
- Organize campaigns with a view to raising people's awareness about environmental protection.

Table 7.5.1 The monitoring program for air quality

Items	In operation phase	Post operation phase
I. Parameters for the air quality to be monitored	CO, SO_2, NOx, H_2S, CH_4, NH_3, dust, Pb in dust and Cd in dust	CO, SO_2, NOx, H_2S, CH_4
II. Proposed sites for observation points to monitor the air quality.	Three sites in the landfill: - non -hazardous waste burial hollow. - Hazardous waste burial hollow - Incinerators or composting plants Two sites in the nearest residential area in the wind directions	3 sites in the landfill 2 sites in the nearest residential area in the wind directions
III. Frequency for sample collection and analysis	Four times a year	Two times a year
IV. Application standard during the monitoring	Vietnam standards on the environment TCVN 5937-1995, TCVN 5938-1995, TCVN 5939-1995 and TCVN 5940-1995.	Vietnam standards on the environment TCVN 5937- 1995 and TCVN 5938 - 1995
V. Organizations to be responsible for the monitoring	The Department of Science, Technology and Environment of Hanoi	The Department of Science, Technology and Environment of Hanoi
VI. Expenditures for monitoring	From the city budget	From the city budget

Source: Environmental impact assessment study of the Nam Son proposed sanitary landfill – Phase 2

Table 7.5.2 The program for the surface water monitoring

Items	In Operation phase	Post operation phase
I. Parameters for the surface water quality to be monitored	31 Parameters in accordance with the Vietnam standard TCVN 5942-1995. Additional parameters can be monitored when necessary.	31 parameters in accordance with Vietnam standard TCVN 5942 - 1995
II. Proposed sites for observation points to monitor the surface water quality	As illustrated in the above	As illustrated in the above
III. Frequency of sample collection and analysis	Four times a year	Two times a year
IV. Application standards during the monitoring	Vietnam standards on the environment TCVN 5942 - 1995 and TCVN 5945 - 1995.	Vietnam standards on the environment TCVN 5942- 1995
V. Organizations responsible for the monitoring	The Department of Science, Technology and Environment	The Department of Science, Technology and Environment
VI. Expenditures for the monitoring	From the city budget	From the city budget

Source: Environmental impact assessment study of the Nam Son proposed sanitary landfill – Phase 2

Table 7.5.3. The program for groundwater quality monitoring

Items	In operation phase	Post operation phase
I. Parameters for groundwater quality to be monitored	22 parameters in accordance with Vietnam standard TCVN 5944-1995. Other additional parameters can be monitored when necessary	22 parameters in accordance with Vietnam standard TCVN 5944- 1995
II. Proposed sites for the observation points to monitor the groundwater quality	Four wells in the flow directions: near the enclosure, 50 and 100 meters from the enclosing and in the nearest residential area.	Four wells in the flow directions: near the enclosure, 50 and 100 meters from the enclosing and in the nearest residential area.
III. Frequency of sample collection and analysis	Four times a year	Two times year
IV. Application criteria during the monitoring	Vietnam standards on the environment TCVN 5944- 1995, and TCVN 5945 - 1995.	Vietnam standard on the environment TCVN 5944 -1995.
IV. Organizations to be responsible for the monitoring	The Department of Science, Technology and Environment	The Department of Science, Technology and Environment
V. Expenditures for the monitoring	From the city budget	From the city budget

Source: Environmental impact assessment study of the Nam Sôn proposed sanitary landfill – Phase 2

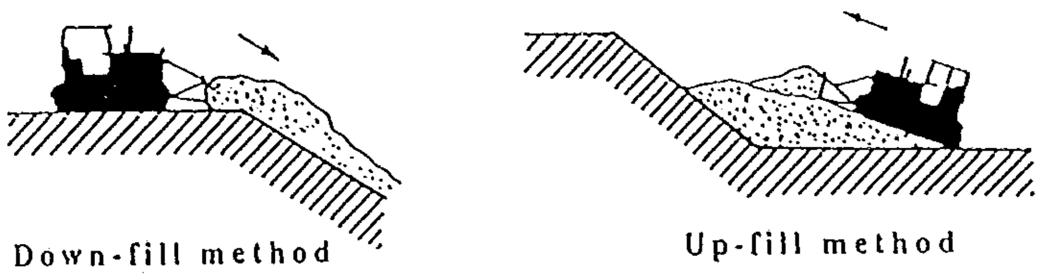


Fig. 7.5.1 Method of Bedding and Compaction

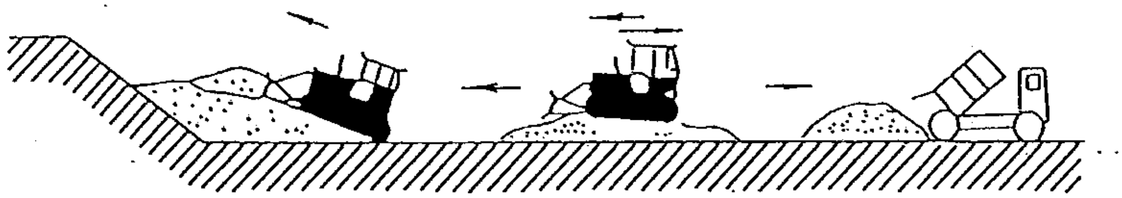


Fig. 7.5.2 Preparation of A Unit of Cell with the Up-fill Method

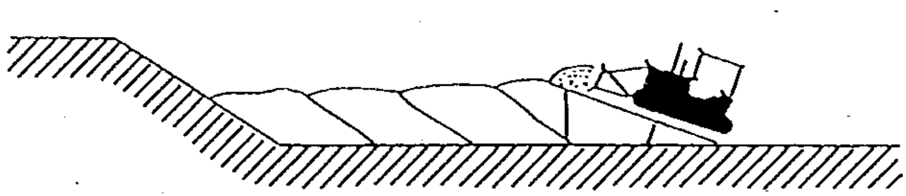


Fig. 7.5.3 Preparation of Cell with the Up-fill Method

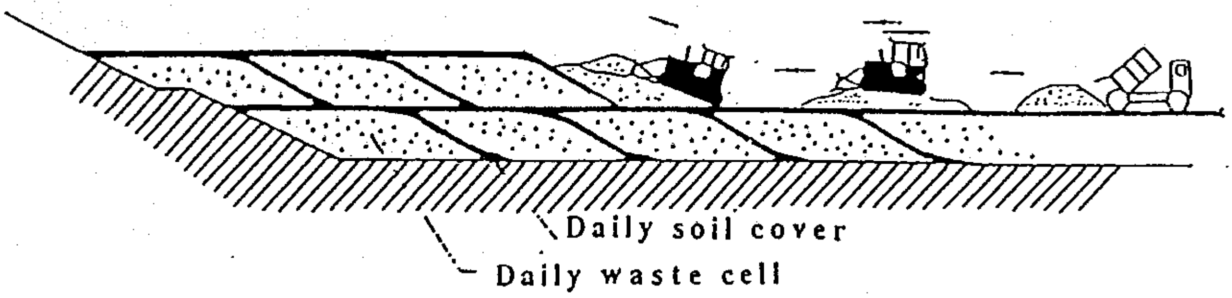
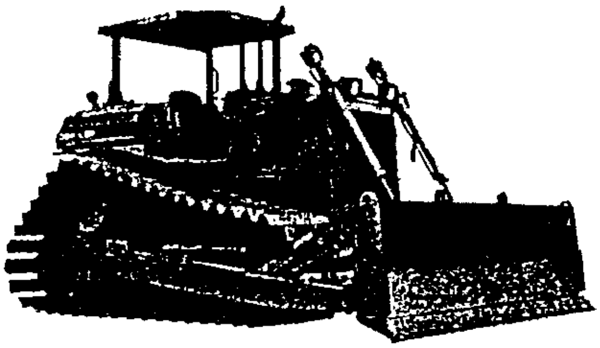
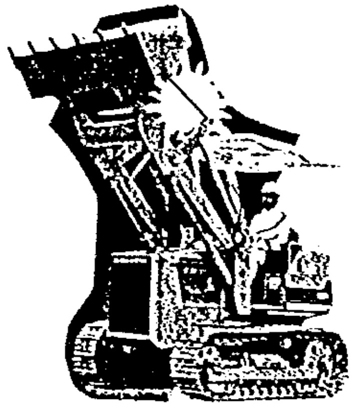
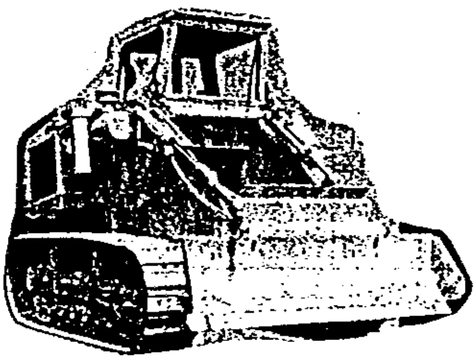
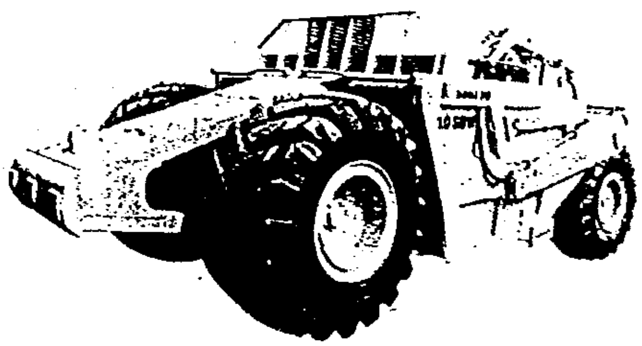


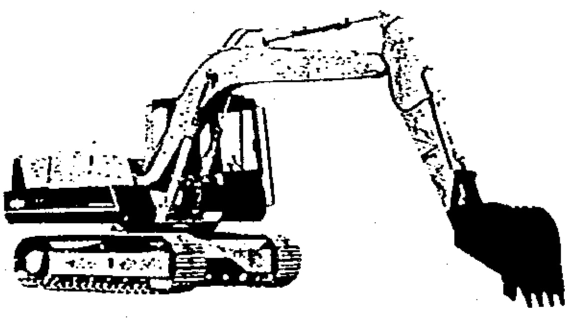
Fig. 7.5.4 Typical Landfill by Cell Method


Bulldozer


Crawler loader


Scrapper dozer


Scrapper


Power shovel

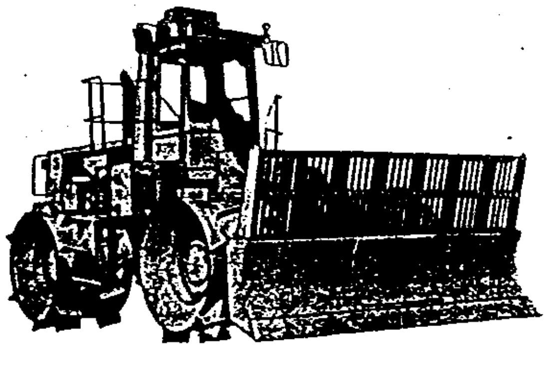

Landfill compactor

Fig. 7.5.5 Heavy equipment examples

7.6 Organizational and Institutional Arrangement

The following table shows a proposed staffing plan for Nam Son Landfill Phase 2.

Landfill Site Team Composition

Staffing	Numbers of site staff						
	2004	2007	2009	2010	2014	2018	total
Site Manager	1	-	-	-	-	-	1
Deputy Manger	1	-	-	-	-	-	1
Clerk	1	-	-	-	-	-	1
Chief engineer	1	-	-	-	-	-	1
Truck scale engineer	1	-	-	-	-	-	1
Truck scale operator	3	-	-	-	-	-	3
Environmental control engineer	1	-	-	-	-	-	1
Chief operator	1	-	-	-	-	-	1
Operator*	18	+2	+1	+2	+3	+2	28
Total	28	30	31	33	36	38	38

*1 Operator includes heavy equipment operators and workers

The defined responsibilities of the landfill site team are as follows.

- Site manager

All the responsibility of handling the site, and contact and reporting to the Director and Landfill control division manager of URENCO

- Deputy site manager

The deputy site manager should assist the site manager and perform the duties of the site manager on his/her behalf within the limits of the works to be authorized by the site manager when he/she is absent.

- Clerk

Controls and regulates the schedule of Director, registers income and outlay of daily management

- Chief engineer

Responsible for all engineering matters, planning and conduct suitable landfill operation method

- Truck scale engineer

Operates truck scale to measure the waste quantity and quality; and directs trucks to designated landfill area. Also has responsibility to keep those data and location of buried area.

- Environmental control engineer

Responsible for all kind of environmental monitoring with cooperative relationship with related organization such as DOSTE and other environmental institutions.

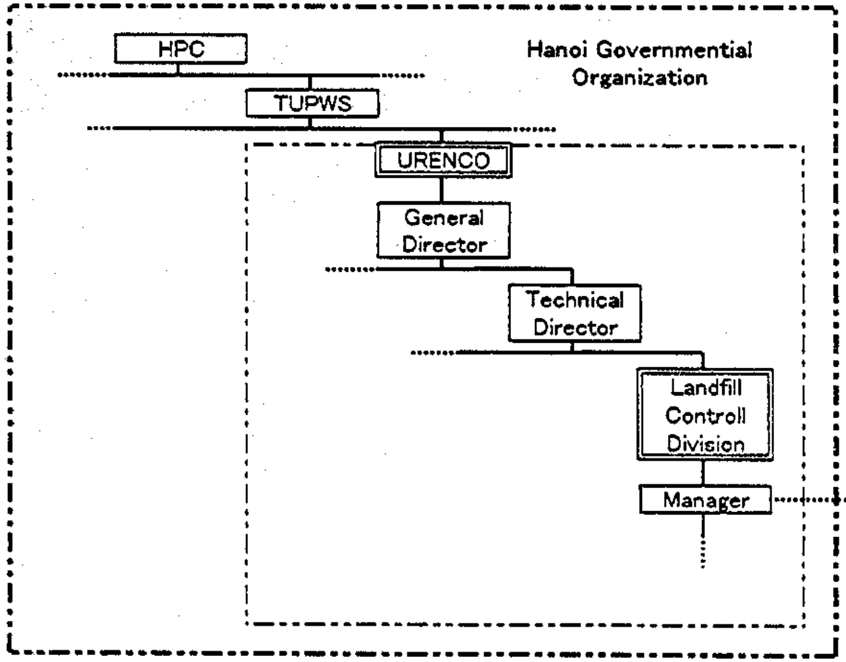
- Chief operator

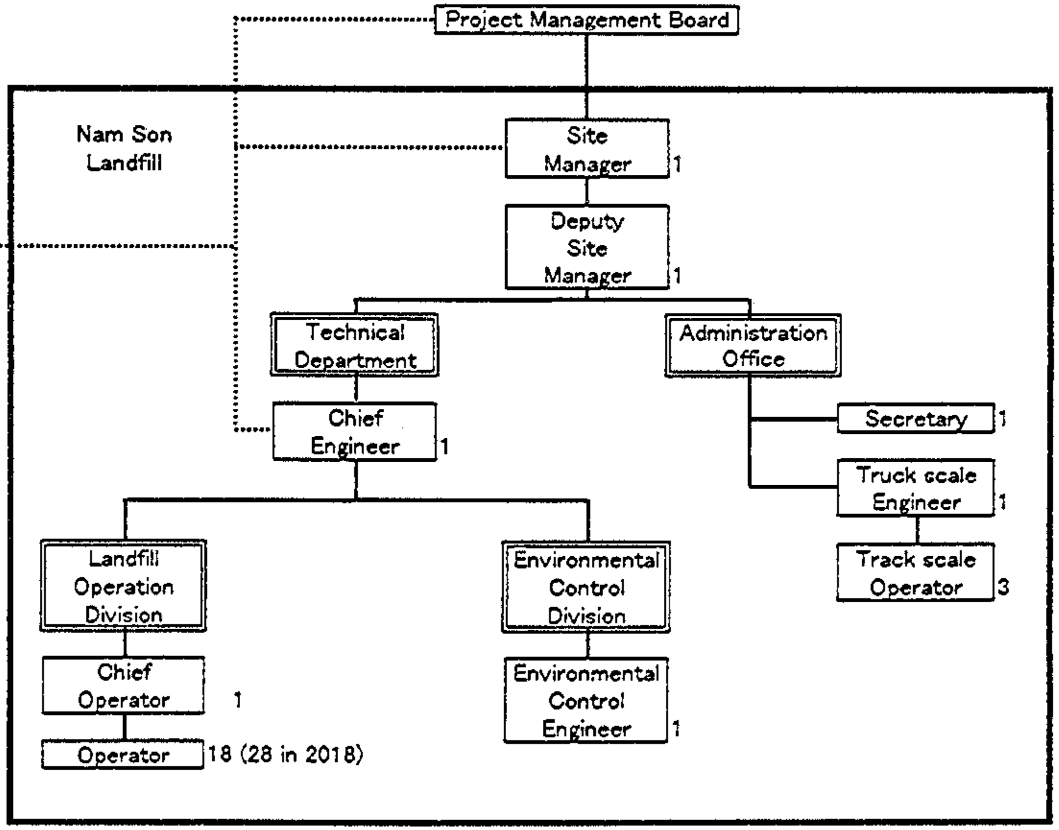
Controls daily operator's work and directs trucks to the designated landfill area in site; and

- Operator

Landfills the waste and cover soil.

A proposed organization chart is shown in Figure 7.6.1.





	Number
Site Manager	1
Deputy Site Manager	1
Secretary	1
Chief Engineer	1
Truck Scale engineer	1
Track Scale Operator	3
Environmental Control	1
Engineer	1
Chief Operator	1
Operator	18 - 28
Total	28 - 38

Figure 7.6.1 Organization Chart of Nam Son Landfill Operation

7.7 Construction Schedule

Table 7.7.1 shows schedule for the development and operation of the Nam Son landfill.

Because of saving the initial construction investment, it is recommended that Construction of Nam Son Landfill Phase 2 will be divided into two parts; part 1 and part 2.

It is planned that the design and engineering services for part 1 of the Phase 2 will start in early 2002. The construction of the part 1 site will start before mid 2003 and finished one year later in 2004. The Phase 2 area will start receiving waste in January 2004 using some completed compartments of the part 1.

Construction for part 2 of the Landfill Phase 2 will start in early 2004 and ended at the end of 2005 so that the waste will be received at the beginning of 2006.

Construction plan of the phase 2 is shown in Figure 7.7.1.

Table 7.7.1 Nam Son Landfill Development and Operation Schedule

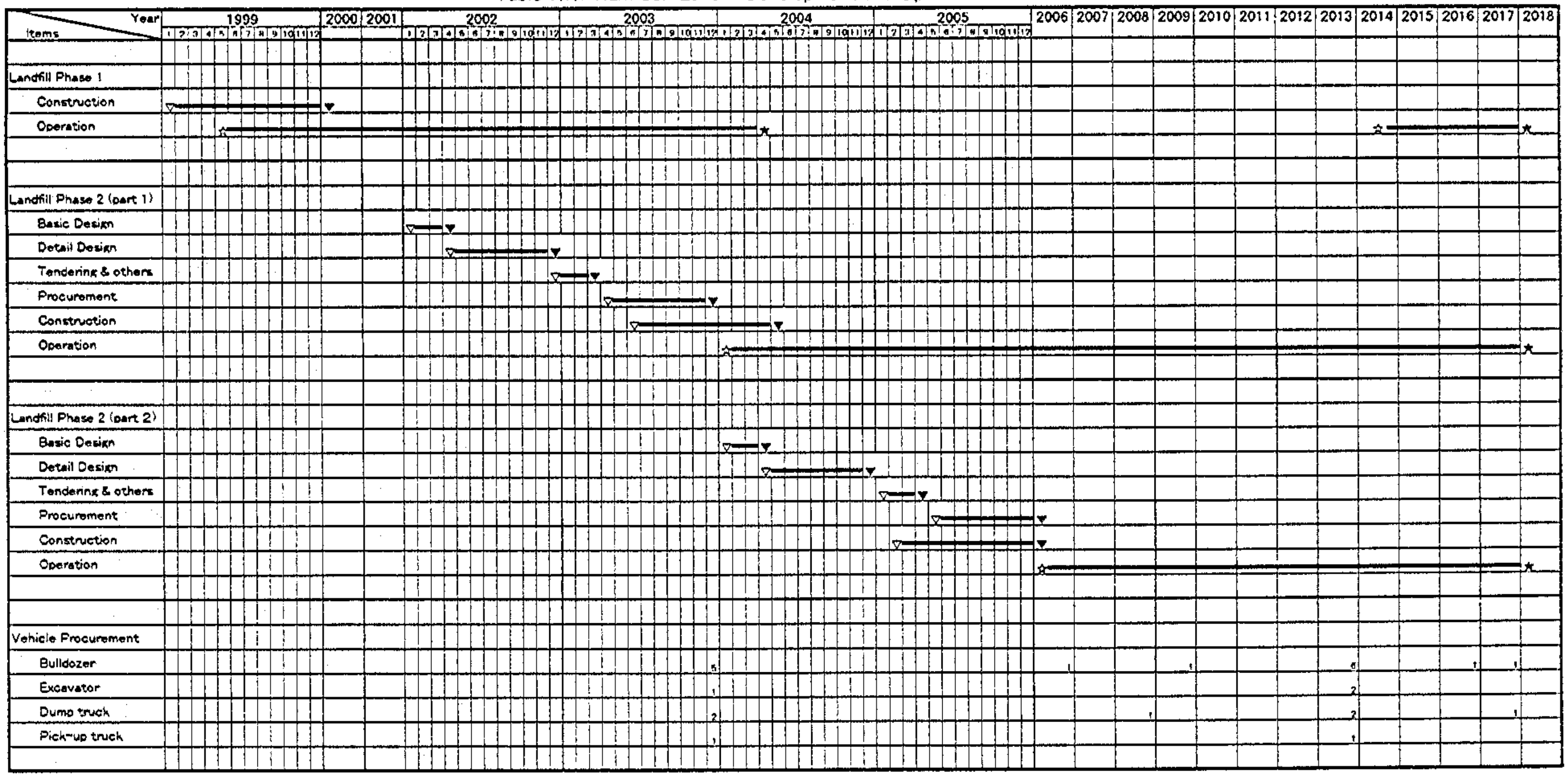


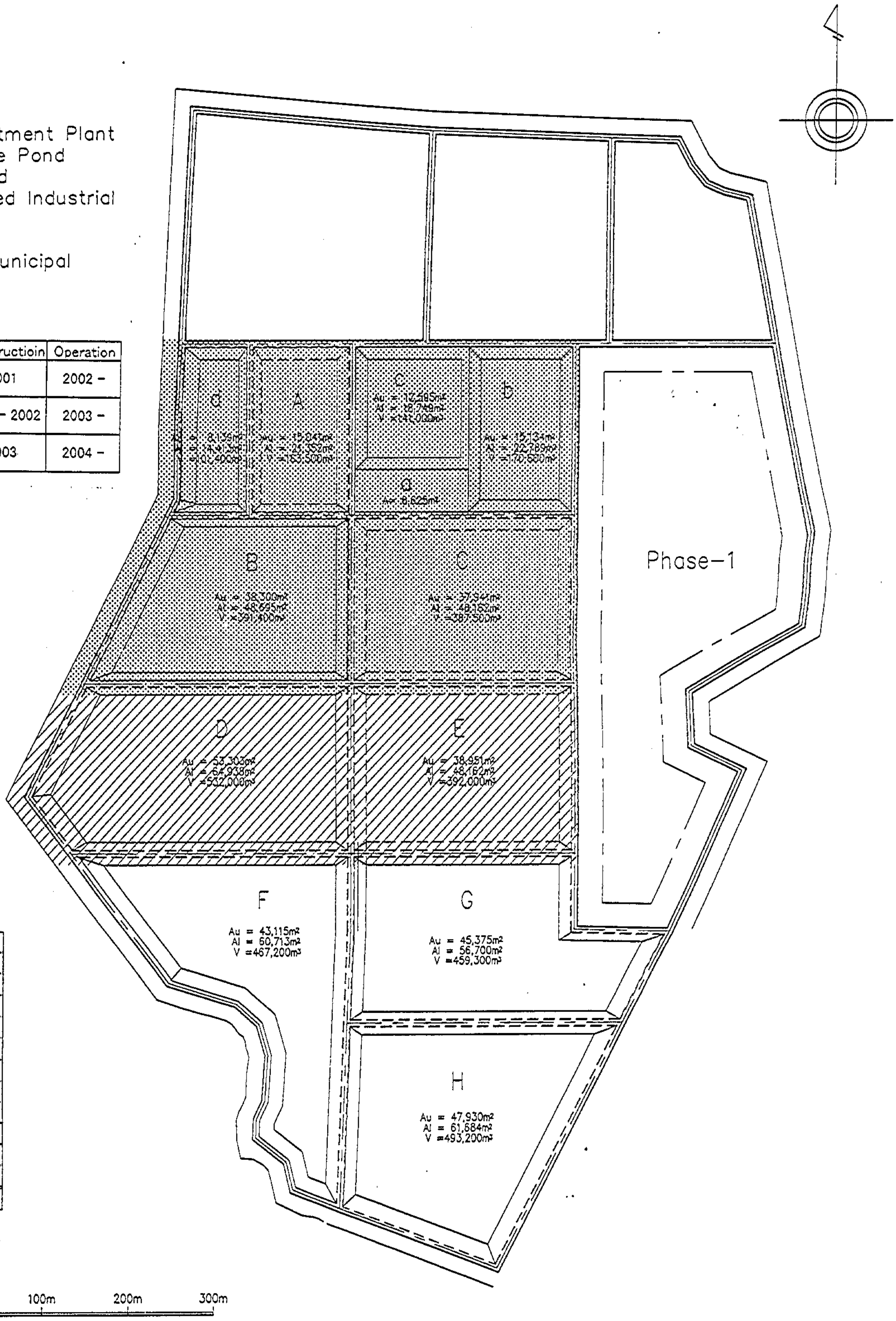
Fig.7.7.1 Construction Plan of Phase 2

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		Constructioin	Operation
(dotted)	a, b, c, d A, B, C	Phase 2 (Part 1)	2001	2002 -
(hatched)	D, E		2001 - 2002	2003 -
(blank)	F, G, H	Phase 2 (Part 2)	2003	2004 -



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

7.8 Preliminary Estimate of Costs

7.8.1 Construction and Procurement Cost

Construction cost includes detail designing fee, and supervision fee, and site acquisition and development cost. The estimated construction cost includes 1) overhead which is assumed to be 20% of the direct construction cost, 2) contingency that is assumed to be 10% of the total cost. Taxation is not considered in this study.

The construction is divided into two parts, Part 1 from 2003 to 2004 and Part 2 in 2005. The construction expenditure of Part 1 is estimated to be about US$16.0 million, of which US$ 12.0 million is invested in 2003, and US$ 4.0 million in 2004. The construction expenditure of Part 2 in 2005 is about US$6.3 million. Construction expenditure of the surrounding slope and re-circulation bed is estimated to be about US$6.1 million totally from 2007 to 2018. Thus, total construction expenditure of the Phase 2 is estimated to be approximately US$28.4 million. ($16.0 million + $6.3 million + $6.1 million)

Procurement cost is the cost for purchasing heavy equipment for landfill operation and small vehicles. Procurement cost includes 10% price contingency. Initial procurement expenditure in 2003 before starting to receive the wastes is estimated to be about US$1.7 million for purchasing 5 bulldozers, 1 excavator, 2 dumptrucks and 1 pick-up truck. Additional procurement expenditure is necessary as waste volume increases.

Costs of site development and procurement are shown in Table 7.8.1, 7.8.2 and Table 7.8.4 and Table 7.8.6.

7.8.2 Operation and Maintenance Costs

Annual operation and maintenance cost is estimated to be about US$1.2 million at the beginning of the Phase 2 operation in 2004. It will increase gradually as waste volume increases.

Detail costs of operation and maintenance cost are shown in Table 7.8.3 and Table 7.8.5.

Table 7.8.1 Annual Expenditures for the Nam Son Landfill phase 2

Unit: US dollar in 1999 price

Year	Total Investment	Total Operation & Maintenance	Administration cost for Initial	Total Cost	Contin-gency	Total including contingency
a	b	c	d	e	f	g
				b+c+d	e*10%	e+f
2002	2,925,000	0	239,000	3,163,591	316,359	3,479,950
2003	13,012,000	0	239,000	13,251,312	1,325,131	14,576,443
2004	4,125,000	1,113,645	153,000	5,392,015	539,201	5,931,216
2005	6,071,000	1,169,197	153,000	7,393,539	739,354	8,132,893
2006	227,000	1,384,107	0	1,611,098	161,110	1,772,208
2007	1,406,000	1,447,110	0	2,853,540	285,354	3,138,894
2008	81,000	1,489,769	0	1,571,095	157,110	1,728,205
2009	227,000	1,539,240	0	1,766,231	176,623	1,942,855
2010	1,406,000	1,598,845	0	3,005,275	300,527	3,305,802
2011	,000	1,621,320	0	1,621,320	162,132	1,783,452
2012	,000	1,660,482	0	1,660,482	166,048	1,826,531
2013	3,388,000	1,701,149	0	5,089,415	508,942	5,598,357
2014	,000	1,767,593	0	1,767,593	176,759	1,944,352
2015	,000	1,811,453	0	1,811,453	181,145	1,992,598
2016	1,633,000	1,841,767	0	3,475,188	347,519	3,822,707
2017	227,000	1,889,083	0	2,116,074	211,607	2,327,681
2018	,000	859,035	0	859,035	85,904	944,939
2019	,000	757,024	0	757,024	75,702	832,726
2020	,000	757,024	0	757,024	75,702	832,726
2021-2035	,000	11,355,357	0	11,355,357	1,135,536	12,490,893
A. Total 2002-2005	26,134,000	2,283,000	784,000	29,200,000	2,920,000	32,121,000
B. Total 2006-2035	8,597,000	33,480,000	,000	42,077,000	4,208,000	46,285,000
C. Total 2002-2035 (A+B)	34,730,000	35,763,000	784,000	71,278,000	7,128,000	78,405,000
D. Cost Not Depreciated during	2,608,000	,000	,000	2,608,000	261,000	2,869,000
E. Total Cost 2002-2035 (C-D)	32,122,000	35,763,000	784,000	68,670,000	6,867,000	75,536,000

Table 7.8.2 Annual Investment for the Nam Son Landfill phase 2

Unit: US dollar in 1999 price

		Engineering	Civil, Mechanical & Building Works				Heavy Equipment & Vehicles									
Year	Land Purchase and conpensa-tions	Engineering	Civil Works	Leachate treatment facility including Training Costs	Workshop Equip-ment	Total	Buldozer	Excavater	Dump truck	Pick-up truck	Sub Total	Total	Admini-stration Cost for Initial Investment in 2002 & 2003	Total including Administrati ve cost	Contin-gency (10%)	Total Including Contin-gency
						d+e+f					h+I+j+k	b+c+g+l	3% of m	m + n	10% of o	m+n
a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p	q
Unit Price							226,991	218,664	81,326	19,910						
2002	2,308,273	616,265	0	0	0	0	0	0	0	0	0	2,925,000	239,000	3,164,000	316,000	3,480,000
2003	0	513,554	5,948,125	5,000,000	14,400	10,962,525	1,134,955	218,664	162,652	19,910	1,536,181	13,012,000	239,000	13,251,000	1,325,000	14,576,000
2004	0	513,554	3,611,864	0	0	3,611,864	0	0	0	0	0	4,125,000	153,000	4,278,000	428,000	4,706,000
2005	0	410,843	5,660,546	0	0	5,660,546	0	0	0	0	0	6,071,000	153,000	6,224,000	622,000	6,847,000
2006	0	0	0	0	0	0	226,991	0	0	0	226,991	227,000	,000	227,000	23,000	250,000
2007	0	0	1,406,430	0	0	1,406,430	0	0	0	0	0	1,406,000	,000	1,406,000	141,000	1,547,000
2008	0	0	0	0	0	0	0	0	81,326	0	81,326	81,000	,000	81,000	8,000	89,000
2009	0	0	0	0	0	0	226,991	0	0	0	226,991	227,000	,000	227,000	23,000	250,000
2010	0	0	1,406,430	0	0	1,406,430	0	0	0	0	0	1,406,000	,000	1,406,000	141,000	1,547,000
2011	0	0	0	0	0	0	0	0	0	0	0	,000	,000	,000	,000	,000
2012	0	0	0	0	0	0	0	0	0	0	0	,000	,000	,000	,000	,000
2013	0	0	1,406,430	0	0	1,406,430	1,361,946	437,328	162,652	19,910	1,981,836	3,388,000	,000	3,388,000	339,000	3,727,000
2014	0	0	0	0	0	0	0	0	0	0	0	,000	,000	,000	,000	,000
2015	0	0	0	0	0	0	0	0	0	0	0	,000	,000	,000	,000	,000
2016	0	0	1,406,430	0	0	1,406,430	226,991	0	0	0	226,991	1,633,000	,000	1,633,000	163,000	1,797,000
2017	0	0	0	0	0	0	226,991	0	0	0	226,991	227,000	,000	227,000	23,000	250,000
2018	0	0	0	0	0	0	0	0	0	0	0	,000	,000	,000	,000	,000
A. Total 2002-2005	2,308,000	2,054,000	15,221,000	5,000,000	14,000	20,235,000	1,135,000	219,000	163,000	20,000	1,536,000	26,134,000	784,000	26,918,000	2,692,000	29,609,000
B. Total 2005-2018	,000	,000	5,626,000	,000	,000	5,626,000	2,270,000	437,000	244,000	20,000	2,971,000	8,597,000	,000	8,597,000	860,000	9,457,000
C. Total 2002-2018 (A+B)	2,308,000	2,054,000	20,846,000	5,000,000	14,000	25,861,000	3,405,000	656,000	407,000	40,000	4,507,000	34,730,000	784,000	35,514,000	3,551,000	39,066,000
F. Contingency	231,000	205,000	2,085,000	500,000	1,000	2,586,000	340,000	66,000	41,000	4,000	451,000	3,473,000	78,000	3,551,000		
G. Total including contingency	2,539,000	2,260,000	22,931,000	5,500,000	16,000	28,447,000	3,745,000	722,000	447,000	44,000	4,958,000	38,203,000	862,000	39,066,000		

Table 7.8.3 Annual Operation and Maintenance Costs for the Nam Son Landfill phase 2

Unit: US dollar in 1999 price

Year	Waste Landfill Amount (t/d)	Salary	cover soil	Electricity	Operation and maintenance for Leachate	Fuel for Vehicle	Maintenance Cost for Vehicle	Environmental monitoring and control	Maintenance cost for site, etc.	Total	Contin-gency	Total including contingency
a	b	c	d	e	f	g	h	I	j	k	l	m
			$2/m3	$0.4/kWh	5 % of initial	$0.5/waste-ton	5 % of initial		1.5 % of initial	(c+d+e+f+g +h+I+j)	10% of k	k+l
2004	1,464	37,200	215,229	99,864	173,725	267,151	76,809	25,050	218,616	1,113,645	111,364	1,225,009
2005	1,588	37,200	233,453	99,864	188,435	289,771	76,809	25,050	218,616	1,169,197	116,920	1,286,117
2006	1,690	37,200	248,417	99,864	200,513	308,344	76,809	25,050	387,910	1,384,107	138,411	1,522,518
2007	1,802	38,486	264,939	99,864	213,849	328,853	88,159	25,050	387,910	1,447,110	144,711	1,591,821
2008	1,897	38,486	278,933	99,864	225,145	346,223	88,159	25,050	387,910	1,489,769	148,977	1,638,746
2009	1,997	39,129	293,617	99,864	236,997	364,449	92,225	25,050	387,910	1,539,240	153,924	1,693,165
2010	2,102	40,414	309,025	99,864	249,434	383,573	103,574	25,050	387,910	1,598,845	159,884	1,758,729
2011	2,152	40,414	316,398	99,864	255,385	392,725	103,574	25,050	387,910	1,621,320	162,132	1,783,452
2012	2,239	40,414	329,245	99,864	265,754	408,671	103,574	25,050	387,910	1,660,482	166,048	1,826,531
2013	2,330	40,414	342,585	99,864	276,522	425,230	103,574	25,050	387,910	1,701,149	170,115	1,871,264
2014	2,424	42,343	356,439	99,864	287,705	442,425	125,857	25,050	387,910	1,767,593	176,759	1,944,352
2015	2,522	42,343	370,827	99,864	299,318	460,284	125,857	25,050	387,910	1,811,453	181,145	1,992,598
2016	2,590	42,343	380,771	99,864	307,345	472,628	125,857	25,050	387,910	1,841,767	184,177	2,025,944
2017	2,695	42,343	396,292	99,864	319,873	491,893	125,857	25,050	387,910	1,889,083	188,908	2,077,991
2018	2,805	21,236	35,494	99,864	233,991	44,057	11,434	25,050	387,910	859,035	85,904	944,939
2019	2,919	19,200	0	99,864	225,000	0	0	25,050	387,910	757,024	75,702	832,726
2020	3,037	19,200	0	99,864	225,000	0	0	25,050	387,910	757,024	75,702	832,726
2021 - 2035		288,000	0	1,497,960	3,375,000	0	0	375,750	5,818,647	11,355,357	1,135,536	12,490,893
Total 2004-2018		579,965	4,371,664	1,497,960	3,733,991	5,426,277	1,428,130	375,750	5,480,059	22,893,796	2,289,380	25,183,175
Total 2004-2018/1		562,000	4,372,000	1,406,000	3,519,000	5,426,000	1,428,000	353,000	5,124,000	22,192,000	2,219,000	24,411,000
Total 2004 - 2035		906,000	4,372,000	3,196,000	7,559,000	5,426,000	1,428,000	802,000	12,075,000	35,763,000	3,576,000	39,340,000
Share of each cost ite		3%	19%	7%	16%	24%	6%	2%	24%	100%		

Note: It is assumed that annual cost of operation and maintenance will increase in proportion to waste increase except for total salary of managers and maintenance cost of building, etc.

Table 7.8.4 Cost of Site Development and Procurement (1/5)

10,852,554 ton for the year of 2004-2018

Item No.	Item	Unit cost (US$/unit)	unit	Site Quantity	Cost (US$)	Remark
Construction cost						
1-a	Acquisition of site :					
	Acquisition of site	2.01	m2	600,000	1,208,633	28,000 VND/m2, 1 US$ = 13,900
	Subtotal				1,208,633	
1-b	Conpensations					
	Compensation for existing property	3,597.12	family	135	485,612	50,000,000 VND/family
	Compensation for surronding residents	0.37	m2	1,200,000	440,288	5,100 VND/m2
	Conpensation for building new individual houses	575.54	family	105	60,432	8,000,000 VND/family
	Cost of new housing for 40 households	3,776.98	family	30	113,309	2,100,000,000 VND for 40 families x 75%
	Subtotal				1,099,640	
2-a	Surrounding Embankment (2003)					
	Material	2.20	m3	17,632	38,789	
	Embankment	4.50	m3	11,053	49,737	
	Penetration clay covering	5.00	m3	12,336	61,678	
	Excavation	1.50	m3	71,316	106,974	
	Road Surface	5.00	m2	3,289	16,447	
	Surface adjustment	1.50	m2	21,447	32,171	
	Subtotal				305,796	
2-b	Surrounding Embankment (2004)					
	Material	2.20	m3	10,579	23,274	
	Embankment	4.50	m3	6,632	29,842	
	Penetration clay covering	5.00	m3	7,401	37,007	
	Excavation	1.50	m3	42,789	64,184	
	Road Surface	5.00	m2	1,974	9,868	
	Surface adjustment	1.50	m2	12,868	19,303	
	Subtotal				183,478	
2-c	Surrounding Embankment (2005)					
	Material	2.20	m3	38,789	85,337	
	Embankment	4.50	m3	24,316	109,421	
	Penetration clay covering	5.00	m3	27,138	135,691	
	Excavation	1.50	m3	156,895	235,342	
	Road Surface	5.00	m2	7,237	36,184	
	Surface adjustment	1.50	m2	47,184	70,776	
	Subtotal				672,751	
3-a	Section Embankment (2003)					
	Material	2.20	m3	83,200	183,040	
	Embankment	4.50	m3	74,000	333,000	
	Penetration clay covering	5.00	m3	17,250	86,250	
	Excavation	1.50	m3	46,000	69,000	
	Road Surface	5.00	m2	8,640	43,200	
	Surface adjustment	1.50	m2	33,680	50,520	
	Subtotal				765,010	
3-b	Section Embankment (2004)					
	Material	2.20	m3	62,400	137,280	
	Embankment	4.50	m3	55,500	249,750	
	Penetration clay covering	5.00	m3	12,938	64,688	
	Excavation	1.50	m3	34,500	51,750	
	Road Surface	5.00	m2	6,480	32,400	
	Surface adjustment	1.50	m2	25,260	37,890	
	Subtotal				573,758	
3-c	Section Embankment (2005)					
	Material	2.20	m3	62,400	137,280	
	Embankment	4.50	m3	55,500	249,750	
	Penetration clay covering	5.00	m3	12,938	64,688	
	Excavation	1.50	m3	34,500	51,750	
	Road Surface	5.00	m2	6,480	32,400	
	Surface adjustment	1.50	m2	25,260	37,890	
	Subtotal				573,758	
4-a	On site road up and down to compartment					
	Material	2.20	m3	25,200	55,440	
	Embankment	4.50	m3	25,200	113,400	
	Road Surface	5.00	m2	2,813	14,063	
	Subtotal				182,903	

Table 7.8.4 Cost of Site Development and Procurement (2/5)

4-b	On site road up and down to compartment (2004)					
	Material	2.20	m3	16,800	36,960	
	Embankment	4.50	m3	16,800	75,600	
	Road Surface	5.00	m2	1,875	9,375	
	Subtotal				121,935	
4-c	On site road up and down to compartment (2005)					
	Material	2.20	m3	25,200	55,440	
	Embankment	4.50	m3	25,200	113,400	
	Road Surface	5.00	m2	2,813	14,063	
	Subtotal				182,903	
5	Slope construction (2007 - 2018)					
	Embankment for mounting up (2007 - 2018)	4.50	m3	1,000,000	4,500,000	
	Subtotal				4,500,000	(Total of 2007 - 2018)
6	Re-circulation bed (2007 - 2018)					
	Excavation (2007 - 2018)	1.50	m3	34,200	51,300	
	PVC pipe(D=200mm) (2007 - 2018)	1.50	m	22,800	34,200	
	Gravel (2007 - 2018)	1.20	m3	34,200	41,040	
	Plastic sheet (2007 - 2018)	1.80	m2	34,200	61,560	
	Subtotal				188,100	(Total of 2007 - 2018)
7-a	Landfill area excavation (2003)	1.50	m3	727,579	1,091,368	
	Subtotal				1,091,368	
7-b	Landfill area excavation (2004)	1.50	m3	464,842	697,263	
	Subtotal				697,263	
7-c	Landfill area excavation (2005)	1.50	m3	727,579	1,091,368	
	Subtotal				1,091,368	
8-a	Leachate collection facility (2003)					
	PVC Pipe (D=600mm)	9.00	m	450	4,050	
	(D=400mm)	5.00	m	1,425	7,125	
	(D=200mm)	1.50	m	3,000	4,500	
	Excavation for D600	1.50	m3	540	810	
	for D400	1.50	m3	1,214	1,820	
	For D200	1.50	m3	1,653	2,479	
	Gravel (50-150mm) for D600	1.20	m3	1,890	2,268	
	for D400	1.20	m3	4,804	5,764	
	For D200	1.20	m3	7,681	9,217	
	Sand for D 600	4.60	m3	136	627	
	for D 400	4.60	m3	257	1,184	
	for D 200	4.60	m3	272	1,250	
	Subtotal				41,095	
8-b	Leachate collection facility (2004)					
	PVC Pipe (D=600mm)	9.00	m	400	3,600	
	(D=400mm)	5.00	m	1,425	7,125	
	(D=200mm)	1.50	m	3,200	4,800	
	Excavation for D600	1.50	m3	480	720	
	for D400	1.50	m3	1,214	1,820	
	For D200	1.50	m3	1,763	2,645	
	Gravel (50-150mm) for D600	1.20	m3	1,680	2,016	
	for D400	1.20	m3	4,804	5,764	
	For D200	1.20	m3	8,193	9,832	
	Sand for D 600	4.60	m3	121	558	
	for D 400	4.60	m3	257	1,184	
	for D 200	4.60	m3	290	1,333	
	Subtotal				41,397	

Table 7.8.4 Cost of Site Development and Procurement (3/5)

8-c	Leachate collection facility (2005)					
	PVC Pipe (D=600mm)	9.00	m	800	7,200	
	(D=400mm)	5.00	m	1,600	8,000	
	(D=200mm)	1.50	m	4,400	6,600	
	Excavation for D600	1.50	m3	960	1,440	
	for D400	1.50	m3	1,363	2,044	
	For D200	1.50	m3	2,424	3,636	
	Gravel (50-150mm) for D600	1.20	m3	3,360	4,032	
	for D400	1.20	m3	5,394	6,472	
	For D200	1.20	m3	11,266	13,519	
	Sand for D 600	4.60	m3	242	1,115	
	for D 400	4.60	m3	289	1,330	
	for D 200	4.60	m3	398	1,833	
	Subtotal				57,221	
9-a	Surface water collction facility (2003)					
	U type drainage ditch (450*450)	12.50	m	500	6,250	
	Excavation	2.00	m3	395	789	
	Gravel (50-150mm)	1.20	m3	61	73	
	Subtotal				7,112	
9-b	Surface water collction facility (2004)					
	U type drainage ditch (450*450)	12.50	m	300	3,750	
	Excavation	2.00	m3	237	474	
	Gravel (50-150mm)	1.20	m3	36	44	
	Subtotal				4,267	
9-c	Surface water collction facility (2005)					
	U type drainage ditch (450*450)	12.50	m	1,100	13,750	
	Excavation	2.00	m3	868	1,737	
	Gravel (50-150mm)	1.20	m3	133	160	
	Subtotal				15,647	
10-a	Liner facilities (2003)					
	Excavation	1.50	m3	149,132	223,698	
	Penetration clay covering	5.00	m3	149,132	745,660	
	Geomembrane FML(PE t=1.5mm)	3.60	m2	164,730	593,028	HDPE t=1.5mm (PVC is available)
	Sand protection layer (500mm)	2.30	m3	60,800	139,840	
	Subtotal				1,702,226	
10-b	Liner facilities (2004)					
	Excavation	1.50	m3	138,381	207,572	
	Penetration clay covering	5.00	m3	138,381	691,905	
	Geomembrane FML(PE t=1.5mm)	3.60	m2	104,040	374,544	HDPE t=1.5mm (PVC is available)
	Sand protection layer (500mm)	2.30	m3	38,400	88,320	
	Subtotal				1,362,341	
10-c	Liner facilities (2005)					
	Excavation	1.50	m3	204,630	306,945	
	Penetration clay covering	5.00	m3	204,630	1,023,150	
	Geomembrane FML(PE t=1.5mm)	3.60	m2	164,730	593,028	HDPE t=1.5mm (PVC is available)
	Sand protection layer (500mm)	2.30	m3	60,800	139,840	
	Subtotal				2,062,963	
11	Leachate treatment facility					
	Aeration pond & Precipitation	#########	station	1	5,000,000	(1200 m3/day) including overhead
	Subtotal				5,000,000	
12	Leachate adjusting pond				(141,000 m3)	including development of leachate treatment area
	Excavation	1.50	m3	75,400	113,100	
	Penetration clay covering	5.00	m3	18,900	94,500	
	Geomembrane FML(PE t=1.5mm)	3.60	m2	20,000	72,000	HDPE t=1.5mm (PVC is available)
	Sand protection layer (500mm)	2.30	m3	10,000	23,000	
	Embankment	4.50	m3	49,800	224,100	
	Surface adjustment	1.50	m2	8,700	13,050	
	Subtotal				539,750	
13-a	Passive gas vents (2003)					
	Vertical gas vents (D150 pipe + section timber)	600.00	No	32	19,200	
	Subtotal				19,200	

Table 7.8.4 Cost of Site Development and Procurement (4/5)

13-b	Passive gas vents (2004)					
	Vertical gas vents (D150 pipe + section timber)	600.00	No	28	16,800	
	Subtotal				16,800	
13-c	Passive gas vents (2005)					
	Vertical gas vents (D150 pipe + section timber)	600.00	No	48	28,800	
	Subtotal				28,800	
14-a	Fencing (2003)					
	2m security, cranked tops (Surrounding area)	12.80	m	500	6,400	
	(transfer type for compartment)	9.00	m	800	7,200	
	Sign (notice) board	24.50	No	4	98	
	Sign (guide) board in site	24.50	No	4	98	
	Subtotal				13,796	
14-b	Fencing (2004)					
	2m security, cranked tops (Surrounding area)	12.80	m	300	3,840	
	Subtotal				3,840	
14-c	Fencing (2005)					
	2m security, cranked tops (Surrounding area)	12.80	m	1,100	14,080	
	Subtotal				14,080	
15	Lighting system	4,800.00	Set	1	4,800	
	Subtotal				4,800	
16-a	Landscape planting (2003)					
	Standard trees (5m pitch * 2km)	8.00	No	100	800	
	Hedges	5.00	m	126	632	
	Grass seeding	0.66	m2	9,974	6,583	
	Subtotal				8,014	
16-b	Landscape planting (2004)					
	Standard trees (5m pitch * 2km)	8.00	No	60	480	
	Hedges	5.00	m	76	379	
	Grass seeding	0.66	m2	5,984	3,950	
	Subtotal				4,809	
16-c	Landscape planting (2005)					
	Standard trees (5m pitch * 2km)	8.00	No	220	1,760	
	Hedges	5.00	m	278	1,389	
	Grass seeding	0.66	m2	21,942	14,482	
	Subtotal				17,631	
17	Groundwater monitoring boreholes					
	100mm * 20m * 6 places	100.00	m	120	12,000	
	Subtotal				12,000	
18	Fuel stores/ garages/workshops	12,000.00	item	1	12,000	Amendment of existing buildings
	Subtotal				12,000	
19	Site services :					
	Water	190,600.00	item	1	190,600	
	Electricity	72,300.00	item	1	72,300	
	Telephone	400.00	item	2	800	
	Subtotal				263,700	
	Land purchase in 2002				1,208,633	
	Conpensation in 2002				1,099,640	
A	Total direct cost in 2003				9,135,437	
	Overhead				1,827,087	
	Total cost in 2003				10,962,525	
B	Total direct cost in 2004				3,009,886	
	Overhead				601,977	
	Total cost in 2004				3,611,864	
C	Total direct cost in 2005				4,717,122	
	Overhead				943,424	
	Total cost in 2005				5,660,546	
D	Total direct cost in 2007 - 2018				4,688,100	
	Overhead				937,620	
	Total cost in 2007 - 2018				5,625,720	

Table 7.8.4 Cost of Site Development and Procurement (5/5)

Procurement cost						
1	Heavy equipment (2003)					purchase in 2003 for 2004 operation start
	Bulldozer (15t)	226,991.00	No	5	1,134,955	
	Excavator (1.0 m3)	218,664.00	No	1	218,664	
	Dumptruck (11t)	81,326.00	No	2	162,652	
	Pick-up truck	19,910.00	No	1	19,910	
a	Subtotal				1,536,181	
2	Additional heavy equipment					After 2005
	Bulldozer (15 T) in 2006	226,991.00	No	1	226,991	
	Bulldozer (15 T) in 2009	226,991.00	No	1	226,991	
	Bulldozer (15 T) in 2009	226,991.00	No	1	226,991	
	Bulldozer (15 T) in 2013	226,991.00	No	6	1,361,946	
	Bulldozer (15 T) in 2016	226,991.00	No	1	226,991	
	Bulldozer (15 T) in 2017	226,991.00	No	1	226,991	
	Excavator (1.0 m3) in 2013	218,664.00	No	2	437,328	
	Dump truck in 2008	81,326.00	No	1	81,326	
	Dump truck in 2013	81,326.00	No	2	162,652	
	Pick-up truck in 2013	81,326.00	No	1	81,326	
b	Subtotal				3,259,533	

total 32,964,642

Table 7.8.5 Cost of Site Operation (1/2)

Accepted Waste: 770,778 ton/year (average)

Item No.	Item	Unit cost (US$/unit/year)	unit	Site Quantity	Yearly Cost (US$/year)	Remark
1	Wages and salaries					
	Manager	6,857.14	employee	1	6,857	8,000,000VND/month
	Deputy manager	5,142.86	employee	1	5,143	6,000,000VND/month
	Secretary	2,571.43	employee	1	2,571	3,000,000VND/month
	Chief engineer	4,285.71	employee	1	4,286	5,000,000VND/month
	Truck scale engineer	2,057.14	employee	1	2,057	2,400,000VND/month
	Truck scale operator	600.00	employee	3	1,800	700,000VND/month
	Leachate control engineer	2,057.14	employee	1	2,057	2,400,000VND/month
	Chief operator	857.14	employee	1	857	1,000,000VND/month
	Operator	642.86	employee	18	11,571	750,000VND/month
	Additional operator in 2007	642.86	employee	2	1,286	
	Additional operator in 2009	642.86	employee	1	643	
	Additional operator in 2010	642.86	employee	2	1,286	
	Additional operator in 2014	642.86	employee	3	1,929	
	Additional operator in 2018	642.86	employee	2	1,286	
	Sub total				37,200	Until 2006
					19,200	after 2019 (Mgr, Sec, C Eng, LC Eng, C Ope, Ope*4)
2	Machine repair and maintenance:					
	Buldozer (15t)	11,349.55	No	5	56,748	5% of purchase cost
	Excavator (1.0 m3)	10,933.20	No	1	10,933	5% of purchase cost
	Dumptruck (11t)	4,066.30	No	2	8,133	5% of purchase cost
	Pick-up truck	995.50	No	1	996	5% of purchase cost
	Buldozer (15t) from 2007	11,349.55	No	1	11,350	5% of purchase cost
	Buldozer (15t) from 2010	11,349.55	No	1	11,350	5% of purchase cost
	Buldozer (15t) from 2014	11,349.55	No	1	11,350	5% of purchase cost
	Buldozer (15t) from 2018	11,349.55	No	1	11,350	5% of purchase cost
	Excavator (1.0 m3) from 2014	10,933.20	No	1	10,933	5% of purchase cost
	Dumptruck (11t) from 2009	4,066.30	No	1	4,066	5% of purchase cost
	Sub total				76,809	Until 2006
3	Fuel	0.50	ton of waste	770,778	385,389	
	Sub total				385,389	
4	Soil material:					
	Daily cover	2.00	m3	155,244	310,488	
	Sub total				310,488	
5	Site maintenance(roads, grass, cutting,					
	Sub total in 2004 - 2005	218,615.83	site	1	218,616	1.5% of construction cost in 2002 - 2003
	Sub total after 2006	387,909.82	site	1	387,910	1.5% of total construction cost
6	Environmental control (pests, wind, etc.)	10,000.00	site	1	10,000	
	Sub total				10,000	
7	Environmental monitoring					
	Leachate and treated water	500.00	per year	12	6,000	
	Groung water	250.00	per year	12	3,000	
	Gas	100.00	per year	12	1,200	
	Settlement	1,200.00	per year	4	4,800	
	Odor	50.00	per year	1	50	
	Sub total				15,050	
8	Electricity					
	for lighting system	0.40	kWh	65,700	26,280	
	for water supply station	0.40	kWh	140,160	56,064	
	for administration office	0.40	kWh	43,800	17,520	
	Sub total				99,864	
9	Electricity & Chemical Additives					
	for leachate treatment	250,000.00	per year	1	250,000	5% of construction cost
	Sub total				250,000	
	Total annual operating cost (2004-2005)				1,403,415	
	Total annual operating cost (2004-2005)				1.82	
	Total annual operating cost (2006)				1,572,709	

Table 7.8.5 Cost of Site Operation (2/2)

	Total annual operating cost (2006) (US$/t):				2.04	
	Total annual operating cost (2007-2008)				1,585,345	
	Total anaual operating cost (2007-2008)				2.06	
	Total annual operating cost (2009)				1,590,054	
	Total annual operating cost (2009) (US$/t):				2.06	
	Total annual operating cost (2010-2013)				1,602,689	
	Total annual operating cost (2010-2013)				2.08	
	Total annual operating cost (2014-2017)				1,626,900	
	Total annual operating cost (2014-2017)				2.11	
	Total operating cost (January 2018)				136,628	only for one month
	Total operating cost after closure (2018/2～12)				707,689	
	Total annual operating cost (2018)				844,316	
	Total operating cost (January 2018) (US$/t):				0.92	
	Annual operating cost after closure (2019～2035)				757,024	Sarary + Electricity + OM for leachate for 2017 waste base + Environmental controll and maintenance + Site Maintenance
	Total operationg cost (2021 - 2035)				11,355,357	

Table 7.8.6 Land Acquisition Cost and Compensation for Nam Son Landfill

Item	Unit Cost	Quantity			Amout (Dong)			Amount (US Dollar)		
	Dong	Phase 1	Phase 2	Unit	Phase 1	Phase 2	Total	Phase 1	Phase 2	Total
1. Compensation for land	28,000	130,000	600,000	m2	3,640,000,000	16,800,000,000	20,440,000,000	261,871	1,208,633	1,470,504
2. Compensation for existing property	50,000,000	45	135	household	2,250,000,000	6,750,000,000	9,000,000,000	161,871	485,612	647,482
3. Compensation for surrounding residents	5,100	400,000	1,200,000	m2	2,040,000,000	6,120,000,000	8,160,000,000	146,763	440,288	587,050
4. Conpensation for building new individual houses	8,000,000	35	105	households	280,000,000	840,000,000	1,120,000,000	20,144	60,432	80,576
5. Cost of new housing for 140 households	2,100,000,000	25%	75%	lot	525,000,000	1,575,000,000	2,100,000,000	37,770	113,309	151,079
Sub Total (2+3+4+5)					5,095,000,000	15,285,000,000	20,380,000,000	366,547	1,099,640	1,466,187
Total (1+2+3+4+5)					8,735,000,000	32,085,000,000	40,820,000,000	628,417	2,308,273	2,936,691

7.9 Image Graphics of Nam Son Landfill Site

Figures 7.9.1 – 7.9.3 show the images of Nam Son Landfill site created using computer graphics.

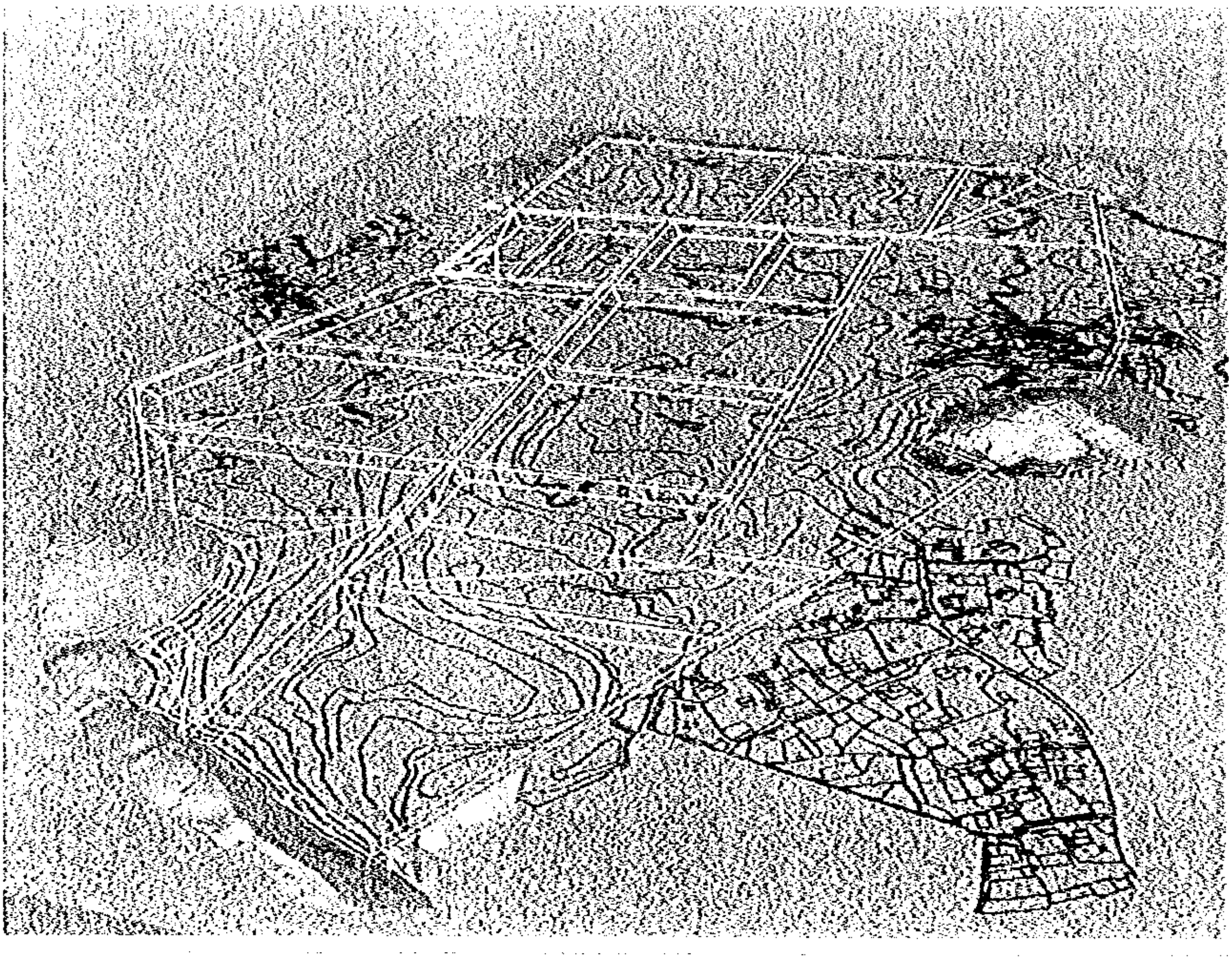


Fig. 7.9.1 Image Graphic of Nam Son Landfill Phase 2 (Before Construction)

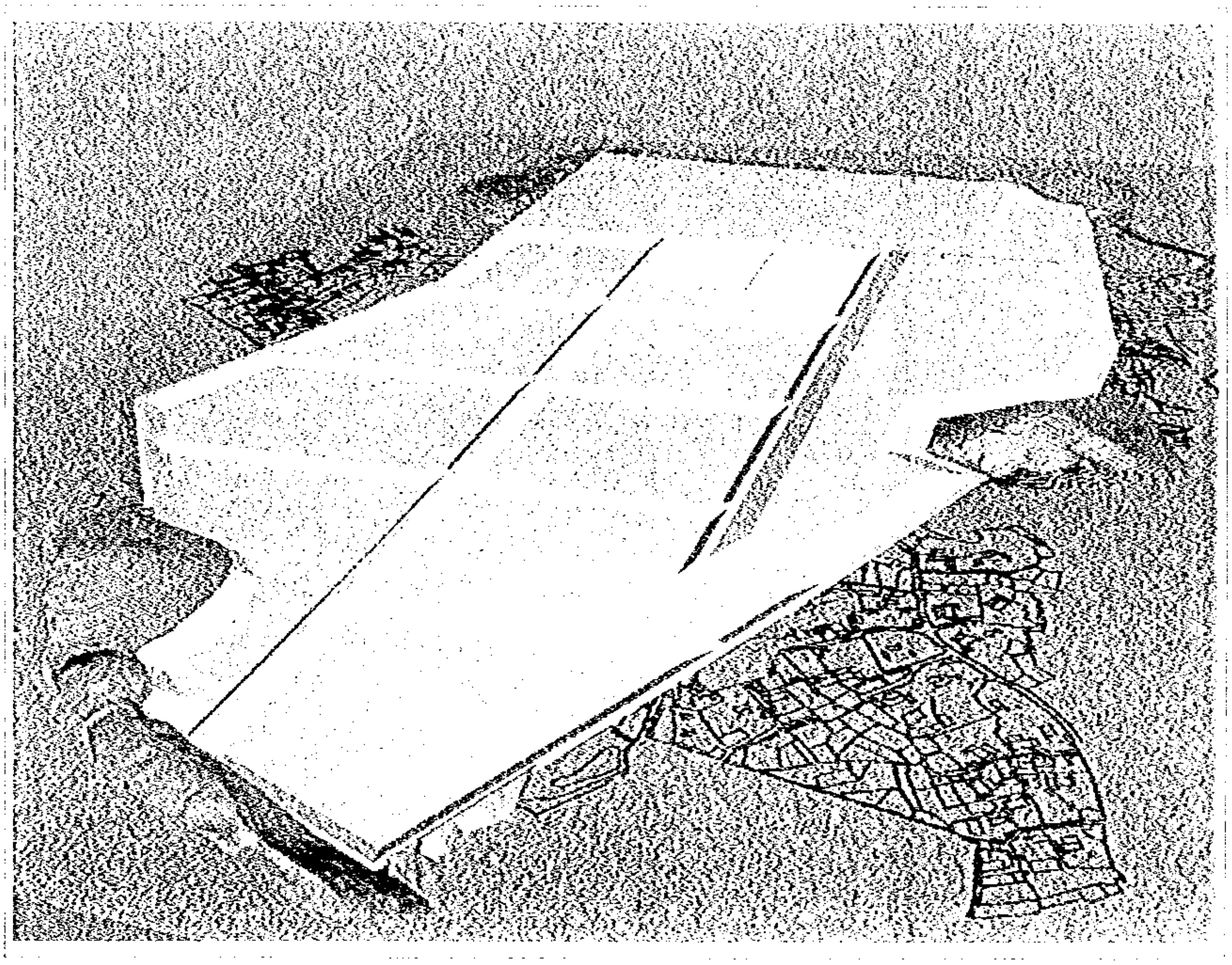


Fig. 7.9.2 Image Graphic of Nam Son Landfill Phase 2 (After Land Preparation)

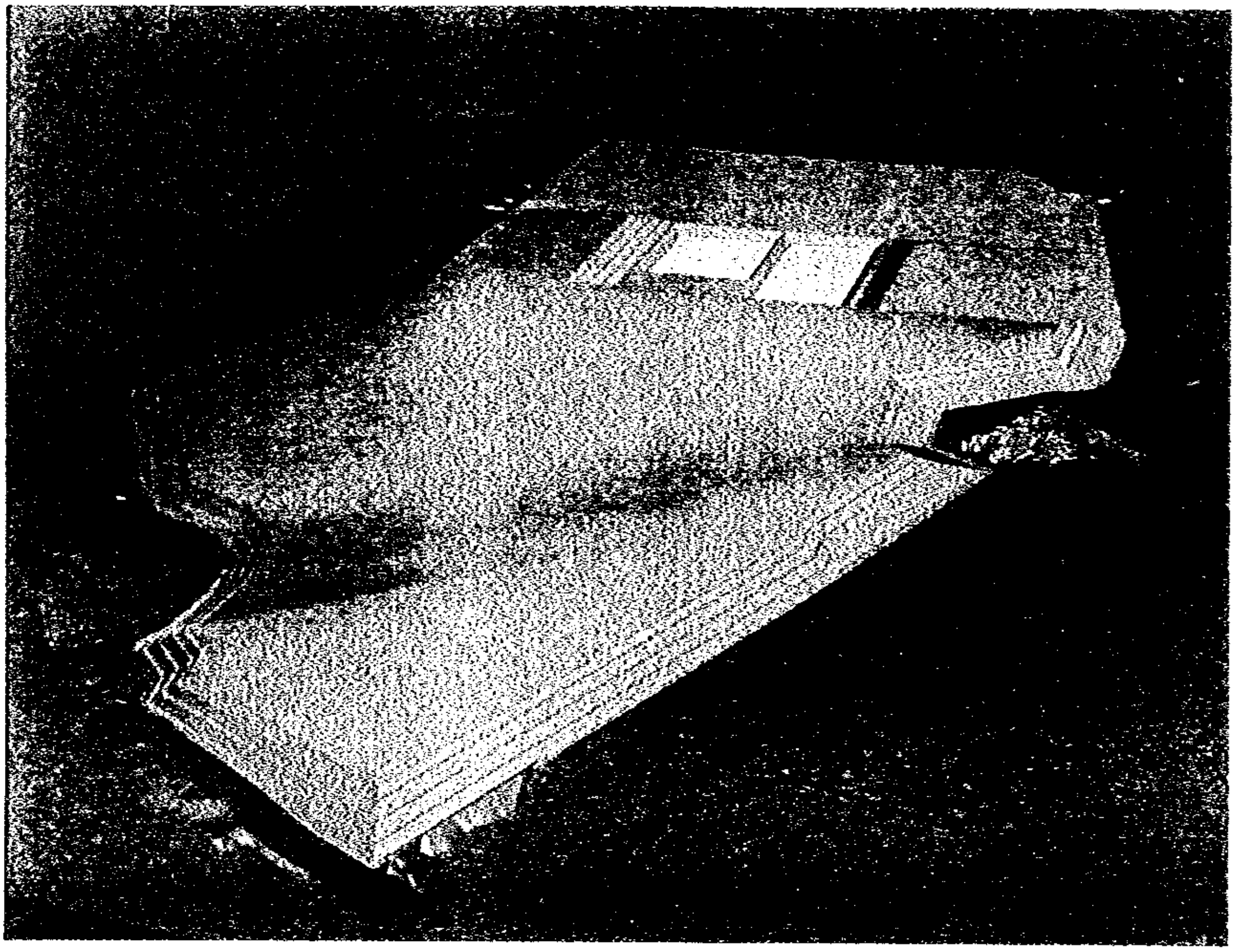


Fig. 7.9.3 Image Graphic of Nam Son Landfill Phase 2 (After Completion of Landfill)

CHAPTER 8 PLAN FOR TRANSFER SYSTEM

8.1 Objective of the Project

8.1.1 Background

HPC constructed and began using a small part (1.2 ha) of Nam Son Landfill in June 1999. HPC could not expand the landfill area further because it has not reached agreement with some local residents. As of September 1999, this part is almost full with solid waste. Though it was intended that URENCO would close Tay Mo landfill site after opening Nam Son Landfill, URENCO uses Tay Mo landfill site even after the opening of Nam Son landfill. In addition URENCO started using Kieu Ky landfill site in mid September as the local residents using agricultural land near the existing Tay Mo landfill have prevented URENCO trucks from coming into the landfill site. This landfill site has been planned by Gia Lam suburban district for its own use. Construction of this landfill site was to be completed in November 1999.

8.1.2 Objective

The objective of having a transfer system is to minimize the direct cost of waste transport from the waste collection area (city center) to Nam Son landfill site. It is estimated that the direct transport without a transfer system is twice as costly as the transport with a transfer system as shown in Chapter 3.

A transfer system also helps reduce the number of waste transport trucks going to a landfill site as compared to the case of direct transport. This helps to reduce traffic pollution problems such as noise, vibration, and congestion that may affect the local residents living nearby the landfill site. In Japan, this benefit of the transfer system is considered as important as the cost reduction because the traffic pollution caused by waste trucks around landfill sites is not negligible.

8.1.3 Components of Transfer System

The waste transfer system has the following two major components:

a) transfer station
b) transfer vehicles (secondary transport vehicles which transport waste from transfer station to landfill site)

(Remark: In this report, vehicles that transport waste from collection areas to transfer station are referred to as primary transport vehicles.)

In principle, number and locations of transfer station should be decided so as to minimize overall cost of transport from waste collection areas to the landfill site.

8.2 Planning and Design Policy

A transfer system has been planned and designed based on the following policy and consideration.

a) economical system
b) to design equipment that can be locally procurement
c) to meet local capacity of operation and maintenance
d) environmentally sound system
e) nice view (not ugly)

(1) Economical System

In order to meet the fundamental objective of transfer system, the planned system should be the most economical one provided that all safety, technical, social and legal requirements are satisfied. Sites for the transfer station will also be chosen to achieve the lowest waste transport costs given the constraints of land availability.

(2) To design equipment that can be locally procured

URENCO has the capacity to manufacture bodies (other than chassis) of waste collection trucks, and actually manufacture them at its workshop. For example, containers used for the secondary transport vehicles should be of design that can be manufactured by URENCO.

(3) To meet local capacity of operation and maintenance

All facilities and equipment should be of type and design that can be operated and maintained technically and financially by URENCO without causing any difficulty.

(4) Environmentally Sound System

The transfer system must be environmentally sound without causing significant pollution and public nuisance. Major measures are as follows:

1) To avoid contamination of ground soil and water with leachate at transfer stations the following structures and facilities will be provided.
   - Waste transfer structure will be of elevated platform with concrete surface.
   - Leachate collection and storage facilities (drainage and tanks, etc.) will be provided.
2) Against odor and noise

Measures: Transfer sites will be selected in areas distant from local residents. During the design stage, HPC will decide on whether or not a deodorization system will be provided. All waste will be transferred within 24 hours after arrival.

(5) Nice View (Not Ugly)

Waste transfer structure will be of a closed type. A roof and walls will be provided so that waste and waste transfer operation may not be seen from outside. There will be fences surrounding the transfer station site. Trees will be planned along the fence.

8.3 Options for Transfer System

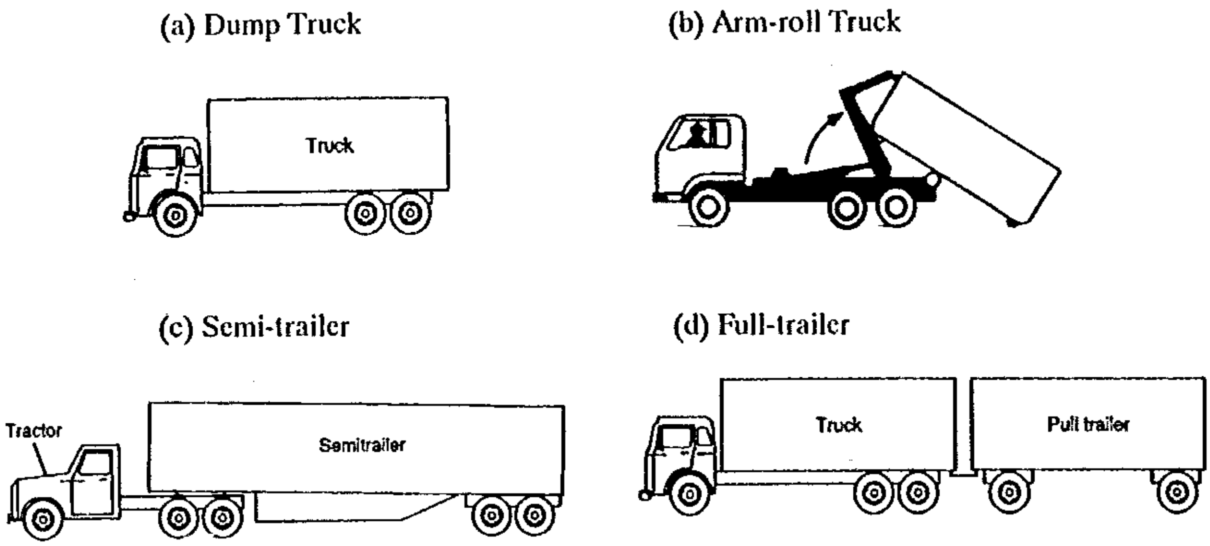
The transfer system consists of (1) secondary transport vehicles and (2) a transfer station. Since feasible types of transfer stations depend much on type of secondary transport vehicles, options of the secondary transport vehicles are studied first, and then options of transfer system will be examined.

8.3.1 Vehicle Options

Large dump truck is the most economical and recommendable. Description of vehicle options, evaluation criteria, and results are shown below.

(1) Vehicle Options

There are four vehicle options to be considered for the secondary transport: (a) dump trucks, (b) arm-roll trucks, (c) semi-trailers and (d) full-trailers as shown in the following figure.



Vehicle Options for the Secondary Transport

A dump truck is a common vehicle used for transporting especially construction materials. Dump trucks are mass-produced, and their purchase price is the cheapest among the 4 options.

According to the Vietnamese road regulations applicable to the National Road No 2 and No 3, which will be used as route from Dong Ngac to Nam Son, the maximum load per axle is 8.2 ton. A standard large dump truck has 3 axles, and the maximum GVW (gross vehicle weight) is 25 ton. Weight of a large dump truck proposed by the JICA Study Team is 14 ton, and therefore the maximum load of solid waste is 11 ton (25 ton – 14 ton = 11 ton).

(b) Arm-roll truck

Arm-roll trucks use a detachable container as a body. Operation is easy, and therefore commonly used as waste transport equipment. Maximum waste load is also 11 ton. Since the standard arm roll truck has 3 axles, the maximum GVW will be same as that of the large dump truck.

(c) Semi-trailer

A semi-trailer combines a tractor with a semi-trailer. Its operation is easier than a full-trailer. An operator can manipulate waste dumping operation in the driving seat. Maximum waste load is 17 ton. A semi-trailer has five axles.

(d) Full-trailer

A full-trailer consists of a tractor with body (front part) and a pull trailer (rear part). Maximum waste load is 18 ton. A full trailer has 5 axle. It is possible to transport a small quantity of waste with only a tractor without a pull trailer. The full-trailer has the following operational disadvantage:

a) A pull trailer has to be detached when waste is dumped from the bodies of a tractor.
b) Making a turn requires large area as its turning radius is long (12m). In addition, when turning, full-trailers may be swung, which could be dangerous.

Waste load of each vehicle option and number of required units are shown in the following table.

Vehicle Weight and Load Weight of Vehicle Options

Unit: ton

	Dump Truck	Arm-roll Truck	Semi-trailer	Full-trailer
1. Weight of a vehicle	14	14	18	16
2. Maximum load of waste	11	11	17	18
3. Total (1 + 2)	25	25	35	34

(2) Evaluation Criteria

Relevant criteria for the evaluation of the vehicle options are:

a) Cost of secondary transport associated with option
b) Operational and safety aspects
c) Compliance with road conditions

(3) Conclusion

Among the four vehicle options, dump truck is considered the best based on this evaluation criteria. Dump truck is the most economical among the options. In terms of operational and safety aspect as well as the compliance with the road conditions, both dump truck and arm truck are also better than the other vehicles options. Arm roll truck is the worst option in terms of cost. Therefore, dump truck is the considered the best. Results of evaluation from respective criterion are shown below.

(4) Cost

In terms of cost, dump truck is of the lowest cost (cost index: 100), the second is the full trailer (106), the third is semi-trailer (115), the fourth is arm roll truck

(137). In the cost comparison, costs related to procurement, operation and maintenance of the secondary transport vehicles were compared. Costs of facilities and equipment commonly applied to all four options such as site development and construction costs are excluded. Detailed cost comparison is shown in Table 8.3.1.

(5) Operation and Safety

In terms of operation and safety, both dump truck and arm roll truck are considered more advantageous than semi-trailer and full trailer. Main evaluation criteria are 1) safety and easiness of driving, 2) easiness of waste discharge operation, 3) adverse impacts on traffic and roads, and 4) air pollution with emission.

In terms of operation and safety, the vehicle options are graded as follows: dump truck (7.5), arm roll truck (7.5), semi trailer (5.0), and full trailer (1.5). From the operation and safety point of view, full trailer is the worst though it is the second most economical type. Table 8.3.2 for detailed evaluation.

(6) Compliance with the Existing Road Conditions

At present, there are no routes from Dong Ngac to Nam Son that legally accommodate secondary transport vehicle of 25 ton GVW in terms of the bearing capacity. Some roads and bridges on the route need to be upgraded. Obviously, the cost of upgrading for accommodating the secondary transport vehicles of 25 ton GVW is much lower than the cost required for 35 ton GVW vehicles. Therefore, the secondary transport vehicles of 25 GVW is more economical than those of 35 ton GVW considering the road conditions.

Conditions of the existing roads and needs for the upgrading are discussed in Section 8.4.

8.3.2 Transfer Station

(1) Description of Options

The types of transfer stations can be classified into two: non-compaction and compaction. Each option has sub-options. Each sub-option is described below, and illustrated in Figure 8.3.2.

<u>A. Non-compaction types</u>

The non-compaction types have the following options: (a) plane system, (b) storage-load system, and (c) direct load system. For the plane system (a) and storage load system (b), dump truck should be used as secondary transport vehicle as it is more economical than the arm-roll truck. For the direct load system (c), arm-roll truck has to be used as the dump truck is not compatible.

1. Plane system (A1 type) (Indirect load)

   The waste collected by the primary transport vehicles is dumped on a plane concrete-paved yard, and then it is loaded in the dump truck by means of bucket loaders (wheel loaders).

2. Storage-load system (A2 type) (Mainly indirect load, but direct load is also possible)

   A feature of A2 system is that the system allows both direct and indirect loading. The primary transport vehicles go up to an elevated platform where waste is unloaded, then a wheel loader pushes waste to a dumping hole in the platform, from which waste falls into an open-top dump truck parked below the hole. Alternatively, it is possible for a primary transport vehicle to dump waste directly into a dump truck through a hole. There will be about 6 holes in the platform, 2-3 out of the 6 holes will be designed to allow the direct unloading.

3. Direct-load system (A3 type)

   The primary transport vehicle go up to an elevated platform and waste is discharged directly into secondary transport vehicle (arm-roll truck) through a hopper. Direct load system requires many containers in order to receive waste directly from primary transport trucks.

B. Compaction types

For the compaction systems, arm-roll truck will be used as secondary transport vehicle as the dump truck is incompatible with the compaction system.

4. Storage-load system (B1 type) (Indirect load)

   The primary transport vehicles go up to an elevated platform and waste is unloaded onto the platform, then waste is pushed into a hopper by a wheel loader. The compacting machine installed under the hopper packs the waste into the secondary transport vehicle.

5. Direct load system (B2 type)

   The primary transport vehicle goes up to an elevated platform and unload the waste directly into a hopper. The compacting machine installed under the hopper packs the waste into the secondary transport vehicle.

(2) Evaluation Criteria

Relevant criteria for evaluation of the transfer system options are:

a) cost
b) operational and environmental aspects

(3) Conclusion

Option A2 (Non compaction storage load system) is the most economical and the most recommendable. Evaluation of the options from each criterion is shown below.

Explanation: Option A1 (non compaction plane system) is almost as economical as Option A2. However, A2 has a serious operational disadvantage, i.e., loading into the secondary transport vehicles are rather difficult because the waste has to be lifted by wheel loaders from the ground to the top of the secondary transport vehicle with 3.6 m height. Options with compaction system is much more costly than the options without compaction. Options with direct waste loading is more costly than the options with indirect loading (storage type) because arm roll trucks and many detachable containers have to be used instead of economical dump trucks.

(4) Cost Evaluation

Costs are calculated for each system option with the capacity of transferring 1,600 ton/day of waste. Estimated costs include all investment in the equipment and facilities, cost of land acquisition, and operation/maintenance. It is assumed that all waste will be transferred to one transfer station in Dong Ngac.

As shown in the following table, both Option A2 (non-compaction storage load system) and Option A1 (non-compaction plane system of indirect load) are the least cost options. Option 1 only very slightly higher than A2. Unit costs of Options A1 and A2 are $3.05/ton and $3.06, respectively.

Option 3 (Non-compaction direct load system) is the third option. Its unit cost is $3.77/ton. The compaction systems, both B1 (compaction storage-load system) and B2 (compaction direct load system), are much more costly than the non-compaction systems. Unit costs of B1 and B2 are $5.19/ton and $6.66/ton, respectively. In terms of cost, A1 and A2 options are recommended. Detailed cost comparison between the options are shown in Table 8.3.3.

(5) Evaluation of Operational and Environmental Aspects

1) Evaluation aspects

The important operational aspects to be evaluated are as follows:

a) Non-possibility of causing troubles to compactor machine
b) Odor to local residents
c) Compatibility with waste quality of Hanoi
d) Ease of waste loading into secondary transport vehicles
e) Easiness of facility maintenance
f) Easiness of keeping the site clean

Each option of the transfer system is evaluated and graded in terms of each criterion. Judging from the importance of each criterion, certain points are assigned for each level of grade as noted in Table 8.3.4

2) Conclusion

In terms of operation and environment, the options are ranked as follows: A3 (16 points), A2 (13 points), A1 (10 points), B2 (9 points), and B1 (4 points).

3) Evaluation of each option from operation and environmental aspect

(a) Non-possibility of causing troubles to compactor machine

In view of the high bulk density of Hanoi waste, the compaction system is not effective. In addition, bricks and stones contained in the waste may cause troubles to the compactor.

(b) Odor to local residents

Compaction of direct load system is the best in terms of odor.

(c) Compatibility with waste quality in Hanoi

As explained later, compaction system is not effective for solid waste of Hanoi because the bulk density of the waste is too high.

(d) Ease of waste loading into secondary vehicles

In case of Option A1, waste loading operation is rather difficult because a wheel loader operator has to lift waste from ground floor to the secondary transport vehicle that is 3.6 meter high.

(e) Easiness of facility maintenance

Non-compaction systems are less mechanical and simpler, and therefore easier for maintenance.

(f) Easiness of keeping the site clean

Direct-load system (A3 and B2) are superior to other systems in terms of cleanliness because waste is directly transferred to the secondary transport vehicles, and the floor can be kept clean.

Technical comments on compaction system

1. In general, a compactor can press waste until bulk density become 0.5~0.6 ton/m^3. The bulk density of the current Hanoi waste is 0.385 ton/m^3 (present level). Therefore, the compaction ratios of a compactor for Hanoi waste would range 1.3~1.6. In the future, assuming 0.35 ton/m^3, compaction ratios will be 1.4 ~ 1.7.

2. Assuming an average compaction ratio is 1.6 in future, waste of 10m^3 can be reduced to 6.25 m^3 (10m^3/1.6=6.25m^3). When loading waste into trailers without compaction system, waste is also compacted naturally by its own weight. In the non-compaction options, a worker should move loaded waste in the secondary transport vehicle to level waste. This action will help to increase the bulk density of waste in the secondary transport vehicle. Consequently, even under the non-compaction system, the bulk density will increase by about 20% at least. Waste volume of 10m^3 can be reduced to 8.33m^3 (10m^3/1.2=8.33) without a mechanical compaction system. The difference is only about 2 m^3. (8.33 m^3 – 6.25 m^3 = 2.08 m^3)

3. Hanoi waste contains much sand and ash of briquets used and burned in kitchen (20~45% on weight base). It also contains bricks and stones (about 4~9%). These materials are very unsuitable for compaction, and may cause problems to the compaction equipment from time to time. Dry ash, if entered into cylinder of compactor, may damage the cylinder.

4. Thus, compaction system is not suitable for Hanoi waste from both economic and operational point view.

5. In general, the lower the bulk density of waste, more feasible the compaction system is. It is advised that HPC should examine the feasibility of introducing compaction system when the bulk density is lowered to 0.25 in future from the current 0.385.

6. In general, the bulk density decreases as the life standard rises. The higher the standard of life, the more package materials used. Dominant part of Japanese urban solid waste is package waste. Use of more packages will cause the bulk density of waste to decrease. Bulk density of typical Japanese urban solid waste is 0.2 or less.

7. Future Hanoi Waste Quality in Case the Citizens Do not Use Briquet

   Hanoi people commonly use briquet in the kitchen as fuel. Non-use of briquet will help in lowering the bulk density of waste. Based on the waste composition analysis conducted by the JICA Study Team, and on certain assumptions, it is projected that the bulk density of Hanoi waste will be 0.29

instead of the current average of 0.385 if the Hanoi citizens do not use briquets. As mentioned above, a compaction system is suitable for solid waste that has bulk density of 0.25 or less. This implies that a compaction system would not be feasible for Hanoi waste even if the citizens stops using briquets now.

Table 8.3.1 Cost Comparison by Types of Secondary Transport Vehicles (Non-Compaction System)

(Dollars indiated are US$ of the beginning of 1999)

ITEM		Dump Truck	Arm-roll Truck	Semi-trailer	Full-trailer
1 System description		Non-Compaction Storage-load System (Direct loading & indirect loading with wheel loader)	Same as left	Same as left	Same as left
2 Design criteria					
2.1 waste weight/day (ton)		1,600 ton	1,600 ton	1,600 ton	1,600 ton
2.2 waste volume/day (cum)		4,571 cum	4,571 cum	4,571 cum	4,571 cum
2.3 Specific density (ton/cum)		0.35 ton/cu	0.35 ton/cu	0.35 ton/cu	0.35 ton/cum
2.4 Operation hour (hour)		16 hours	16 hours	16 hours	16 hours
2.5 Hour/1round trip to landfill		3.0 hours	3.0 hours	3.0 hours	3.0 hours
2.6 Roudtrip lenetly		75.2 km	75.2 km	75.2 km	75.2 km
2.7 Compaction ratio		1.2	1.2	1.2	1.2
2.8 Volume per vehicle		26 cum	26 cum	40 cum	43 cum
2.9 Payload per vehicle		11 ton	11 ton	17 ton	18 ton
2.10 Nos. of trip/day/vehicle		4 trip/ve	4 trip/ve	4 trip/ve	4 trip/veh
3 Equipment (include 20 % spare)					
3.1 Dumpt truck		44 unit	0 unit	0 unit	0 unit
3.2 Arm-roll truck		0 unit	44 unit	0 unit	0 unit
3.3 Semi-trailer		0 units	0 units	29 units	0 units
3.4 Full trailer		0 unit	0 unit	0 unit	27 unit
4 Equipment (include 20% spare)					
4.1 Dump truck	$83,000 /unit	$3,652,000	$0	$0	$0
4.2 Arm-roll truck	$130,000 /unit	$0	$5,720,000	$0	$0
4.3 Semi-trailer	$170,000 /unit	$0	$0	$4,930,000	$0
4.4 Full trailer	$167,000 /unit	$0	$0	$0	$4,509,000
5 Numbers of staffs					
5.1 Driver		88 persons	88 persons	58 persons	54 persons
5.2 Maintenance crew		4 persons	4 persons	3 persons	3 persons
5.3 Total		92 persons	92 persons	61 persons	57 persons
6 Required power					
6.1 Fuel consumption per km		0.25 km	0.25 km	0.3 km	0.3 km
7 Running cost per year					
7.1 Salary	$75.00 /man	$6,930 /year	$6,930 /year	$4,568 /year	$4,253 /year
7.2 Fuel	$0.26 /liter	$276,073 /year	$276,073 /year	$214,362 /year	$202,453 /year
7.3 Vehicle maintenance cost(% to initial cost)	5.0%	$182,600 /year	$286,000 /year	$246,500 /year	$225,450 /year
7.4 Sub Total		$465,603 /year	$569,003 /year	$465,430 /year	$432,156 /year
8 Useful Period					
8.1 Secondary transport vehicles	10 years				
9 Annual cost					
9.1 Amortization of Secondary transport vehicles		$365,200	$572,000	$493,000	$450,900
9.2 Running cost		$465,603	$569,003	$465,430	$432,156
9.3 Total		$830,803	$1,141,003	$958,430	$883,056
10 Cost per ton per day		1.42 /ton	1.95 /ton	1.64 /ton	1.51 /ton
11 Cost Index		100	137	115	106

Table 8.3.2 Comparison of Operational and Safety Aspects of Vehicle Options

	Dump truck	Arm-roll truck	Semi-trailer	Full-trailer
Size Length Width Height	 11.2 m 2.5 m 3.6 m	 11.2 m 2.5 m 3.6 m	 13.4 m 2.5 m 3.9 m	 16 m 2.5 m 3.8 m
Length of minimum revolving radius	7 m	7 m	9 m	12 m
1. Safety and easiness of driving	A Relatively easy	A relatively easy	B Not difficult.	C Difficult. Trailer may swing when turning at a high speed
2. Easiness of waste discharge operation	A Easy : Driver can unload waste from driver seat	A Easy : Driver can unload waste from driver seat	A Easy : Driver can unload waste from driver seat	C Takes a longer time : after unload trailer, Driver has to disconnect trailer to unload waste
3. Adverse impact on traffic (other cars)	A Length is 9.5m	A Length is 9.5m	B Length is 13.4m	C Length is 16m
4. Adverse impacts on roads	B GCW is 24 ton	B GCW is 24 ton	C GCW is 35 ton	C GCW is 34 ton
5. Air pollution with emission	C Much emission as many trucks (24) are needed	C Much emission as many trucks (24) are needed	B Less emission. Number of trucks is 14.	B Less emission. Number of trucks is 13.
6. Adjustment of load capacity	B Loading capacity is unchangeable	B Loading capacity is unchangeable	B Loading capacity is unchangeable	A Loading capacity is changeable by disconnecting trailer
7. Score	7.5	7.5	5.0	1.5

Note: The total scores are calculated with the following assignment of points:

Grade	Points For Criteria 1 - 4	Points For Criteria 5 & 6
A	2	1
B	1	0.5
C	0	0

Table 8.3.3 Comparison of Transfer System Options (25 ton GVW 4 Trips)

(Dollars indicated are US$ of the beginning of 1999)

ITEM	Unit Cost	TYPE A1 Non-Compaction Plane System (Indirect loading)	TYPE A2 Non-Compaction Storage-load System (Direct loading is possible)	TYPE A3 Non-Compaction Direct-load System	TYPE B1 Compaction Storage-load System (Indirect loading)	TYPE B2 Compaction Direct-load System
1 System description						
1.1 Loading method		Wheel loader	Wheel loader & direct load	Direct-Load	Wheel loader and Stationary compacto	Hopper-Feeder and Stationary compactor
1.2 Transportation vehicles		Dump Truck	Dump Truck	Arm-roll Truck	Arm-roll Truck	Arm-roll Truck
2 Design criteria						
2.1 waste weight/day (ton)		1,600 ton	1,600 ton	1,600 ton	1,600 ton	1,600 ton
2.2 waste volume/day (cum)		4,571 cum	4,571 cum	4,571 cum	4,571 cum	4,571 cum
2.3 Specific density (ton/cum)		0.35 ton/cu	0.35 ton/cu	0.35 ton/cu	0.35 ton/cu	0.35 ton/cum
2.4 Operation hour (hour)		15 hours	15 hours	15 hours	15 hours	15 hours
2.5 Hour/1round trip to landfill		3.0 hours	3.0 hours	3.0 hours	3.0 hours	3.0 hours
2.6 Roundtrip distance		80.0 km	80.0 km	80.0 km	80.0 km	80.0 km
2.7 Compaction ratio		1.2	1.2	1.2	1.5	1.5
2.8 Volume per vehicle		26 cum	26 cum	26 cum	21 cum	21 cum
2.9 Payload per vehicle		11 ton	11 ton	11 ton	11 ton	11 ton
2.10 Nos. of trip/day/vehicle		4 trip/ve	4 trip/ve	4 trip/ve	4 trip/ve	4 trip/veh
3 Equipment & Facility for 10 years except for Items 3.5 & 3.6						
3.1 Transfer station (structure & facilities)		1 lot	1 lot	1 lot	1 lot	1 lot
3.2 Transfer station (logistics)		1 lot	1 lot	1 lot	1 lot	1 lot
3.3 Compactor & Associated equip		0 unit	6 unit	6 unit	1 unit	3 unit
3.4 Hopper		0 unit	6 unit	6 units	1 unit	3 unit
3.5 Dump Truck (include. Spare units 20%)		44 units	44 units	0 units	0 units	0 units
3.6 Arm-roll truck (include. Spare units 20%)		0 unit	0 unit	44 unit	44 unit	44 unit
3.7 Container (11 ton)(include Spare units 20%)		0 unit	0 unit	93 unit	0 unit	0 unit
3.8 Container for compaction (11 ton)(include spare units 20%)		0 unit	0 unit	0 unit	44 unit	93 unit
3.9 Wheel loader		6 units	3 units	0 units	5 units	0 units
3.10 Tank Lorry		1 units	1 units	1 units	1 units	1 units
3.11 Weigh bridge		2 units	2 units	2 units	2 units	2 units
3.12 Work shop		1 lot	1 lot	1 lot	1 lot	1 lot
4 Equipment & Facility Expenditure for 10 years						
4.1 Transfer station (direct cost of construction)	$33 /sqm	$3,340,000	$4,340,000	$4,840,000	$5,340,000	$5,340,000
4.2 Transfer station (indirect cost of construction)	$200 /sqm	$1,450,000	$1,450,000	$1,450,000	$1,450,000	$1,450,000
4.3 Compactor & Associated equip	$3,200,000 /unit	$0	$0	$0	$3,200,000	$9,600,000
4.4 Hopper	$22,000 /unit	$0	$132,000	$132,000	$22,000	$66,000
4.5 Dump Truck (11 ton)	$91,000 /unit	$4,004,000	$4,004,000	$0	$0	$0
4.6 Arm-roll truck	$127,000 /unit	$0	$0	$5,588,000	$5,588,000	$5,588,000
4.7 Container (11 ton)	$14,000 /unit	$0	$0	$1,302,000	$0	$0
4.8 Container for compaction (11 ton)	$64,000 /unit	$0	$0	$0	$2,816,000	$5,952,000
4.9 Wheel loader	$182,000 /unit	$1,092,000	$546,000	$0	$910,000	$0
4.10 Weigh bridge	$33,000 /lot	$66,000	$66,000	$66,000	$66,000	$66,000
4.11 Work shop	$200,000 /unit	$200,000	$200,000	$200,000	$200,000	$200,000
4.11 Tank Lorry	$210,000 /unit	$210,000	$210,000	$210,000	$210,000	$210,000
4.12 Engineering & Supervision	/unit	$611,720	$714,000	$910,800	$1,218,280	$1,907,200
4.13 Access road construction	$200,000 /unit	$200,000	$200,000	$200,000	$200,000	$200,000
4.15 Land acquisition	$400,000 /unit	$400,000	$400,000	$400,000	$400,000	$400,000
4.16 Sub Total		$11,573,720	$12,262,000	$15,198,800	$21,620,260	$28,472,000
4.18 Contingency	10%	$1,157,372	$1,226,200	$1,519,880	$2,162,028	$2,847,200
4.19 Total Investment		$12,731,092	$13,488,200	$16,718,680	$23,782,308	$31,319,200
5 Numbers of staffs						
5.1 Manager & engineer		4 person	4 persons	4 person	5 persons	5 persons
5.2 Office Clerk		6 person	6 persons	6 person	6 persons	6 persons
5.3 Plant operation		26 person	24 persons	14 person	24 persons	14 persons
5.4 Driver		114 person	96 persons	90 person	100 persons	90 persons
5.5 Maintenance		8 person	8 persons	8 person	8 persons	8 persons
5.6 Guardmen		3 person	3 persons	3 person	3 persons	3 persons
6 Required power						
6.1 Electricity Building	0.4 kW/t	640 kW	640 kW	640 kW	640 kW	640 kW
6.2 Electricity Equipment	80 kW/un	0 kW	480 kW	480 kW	80 kW	240 kW
6.3 Electricity Total		640 kW	1,120 kW	1,120 kW	720 kW	880 kW
6.4 Water	0.01 m3/t	16 m3	16 m3	16 m3	16 m3	16 m3
6.5 Fuel mileage	4 km litter	0.25 l/km	0.25 l/km	0.25 l/km	0.25 l/km	0.25 l/km
7 Running cost per year						
7.1 Electricity	$0.40 /kWh	$9,729 /year	$19,459 /year	$19,459 /year	$11,383 /year	$14,594 /year
7.2 Water	$2.50 /cum	$14,600 /year	$14,600 /year	$14,600 /year	$14,600 /year	$14,600 /year
7.3 Salary Manager	$166.67 /man	$8,000 /year	$8,000 /year	$8,000 /year	$10,000 /year	$10,000 /year
7.4 Salary Staff	$75.00 /man	$141,300 /year	$123,300 /year	$108,900 /year	$126,900 /year	$108,900 /year
7.5 Fuel for vehicles	$0.26 /liter	$276,073 /year	$276,073 /year	$276,073 /year	$276,073 /year	$276,073 /year
7.6 Maintenance cost for vehicles	5.0% /initia	$265,300 /year	$238,000 /year	$355,000 /year	$476,200 /year	$587,500 /year
7.7 Maintenance cost for structure& faciliteis	1.5% /initia	$54,090 /year	$71,070 /year	$78,570 /year	$84,420 /year	$85,080 /year
7.8 Sub Total		$769,092 /year	$750,502 /year	$860,602 /year	$999,576 /year	$1,096,747 /year
7.9 Contingency	10%	¥76,909	¥75,050	¥86,060	¥99,958	¥109,675
7.1o Total (7.8 + 7.9)		$846,001	$825,552	$946,662	$1,099,534	$1,206,422
8 Total expenditures for 10 years [Item 4.19 + (Item7.10 x 10 years)]		21,191,106	21,743,718	26,185,298	34,777,646	43,383,416
9 Expenditures Not Depreciated during the first 10 years		3,329,250	3,904,250	4,191,750	4,479,250	4,479,250
10 Project Cost for 10 years (8 - 9)		$17,861,856	$17,839,468	$21,993,548	$30,298,396	$38,904,166
11 Cost per ton per day		3.06 /ton	3.05 /ton	3.77 /ton	5.19 /ton	6.66 /ton
12 Cost Index		100.1	100	123.3	169.8	218.1

Table 8.3.4 Evaluation of Operational and Environmental Aspects

Evaluation Criteria	Option A1 Plane System	Option A2 Non-Compac-tion Storage load System	Option A3 Non-Compac-tion Direct Load System	Option B1 Compac-tion Storage-load System	Option B2 Compac-tion Direct Load System
1. Non-possibility of causing troubles to compactor machine	A (4)	A (4)	A (4)	C (0)	C (0)
2. Odor to local residents	C (0)	C (0)	B (2)	C (0)	A (4)
3. Compatibility with waste quality of Hanoi	A (4)	A (4)	A (4)	C (0)	C (0)
4. Ease of waste loading into the secondary transport vehicles	C (0)	A (2)	A (2)	A (2)	A (2)
5. Easiness of facility maintenance	A (2)	A (2)	A (2)	B (1)	B (1)
6. Easiness of keeping the site clean	C (0)	B (1)	A (2)	B (1)	A (2)
7. Total	10	13	16	4	9

Notes: 1) Total scores are calculated with the following assignment of points:

For Criteria 1, 2 and 3	For Criteria 4, 5, 6
A : 4 points	A: 2 points
B : 2 points	B: 1 point
C : 0 point	C: 0 point

2) Option A1 is evaluated as B in Criteria item 3 because of the difficulty of loading waste with wheel loaders from the floor to the high secondary vehicles.

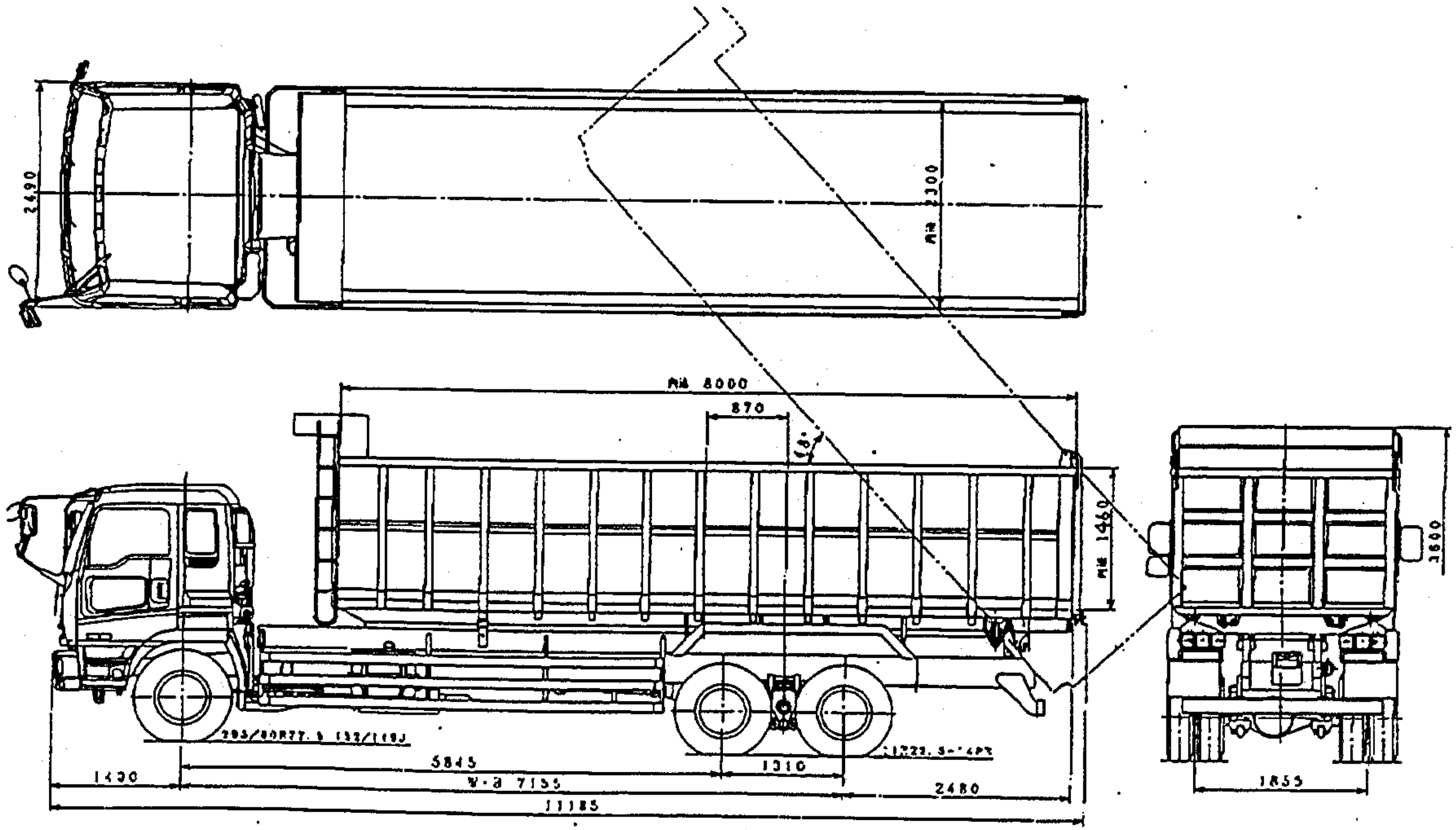


Fig.8.3.1 Dimensions of Recommended Option of Secondary Transport Vehicle (Large Dump Truck)

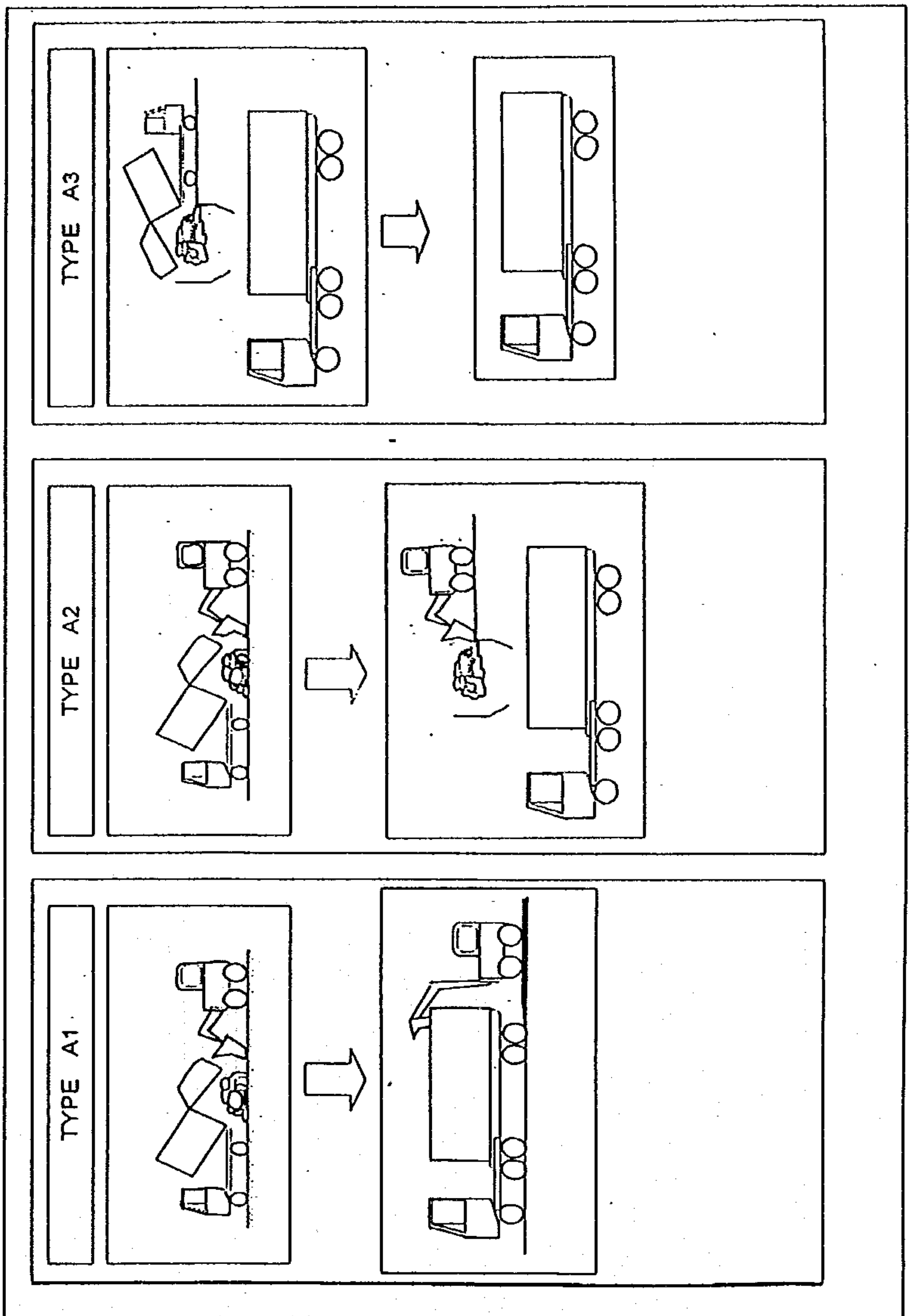


Fig 8.3.2 | The Options for the Transfer Station System (1/2)

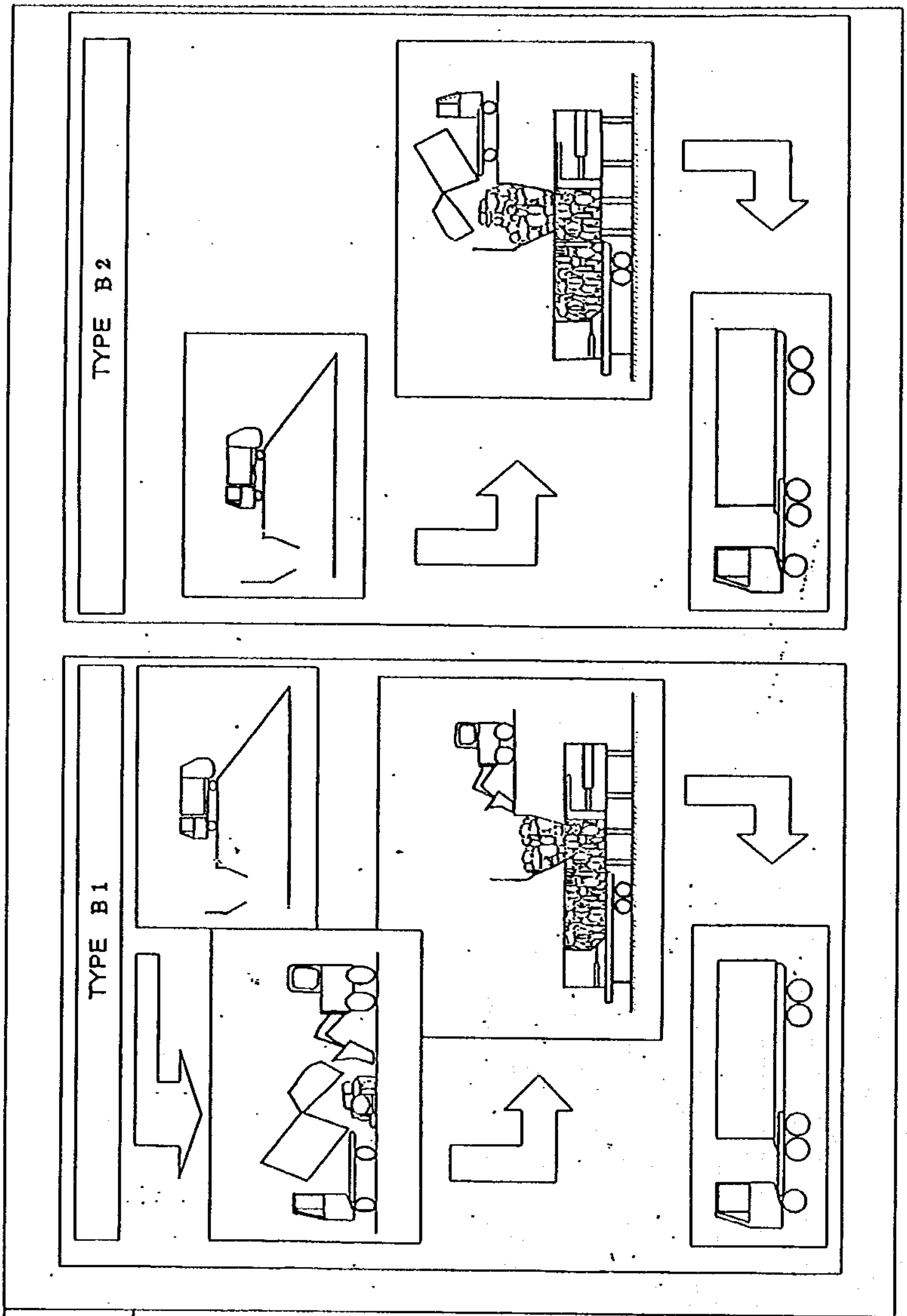


Fig.8.3.3	The Options for the Transfer Station System (Continued) (2/2)