

f.4 Monitoring Borehole

To confirm whether leachate has contaminated groundwater resources, monitoring wells 30m deep with a diameter of 100mm will be installed in the site

g. Personnel and Heavy Vehicle Plan

The following personnel and heavy vehicle are required to operate the sanitary landfill.

Table 8-31: Personnel and Heavy Vehicle Plan in Sofulu

Personnel and heavy vehicle	Number	
<u>Personnel</u>		
Site Manager	1 person	(2002-2005)
Waste controller	1 person	(2002-2005)
Operator	5 person	(2002-2005)
Driver	3 person	(2002-2005)
Worker	2 person	(2002-2005)
Security guard	2 person	(2002-2005)
Total	14	(2002-2005)
<u>heavy vehicle</u>		
Bulldozer(230HP)	3Unit	(2002-2005)
Excavator(99HP)	1Unit	(2002-2005)
Dump truck(8m ³)	3Unit	(2002-2005)
Water truck	1Unit	(2002-2005)
Total	8unit	(2002-2005)

g.1 A Site Manager

Who has overall financial responsibilities and management duties, i.e.,

- Management and supervision of landfill operation, maintenance of landfill equipment, and performance of control procedures, e.g., registration of incoming waste and control of the groundwater.
- Planning of the future extensions of the landfill, i.e., the construction of further landfill sections and preparation of new excavation areas for soil coverage.

g.2 Waste Controller

Who undertakes the task of controlling the incoming waste by using the weighbridge system.

g.3 Heavy Vehicle Operator and Truck Drivers

For the operation of the sanitary landfill, one bulldozer for smoothing and compacting waste, one excavator for digging the daily cover soil, one or two tipper truck for transporting covering soil will be required. And one operator for a Bulldozer for medical waste shall operate water tanker also. Therefore, 3operators and 1 or 2 drivers are required.

g.4 Worker

To generally perform auxiliary functions.

g.5 Security Guards

responsible for the security of the disposal site.

h. Ultimate Landuse Plan

After completion of phase 3 landfill, 1m thick final earth cover will be executed. Ultimate landuse for a completed landfill will be for a green park or a recreation area.

8.6 Design of a Medical Waste Disposal Site

a. Fundamental Issues

a.1 Target Wastes

Target waste to be disposed at medical waste Disposal site is defined as shown in Table 8-32, according to the regulation on control of medical wastes.

Table 8-32: Target Wastes to be Disposed at Medical Waste Disposal Site in Sofulu

Type	Target	Definition
medical	yes	pathological or nonpathological, infected, chemical and pharmaceutical wastes, laceration and piercing materials and compressed containers
infected	yes	all sorts of human tissues and organs, urine containers, blood or placenta contaminated waste bacteria cultures, infectious diseases ward and emergency ward wastes, bacteria and virus retaining air filters, feces and feces-contaminated articles corpses of biological research animals and wastes of quarantined patients of likely to be contaminated by disease agents(collection after sterilisation)
pathogenic	yes	waste bearing pathogenic factors(collection after sterilisation)
Pathological	yes	organs, parts of body, animal corpses, blood and other body fluid, pathogenic or bearing the risk of pathogenicity. Pathogenic waste is defined as waste bearing pathogenic factors.
Radio-active waste	no	Disposal in accordance with statute(2690.9.7.1982)
safe chemicals	no	irrecoverable waste(through municipal collection) liquid waste(by water pollution control regulation)
dangerous chemicals	no	(1)recoverable dangerous waste and expired medicines(individual collection with care to eliminate undesirable reactions. (2) Mercury (separate collection) (3)shock-sensitive substances and materials reacting or readily reactional with water(separately destroy with attention to noxious effects)
waste of domestic nature	no	uninfected kitchen waste garden waste, office package materials bottles and like

a.2 Location of the Medical Waste Disposal Site

As shown in Figure 8-27, a medical waste disposal site will be constructed at the eastern centre of the proposed Sofulu disposal site. The reasons are:

- The site needs to be isolated from the view of the population.
- The site is far from working area for municipal waste Disposal site.
- Availability of cover soil more than necessary
- The operation of the medical waste disposal site shall be separately conducted from municipal waste disposal from now to the termination of the Sofulu final disposal site. This location makes it possible, for instance, in all phases of the landfill operation the access to the site can be possible.

The proposed location allows closed landfill operation, especially in terms of the leachate treatment.

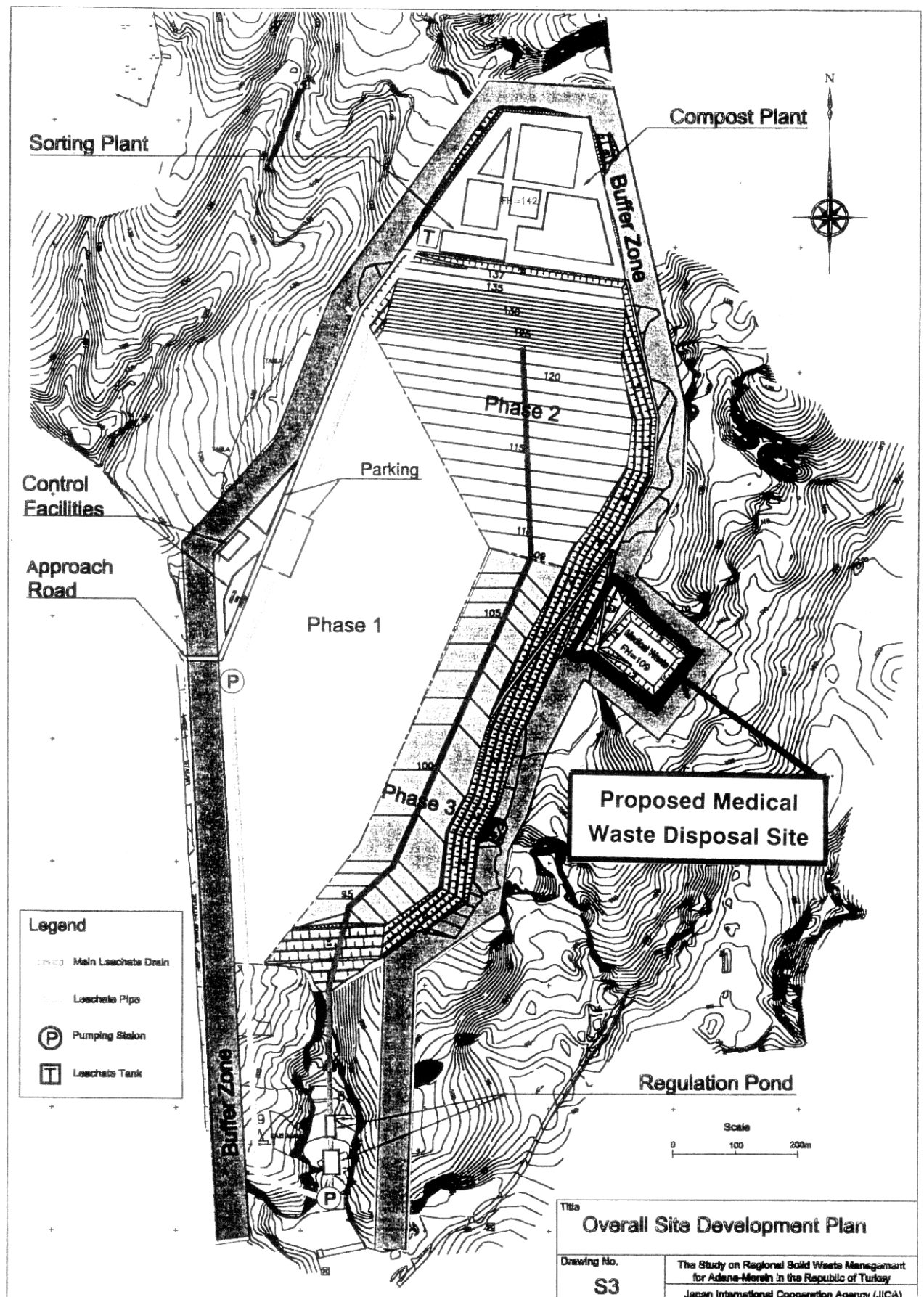


Figure 8-27: Proposed Medical Waste Disposal Site in Sofulu

a.3 Life Span of the Medical Waste Disposal Site

Since the medical waste disposal site is located in the same site of the municipal solid waste(MSW) disposal site. The life span of the medical waste disposal site should be determined equal to that of MSW disposal site. According to the estimate of the MSW generation amount including required cover soil, Sofulu disposal site will be full in 2009. Therefore medical disposal site shall be designed to reach life span in the same year 2009. AGM will need to construct a new landfill site after 2010.

a.4 One Phase Construction of Medical Disposal Site

Although Sofulu disposal site will be developed in 3 phases, medical waste disposal site is developed in one phase. The reasons are as follows :

- Medical waste disposal amount is too small comparing with the municipal waste.
- Phased medical waste disposal site development will require more area than one phase development landfill.

b. Design of the Medical Waste Disposal Site

b.1 Design Standard

The Design standard to be followed is mainly the Regulation on Control of Medical Wastes except the distance to the residential area, which may not be less than 3,000 meters.

b.2 Preliminary Design of Medical Waste Final Disposal Site

b.2.1 Basic Concept of Preliminary Design

Basic concept of preliminary design of medical waste disposal site in Sofulu is summarised as shown in Table 8-33.

Table 8-33: Basic Concept of Preliminary Design of Medical Waste Final Disposal Site in Sofulu

Item	Sub-Item	During Operation
(1) Landfill planning	basic idea	- open dumping to sanitary landfill(Sofulu) - from trench method to sanitary landfill
(2) Landfill Implementation	landfill method	- cover soil immediately after dumping of medical waste - landfill division by divider(1 year / divider) - cover soil from quarry site in landfill site
	final disposal foundation	article 34 of design standard(see Table 8-37)
	Disposal site floor	article 35 of design standard(see Table 8-38)
	drainage system	article 36 of design standard(see Table 8-39)
	deposition of waste	article 37 of design standard(see Table 8-39)
	top cover	article 38 of design standard(see Table 8-39)
	gas removal	Every 50 meters(vertically and horizontally)
	vegetation of disposal site	article 39 of design standard(see Table 8-32)
(3) Leachate	system	-circulation system -gravity fall from slope surface(every 30 m)
(4)rain water	drainage system	-individual collection and direct discharge

Item	Sub-Item	During Operation
(5)Monitoring	hauled waste	-weighing at the entrance of Sofulu site -visual observation of truck, quantity and quality of waste -visual observation after unloading of medical waste -record and report to Municipality every month
	Leachate	-quantities and qualities of leachate -Report of quantities and qualities to MoE -cancellation of circulation system after closure of the landfill site
	Discharge	-report to MoE
	underground water	- installation of monitoring well at 3 points for each sites - monitoring before starting landfill - monitoring during operation: - 10 years monitoring after closure of landfill site
	Gas removal	-during landfill and 10 years after closure of landfill site(every 50 meters vertically and horizontally)
	Security of landfill site	fence and gate at the entrance
(5)Slope	gradient	Cut part : 1:2 embankment part: 1:3
	berm width	2 meters
	vertical interval of berm	5 meters
(6) road planning	maintenance road	-8 m width, asphalt paved,
	onsite road	-4 m width, crushed stone paved

b.2.2 Outline of the Medical Waste Final Disposal Site

Outline of the Medical Waste Final Disposal Site is shown in Table 8-21

Table 8-34: Outline of the Medical Waste Final Disposal Site in Sofulu

Items	Description	
Land Area	Total Area	:3ha
Landfill Volume	<u>Capacity</u> 48,000m ³	<u>Disposal Period</u> 2002-2009
Road	Access road(Asphalt paved) Operation road	:width4.0m,lenght235m
Leachate control facility	Leachate collection pipe 100mm Main leachate drain 200mm Pumping station Pump Leachate pipe 200mm Leachate Pit	:445m :120m :1 set :2set :200m :1set
Drain for runoff water	Open concrete drain Pipe drain for rain fall	:235m :120m
Environmental protection facilities	Fence Gas removal facility(Vertical) Gas removal facility(Horizon)	:400m :27m :445m

Purpose of the facilities and details of the planning are as follows.

b.2.3 Volume of Medical Waste Final Disposal Site

Volume of Medical Waste Final Disposal Site shall be decided based on the medical waste amount generated from year 2002 till 2009. Medical waste amount generated and final disposal amount are shown in Table 8-22.

Table 8-35: Final Disposal Amount in Sofulu of Medical Waste in Sofulu

Item	unit	formula	2002	2003	2004	2005	2006	2007	2008	2009
Waste discharge amount	ton/day	a	5.2	5.5	5.8	6.2	6.5	6.8	7.2	7.6
	ton/day	b=ax365	1,898	2,008	2,117	2,263	2,373	2,482	2,628	2,774
Waste + Cover soil	m ³ /year	c=bx1.5/0.7	4,881	5,163	5,444	5,819	6,102	6,382	6,758	7,133
Total	m ³	c	4,881	10,044	15,488	21,307	27,409	33,791	40,549	47,682

Required volume of the Medical Waste Final Disposal Site is shown in Table 8-36.

Table 8-36: Volume of the Medical Waste Final Disposal Site in Sofulu

Capacity (m ³)	Year of Construction	Disposal Period
48,000m ³	2001	2002-2009

b.2.4 Structure of Bottom and Top Cover of Landfill

(1) Foundation of Final Disposal Site

In accordance with the article 34 of Design Standard, structures stipulated in the design standard is summarised as shown in Table 8-37.

Table 8-37: Foundation of Final Disposal Site(Article 34) in Sofulu

Item	Soil conditions	Remarks
Foundation layer	naturally compacted soil	minimum 3 meters thick compressibility factor more than 95%
relation with ground water table	Difference between the foundation and the highest level of underground water table	not less than 2 meters

(2) Floor of Disposal Site

In accordance with the article 35 of Design standard, floor of final disposal site shall be prepared to absolutely eliminate mixture of leachate with underground water. The composition of disposal floor is stated as shown in Table 8-38.

Table 8-38: Structure of Floor of Medical Waste Disposal Site(Article 35) in Sofulu

Layer from the foundation	Depth or gradient	Permeability
impervious mineral layer	min1.5 m thick	not less than 1.0×10^{-9} m/s
plastic impervious membrane (liner)	min 2.5 mm thick	
	min3 % (longitudinal floor Incline)	
	minimum 1 % (lateral floor incline)	
Drain bed (drain pipes, main collector)	minimum 0.3m thick(drain bed)	permeability factor 1.0×10^{-3} /m

b.2.3 Top Cover

After completion of the medical waste disposal, a top cover will be formed by building-up the layers shown in Figure 8-28.

In order to provide for ultimate land use of disposal site, implantation and vegetation of disposal area shall be considered. Thickness of farm soil shall be determined according to root depths of plants to be planted or grown.

Inclination of farm soil layer shall be more than 3 %, to secure rapid runoff of precipitation water.

Structure of top cover of Medical Disposal Site is shown in Table 8-39.

Table 8-39: Structure of Top Cover of Medical Disposal Site in Sofulu

Item	Depth or gradient	Permeability
homogeneous and non-cohesive soil	not less than 0.5m thick,	
impervious mineral layer	not less than 0.5m thick	1.0×10^{-9} m/s or less
plastic membrane	minimum 2.5mm thick	
Final inclination of top cover surface	greater than 5%	
Drain layer	0.3 meter thick	
agriculture soil layer on impervious membrane	not less than 1 m	

Typical sections of foundation, floor and top cover are shown in Figure 8-28.

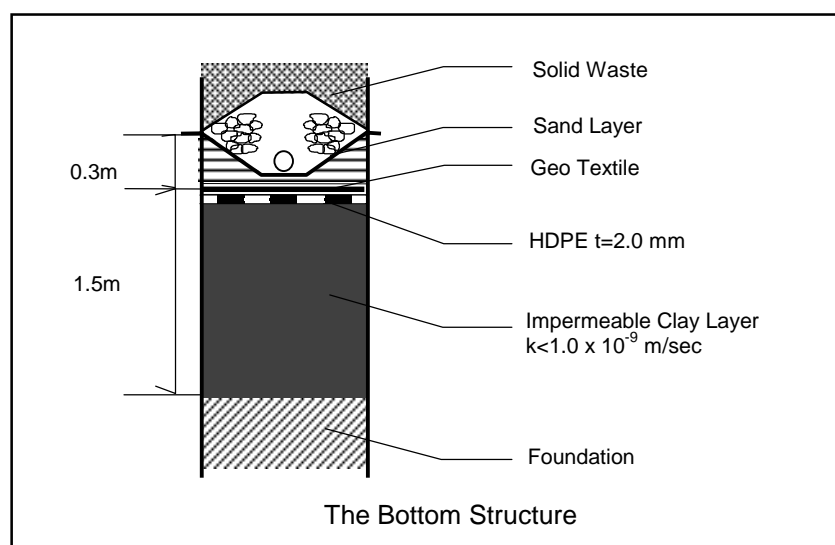
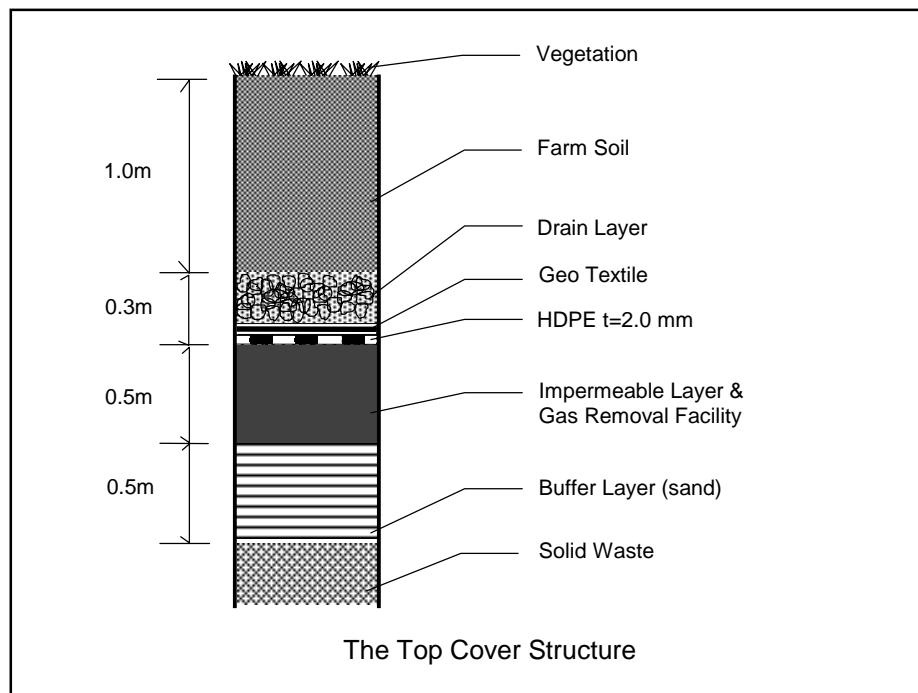
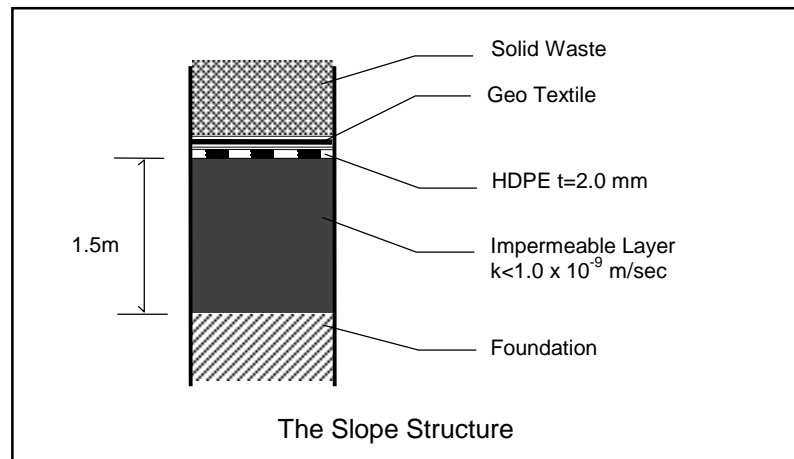


Figure 8-28: Diagrams of the Landfill's Impermeable Strata (Slope, Top Cover and Bottom)

b.2.4 Leachate Collection Facilities and Regulation Pit

(1) During Operation

A strict leachate circulation system shall be applied to the landfill. So that the rain water intrusion from outside shall be restricted and leachate generated in the site shall not be discharged outside and shall be stored/circulated in the site.

A regulation pit with pumps enough to store the excess leachate in winter shall be constructed in the medical waste disposal site.

(2) After Closure of Disposal Site

Since the disposal site will be covered with water-proof liner after the closure of medical waste disposal site, no leachate will be received in the regulation pit. Namely, leachate circulation system will be cancelled after the closure of the disposal site.

8.7 Cost Estimation

8.7.1 Conditions of the Cost Estimate

The following cost estimates meet the construction and operation costs of the sanitary landfill in Sofulu constructed and operated at Turkish Solid Waste Regulation. Sanitary Landfill with primary Leachate circulation system.

The estimates are based on preconditions as follows.

- The estimates do not include costs for the procurement of land.
- The estimates are based on unit prices obtained in Turkey as of May 1999.
- The estimates are based on Turkey prices as May 1999

US\$ 1 = 407,000 TL

Unit cost is shown in Table 8-40.

Table 8-40: : Unit Cost

Description	Unit	Unit cost (US\$)
Personnel		
manager	man. Month	980.0
engineer	man. month	810.0
site manager	man. month	740.0
driver, operator, mechanic	man. month	430.0
secretary, clerk	man. month	210.0
collection worker, labourer, watchmen	man. month	270.0
Earthwork		
machine excavation, 200 m transport, and stockpiling of soil	m ³	1.5
machine excavation, 500 m transport, and stockpiling of soil	m ³	1.9
machine excavation, 1,000 m transport, and stockpiling of soil	m ³	2.4
construction of embankment, machine filling and compacting of soil	m ³	2.9
s/t geomenbran with geotextile t=2mm	m ²	16.0
Installation of geomenbran with geotextile t=2mm	m ²	2.1
s/t compacted clay layer	m ³	4.3
s/t vegetation soil	m ³	6.1
Drainage		
provide 100 mm PVC-drainage pipe (earthwork is not included)	m	0.8
provide 150 mm PVC-drainage pipe (earthwork is not included)	m	1.7
provide 200 mm PVC-drainage pipe (earthwork is not included)	m	2.5
Perforated pvc pipe dai.=80mm	m	1.2
Perforated pvc pipe dai.=100mm	m	1.7
Perforated pvc pipe dai.=125mm	m	2.4
Perforated pvc pipe dai.=160mm	m	3.6
Perforated pvc pipe dai.=200mm	m	7.3
Concrete pipe dai.=300mm	m	3.0
Concrete pipe dai.=400mm	m	5.0
Concrete pipe dai.=500mm	m	7.0
Concrete work		
s/t/p reinforced concrete paving (200mm) on prepared gravel base (300mm) and sub grade	m ²	12.0
s/t/p premixed concrete 180 kg/cm ²	m ³	38.0
s/t/p premixed concrete 240 kg/cm ²	m ³	40.0
Road work		
s/t/p concrete road pavement (t = 0.15m)	m ²	20.0
s/t/p hot-mix asphalt road pavement (t = 0.1m)	m ²	10.0
s/t/p gravel road (t=0.3m) and subgrade preparation	m ²	4.9
Miscellaneous		
s/t/p turf	set (m ²)	42.0
s/t/p plant trees 2 to 5 m in height	tree	49.0
Gate 8m wide	set	890.0
s/t/p fence (timber pole H=2.5m, barbed wire)	m	7.4
s/t/p steel pipe(Dai.=100mm)	m	40.0
Basic materials		
diesel oil	lit.	0.5
gasoline	lit.	1.0
crushed rock	m ³	14.0
sand	m ³	15.0
reinforcing bar	ton	332.0
Building Works		
Garage from a steel structure with steel cladding including foundation and floor	m ²	131.0
Office building R/C including all works	m ²	270.0
Sorting Plant & Compost Plant	m ²	123.0
Heavy vehicles and equipment (brand-new)		
s/t Bulldozer (19-20 ton)	Nos.	253,000
s/t Bulldozer (24-25 ton)	Nos.	322,000
s/t Excavator (21 ton) (Bucket capacity 1.0m ³)	Nos.	126,000
s/t Crawler loader(Bucket capacity 1.8 m ³)	Nos.	164,000
s/t Crawler loader (Bucket capacity 2.5 m ³)	Nos.	182,000
s/t Dump truck (capacity 34 ton)	Nos.	57,000
s/t Dump truck (capacity 26 ton 12~18 m ³)	Nos.	37,000
s/t Compactor vehicle (16m ³) (16 ton)	Nos.	64,000
s/t Compactor vehicle (14m ³)	Nos.	60,000
s/t Compactor vehicle (12m ³) (12 ton)	Nos.	58,000
Water Tanker (9,000lit.)	Nos.	50,000

Note : s: supply of material, t: transport, p: placement

8.7.2 Investment

a. Final Disposal Site

Investment for Final disposal site consists of Construction works and Vehicle & Equipment.

a.1 Construction Works

The following cost estimate is based on the preliminary design of the proposed Sofulu sanitary landfill carried out during the F/S. Total cost of construction works and design and supervision will be calculated based on the following formula.

Construction Works

Total Cost of Construction Works	:A	
Miscellaneous(10%)	:B	=A×10%
Direct Cost	:C	=A+B
General expenses/overhead(30%)	:D	=C×30%
Total Cost	:E	=C+D
Physical contingency(10%)	:F	=E×10%
VAT(15%)	:G	=E×15%
Total Investment Cost	:H	=E+F+G

Design and Supervision

Total Cost of Construction Works	:A	
Total Cost of Design and Supervision	:I	=A×7%
(Design 5%+Supervision2%)		
Physical contingency(10%)	:J	=I×10%
VAT(15%)	:K	=I×15%
Total Investment Cost	:L	=I+J+K

Table 8-41: Investment Cost of Construction of Municipal Solid Waste Landfill Site (Phase2) & Administration Area

Description	Quantity	Unit	Unit Cost(US\$)	Amount(US\$)
Control Facilities				
site cleaning	360,000	m ²	0.2	72,000
entrance area, asphalt pavement	9,000	m ²	10	90,000
site office	300	m ²	270	81,000
weigh bridge	2	set	100,000	200,000
tire washing pit	1	set	5,000	5,000
gate	1	set	890	890
power supply	1	set	20,000	20,000
water supply system	1	set	20,000	20,000
parking, washing area, reinforced conc.pav	2,000	m ²	20	40,000
Approach road (w=8.0m)	780	m	80	62,400
Fence	4,570	m	7.4	33,818
planting of buffer zone	1,950	tree	49	95,550
Phase2 Municipal Solid Waste landfill site & Plant				
Access road (w=4m)	1,885	m	40	75,400
leachate collection	2,485	m	7.0	17,395
main leachate drain	990	m	18	17,820
pumping station	2	set	5,000	10,000
pump	4	set	15,000	60,000
regulation pond	1	set	52,300	52,300
leachate pipe	1,680	m	14	23,520
Gas removal facility(Vertical)	900	m	43	38,700
Gas removal facility(Horizon)	2,485	m	6.0	14,910
excavation of soil	1,227,700	m ³	1.9	2,332,630
construct embankment	142,300	m ³	2.9	412,670
construct basement & side slope using imported clay	42,100	m ²	53	2,231,300
soil(HDPEt=2mm)	2,200	m	8	21,320
open concrete drain	990	m	6	5,940
Pipe drain for rain fall	3	set	500	1,500
monitoring borehole				
Total				6,036,063
Miscellaneous(10%)				603,606
Direct cost				6,639,669
General expenses/overhead(30%)				1,991,901
Total cost				8,631,570
Physical contingency(10%)				863,157
VAT(15%)				1,294,736
Total investment cost				10,789,463

Table 8-42: Investment Cost of Construction of Municipal Solid Waste Landfill Site (Phase3)

Phase3 Municipal Solid Waste landfill site	Quantity	Unit	Unit Cost(US\$)	Amount(US\$)
leachate collection	4,340	m	7.0	30,380
main leachate drain	350	m	18	6,300
Gas removal facility(Vertical)	1,081	m	43	46,483
Gas removal facility(Horizon)	4,340	m	6.0	26,040
excavation of soil	1,580,700	m ³	1.9	3,003,330
construct embankment	25,600	m ³	2.9	74,240
construct basement & side slope using imported clay	84,200	m ²	53	4,462,600
soil(HDPEt=2mm)	350	m	6	2,100
Pipe drain for rain fall				
Total				7,651,473

Phase3 Municipal Solid Waste landfill site	Quantity	Unit	Unit Cost(US\$)	Amount(US\$)
Miscellaneous(10%)				766,147
Direct cost				8,416,620
General expenses/overhead(30%)				2,524,986
Total cost				10,941,606
Physical contingency(10%)				1,094,161
VAT(15%)				1,641,241
Total investment cost				13,667,247

Table 8-43: Investment Cost of Construction of Medical Solid Waste Landfill Site

Medical Waste landfill site	Quantity	Unit	Unit Cost(US\$)	Amount(US\$)
Approach road (w=4m)	235	m	20	9,400
leachate collection	445	m	7.0	3,115
main leachate drain	120	m	18	2,160
pumping station	1	set	5,000	5,000
pump	2	set	15,000	30,000
leachate pipe	200	m	14	2,800
Gas removal facility(Vertical)	27	m	43	1,161
Gas removal facility(Horizon)	445	m	6.0	2,670
excavation of soil	66,600	m ³	1.9	126,540
construct basement without using imported clay soil(HDPE t=2mm)	5,000	m ²	24	120,000
construct basement & side slope using imported clay soil(HDPEt=2mm)	4,500	m ²	53	238,500
open concrete drain	235	m	8	1,800
Pipe drain for rain fall	120	m	6	720
Total				543,946
Miscellaneous(10%)				54,395
Direct cost				598,341
General expenses/overhead(30%)				179,502
Total cost				777,843
Physical contingency(10%)				77,784
VAT(15%)				116,676
Total investment cost				972,303

Investment schedule for Municipal Solid Waste Landfill and Medical Solid Waste Landfill are shown in Table 8-44 and Table 8-45 respectively.

Table 8-44: Investment Schedule for Municipal Solid Waste Landfill Site in Sofulu (2002-2005)

unit: US\$ 1,000

	2000	2001	2002	2003	2004	2005
Civil works	-	10,790	-	-	-	13,676
Design and supervision	1,007	-	-	-	191	-
Total	1,007	10,790	-	-	191	13,676

Table 8-45: : Investment Schedule for Medical Solid Waste Landfill Site in Sofulu (2000-2005)

unit: US\$ 1,000

	2000	2001	2002	2003	2004	2005
Civil works	-	972	-	-	-	-
Design and supervision	48	-	-	-	-	-
Total	48	972	-	-	-	-

a.2 Vehicle & Equipment

The municipal solid waste landfill vehicle and equipment procurement schedule, determined in previous sections, is summarised in Table 8-46. From this table, following investment schedule is made.

Total cost for Vehicle & Equipment will be calculated based on the following formula.

Vehicle & Equipment

Total Cost of Equipment	:A	
Spare parts(10%)	:B	=A×10%
Physical contingency(10%)	:C	=A×10%
VAT(15%)	:D	=A×15%
Total Investment Cost	:E	=B+C+D

Table 8-46: Procurement Schedule for Vehicle & Equipment of Municipal Solid Waste Landfill Site in AGM (2002-2005)

	2002	2003	2004	2005
Bulldozer(180HP)	3	-	-	-
Excavator(168HP)	1	-	-	-
Dump truck(8m ³)	3	-	-	-
Water tanker	1	-	-	-

Table 8-47: Investment Schedule for Vehicle & Equipment of Municipal Solid Waste Landfill Site in AGM (2001-2004)

unit: US\$ 1,000

	2001	2002	2003	2004
Bulldozer(180HP)	966	-	-	-
Excavator(168HP)	126	-	-	-
Dump truck(8m ³)	111	-	-	-
Water tanker	50	-	-	-
Sub Total	1,253	-	-	-
Spare parts(10%)	125	-	-	-
Physical contingency(10%)	125	-	-	-
VAT(15%)	188	-	-	-
Total	1,691	-	-	-

The medical solid waste landfill vehicle and equipment procurement schedule, determined in previous sections, is summarised in Table 8-48. From this table, following investment schedule is made.

Table 8-48: Procurement Schedule for Vehicle & Equipment of Medical Solid Waste Landfill Site in AGM (2002-2005)

	2002	2003	2004	2005
Bulldozer(180HP)	1	-	-	-

Table 8-49: Investment Schedule for Vehicle & Equipment of Medical Waste
Landfill Site

unit: US\$ 1,000

	2001	2002	2003	2004
Bulldozer(180HP)	253	-	-	-
Sub Total	253			
Spare parts(10%)	25	-	-	-
Physical contingency(10%)	25	-	-	-
VAT(15%)	38	-	-	-
Total	341	-	-	-

b. Sorting Plant

Investment cost estimate is presented in Table 8-50. The cost has two components: facility construction and operation equipment. It should be noted that the cost for land preparation is not included here but in the cost estimate of the landfill site.

Table 8-50 : Investment Cost of the Sorting Plant in Sofulu

Item	Details	unit	Unit Cost US\$	Quantify	Cost US\$
Sorting plant construction					
Facility construction	max.height=15m	m ²	123	2,800	344,400
Facility floor pavement	Concrete t=0.1m	m ²	10	2,500	25,000
Road pavement	for common item	m ²	---	---	---
Structure Total					369,400
Equipment					
Weighbridge	for common item	unit	---	---	---
Waste reception section					
Feeding conveyor with hopper	W=550, Side angle 35%	unit	105,000	1	105,000
Hand-sorting section					
Plastic bag breaker	Conveyor Type	unit	266,000	1	266,000
Hand-sorting conveyor	W=850, Flat belt type	unit	137,000	1	137,000
Magnetic separator	Permanent magnet	unit	11,000	1	11,000
Residue conveyor	W=450, Belt type	unit	10,000	1	10,000
Reversible conveyor	W=450, Belt type	unit	14,000	1	14,000
Product section					
Press machine for metals	Oil pressure type	unit	125,000	1	125,000
Baler machine	Oil pressure type	unit	183,000	1	183,000
Press machine for PET	Oil pressure type	unit	133,000	1	133,000
Recover box	---	unit	34,000	1	34,000
Other section					
Electric facilities	---	unit	198,000	1	198,000
Drainage facilities	---	unit	70,000	1	70,000
Ventilation facilities	---	unit	87,000	1	87,000
Machine floors, etc.	---	unit	80,000	1	80,000
Heavy vehicles					
Wheel loader for reception	2.9 m ³ refuse bucket	unit	116,000	1	116,000
Dump truck	3 ton , 6m ³	unit	37,000	2	74,000
Fork lift	capacity 1 ton	unit	54,000	1	54,000
Equipment Total			---	---	1,697,000
Sub-total					2,066,400
Miscellaneous	10%				206,600
Direct cost					2,273,000
General expenses/overhead	30%				681,000
Total construction cost					2,954,000
Physical contingency	10%				296,000
VAT	15%				443,000
Total Cost					3,693,000

Table 8-51 shows costs for the sorting project from 2000 to 2005 annually.

Table 8-51: Investment Schedule of Sorting Plant in Sofulu

unit : US\$ 1,000

	2000	2001	2002	2003	2004	2005	Total
D/D	199	---	---	---	---	---	199
Civil	---	661	---	---	---	---	661
Machine	---	2,597	---	---	---	---	2,597
V&E	---	435	---	---	---	---	435
O&M	---	---	446	446	446	446	1,784
Total	199	3,693	446	446	446	446	5,676

Note: D/D : Detailed design, Civil : Civil works, Machine : Machinery
V&E : Vehicles and Equipment, O&M : Operation and maintenance

c. Compost Plant

Investment cost estimate is presented in Table 8-52. The cost has two components: facility construction and operation equipment. It should be noted that the cost for land preparation is not included here but in the cost estimate of the landfill site.

Table 8-52: Investment Cost of the Compost Plant in Sofulu

Item	Details	unit	Unit Cost US\$	Quantify	Cost US\$
Compost plant construction					
Pre-treatment section construction	max.height=11m	m ²	123	2,200	270,600
Pre-treatment floor pavement	Concrete t=0.1m	m ²	10	2,200	22,000
Static pile section construction	max.height=7m	m ³	22	7,300	160,600
Static pile section pavement	Concrete t=0.1m	m ²	10	6,600	66,000
Maturation area section pavement	Concrete t=0.1m	m ²	10	9,600	96,000
Screen section pavement	Concrete t=0.1m	m ²	10	1,200	12,000
Road pavement	Hot-mix asphalt t=0.1m	m ²	10	4,800	48,000
Structure Total					675,200
Equipment					
Weighbridge	for common item	unit	---	---	---
Pre-treatment section					
Waste reception section					
Feeding conveyor with hopper	W=450, Side angle 35%	unit	95,000	1	95,000
Pre-treatment facilities					
Selective crushing separator	dia.=2.6m	unit	1,057,000	1	1,057,000
Pre-treated conveyor (A)	W=350,belt type	unit	11,000	1	11,000
Pre-treated conveyor (B)	W=350,belt type	unit	20,000	1	20,000
Residue conveyor	W=300,belt type	unit	9,000	1	9,000
Moisture adjusting agent section					
Grinder	wood	unit	51,000	1	51,000
Feeding conveyor with hopper	W=400, belt type	unit	15,000	1	15,000
Other section					
Ventilation facilities	---	unit	57,000	1	57,000
Machine floors, etc.	---	unit	71,000	1	71,000
Composting section					
Ventilation facilities	---	unit	78,000	1	78,000
Maturation section					
Biological deodorising facilities	---	unit	258,000	1	258,000
Screen section					
Primary screen section					
Trommel	with hopper and conveyor	unit	133,000	1	133,000

Item	Details	unit	Unit Cost US\$	Quantify	Cost US\$
Magnetic separator	Permanent magnet	unit	6,000	1	6,000
Inertial separator	Ballistic type	unit	8,000	1	8,000
Final Primary screen section					
Trommel	with hopper and conveyor	unit	160,000	1	160,000
Magnetic separator	Permanent magnet	unit	6,000	1	6,000
Inertial separator	Ballistic type	unit	8,000	1	8,000
Bagged machine	Plastic bag 20kg	unit	12,000	1	12,000
Other section					
Electric facilities	---	unit	358,000	1	358,000
Drainage facilities	---	unit	143,000	1	143,000
Heavy vehicles					
Wheel loader					
Wheel loader for reception	2.1 m ³ refuse bucket	unit	100,000	1	100,000
Wheel loader for static pile	1.5 m ³ refuse bucket	unit	83,000	1	83,000
Wheel loader for raw compost	2.1 m ³ refuse bucket	unit	100,000	1	100,000
Wheel loader for screen section	1.5 m ³ refuse bucket	unit	83,000	1	83,000
Dump truck					
Dump truck for pre-treated material	3 ton , 6m ³	unit	37,000	2	74,000
Dump truck for raw compost	5 ton , 10m ³	unit	41,000	2	82,000
Dump truck for screened compost	3 ton , 6m ³	unit	37,000	1	37,000
Equipment Total			---	---	3,115,000
Sub-total					3,790,200
Miscellaneous	10%				379,800
Direct cost					4,170,000
General expenses/overhead	30%				1,252,000
Total construction cost					5,422,000
Physical contingency	10%				543,000
VAT	15%				813,000
Total Cost					6,778,000

Table 8-53 shows costs for the composting project from 2000 to 2005 annually.

Table 8-53: Investment Schedule of Compost Plant (2000-2005)

unit : US\$ 1,000

	2000	2001	2002	2003	2004	2005	Total
D/D	365	---	---	---	---	---	365
Civil	---	1,208	---	---	---	---	1,208
Machine	---	4,570	---	---	---	---	4,570
V&E	---	1,000	---	---	---	---	1,000
O&M	---	---	549	549	549	549	2,196
Total	365	6,778	549	549	549	549	9,339

Note: D/D : Detailed design, Civil : Civil works, Machine :Machinery
V&E : Vehicles and Equipment, O&M : Operation and maintenance

d. Collection System

Investment cost for Collection System has two components. One is for Container for Separate and the other is for Collection Vehicle.

d.1 Container for Separate Collection

The container for separate collection procurement schedule, determined in previous sections, is summarised in Table 8-54. From this table, the following investment schedule is made.

Table 8-54: Procurement Schedule of Container for Separate Collection
(2000-2005)

	2000	2001	2002	2003	2004	2005
Container(800lit.)	800	931	114	123	128	123

Table 8-55: Investment Schedule for of Container for Separate Collection
(2000-2005)

unit: US\$ 1,000

	2000	2001	2002	2003	2004	2005
Container(800lit.)	28	33	4	4	4	4

d.2 Collection Vehicle

The collection vehicle, determined in previous sections, is summarised in Table 8-56.

From this table, the following investment schedule is made.

Table 8-56: Procurement Schedule of Collection Vehicle (2001-2005)

	2001	2002	2003	2004	2005
Compactor (16m ³)	26	5	6	6	6

Table 8-57: Investment Schedule for of Collection Vehicle

unit: US\$1,000

	2001	2002	2003	2004	2005
Compactor(16m ³)	1,664	320	384	384	324

8.7.3 Operation and Maintenance Costs

Operation & Maintenance Cost will be required for Final Disposal Site, Sorting Plant, Compost Plant and Collection System

a. Final Disposal Site

Operation cost will be required for Municipal Solid Waste, Final Disposal Site and Medical Solid Waste Final Disposal Site. Operation and maintenance cost will be composed of Civil Work, Equipment and Manpower. The contents are explained as follows.

- The operation cost for civil works, such as temporary dike construction and repairing for site building, shall be added 1 % of Direct Cost on top of it.
- The operation cost for Equipment, such as Fuel and oil, shall be added 10% of basic price on top of it.
- The operation cost for personnel shall be considered only for Municipal Solid Waste Landfill, since they will work for both.

a.1 Municipal Solid Waste Final Disposal Site

Operation & Maintenance Quantities and Cost for Municipal Solid Waste Final Disposal Site are shown in Table 8-58 and Table 8-59 respectively.

Table 8-58: Operation & Maintenance Quantities of Municipal Solid Waste Final Disposal Site in Sofulu (2002-2005)

Item	2002	2003	2004	2005
Municipal Solid Waste Landfill (US\$ 1,000)	108	108	108	108
Vehicles & Equipment (US\$ 1,000)	153	153	153	153
Personnel				
Site Manager	1	1	1	1
Waste controller	1	1	1	1
Operator	6	6	6	6
Driver	2	2	2	2
Worker	2	2	2	2
Security guard	2	2	2	2
Total	14	14	14	14

Table 8-59: Operation & Maintenance Cost of Medical Solid Waste Final Disposal Site in Sofulu (2002-2005)

Item	2002	2003	2004	2005
Municipal Solid Waste Landfill (US\$ 1,000)	108	108	108	108
Vehicles & Equipment (US\$ 1,000)	153	153	153	153
Personnel				
Site Manager	12	12	12	12
Waste controller	5	5	5	5
Operator	31	31	31	31
Driver	10	10	10	10
Worker	6	6	6	6
Security guard	6	6	6	6
Total	331	331	331	331

a.2 Medical Solid Waste Final Disposal Site

Personnel for Medical Solid Waste Final Disposal Site shall not be required. Operation & Maintenance Cost for Medical Solid Waste Final Disposal Site are shown in Table 8-60.

Table 8-60: Operation & Maintenance Cost of Medical Solid Waste Final Disposal Site in Sofulu (2002-2005)

Item	2002	2003	2004	2005
Medical Solid Waste Landfill (US\$ 1,000)	10	10	10	10
Vehicles & Equipment (US\$ 1,000)	13	13	13	13
Total	23	23	23	23

b. Sorting Plant

Operation & Maintenance Cost for Sorting Plant is shown in Table 8-61.

Table 8-61: Operation & Maintenance Cost of Sorting Plant in Sofulu
(2002-2005)

unit: US\$ 1,000

	2002	2003	2004	2005
O & M Cost	518	518	518	518

c. Compost Plant

Operation & Maintenance Cost for Compost Plant is shown in Table 8-62.

Table 8-62: Operation & Maintenance Cost of Compost Plant in Sofulu
(2002-2005)

unit: US\$ 1,000

	2002	2003	2004	2005
O & M Cost	629	629	629	629

d. Collection System

The Operation & Maintenance Cost for 16m³ Compactor Truck shall be considered under Collection System. Annual Operation & Maintenance Cost for one collection vehicle is shown in Table 8-63.

Table 8-63: Annual Operation & Maintenance Cost for One Collection Vehicle
in Sofulu

Item	formula	Unit	
Working time	a	(hr)	8
Collection days per year	b	days	300
Fuel consumption per hour	c		0.039
Flywheel power	d	HP	319
Diesel Consumption rate per hour	e=cxd	lit./hr/unit	12.441
Diesel Consumption rate per day	f=axe	lit./day/unit	100
Diesel consumption cost per day	g=bxg	US\$/year/unit	15,000
Lubrication Oil (10% of Diesel consumption)	h=gx10%	US\$/year/unit	1,500
Spare parts (10% of unit cost of compactor truck)	i	US\$/day/unit	6,400
Repair (10% of unit cost of compactor truck)	j	US\$/year/unit	6,400
Driver 1person	k	US\$/year	5,160
Worker1car=2person	l	US\$/year	6,480
O&M total		US\$/year/unit	41,000

Operation & Maintenance cost for collection system is shown in Table 8-64.

Table 8-64 Operation & Maintenance Cost of Collection Vehicle in Sofulu
(2002-2005)

Item	2002	2003	2004	2005
Number of Collection Vehicles	26	31	37	43
O & M cost (US\$ 1,000)	1,066	1,271	1,517	1,763

e. Summary of Cost Estimation

unit: US\$ 1,000

ADANA			2000	2001	2002	2003	2004	2005
Separate Collection System	Container	Invest		33	4	4	4	4
	Compactor	Invest		1,664	320	384	384	384
		O&M for Compactor			1,066	1,271	1,517	1,763
Plant	Sorting Plant	Design & Supervision	199					
		Invest. for civil work		661				
		Invest. for machine		2,597				
		Invest. for V&E		435				
		O&M			446	446	446	446
	Compost Plant	Design & Supervision	365					
		Invest. for civil work		1,208				
		Invest. for machine		4,570				
		Invest. for V&E		1,000				
		O&M			549	549	549	549
Final Disposal	Municipal Waste	Design & Supervision	1,007				191	
		Invest. for civil work		10,790				13,676
		Invest. for V&E		1,691				
		O&M					331	331
	Medical Waste	Design & Supervision	48		331	331		
		Invest. for civil work		972				
		Invest. for V&E		341				
		O&M			23	23	23	23