6.2.2 Final disposal Sites

6.2.2.1 Vertical Expansion Plan of Etapa IV

The vertical expansion plan proposes to place waste to 24m elevation in order to expand the lifetime.

a. Physical Impacts of Proposed Vertical Expansion

The Bordo Poniente area stands on the 60-meter thick highly compressible clayey layer of the ex-lake Texcoco area. Etapa IV is located on such soil conditions. The waste load causes settlement of the subsoil under the landfill due to the soil character. In the vertical expansion plan, further placement of waste on the existing one is forecast to cause further subsoil settlement.

In this section, issues examined regarding physical impacts of the proposed vertical expansion are:

- influence on the Canal (Canal de la Compañia).
- influence on the impermeable liner.
- influence on stability of the landfill slope.

a.1 Vertical Expansion Influence on the Canal

a.1.1 Conditions for Estimation of Influence

Data on soil layers at SM-8 (see Annex H) bore hole are employed for the estimation. The lacustrine layer is subdivided into 10 layers as shown in Table 6-8. The waste load is assumed to be the one when the landfill becomes 24m high and the unit weight of waste after initial compression at the landfill is assumed to be 0.8 ton/m^3. And two cases are set depending on whether buoyancy caused by the groundwater is considered or not. Case 1 ignores such buoyancy, on the other hand, Case 2 takes buoyancy into consideration.

Table 6-8: Subsoil Conditions

Layer	Thickness of layer (m)	Unit weight (ton/m^3)
1	1.0	1.80
2	5.5	1.13
3	1.0	1.80
4	8.5	1.26
5	5.0	1.18
6	5.0	1.18
7	6.0	1.18
8	10.0	1.18
9	2.0	1.67
10	10.0	1.18

Note: The water level is assumed at 0m depth, because the groundwater level at SM-7 was 0.03m and at SM-8 was 0.35m.

a.1.2 Results of the Estimation

The result of Case 1, without consideration of the buoyancy, is that the final subsoil settlement (theoretical maximum) is 19.6 m in the landfill center which may cause 8cm settlement at the 80m off-set drainage canal. Meanwhile, the final subsoil settlement (theoretical maximum) of Case 2, with consideration of the buoyancy, is 12.6m in the landfill center which may cause 4cm subsidence at the 80m off-set drainage canal.

a.2 Vertical Expansion Influence on the Impermeable Liner

The part of liner under the first lift's slope will undergo the largest tensile stress. The tensile stress can be expressed as 3.0% in elongation terms (32.47m/32m=1.015, i.e., 1.5% of stretch, taking into consideration the stretch of two-dimension, $32.47^2/32^2$=1.030, i.e., 3.0% of stretch). This elongation would be absorbed in the tensile performance of the impermeable liner.

a.3 Vertical Expansion Influence on Stability of Landfill Slope

The present landfill slope has an inclination of 1 in 4, and this inclination is also employed for both elevation of 8 to 16m and 16m to 24m. The minimum factor of the slope 0 to 8m shows 0.948 which is the least among others. Although a slope failure could occur as the minimum factor is less than 1.0 theoretically, it has not happened. On the other hand, minimum factors of other slopes exceed 1.0, therefore, the vertical expansion is viable from a viewpoint of landfill slope stability.

Table 6-9: Result of Slope Stability Calculation (Bishop Method)

Slope	Landfill Height	Minimum Safety Factor	Coordinates of the Rotational Slope		Radius of the Rotational Slip (m)	Resist Moment (ton-m)	Slip Moment (ton-m)
			X	Y			
1	0 to 8m	0.948	10.00	15.00	30.13	2,001.15	2,111.67
2	8 to 16m	1.077	146.00	16.00	51.00	8,584.00	7,968.72
3	16 to24m	1.313	280.00	25.00	60.00	11,634.95	11,149.46

b. Leachate Management

b.1 Leachate Generation Estimation

Estimation of leachate generation quantity, which will be generated under the existing situation, was carried out by using meteorological data at the Mexico City International Airport station (Estacion meteorologica Aeropuerto Internacional Benito Juarez). The result shows that 101 mm/year out of the precipitation will percolate through the cover soil, then water contents of waste and soil under the cover soil will reach the field capacities in 3 years, finally 101 mm/year of leachate will be generated at the bottom of the landfill in the 4th year and afterward (See Figure 6-6). Details of the estimation is described Annex II.

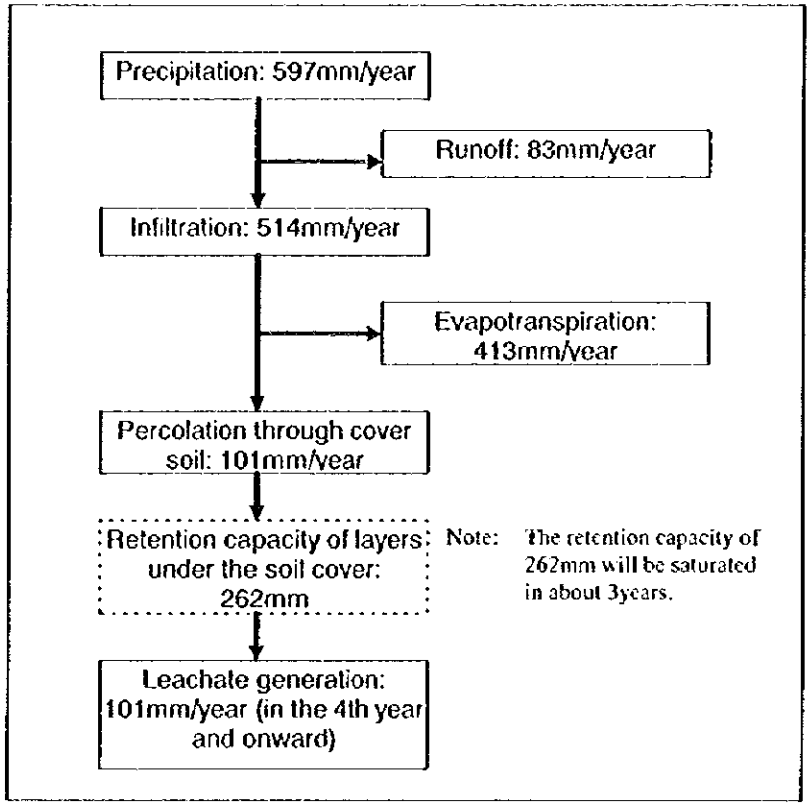


Figure 6-6: Leachate Generation

c. Waste Disposal Amount

The forecast of waste amount to be disposed of during the 10 years is shown in Table 6-10.

Table 6-10: Waste Disposal Amount from 2001 to 2010

Year	Disposed Waste					
	Total		Etapa IV		Etapa V	
	1000 ton	1000 m^3	1000 ton	1000 m^3	1000 ton	1000 m^3
2001	3,876	4,845	3,876	4,845		
2002	3,609	4,511			3,609	4,511
2003	3,493	4,366			3,493	4,366
2004	3,385	4,231			3,385	4,231
2005	3,373	4,216	3,373	4,216		
2006	3,358	4,198	3,358	4,198		
2007	3,340	4,175			3,340	4,175
2008	3,321	4,151			3,321	4,151
2009	3,300	4,125	3,300	4,125		
2010	3,278	4,098	3,278	4,098		
Total	34,333	42,916	17,185	21,482	17,148	21,434

Note: bulk density of the waste at landfill is assumed to be 800kg/m^3.

d. Conceptual Design and Cost Estimates

d.1 Key Design Data

Key data for landfill design are set as follows:

- bulk density of waste after compaction in landfill: 800kg/m^3
- operation schedule of landfill: 24 hours/day, 365 days/year
- life year of trucks and heavy equipment: 7 years
- life year of building and civil works: 30 years
- exchange rate: US$ 1.00 = 9.1pesos
- daily (intermediate) soil cover: 30cm
- final landfill elevation: 24m

d.2 Outline of the Conceptual Design and Spray

Outline of the conceptual design for the Vertical Expansion Plan is presented in Table 6-11.

Table 6-11: Outline of the Conceptual Design for the Vertical Expansion Plan

Items	Facilities
Landfill capacity	25,849,000m^3(20,679,000ton) is available for waste disposal.
Access	at 0m elevation outer road: 8,285m (existing) inner road: 26,675m (existing) at 8m elevation outer road: 7,075m inner road: 19,623m at 16m elevation outer road: 5,160m inner road: 6,453m
Leachate management	Leachate extraction wells concrete pipes with 600mm diameter: 24 nos. Leachate extraction and spray pumps: 24 nos. Leachate collection lines at 0m elevation: 26,675m at 8m elevation: 26,708m at 16m elevation: 11,613m
Landfill gas management	Gas extraction wells concrete pipes with 600mm diameter: 198nos. Gas extraction pipes - PVC200 at 8m elevation: 141 nos. at 16m elevation: 102 nos.
Surface water management	Daily/intermediate soil cover: 30cm (Compost is also usable.)
Monitoring	Monitoring items: -settlement of the landfill -leachate quality -landfill gas quality
Aesthetic design	Mobile screen Daily/intermediate soil cover: 30cm (Compost is also usable.)

Items	Facilities
Closure and post-closure	Final soil cover: 60cm Greening by seeding the final cover with grass
Landfill equipment	Bulldozers (300hp class): 4 nos. Sprinkler trucks (15,000liter class): 2 nos. Excavators (85hp class): 2 nos.

d.3 Landfill Capacity

Table 6-12: Waste Disposal Amount in Etapa IV

Unit: 1,000m^3

Elevation	Landfill capacity	Waste disposal amount						Remaining capacity
		2001	2005	2006	2009	2010	Total	
8-16m	16,447	4,845	4,216	4,198	3,188		16,447	0
16-24m	9,402				937	4,098	5,035	4,367
Total	25,849	4,845	4,216	4,198	4,125	4,098	21,482	4,367

d.4 Cost Estimates

Two cases are set for operation of the landfill as follows:

- Case 1: Investment and operation by the DGSU.
- Case 2: Investment by the DGSU and contracting out operation.

This makes cost estimates for this Vertical Expansion Plan different, so that the estimates are carried out in Case 1 and Case 2 respectively.

Table 6-13: Summary of Costs for the Vertical Expansion Plan (Case 1)

Unit: US$ 1,000

Year	B/D	D/D	Con (Ini.)	Con(Rec)	Equip.	O&M	Land fee	Total
1999	33							33
2000		298	7,902		2,777			10,977
2001				2,164		728	425	3,317
2002						111	425	536
2003						21	425	446
2004						111	425	536
2005				1,883		728	425	3,036
2006				1,874		818	425	3,117
2007						21	425	446
2008						111	425	536
2009				1,773		728	425	2,926
2010				1,528		818	425	2,771
Total	33	298	7,902	9,222	2,777	4,195	4,250	28,677

B/D: Basic design for construction and equipment.
D/D: Detailed design for construction and equipment. The amount complies costs for supervision as well.
Con. (Ini.): Initial investment cost for construction
Con(Rec): Recurrent cost for construction
Equip.: Landfill equipment
O&M: Operation and maintenance
Land fee: Land rental fee

Table 6-14: Summary of Costs for the Vertical Expansion Plan (Case 2)

Unit: 1,000US$

Year	B/D	D/D	Con. (Ini.)	Con(Rec)	Equip.	O&M	Land fee	Total
1999	33							33
2000		298	7,902					8,200
2001				2,164	901	619	425	4,109
2002						111	425	536
2003						21	425	446
2004						111	425	536
2005				1,883	901	619	425	3,828
2006				1,874	901	709	425	3,909
2007						21	425	446
2008						111	425	536
2009				1,773	901	619	425	3,718
2010				1,528	901	709	425	3,563
Total	33	298	7,902	9,222	4,505	3,650	4,250	29,860

B/D: Basic design for construction.
D/D: Detailed design for construction. The amount complies costs for supervision as well.
Con. (Ini.): Initial investment cost for construction
Con(Rec): Recurrent cost for construction
Equip.: Landfill equipment
O&M: Operation and maintenance
Land fee: Land rental fee

6.2.2.2 New Landfill Development (Etapa V)

a. Physical Impact of Proposed Landfill Development

Similarly to the Etapa IV landfill site, this candidate site for a new landfill is located on highly compressible clay layer of the ex-Texcoco area. Therefore, influence on a canal flowing along the site, influence on the impermeable liner and influence on stability of the landfill slope are examined on the basis of a geological survey conducted during the 2nd study work in Mexico.

a.1 Landfill Development Influence on Dren Texcoco Norte

Examination of influence on the canal, Dren Texcoco Norte, which is flowing the south side of the site, caused by the New Landfill Development was carried out by using soil data acquired through the soil survey. Conditions set for estimation of subsoil settlement and the results of the examination are presented below.

a.1.1 Conditions for Estimation of Influence

The lacustrine layer is subdivided into 8 layers as shown in Table 6-15. The waste load is assumed to be the one when the landfill becomes 24m high and the unit weight of waste after initial compression at the landfill is assumed to be 0.8 ton/m^3. And two cases are set depending on whether buoyancy caused by the groundwater is considered or not. Case 1 ignores such buoyancy, on the other hand, Case 2 buoyancy takes into consideration.

Table 6-15: Subsoil Conditions

Layer	Thickness of layer (m)	Unit weight (ton/m^3)
1	5.0	1.14
2	5.0	1.23
3	5.0	1.25
4	5.0	1.17
5	5.0	1.25
6	6.8	1.25
7	0.7	1.60
8	4.1	1.24

Note: The water level is assumed at 0m depth, because the groundwater level at SM-1 was 0.35.

a.1.2 Results of the Estimation

The result of Case 1, without consideration of the buoyancy, is that the final subsoil settlement (theoretical maximum) will be 13.82 m in the landfill center which may cause 5mm settlement at the 100m off-set drainage canal. Meanwhile, the final subsoil settlement (theoretical maximum) of Case 2, with consideration of the buoyancy, will be 9.35m in the landfill center which may cause 2mm subsidence at the 100m off-set drainage canal.

The duration of settlement was also estimated. The result shows that it will take 3 to 4 years to reach 60% settlement (See Table 6-16). Therefore, it is recommended that enough interval should be secured before waste placement on a next lift, i.e., alternate use of Etapa IV and V is recommended.

Table 6-16: Duration of Settlement

Consolidation (%)	10	20	30	40	50	60	70	80	90	100
Duration (days)	19	74	186	384	726	1378	2667	5072	9879	-
Settlement (m)	1.38	2.76	4.14	5.52	6.91	8.29	9.67	11.05	12.44	13.82

(See Data L of Data Book)

a.2 Landfill Development Influence on the Impermeable Liner

The part of liner under the first lift's slope will undergo the largest tensile stress. The tensile stress can be expressed as 1.1% in elongation terms (48.26m/48m=1.0054, i.e., 0.54% of stretch, taking into consideration the stretch of two-dimension, $48.26^2/48^2$=1.011, i.e., 1.1% of stretch). This would be absorbed in the tensile performance of the impermeable liner.

a.3 Influence on Stability of Landfill Slope

The minimum factor of 0 to 8m elevation with a slope of 1 in 4 shows 0.920 which means that slope failure could occur as the minimum factor is less than 1.0. Although a slope failure has not happened in the existing landfill of Etapa IV of which slope is 1 in 4, a gentler slope of 1 in 6 is recommendable for the first lift of 0 to 8m elevation as the minimum safety factor of the slope exceeds 1.0.

On the other hand, minimum factors of other slopes exceed 1.0, therefore, the vertical expansion is viable from a viewpoint of landfill slope stability.

Table 6-17: Result of Slope Stability Calculation (Bishop Method)

Slope	Landfill Height	Minimum Safety Factor	Coordinates of the Rotational Slope		Radius of the Rotational Slip (m)	Resist Moment (ton-m)	Slip Moment (ton-m)
			X	Y			
1	0 to 8m (1:4)	0.920	15.00	15.00	29.91	1,668.55	1,812.72
1	0 to 8m (1:6)	1.044	25.00	25.00	41.55	3,632.08	3,478.33
2	8 to 16m	1.089	140.00	22.00	39.70	4,826.92	4,433.46
3	16 to24m	1.302	270.00	25.00	48.34	9,234.27	7,093.06

a.2 Waste Disposal Amount

Waste amount to be disposed of in Etapa V is shown with that of Etapa IV in the section of the 'Vertical Expansion Plan of Etapa IV' (See Table 6-10).

b. Conceptual Design and Cost Estimates

b.1 Key Design Data

Key data for landfill design are the same as those of Etapa IV.

- bulk density of waste after compaction in landfill: 800kg/m^3
- operation schedule of landfill: 24 hours/day, 365 days/year
- life year of trucks and heavy equipment: 7 years
- life year of building and civil works: 30 years
- exchange rate: US$ 1.00 = 9.1pesos
- daily (intermediate) soil cover: 30cm
- final landfill elevation: 24m

b.2 Outline of the Conceptual Design

Outline of the conceptual design for the Vertical Expansion Plan is presented below.

Table 6-18: Outline of the Conceptual Design for A New Landfill Development

Items	Facilities
Area	Site area: 256ha Filling area: 194 ha
Landfill capacity	29,032,000m^3(23,226,000ton) is available for waste disposal.
Access	Access road: 605m Ring road: 5,950m at 0m elevation outer road: 5,950m inner road: 19,155m at 8m elevation outer road: 4,878m inner road: 11,743m at 16m elevation outer road: 3,854m inner road: 3,991m
Waste transport control facilities	gate: 1 (existing) weighbridge: 2 tire washing pit: 1 site office: 1 garage: 1 car park:1 parking area for heavy equipment and/or storage yard: 1
Leachate management	Leachate extraction wells concrete pipes with 600mm diameter: 15 nos. Leachate extraction and spray pumps: 15 nos. Leachate collection lines at 0m elevation: 25,105m at 8m elevation: 16,621m at 16m elevation: 7,845m
Landfill gas management	Gas extraction wells concrete pipes with 600mm diameter: 116nos. Gas extraction pipes - PVC200 at 0m elevation: 118 nos. at 8m elevation: 91 nos. at 16m elevation: 55 nos.
Surface water management	Daily/intermediate soil cover: 30cm (Compost is also usable.)
Monitoring	Monitoring items: -settlement of the landfill -leachate quality -landfill gas quality -groundwater -surface water Monitoring facilities -monitoring wells: 4 nos.
Aesthetic design	Mobile screen Daily/intermediate soil cover: 30cm (Compost is also usable.)
Closure and post-closure	Final soil cover: 60cm Greening by seeding the final cover with grass
Landfill equipment	Bulldozers (300hp class): 4 nos. Sprinkler trucks (15,000liter class): 2 nos. Excavators (85hp class): 2 nos.

b.3 Landfill Capacity

Table 6-19: Waste Disposal Amount in Etapa V

Unit: 1,000m^3

Elevation	Landfill capacity	Waste disposal amount						Remaining capacity
		2002	2003	2004	2007	2008	Total	
0-8m	14,720	4,511	4,366	4,231	1,612		14,720	0
8-16m	9,220				2,563	4,151	6,714	2,506
16-24m	5,092							5,092
Total	29,032	4,511	4,366	4,231	4,175	4,151	21,434	7,598

b.4 Landfill Layout

Layout of the landfill are shown in Figure 6-7, and waste transport control facilities are presented in Figure 6-8.

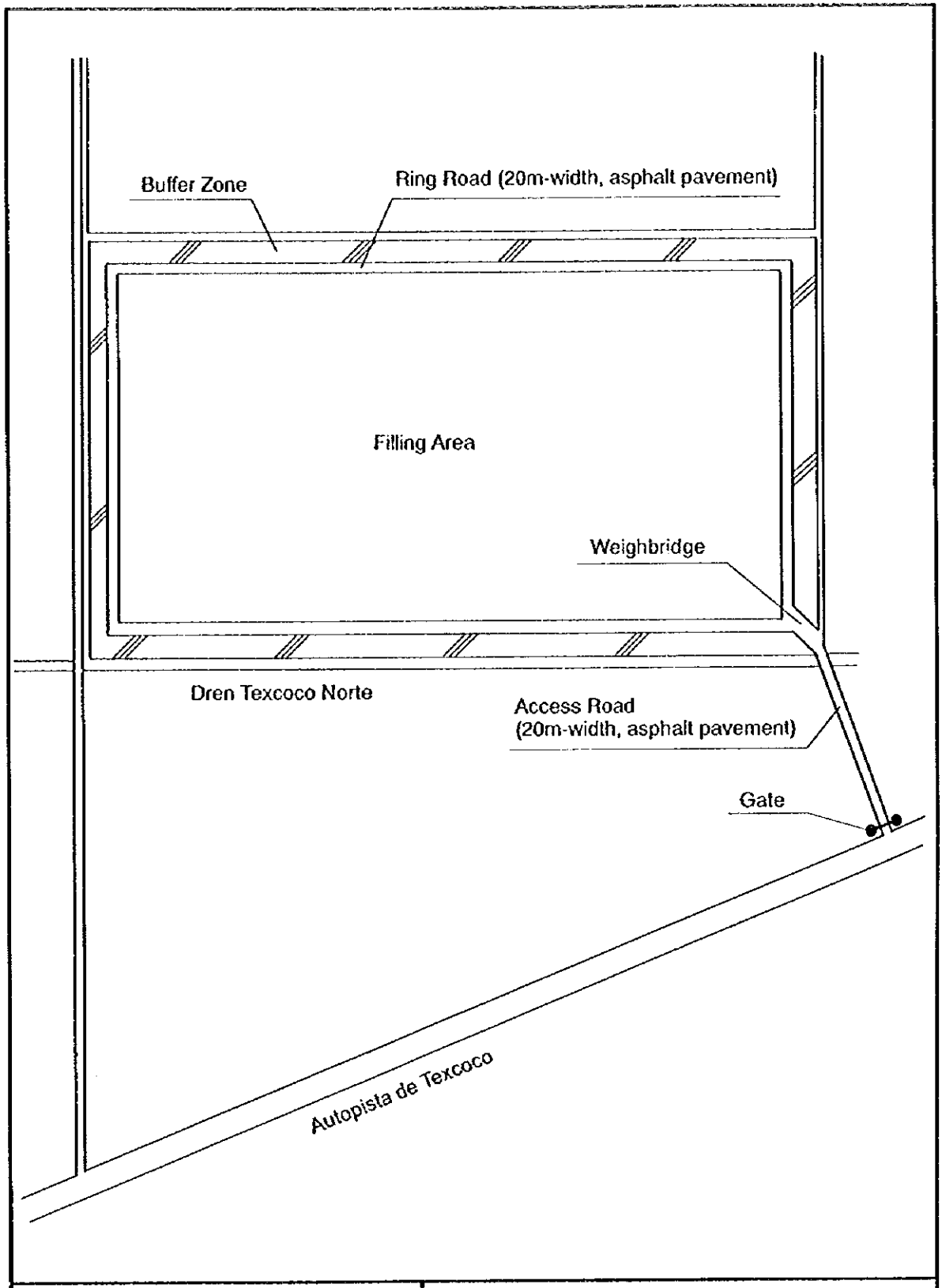


Figure 6-7:

Landfill Layout of Etapa V

KOKUSAI KOGYO Co., Ltd.

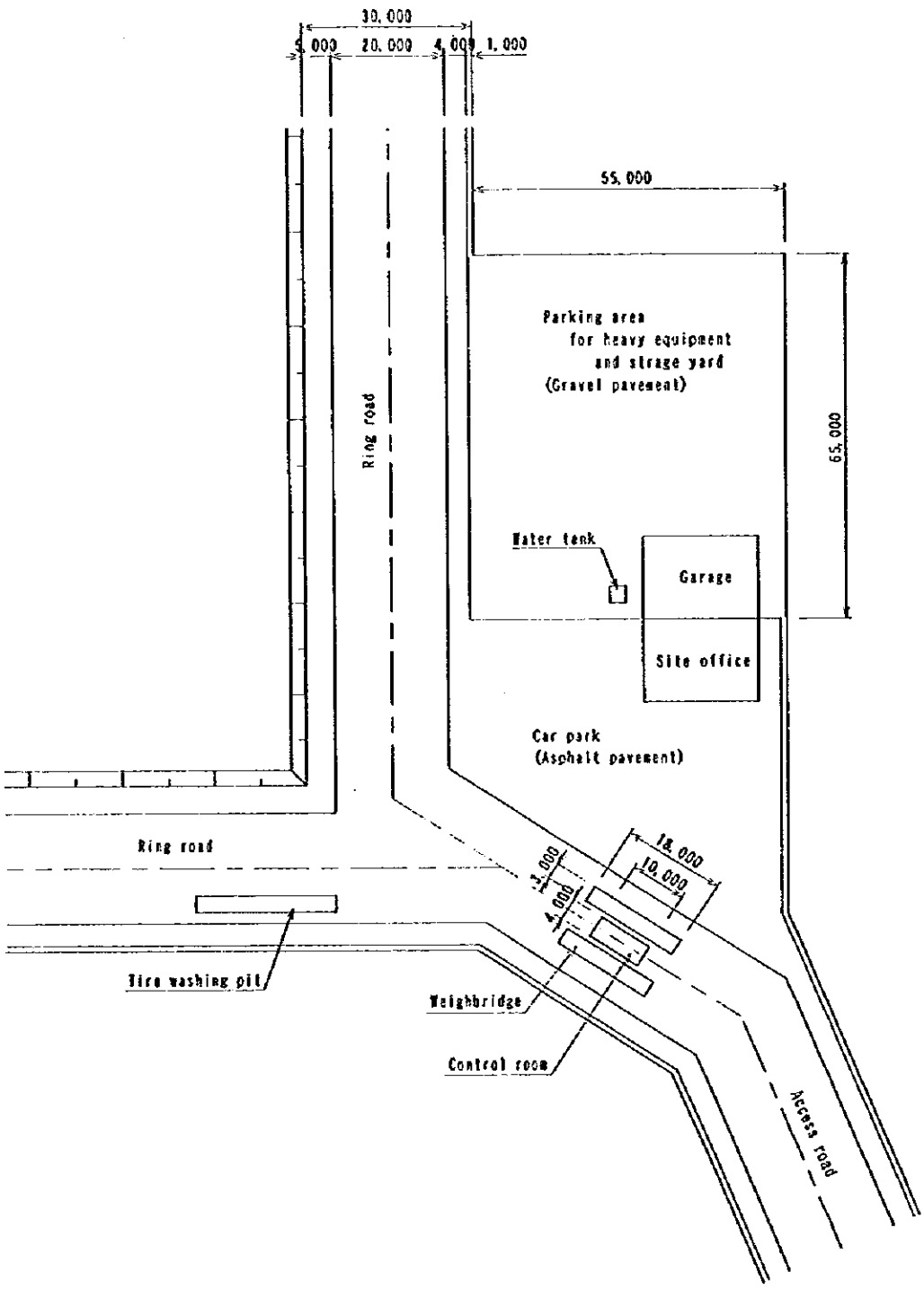


Figure 6-8:

Plan of Waste Transport Control Facilities

KOKUSAI KOGYO Co., Ltd.

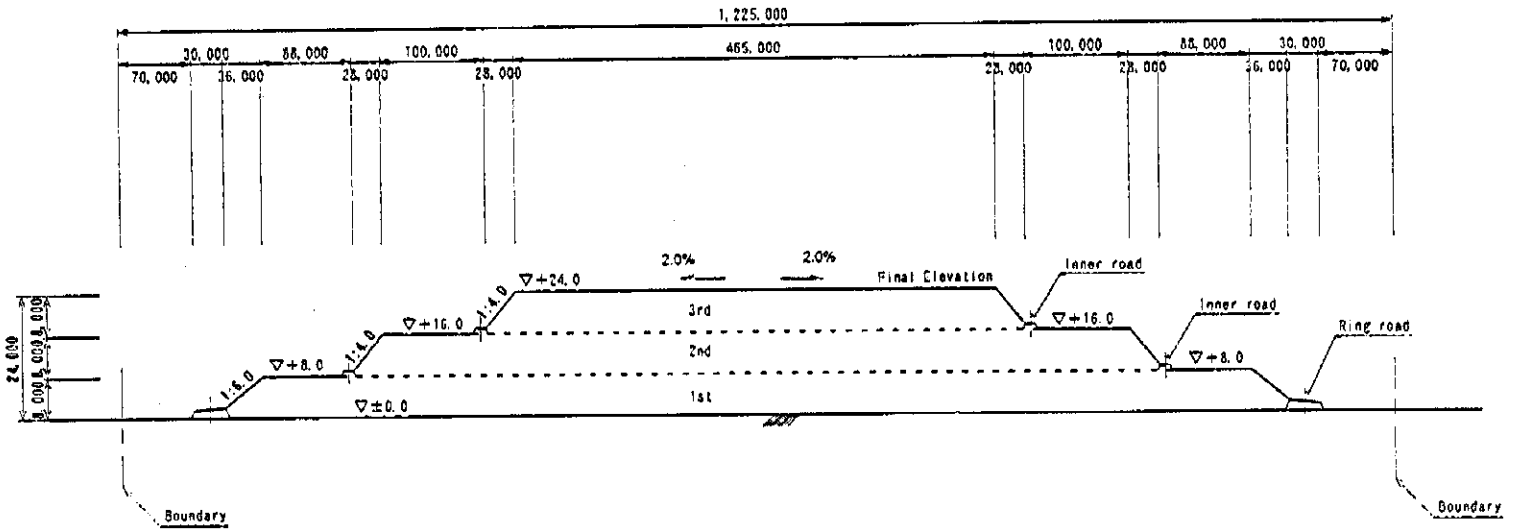
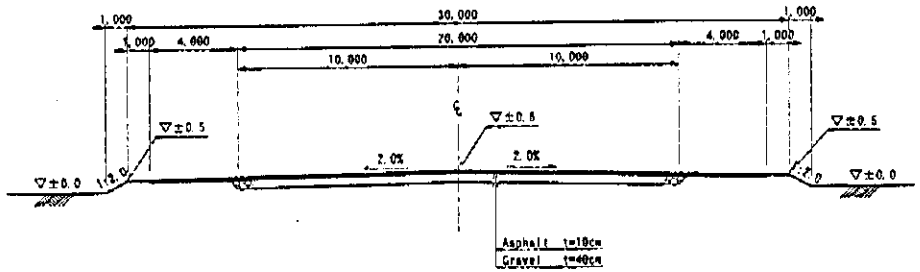
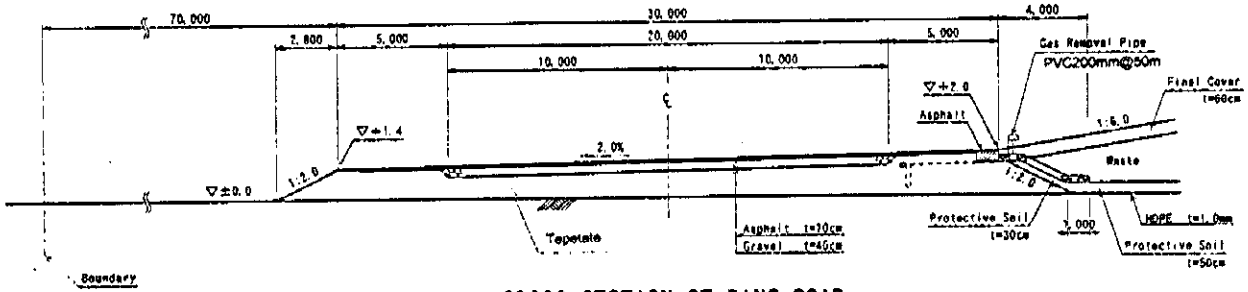


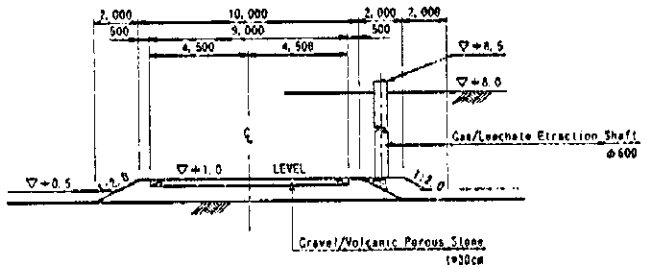
Figure 6-9: Cross Section



CROSS SECTION OF ACCESS ROAD



CROSS SECTION OF RING ROAD



CROSS SECTION OF INNER ROAD

Figure 6-10: Cross Section of Roads

b.5 Cost Estimation

Table 6-20 and Table 6-21 summarize the costs for the New Landfill Development (Etapa V).

Table 6-20: Summary of Costs for A New Landfill Development (Case1)

unit: US$ 1,000

Year	B/D	D/D	Con. (Ini.)	Con(Rec)	Equip.	O&M	Land fee	Total
1999	41							41
2000		204						204
2001		162	4,068				231	4,461
2002				7,464		707	231	8,402
2003				7,224		707	231	8,162
2004				7,001		801	231	8,033
2005						13	231	244
2006						70	231	301
2007		139		3,915	2,777	720	231	7,782
2008				2,022		777	231	3,030
2009						13	231	244
2010						70	231	301
Total	41	505	4,068	27,626	2,777	3,878	2,310	41,205

B/D: Basic design for construction and equipment.
D/D: Detailed design for construction and equipment. The amount complies costs for supervision as well.
Con. (Ini.): Initial investment cost for construction
Con(Rec): Recurrent cost for construction
Equip.: Landfill equipment
O&M: Operation and maintenance
Land fee: Land rental fee

Table 6-21: Summary of Costs for A New Landfill Development (Case 2)

unit: US$ 1,000

Year	B/D	D/D	Con. (Ini.)	Con(Rec)	Equip.	O&M	Land fee	Total
1999	41							41
2000		204						204
2001		162	4,068				231	4,461
2002				7,464	901	598	231	9,194
2003				7,224	901	598	231	8,954
2004				7,001	901	692	231	8,825
2005						13	231	244
2006						70	231	301
2007				3,915	901	611	231	5,658
2008				2,022	901	668	231	3,822
2009						13	231	244
2010						70	231	301
Total	41	366	4,068	27,626	4,505	3,333	2,310	42,249

B/D: Basic design for construction.
D/D: Detailed design for construction. The amount complies costs for supervision as well.
Con. (Ini.): Initial investment cost for construction
Con(Rec): Recurrent cost for construction
quip.: Landfill equipment
O&M: Operation and maintenance
Land fee: Land rental fee

6.2.3 Cost of Priority Projects

Table 6-22: Cost of Priority Projects, Case of Direct Operation by DGSU (Case 1)

Unit : US$ 1,000

			1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
BP Etapa IV	B/D		33	0	0	0	0	0	0	0	0	0	0	0	33
	D/D & S/V		0	298	0	0	0	0	0	0	0	0	0	0	298
	Construction		0	7,902	2,164	0	0	0	1,883	1,874	0	0	1,773	1,526	17,124
	Equipment		0	2,777	0	0	0	0	0	0	0	0	0	0	2,777
	O & M	Contract out	0	0	0	0	0	0	0	0	0	0	0	0	0
		Direct	0	0	728	111	21	111	728	818	21	111	728	818	4,195
	Land fee		0	0	425	425	425	425	425	425	425	425	425	425	4,250
	Total		**33**	**10,977**	**3,317**	**536**	**446**	**536**	**3,036**	**3,117**	**446**	**536**	**2,926**	**2,771**	**28,677**
BP Etapa V	B/D		41	0	0	0	0	0	0	0	0	0	0	0	41
	D/D & S/V		0	204	162	0	0	0	0	0	139	0	0	0	505
	Construction		0	0	4,068	7,464	7,224	7,001	0	0	3,915	2,022	0	0	31,694
	Equipment		0	0	0	0	0	0	0	0	2,777	0	0	0	2,777
	O & M	Contract out	0	0	0	0	0	0	0	0	0	0	0	0	0
		Direct	0	0	0	707	707	801	13	70	720	777	13	70	3,878
	Land fee		0	0	231	231	231	231	231	231	231	231	231	231	2,310
	Total		**41**	**204**	**4,461**	**8,402**	**8,162**	**8,033**	**244**	**301**	**7,782**	**3,030**	**244**	**301**	**41,205**
Landfill Total			***74***	***11,181***	***7,778***	***8,938***	***8,608***	***8,569***	***3,280***	***3,418***	***8,228***	***3,566***	***3,170***	***3,072***	***69,882***
Composting	B/D		50	0	0	0	0	0	0	0	0	0	0	0	50
	P/P		10	10	0	0	0	0	0	0	0	0	0	0	20
	D/D & S/V		0	164	99	33	33	0	0	0	13	2	0	0	344
	Construction		0	0	2,376	551	551	0	0	0	0	0	0	0	3,478
	Equipment		0	0	2,548	520	0	0	0	0	0	2,441	520	0	6,029
	O & M	Contract out	0	0	0	0	0	0	0	0	0	0	0	0	0
		Direct	0	0	0	662	820	820	820	820	820	820	820	820	7,222
	Land fee		0	0	33	33	33	33	33	33	33	33	33	33	330
	Total		60	174	5,056	1,799	1,437	853	853	853	866	3,296	1,373	853	17,473
Total			***134***	***11,355***	***12,834***	***10,737***	***10,045***	***9,422***	***4,133***	***4,271***	***9,094***	***6,862***	***4,543***	***3,925***	***87,355***
Initial Investment															
BP Etapa-IV			***33***	***10,977***											***11,010***
BP Etapa-V			***41***	***204***	***4,230***										***4,475***
Composting			***60***	***174***	***5,023***	***1,104***	***584***								***6,945***
Total			***134***	***11,355***	***9,253***	***1,104***	***584***								***22,430***

B/D : Basic design, D/D :Detailed design, S/V :Supervision, P/P : Pilot project, O&M : Operation and maintenance

Table 6-23: Cost of Priority Projects, Case of Contract-Out (Case 2)

Unit : US$ 1,000

			1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
BP Etapa IV	B/D		33	0	0	0	0	0	0	0	0	0	0	0	33
	D/D & S/V		0	298	0	0	0	0	0	0	0	0	0	0	298
	Construction		0	7,902	2,164	0	0	0	1,883	1,874	0	0	1,773	1,528	17,124
	Equipment		0	0	0	0	0	0	0	0	0	0	0	0	0
	O & M	Contract out	0	0	1,499	0	0	0	1,499	1,499	0	0	1,499	1,499	7,495
		Direct	0	0	21	111	21	111	21	111	21	111	21	111	660
	Land fee		0	0	425	425	425	425	425	425	425	425	425	425	4,250
	Total		33	8,200	4,109	536	446	536	3,828	3,909	446	536	3,718	3,563	29,860
BP Etapa V	B/D		41	0	0	0	0	0	0	0	0	0	0	0	41
	D/D & S/V		0	204	162	0	0	0	0	0	0	0	0	0	366
	Construction		0	0	4,068	7,464	7,224	7,001	0	0	3,915	2,022	0	0	31,694
	Equipment		0	0	0	0	0	0	0	0	0	0	0	0	0
	O & M	Contract out	0	0	0	1,499	1,499	1,499	0	0	1,499	1,499	0	0	7,495
		Direct	0	0	0	0	0	94	13	70	13	70	13	70	343
	Land fee		0	0	231	231	231	231	231	231	231	231	231	231	2,310
	Total		41	204	4,461	9,194	8,954	8,825	244	301	5,658	3,822	244	301	42,249
Landfill Total			***74***	***8,404***	***8,570***	***9,730***	***9,400***	***9,361***	***4,072***	***4,210***	***6,104***	***4,358***	***3,962***	***3,864***	***72,109***
Composting	B/D		50	0	0	0	0	0	0	0	0	0	0	0	50
	P/P		10	10	0	0	0	0	0	0	0	0	0	0	20
	D/D & S/V		0	164	99	33	33	0	0	0	13	2	0	0	344
	Construction		0	0	2,376	551	551	0	0	0	0	0	0	0	3,478
	Equipment		0	0	1,250	177	0	0	0	0	0	1,142	177	0	2,746
	O & M	Contract out	0	0	0	1,051	1,186	1,186	1,186	1,186	1,186	1,186	1,186	1,186	10,539
		Direct	0	0	0	101	124	124	124	124	124	124	124	124	1,093
	Land fee		0	0	33	33	33	33	33	33	33	33	33	33	330
	Total		60	174	3,758	1,946	1,927	1,343	1,343	1,343	1,356	2,487	1,520	1,343	18,600
Total			***134***	***8,578***	***12,328***	***11,676***	***11,327***	***10,704***	***5,415***	***5,553***	***7,460***	***6,845***	***5,482***	***5,207***	***90,709***
Initial Investment															
BP Etapa-IV			***33***	***8,200***											***8,233***
BP Etapa-V			***41***	***204***	***4,230***										***4,475***
Composting			***60***	***174***	***3,725***	***761***	***584***								***5,304***
Total			***134***	***8,578***	***7,955***	***761***	***584***								***18,012***

B/D : Basic design, D/D :Detailed design, S/V :Supervision, P/P : Pilot project, O&M : Operation and maintenance

6.3 Institutional Plan

6.3.1 Alternatives

6.3.1.1 The Sanitary Landfill (SL)

The situation to locate the SL in the ex-lake Texcoco area is sensitive and is subject to restrictions and audits by federal entities and by the GDF, and occasionally by authorities from the state of Mexico. The use of the land owned by the National Water Commission (CNA) was authorized under the commitment of the GDF to carry out work, monitoring and maintenance tasks in the long term. The alternation in the uses of Etapas IV and V would be a technical decision made according to the features of the soil.

For such reason, the DGSU will have a continuous presence at the site. Therefore, it would not be very interested to give concession of the construction of infrastructure, operation and maintenance of SL to a private enterprise, and contracting out such services would be convenient.

The institutional alternatives induce the analysis of three options:

- **SL.1 - Direct administration and operation** by the GDF through the DGSU.
- **SL.2 - Direct administration** by DGSU, and operation through **contracts.**
- **SL.3** - To create a **parastatal entity** to manage and operate the SL; either directly or not.

To be noticed that the investment in the sanitary landfills will be on the part of the GDF in any alternative chosen, and be carried out in Phase I. Besides, the selection of the alternative of operation of the SL will be effective as of year 2002 (Table 6-24).

6.3.1.2 The Composting Plant (CP)

The investment on the CP will be carried out by the GDF in Phase I. However, its operation and commercialization of the compost product will be analyzed and chosen from one of the following options, with its operation beginning as of year 2002 (Table 6-24):

A1. Direct operation by DGSU.
A2. Operation contracted out by DGSU.
B. Parastatal.
C. Concession.

Table 6-24: Options for the Operation of CP and SL

	Phase 1 (1999 - 2001)	Phase 2 (2002-2004)	Phase 3 (2005-2010)	2011-
Composting Plant	Investment by DGSU **1st Priority Financing**	A1. Direct operation by DGSU, or A2. Operation contracted out by DGSU. Analysis of four options: A. Status quo (DGSU), either A1. Or A2., B. Parastatal and C. Concession and prepare B or C if this options is chosen.	A1, A2, B or C.	A1, A2, B or C.
Final Disposal	Investment by DGSU **1st. Priority Financing**	SL1. Direct operation by DGSU, or SL2. Operation contracted out by DGSU. Analysis of three options: Status quo (DGSU), either SL1 or SL2 and SL3. Parastatal and prepare SL3 if this option is chosen.	SL1, SL2 or SL3.	SL1, SL2 or SL3.

Note: This table shows the alternatives proposed by the JICA team, which will be further analyzed by the GDF.

6.3.2 Conclusion

The GDF has financial resources to invest in both SL and CP, taking in consideration the short term to the depletion of the SL/Etapa IV. The GDF thus may choose direct administration or parastatal form - for this last option, a decentralized organism taking over the SL and the CP would be the most suitable; however, the probable span of time and political difficulties to attain the legal acts, the budgetary and administrative resources required to constitute a parastatal seem to indicate **direct administration** as the most opportune form to manage the SL and the CP.

The weak points of the direct administration would be attenuated through contracting out infrastructure works and operation and maintenance services. In the course of time, it will be possible to evolve to better alternatives, previously evaluated as anticipated in Table 5-7 of the Master Plan.

6.4 Public Education Plan

6.4.1 Public Education Program

Table 6-25 summarizes the Public Education Program to be implemented in the 1999-2010 period.

Table 6-25: Public Education Program

Phase 1	Phase2	Phase 3	Phase 4
1999-2001	2002-2004	2005-2010	2011
• Creation of the Executing body within the GDF • Preparation of the educational programs with the participation of delegations • Information to the community • Sensitization and talks • Starting the educational program for the separation at the source within the subsystem • Starting the training program for the personnel • Promotion of the environmental education in elementary schools	• Intensive education for the separation at the source of organic and recyclable material, according to the plan established • Staff training • Fostering the school education • Education for the separation at the source of recyclable materials within the delegations	• Continuation of the training program • Continuation of the program for the separation at the source (system working in the delegations) • Continuation of the maintenance stage of other educational projects • Intermediate evaluation (2005) • Intermediate readjustment of the program	• Final assessment (2011) • Readjustment of the Public Education Program

6.4.2 Education Plan for Priority Projects

Table 6-26 shows the educational plan for the priority projects during the period 1999-2010.

Table 6-26: Educational program for Priority Projects

Educational components	Phase 1 1999-2001	Phase 2 2002-2004	Phase 3 2005-2010
1. Composting Plant			
1.1 Education to market traders to separate organic resources at the source.			
1.2 Education of users in the subsystem on the separation of garden wastes and organic material at the source .			
1.3 Education of users in the delegations on the separation of garden wastes and organic material at the source (Activity subject to a greater demand of the composting plant).			
1.4 Staff training in public parks to prepare pruned tree branches and organic material to be delivered in the collection.			
1.5 Training of separate collection staff for organic material and composting plant personnel on SWM, occupational health and environmental protection.			
2. Sanitary landfills (Etapa IV and V)			
2.1 Education of users in the subsystem on the separation of recyclable wastes at the source.			
2.2 Education of users in the delegations on the separation of recyclable wastes at the source (50% of population in the year 2010).			
2.3 Training the new staff for the collection of recyclable products and the sanitary landfill personnel (IV and V) on SWM, occupational health and environmental protection.			
3. Foster the environmental and school education			

Intensive educational stage

Education maintenance stage

6.5 Financing Plan

Initially in this sub-section, the analysis and the work deliverables therewith are focused entirely on the assessment of the finance needs associated with the possible institutional alternatives and funding sources, and fiscal impacts on DGSU.

6.5.1 Guiding Principles for Analysis of Finance Needs Assessment

a. Configuration

A. Analytical Dimensions

A-1. Overall Project Cost structure
A-2. Financing Requirements and Financing Plan
A-3. Cash Flow Structure

B. Variables and Variations included in Analytical Framework

B-1. Implementation Framework (Cases) and Project Components in concern

Case 1: All three components, vis-à-vis, Final Disposal Sites (FDSs, Etapa IV and Etapa V) and Composting Plant being internalized within DGSU

Case 2: FDSs and Composting Plant are constructed by DGSU and Operated on Contract-Out basis by the private sector business undertaking

With the foregoing in view:

B-2. Financing Sources

Category 1. Own Fund (Equity) Only

Category 2. Equity-Loan Mix

Sub-C 1. World Bank-type (interest capitalized)

Sub-C 2. OECF-type (interest not capitalized)

C. Evaluation Criteria

C-1. Ability to Pay (Aggregate Project Costs)

C-2. Affordability - Annual Cash Outlays within DGSU over the period

b. Schematic Framework - Combination of Variables and Variation

The schematic framework for the analysis in concern will be summarized as follows.

Table 6-27: Institutional Framework (Cases)

		Composting Plant	
		Case 1	Case 2
Final Disposal Sites	Case 1	Alternative 1	Alternative 2
	Case 2	Alternative 3	Alternative 4

Table 6-28: Funding Source

	Own Fund	External Fund: Equity-Loan mix	
		World Bank-type	OECF-type
Alternative 1	Option 1	Option 5	Option 9
Alternative 2	Option 2	Option 6	Option 10
Alternative 3	Option 3	Option 7	Option 11
Alternative 4	Option 4	Option 8	Option 12

6.5.2 Financing Plan

Summary of finance needs is shown in Table 6-29.

Table 6-29: Finance Needs within DGSU by Option

Institutional Framework	Own Fund	External Fund	
	(US$ million)	World Bank-type (US$ million)	OECF-type (US$ million)
All Components Internalized (Alternative 1)	Option 1 – 84.3	Option 5 – 177.1	Option 9 – 224.6
FDSs-Internalized, CP-Externalized (Alternative 2)	Option2 – 85.3	Option 6 – 177.2	Option 10 – 225.6
FDSs-Externalized, CP-Internalized (Alternative 3)	Option 3 – 86.4	Option 7 – 175.6	Option 11 – 226.7
All Components Externalized (Alternative 4)	Option 4 – 87.4	Option 8 – 176.6	Option 12 – 227.2
Average	85.9	176.6	226.0

As attached, a summary of "income statements" numerically elucidating the overall cash flow structure in a time slice of the project period and loan repayment period by Option is provided in Table 6-30.

Table 6-30: Summary "Income Statements" by Option

Alternative 1 EF1CP1

Options	OF 1	EF-WB 5				EF-OECF 9				OF 2	EF-WB 6				EF-OECF 10			
year	Investment Outlay	Investment Outlay	Amortization	Disbursement	Net Outlay	Investment Outlay	Amortization	Disbursement	Net Outlay	Investment Outlay	Investment Outlay	Amortization	Disbursement	Net Outlay	Investment Outlay	Amortization	Disbursement	Net Outlay
1999	0.2	0.2		0.3	-0.03	0.2	0.03	0.3	0.09	0.2	0.2		0.3	-0.04	0.2	0.03	0.3	-0.01
2000	13.7	13.7		14.3	-0.62	13.7	1.5	14.3	0.47	13.7	13.7		14.9	-1.22	13.7	1.5	14.9	0.32
2001	16.0	16.0		12.9	3.13	16.0	4.2	12.9	7.02	13.9	13.9		11.0	2.84	13.9	4.1	11.0	6.99
2002	9.8	9.8		1.7	8.10	9.8	5.7	1.7	13.80	10.3	10.3		2.1	8.14	10.3	5.5	2.1	13.60
2003	9.0	9.0		0.8	8.12	9.0	5.9	0.8	14.07	9.9	9.9		1.7	8.24	9.9	5.8	1.7	14.08
2004	7.8	7.8	12.3		19.76	7.8	5.9		13.87	8.3	8.3	12.2		20.51	8.3	6.0		14.33
2005	3.4	3.4	12.3		15.29	3.4	5.9		9.41	3.9	3.9	12.2		16.05	3.9	6.0		9.56
2006	3.5	3.5	12.3		15.41	3.5	5.9		9.52	4.0	4.0	12.2		16.16	4.0	6.0		9.95
2007	7.6	7.6	12.3		19.43	7.6	5.9		13.60	8.1	8.1	12.2		20.24	8.1	6.0		14.06
2008	6.3	6.3	12.3		18.20	6.3	5.9		12.31	5.5	5.5	12.2		17.65	5.5	6.0		11.47
2009	3.8	3.8	12.3		15.73	3.8	6.2		10.01	4.0	4.0	12.2		16.14	4.0	6.2		10.12
2010	3.2	3.2	12.3		15.13	3.2	6.2		9.41	3.7	3.7	12.2		15.88	3.7	6.2		9.86
2011-2014			36.8		21.90		24.6		24.79			35.6		36.56		24.7		24.66
2015-2029							86.2		86.36							86.3		86.30
Total	84.3	84.3	122.7	30.0	177.10	84.3	170.0	30.0	224.6	85.3	85.3	121.9	30.0	177.2	85.3	170.1	30.0	225.6

Alternative 3 EF2CP1

Options	OF 3	EF-WB 7				EF-OECF 11				OF 4	EF-WB 8				EF-OECF 12			
year	Investment Outlay	Investment Outlay	Amortization	Disbursement	Net Outlay	Investment Outlay	Amortization	Disbursement	Net Outlay	Investment Outlay	Investment Outlay	Amortization	Disbursement	Net Outlay	Investment Outlay	Amortization	Disbursement	Net Outlay
1999	0.2	0.2		0.0	0.20	0.2	0.02	0.0	0.22	0.2	0.2		0.3	-0.03	0.2	0.03	0.3	0.00
2000	10.6	10.6		10.6	0.03	10.6	1.1	10.6	1.13	10.5	10.5		10.9	-0.39	10.5	1.1	10.9	0.76
2001	18.7	18.7		16.9	1.80	18.7	3.8	16.9	5.65	16.5	16.5		15.2	1.37	16.5	3.8	15.2	5.12
2002	10.3	10.3		1.6	8.69	10.3	5.7	1.6	14.39	10.8	10.8		2.1	8.76	10.8	5.5	2.1	14.23
2003	9.6	9.6		0.9	8.74	9.6	5.9	0.9	14.69	10.5	10.5		1.6	8.91	10.5	5.8	1.6	14.78
2004	8.4	8.4	11.9		20.32	8.4	6.0		14.43	8.9	8.9	11.9		20.81	8.9	6.0		14.89
2005	3.8	3.8	11.9		15.73	3.8	6.0		9.85	4.3	4.3	11.9		16.22	4.3	6.0		10.30
2006	3.4	3.4	11.9		15.28	3.4	6.0		9.39	3.8	3.8	11.9		15.77	3.8	6.0		9.85
2007	5.9	5.9	11.9		17.78	5.9	6.0		11.90	6.4	6.4	11.9		18.27	6.4	6.0		12.35
2008	6.8	6.8	11.9		18.75	6.8	6.0		12.87	6.0	6.0	11.9		17.95	6.0	6.0		12.03
2009	4.7	4.7	11.9		16.59	4.7	6.2		10.87	4.8	4.8	11.9		16.74	4.8	6.2		11.02
2010	4.0	4.0	11.9		15.92	4.0	6.2		10.20	4.5	4.5	11.9		16.41	4.5	6.2		10.69
2011-2014			35.8		21.90		24.8		24.79			35.8		21.90		24.8		24.79
2015-2029							86.4		86.36							86.4		86.36
Total	86.4	86.4	119.2	30.0	175.60	86.4	170.2	30.0	226.2	87.4	87.4	119.2	30.0	176.6	87.4	170.1	30.0	227.2

6.5.3 "Totem Pole" Evaluation

A Totem Pole of preferential order with each of the options in the queue by size of aggregate fund needs is depicted as Figure 6-11.

Excellent

Good

Fair

Poor

Terrible

Preferential Order

Totempole-Evaluation (Annual Finance Needs)

I	*Option 1*			
II	*Option 4*	*Option 11*	*Option 12*	
III	*Option 3*	*Option 9*	*Option 10*	
IV	*Option 8*	*Option 7*	*Option 2*	
V	*Option 5*	*Option 6*		

Preferential Order

Totempole-Evaluation (Aggregate Costs and Annual Finance Needs)

I	*Option 1*	*Option 4*			
II	*Option 2*	*Option 3*	*Option 12*		
III	*Option 5*	*Option 6*	*Option 7*	*Option 8*	*Option 9*
IV	*Option 10*	*Option 11*	*Option 12*		

	Evaluation Criteria				
		Annual Expenses			
Option	Project Cost	Initial 5years x<=US$10mil	Operation x<=US$13mil	Amortization x<=US$7mil	Consolidated Points
Option 1	1	2.5	5.0	4.8	2.8
Option 2	2	3.0	5.0	4.6	3.0
Option 3	3	3.5	5.0	4.8	3.3
Option 4	4	4.0	5.0	4.8	3.5
Option 5	5	4.3	2.0	2.6	2.8
Option 6	6	4.6	2.0	2.6	2.9
Option 7	7	4.8	2.0	3.0	3.0
Option 8	8	5.0	2.0	3.0	3.1
Option 9	9	4.0	4.0	3.5	3.2
Option 10	10	4.0	4.0	3.5	3.2
Option 11	11	4.2	4.0	3.5	3.3
Option 12	12	4.2	4.0	3.5	3.3

Figure 6-11: Totempole Evaluation - Preferential Order Amongst Options

With due recognition of the rung of financial hardship that GDF/DGSU would have to endure annually in the forthcoming time-slice of 12-year-period of project implementation, it would be commendable that the project would be financed by own fund, IF and ONLY IF (i) the government in 1999 could decisively commit to the budget allocation of around US$ 30 million for initial investment during 1999 to 2003, and (ii) DGSU could deliberately carry the annual fiscal burden and recurrent costs accrued that accounts for around 10-17 percent of the total DGSU budget annually after the year 2004[3]. Should the occasion arise when DGSU has to consider funding sources embracing external borrowing, it would be recommended that DGSU borrow funds in line with the OECF-type loan conditions where no-capitalized interest to principal and longer repayment period are assumed. This type ensures the lower principal surmounted in the wake of full disbursement of loans, and smaller amortization in the following repayment years.

Nonetheless, it would be noteworthy that the World Bank-type loan be considered where DGSU is not liable to amortization during the initial construction period. While high obligation of debt service during the repayment period is assumed in this case, financial burden during the initial investment period is much lesser than the other two funding sources. This is a kind of trade-off issue between the amortization plans of "continuously so" and "First easy go and later very tough"[4].

In the meantime, the mission was advised that the approved line of credit accorded to DGSU for the year 1999 was around P. 356 million (equivalent to US$ 39.1 million as per P.9.1 per dollar).

6.6 Environmental Impact Assessment (EIA)

6.6.1 Scope of EIA Work

As stated in Annex A.5, Mexico has a legislative base for the realization of EIA for projects with potential environmental impact. The principal structure is given by the LGEEPA, which are in turn supplemented by several regulations on specific issues including EIA. While these are enforced at the federal level by the SEMARNAP, there are bylaws on general environmental matter and regulations on EIA which are issued by local governments (at state, municipality and DF levels) due to the progress of decentralization.

According to the LGEEPA, waste management projects for municipal waste is under the jurisdiction of state governments, and so is the EIA procedure for those projects[5]. The EIA for the proposed F/S projects were, however, considered to follow the EIA guidelines of general modality issued by the SEMARNAP for the following reasons.

---

[3] In the case of all the sub-components being internalized.

[4] In favor of the World Bank type lending, inflation and possible increase in budget allocation to DGSU in conjunction with economic recovery and sound management of macroeconomic policy in Mexico would lessen the financial burden in the years to come.

[5] The EIA regulation of the State of Mexico defines projects subject to the EIA procedure of the state, which include installation and operation of treatment plant and final disposal site for municipal solid waste.

- The proposed land is geographically within the State of Mexico but the land is owned and controlled by the CNA. Therefore, the EIA process would have to involve both organizations and the EIA reports should have to be satisfactory for both the SEMARNAP's EIA guideline and the EIA regulation of the State of Mexico.
- In spite of the above, the EIA regulations of the local states, including the State of Mexico, largely follow the SEMARNAP's EIA guideline and there is little disparity. In other words, EIA which is carried out based on the SEMARNAP's guideline should meet the EIA regulation of the State of Mexico.
- The Federation is responsible of protecting environment in the federal area.

For the EIA of the Etapa V project and composting plant project, Table 6-31 presents a scope of the EIA study: which factors should be paid careful attention (factors of white cells with letters B or C) and which are necessarily not (factors of shaded cells). It should be noted, however, that the scoping was attempted in the IEE process.

Table 6-31: Summary of Scoping

Evaluation Factors	BP V	Composting Plant
Social Environment		
Resettlement		
Economic Activities		
Transport		
Public Facilities		
Division of Community		
Historical Heritage/Cultural Properties		
Water Rights/Access Rights		
Public Health	B	B
Waste (from the project)		
Accidents/Risks	B	B
Natural Environment		
Topography and Geology		
Soil Erosion		
Groundwater	B	B
Hydrological Conditions		
Coastal Zone		
Fauna and Flora	C	
Meteorology		
Landscape/ Aesthetics	B	
Pollution		
Air Pollution	B	B
Water Pollution	B	B
Soil Contamination	B	B
Noise and Vibration		B
Land Subsidence		
Offensive Odor	B	B

6.6.2 EIA for the Composting Plant

Figure 6-12 is a diagram to show the discussion schematically.

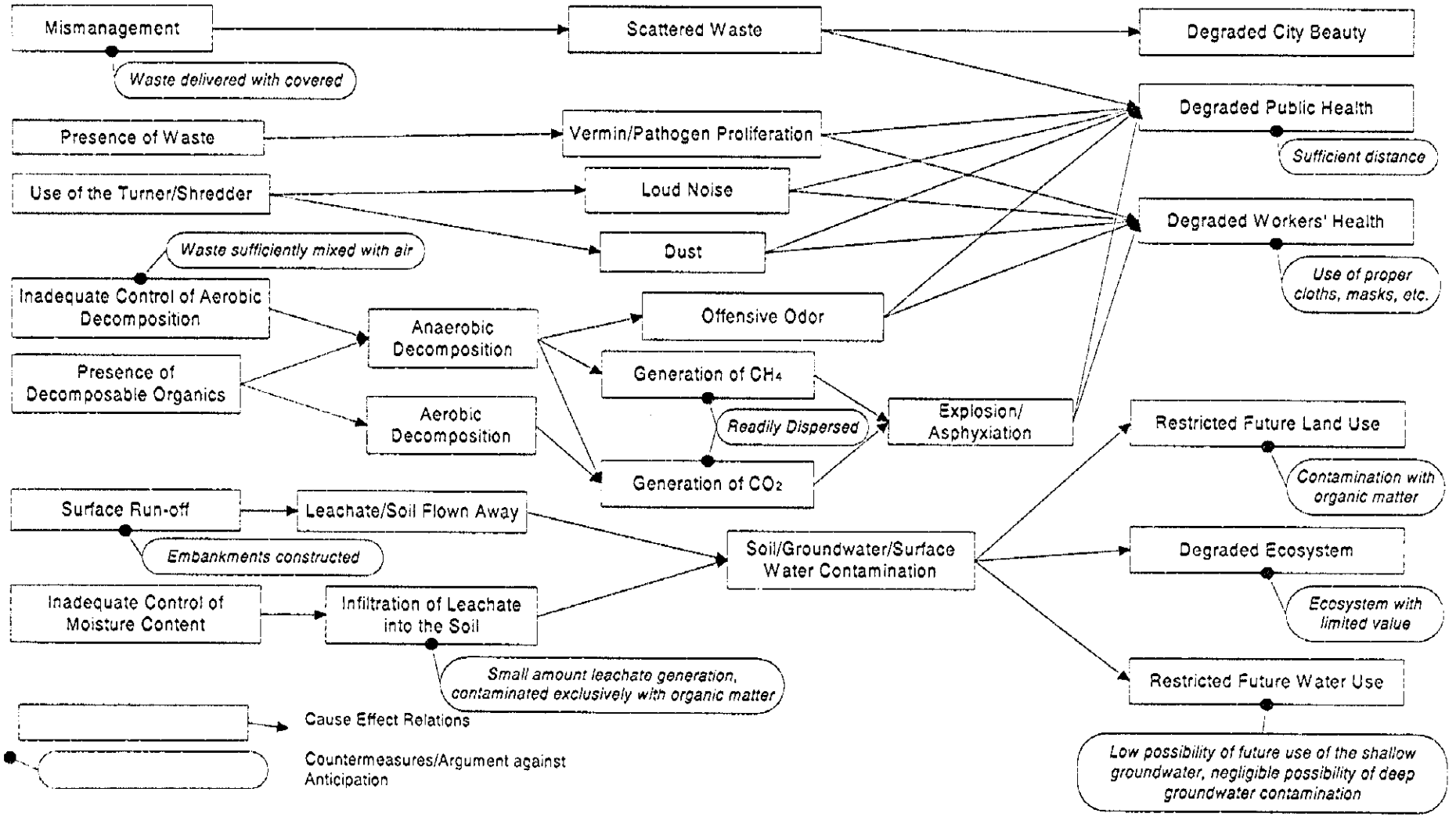


Figure 6-12: Cause Effect Relations (Composting Plant Project)

In conclusion, any major environmental adverse effect is not anticipated. This is, however, based on the several preconditions that compliance with those preconditions and recommendations has to be ensured by controlled operation. These are shown in Table 6-32.

Table 6-32: Preconditions to Prevent Environmental Impacts

Preconditions	Consequence of Failure	Method of Control
A. During the waste transportation, waste is covered with a sheet over the trailer.	Waste is allowed to fall and city beauty and public health will be degraded.	Periodical check of sheets. Use of the sheets to be acknowledged to all workers.
B. Aerobic decomposition in the windrow is securely controlled.	Explosive methane and trace gases with offensive odor will be generated and endanger the adjacent residents and plant workers.	Aerobic decomposition is monitored by measuring temperature and moisture content within the windrows.
C. Water content is carefully controlled.	Leachate infiltrates into the subsoil and reach the high groundwater table when it rains hard.	Regular measurement of water content. Frequent turning may necessary in the rainy season.
D. Organic waste is satisfactorily sorted at its source in the sub-system.	Leachate may contain toxic substances which should not be allowed to be seeped into the subsoil.	Education of waste generators. Compost product quality to be controlled periodically.
E. Embankments is constructed.	Runoff water may bring leachate, soil and compost particles to the surface water.	Plant to be carefully designed. Embankments to be well maintained.
F. The plant workers are provided with proper clothes and protection.	Gases, waste-borne diseases, noise and dust will degrade the workers' health.	Code of plant operation to be prepared. Workers' health to be regularly checked.

Note: Problem D. is to be raised only when problem C. is present.

6.6.3 EIA for the Etapa V Project

Figure 6-13 is a diagram to show the discussion schematically.

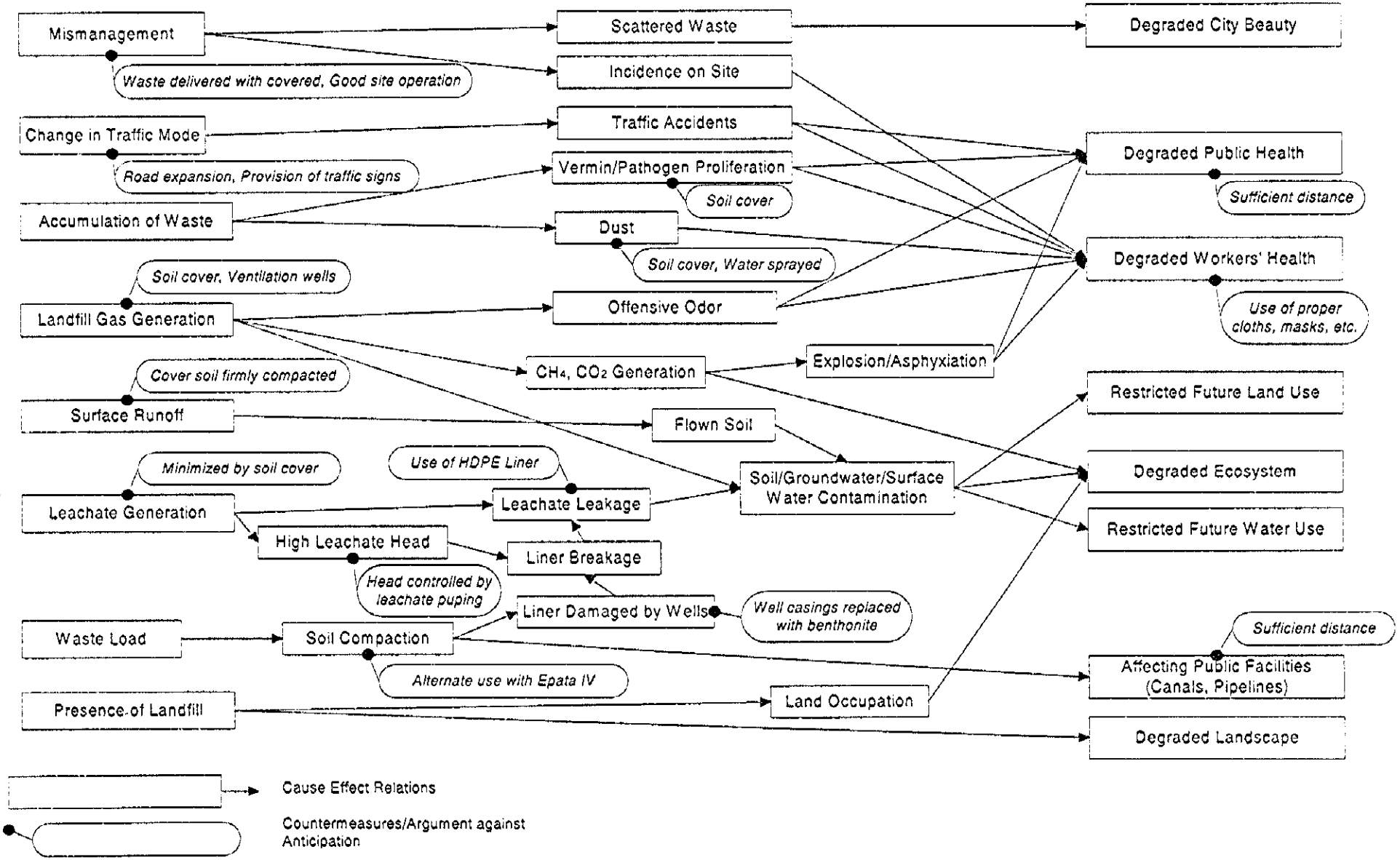


Figure 6-13: Cause Effect Relations (Etapa V Landfill Project)

Although the further study is to be done, major adverse effect on the environment has not been identified, except the impact on fauna which require careful attention. However, the conclusion so far relies on several preconditions which are to be implemented on the project commencement. In other words, if some of those preconditions are not realized in the actual project, the conclusion of EIA presented here can not be guaranteed. Table 6-33 presents such preconditions, consequence of their failure, and method to ensure the preconditions.

Table 6-33: Preconditions to Prevent Environmental Impacts

Preconditions	Consequence of Failure	Method of Control
A. During the waste transportation, waste is covered with a sheet over the trailer.	Waste is allowed to fall and city beauty and public health will be degraded.	Periodical inspection of sheets / Use of the sheets to be acknowledged to all workers.
B. Tipped waste is covered with soil with fairly small interval.	Vermin/pathogens will be proliferated. Offensive odor will be generated. Much leachate will be generated. Waste will catch a fire.	Soil covering practice to be acknowledged to the site workers.
C. Project site is well managed during the construction.	There will be accidents/risks.	Site management is to be checked by experience personnel.
D. Hazardous industrial or medical waste is not disposed of.	Water and soil contamination with toxic substances.	Thorough instruction in regard to the waste disposal method is to be given to people in industry and medicine.
E. Waste is inspected on arrival at the landfill.	Hazardous waste can be disposed of without detected.	Regular waste inspection is to be encouraged.
F. Workers are equipped with proper clothes, masks and protectors (i.e. boots, gloves, ear protectors, etc.)	Sharp material, dust, odor and noise will degrade the workers' health.	Equipping with proper clothes and protectors is to be encouraged.
G. Traffic is controlled at the junctions.	Risk of traffic accident will increase.	Change of traffic is well studied and countermeasures such as road expansion and provision of traffic signs should be implemented if necessary.
H. Well casings are totally removed.	The impermeable liner will be damaged.	Wells to be inspected after the casings removed.
I. Landfill gas is ventilated even for sufficient period.	Landfill gas will migrate and cause problems of methane explosion, asphyxiation, and odor.	Landfill gas is to be monitored and the function of gas ventilation facility is to be inspected.
J. An impermeable liner is laid at the bottom of landfill.	Groundwater will migrate and to generate leachate. Leachate will migrate and contaminate groundwater and soil.	Appropriate site work is to be encouraged in order to securely lay, anchor and protect the liner.
K. Vehicles move within the site in a controlled manner.	There will be accidents/risks and dust problem will be raised.	Vehicle movement is controlled by proper personnel.

6.7 Project Evaluation

Project evaluation was carried out from the technical, institutional, social, environmental, financial and economical perspectives.

6.7.1 Technical Evaluation

Technical systems of the priority projects comprise:

- **Composting plant to treat organic wastes separately discharged from the sub-system;**
- **Vertical expansion of the Bordo Poniente Etapa IV; and**
- **Construction of New Final Disposal Site (Bordo Poniente Etapa V)**

Technical evaluation herewith gives an assessment whether or not these priority projects are enforceable, with reference to the present technical capabilities reserved by the DGSU.

a. Composting Treatment

The delegation Gustavo A. Madero had owned a municipal solid waste composting plant operated until 1993. The facility was shut down and dismantled mainly because mixed municipal waste fed to the facility deteriorated compost quality. Although the project ended in failure, it gave an experience of constructing and operating the facility to the DGSU, which learned that, in order to prevent this failure, a composting facility should be fed with selected organic wastes.

On the other hand, the DGSU is currently operating a small windrow composting plant for processing the garden wastes (e.g., pruned tree branches and grasses), and the compost products are of satisfactory quality.

Therefore, it is judged that the DGSU reserves technical capability to construct and operate the composting plant. In other words, technical problems in constructing and operating the plant are not foreseen.

b. Vertical Expansion of the Bordo Poniente Etapa IV

This project is in line with the current technical practices of landfill operation by the DGSU, and only an additional technical requirement of the leachate collection and spraying is included. Therefore, it is judged that the DGSU could easily comply with the technical requirements of this project.

c. Construction of New Final Disposal Site (Bordo Poniente Etapa V)

The Bordo Poniente Etapa V is proposed to be constructed with the same technical components as what are employed in the present landfill (Etapa IV), and only an additional technical requirement of the leachate collection and spraying is included. Therefore, it is obviously judged that no technical problems are foreseen.

6.7.2 Institutional Evaluation

The priority projects are selected as they have an urgency in implementation. Therefore, an appropriate alternative in practice should be that at first instance the DGSU becomes in charge of project investments and that the project operation for the initial time being should be: directly by DGSU; or by contract-out.

This institutional setting recommended above is in line with the present institutional framework practiced by the DGSU. All existing human and technical resources of the DGSU can continuously be utilized. Therefore it is judged that this institutional alternative is reasonable and workable.

However, in view of the medium and long term target to improve efficiency in SWM by the GDF, whether "maintaining the original institutional setting" or "altering it to other institutional alternatives" should be carefully examined at an appropriate time interval.

6.7.3 Social Evaluation of Priority Projects

The social evaluation of the three projects are shown in Table 6-34. In summary, the social evaluation of such projects does not show significant problems, and hence certain benefits -such as more jobs- will be present.

Table 6-34: Social Evaluation of Priority Projects

Social Items	Composting Plant	Sanitary Landfill (Etapa V)
Location	Texcoco and Nezahualcoyotl Municipalities (State of Mexico).	Texcoco and Atenco Municipalities (State of Mexico).
Closest Urban Concentration	1 Km away (Ciudad Lago *Colonias* of Nezahualcoyotl Municipality), State of Mexico.	2.1 Km away (La Glorieta y Mexico Colonial *colonias* of Ecatepec Municipality), State of Mexico.
Production Activity of the Land	None.	None.
Land Ownership	Federal Property.	Federal Property.
Features of the Surrounding Housing	Houses made of bricks and concrete with water supply, sewerage, electricity, etc.	Houses made of bricks and concrete with water supply, sewerage, electricity, etc.
Underground Water Use	It is believed (yet it has not been confirmed) that there is water supplying wells at the urban concentration -more than 2 km away from the composting facility.	It is believed (yet it has not been confirmed) that there is water supplying wells at the urban concentration of Ecatepec Municipality.
Canal de las Sales	Wastewater canal next to the houses, thus representing a health and environmental problem.	Wastewater canal next to the houses, thus representing a health and environmental problem. Canal is 2 km away from Etapa V.
Employment	Additional 250 jobs will be created during construction phase in the year 2001, 280 new jobs during the operation stage in the years 2002 and 2003, and 420 jobs more from 2004 to 2010.	50 new jobs are estimated during the construction stage of Etapa V in 2001, and 100 additional jobs in the operation of Etapa IV and V from 2001 to 2010.
Population Health in General Terms	• Reduction in the proliferation of vectors through the separation and processing of organic material. • Less illegal dumping sites. • No adverse impacts by noise and furious odors on surrounding populations.	• Reduction of harmful disease-carrying fauna. • Less illegal dumping sites. • No adverse impacts by noise and offensive odors. • Adverse effect by dust, noise and accidents due to the intense traffic of trucks; it must be mitigated through supervision and public education.

6.7.4 Environmental Evaluation

Environmental adverse impacts envisaged to be induced, when and where the priority projects are implemented, are all estimated to be mitigable and/or preventable by some countermeasures to be incorporated in project design or operation manner or others. It is judged that the all priority projects are environmentally sound.

6.7.5 Financial Evaluation

In quantitative analysis to address the major issues of financial sustainability and viability of SWM was attempted by applying FIRR index, four kinds of "benefits"[6] would be estimated by the measurement of proxies, vis-à-vis, (i) money transaction actually taken place from beneficiaries to collectors, (ii) willingness to pay (WTP) currently revealed by people in DF, (iii) empirical WTP, and (iv) long-run marginal cost (LRMC) of service.

Based on the background of model configuration and parameters as reflected in Data M in the Data Book, FIRR estimation was only possible when the benefits are counted by empirical WTP, marginal cost pricing, and market price for composting. The outcomes are summarized in the Table 6-35 down below.

Table 6-35: FIRRs by Benefit Variation and Project Component – Alternative 1

unit: %

	BP E-IV	BP E-V	Composting	Overall
WTP – Paid (i)	Immeasurable 1/	Immeasurable	NA 2/	Immeasurable
WTP – Revealed (ii)	Immeasurable	Immeasurable	NA	Immeasurable
WTP – Empirical (iii)	47.5	82.0	NA	67.5 3/
MC Pricing (iv)	15.5	19.7	37.4	23.3
Market Price (v)	NA	NA	17.5	NA

Table 6-36: FIRRs by Benefit Variation and Project Component – Alternative 2

unit: %

	BP E-IV	BP E-V	Composting	Overall
WTP – Paid (i)	Immeasurable 1/	Immeasurable	NA 2/	Immeasurable
WTP – Revealed (ii)	Immeasurable	Immeasurable	NA	Immeasurable
WTP – Empirical (iii)	47.5	82.0	NA	67.5 3/
MC Pricing (iv)	15.5	19.7	42.4	23.8
Market Price (v)	NA	NA	19.3	NA

[6] Meanwhile, to date, cost recovery scheme to finance the concerned urban sanitation service is yet to come, as such the detailed investigation of financial viability in terms of benefit-cost analysis with costs (of the prospective investment plan) and benefits (profits emanating from tariff on public service) encounters difficulties at this moment in time. In the light of this, it should be noted that the term "benefits" used in the following parts does not presume, except for the tariff system for large-scale consumers in DF, the pecuniary concept of "revenues" from tariff levied on direct beneficiaries.

Table 6-37: FIRRs by Benefit Variation and Project Component – Alternative 3

unit: %

	BP E-IV	BP E-V	Composting	Overall
WTP – Paid (i)	Immeasurable 1/	Immeasurable	NA 2/	Immeasurable
WTP – Revealed (ii)	Immeasurable	Immeasurable	NA	Immeasurable
WTP – Empirical (iii)	58.2	71.7	NA	72.2 3/
MC Pricing (iv)	19.5	22.4	42.4	26.4
Market Price (v)	NA	NA	30.8	NA

Table 6-38: FIRRs by Benefit Variation and Project Component – Alternative 4

unit: %

	BP E-IV	BP E-V	Composting	Overall
WTP – Paid (i)	Immeasurable 1/	Immeasurable	NA 2/	Immeasurable
WTP – Revealed (ii)	Immeasurable	Immeasurable	NA	Immeasurable
WTP – Empirical (iii)	58.2	71.7	NA	72.2 3/
MC Pricing (iv)	19.5	22.4	37.3	27.2
Market Price (v)	NA	NA	19.3	NA

1/ Immeasurable – FIRR is not mathematically calculated due to extraordinary low positive figures in the net cash-flow stream.

2/ NA – By nature of the attributes to the sub-components, FIRRs are not appropriate in estimation of financial sustainability.

3/ Excluding the composting sub-component

(i) Considering money transaction actually taken place from beneficiary to collectors as benefit.
(ii) Considering willingness to pay (WTP) currently revealed by people in the DF as benefit.
(iii) Considering empirical WTP as benefit.
(iv) Considering long-run marginal cost of service as benefit
(v) Obtaining benefit from the sale of compost at 700 pesos/ton.

6.7.6 Economic Evaluation

The index in appraisal of economic feasibility, Economic Net Present Value (ENPV) analysis has duly been carried out in a bid to compare with the breakeven point of zero to reveal its numerical superiority. In measurement of economic benefits, the cost that would have otherwise accrued unless the proposed investment plan did take place (*cost saved*) was used as proxy.

The baseline concepts, guidelines considered and the parameters applied in due course of the analysis are extensively elucidated in Data M in the Data Book.

Economic evaluation has only been carried out for the project component of final disposal sites (FDSs), notably Etapa IV and V, for ENPV, because final disposal site(s) is certainly necessary whether intermediate processing exists or not.

ENPV on the FDS component was readily estimated at respective of US$ 26.2 million and US$ 26.5 million as per 1998 price level for the Alternatives 1,2 (Case 1) and Alternatives 3,4 (Case 2), with the social discount rate of 20 percent over the 12 years of project duration. With this, the overall performance of the project in terms of

allocative efficiency in the economy proved to be preferable, and substantially feasible.

The work outcomes as readily estimated above are summarized in Table 6-40 below. Further, summary net cash-flow tables for FDSs in aggregate and by component are shown in Table 6-39.

Table 6-39: Summary Net Cash-Flow for ENPV

unit: US$ million

Alternative 1 & 2 (Case 1)

Overall Cash Flow for the Project (IniInv-BC+PhyC, O.M-Base)

	BP-ETAPA IV			BP-ETAPA V			Aggregate				Net
	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total	Benefit	Cash Flow
1999	0.04	0.05	0.09	0.004	0.03	0.04	0.04	0.08	0.13	20.00	19.87
2000	4.35	5.58	9.93	0.02	0.17	0.19	4.37	5.75	10.12	30.00	19.88
2001	0.09	2.52	2.61	0.33	3.80	4.13	0.41	6.32	6.73	20.00	13.27
2002	0.07	0.42	0.49	1.60	4.91	6.51	1.67	5.33	7.00		-7.00
2003	0.00	0.42	0.42	1.55	4.78	6.32	1.55	5.20	6.74		-6.74
2004	0.07	0.42	0.49	1.58	4.65	6.23	1.65	5.07	6.72		-6.72
2005	0.09	2.30	2.39	0.00	0.01	0.01	0.09	2.31	2.40		-2.40
2006	0.16	2.30	2.46	0.05	0.01	0.06	0.21	2.31	2.51		-2.51
2007	0.00	0.42	0.42	2.96	3.15	6.10	2.96	3.57	6.52		-6.52
2008	0.07	0.42	0.49	0.13	2.22	2.35	0.20	2.64	2.84		-2.84
2009	0.09	2.22	2.31	0.00	0.01	0.01	0.09	2.23	2.32		-2.32
2010	0.16	2.03	2.19	0.05	0.01	0.06	0.21	2.04	2.25		-2.25
Total	5.2	19.1	24.3	8.2	23.7	32.0	13.4	42.8	56.3	70.0	
	ENPV=	26.2 US$ million									

Alternative 3 & 4 (Case 2)

Overall Cash Flow for the Project (IniInv-BC+PhyC, O.M-Base)

	BP-ETAPA IV			BP-ETAPA V			Aggregate				Net
	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total	Benefit	Cash Flow
1999	0.01	0.02	0.03	0.016	0.05	0.07	0.03	0.07	0.10	20.00	19.90
2000	1.69	5.62	7.30	0.08	0.26	0.33	1.76	5.87	7.64	30.00	22.36
2001	0.00	0.87	0.87	1.61	5.33	6.94	1.61	6.20	7.81	20.00	12.19
2002	0.07	0.42	0.49	1.51	5.60	7.10	1.58	6.02	7.60		-7.60
2003	0.00	0.42	0.42	1.46	5.46	6.92	1.46	5.88	7.34		-7.34
2004	0.07	0.42	0.49	1.49	5.33	6.82	1.56	5.75	7.31		-7.31
2005	0.00	2.58	2.58	0.00	0.23	0.23	0.00	2.81	2.81		-2.81
2006	0.07	2.11	2.18	0.05	0.23	0.27	0.12	2.34	2.46		-2.46
2007	0.00	0.42	0.42	0.54	3.83	4.37	0.54	4.25	4.79		-4.79
2008	0.07	0.42	0.49	0.05	2.90	2.95	0.12	3.32	3.44		-3.44
2009	0.00	2.91	2.91	0.00	0.23	0.23	0.00	3.13	3.13		-3.13
2010	0.07	2.72	2.79	0.05	0.23	0.27	0.12	2.95	3.07		-3.07
Total	2.1	18.9	20.6	6.8	29.7	36.5	8.9	48.6	57.5	70.0	
	ENPV=	26.5 US$ million									

Table 6-40: Summary of Economic Feasibility by Components and Measurement Indices

	FDSs	
	Case 1	Case 2
ENPV (US$ million)	26.2	26.5

6.7.7 Total Evaluation

As a total evaluation, it was concluded that the implementation of the priority projects were feasible in technical, institutional, social, environmental, financial and economical aspects.

7 Conclusions and Recommendations

7.1 Conclusions

The GDF has established and is carrying out the enormous urban solid waste management system covering its 8.6 million population. With respect to urban environmental aspects, the system effectively functions to provide cleansing services to almost the totality of the DF and it consequently maintains the city clean.

Bordo Poniente's final disposal sites in DF practically employs daily soil coverage on disposed wastes. A high level of final disposal management is practiced in general, only leaving a room for the improvement of leachate management.

It is highly evaluated that the DGSU and all delegations, and their staff in charge of cleansing services, are making routinely good efforts to implement appropriate SWM services.

It is regulated that respective delegations are in charge of the domestic wastes collection. Whereas in its practice, it mainly consists of two components: (i) primary collection by road sweeping staff; and (ii) collection by staff of collection vehicles. Workers engaged in these collection services (both sweeping staff and collection vehicle staff) comprise: (i) formal workers employed by DGSU; and (ii) informal workers voluntarily participating in the services. Formally employed workers constitute Section 1 of the Unique Syndicate of GDF Workers which maintains political influences. On the other hand, the informal workers are voluntary participants in the services and therefore are mostly in a socially vulnerable position.

As the cleansing services workers recover recyclable sub-products from the wastes and gain some income by selling such sub-products, their activities of picking sub-products from wastes received make the efficiency of wastes collection very low. In addition to that, as the majority of the collection vehicles are very old, the collection efficiency is further deteriorated.

Municipal waste generation amount in DF reaches 11,400 ton/day, which derives 1,370g/person/day as waste generation per capita. The waste generation per capita in DF is higher than the average of OECD countries (1,333g/person/day).

The wastes generated in DF are not source-separated and the great majority of them are landfilled. Furthermore, as it is estimated that the service life of the existing landfill (Bordo Poniente Etapa IV) will end up in early 2001, it is urgently needed to secure a new landfill site.

Three (3) Selection Plants (S/Ps) are currently operated to recover recyclable sub-products. However, its recovery ratio is not at a satisfactory level at all. The objective of the 3 S/Ps at the time of establishment was the social welfare of pepenadores who were picking the wastes at open dumping waste disposal sites. These plants still are currently operated in line with that objective.

As a consequence, the primary objective of "selection plant": to recover recyclable materials and to promote resource conservation is put aside in their operation. As only highly marketable sub-products are picked up, waste input amount is more than the

double of the appropriate plant capacity and input wastes are mixed municipal wastes, thus recovery ratios of the 3 S/Ps are very low. Further, all costs incurred on maintenance, repair, operation of the facilities are at DGSU's expenses, while ex-pepenadores groups provide their labor and absorb all sales of recovered sub-products as the groups' income. Whereas the groups are not juridical entities, a set of problems in the operation and management of such facilities are present.

With the principal goal to establish a sound solid waste management by the target year 2010, the M/P aims to:

- promote the citizens' well-being.
- implement sustainable solid waste management.
- contribute to environmental conservation.

In practice, it proposes:

- introduction and dissemination of source separation and separate collection.
- improvement of recovery ratio at S/Ps.
- construction of composting plant.
- vertical expansion of Bordo Poniente Etapa IV final disposal site.
- new construction of Bordo Poniente Etapa V final disposal site.

From these components of the M/P,

- construction of composting plant.
- vertical expansion of Bordo Poniente Etapa IV final disposal site.
- new construction of Bordo Poniente Etapa V final disposal site.

were selected as priority projects in view of their urgency. Feasibility studies were carried out for these three priority projects.

It is expected that reuse of resources will be year by year promoted and final disposal amount can be gradually reduced, when the M/P and priority projects are realized. The following can be highlighted in view of the present situation of the SWM in DF:

- Technically, the GDF will not face difficult problems, as the GDF has reserved substantial technical assets.

- In organizational and institutional aspects, inefficiency especially in collection and S/P components are outstanding. Discussion and negotiation with Section 1 and Ex-pepenadores groups should be prepared with due care in a longer time.

With respect to institutional improvement for M/P implementation, the study proposes "recommended alternative for M/P institutionalization" in Table 7-23 in the Main Report, which is subject to further analysis by GDF. Annex F presents a set of discussions on particulars to be considered for the organizational and institutional improvement for M/P implementation, therefore it is recommended, when the authority GDF needs to take action for the institutional improvement, to review the set of discussion for their reference.

The M/P was formulated based on the key precondition that the separate collection is introduced and diffused. Therefore, if separate collection is not implemented, targets described in the M/P could not be realized.

Success or not of separate collection largely depends on waste generators moral on dedicating to source separation. Therefore, it is important to formulate and implement the public education program with reference to the public education plan outlined in this report.

When the plans and projects outlined in the M/P are implemented, final disposal sites of DF will have the service lives up to about the year 2013. However, in view of urbanization in and around DF, it will be very difficult after that time to assure a site for a new landfill near the DF (such as Bordo Poniente). Therefore, before that time, the GDF should start discussion and negotiation regarding a regional-use landfill project with neighboring municipalities in the State of Mexico.

7.2 Recommendation

a. Study Continuity

This development study (The Study on Solid Waste Management for Mexico City in the United Mexican States), under the JICA's technical cooperation program, will be finalized and ended when the Final Report of the Study is submitted to the GDF around May 1999. The solid waste management M/P and the priority projects F/S are to be finalized through the study for the Mexico city. If the M/P and priority projects were not implemented, it means that all time and resources devoted to the study result in vain. Furthermore, benefits such as "promotion of citizens' well-being", "implementation of sustainable SWM" and "contribution for environmental conservation" expected in M/P and priority projects implementation will not be attained. Therefore, the study team strongly recommends that the M/P and priority projects should be implemented.

It is judged that the GDF has reserved the technical capability and financial affordability necessary for the implementation of the M/P and priority projects. Therefore, they can be considered to be ready for implementation.

Generally speaking on the other hand, when a new government is introduced after an election, plans and projects prepared by a former government often disappear before their implementation. In a worst case, reports and/or documents on plans and projects disappear. It makes it impossible even to review all the former plans and projects prepared.

In order to avoid this study from suffering such an unproductive ending, efforts should be made to create such circumstances that the study can be continuously followed up and promoted. In practice, it is recommended that a SWM expert, who can be familiar with the study and politically, institutionally and technically be in a neutral position to advise about SWM, should be dispatched to the DGSU. The dispatch of JICA expert, which is another JICA's t/c scheme, is opportune to provide such an expert being neutral and with least to none cost burden on the counterpart institution (i.e., DGSU). The study recommends that DGSU should make a request of expert dispatch to JICA.

b. Compilation and Utilization of Data

It is recommended that data and information regarding such as "waste-flow" should systematically be measured, compiled and utilized every year in order to follow and

verify what are assumed and planned in the M/P. Such compiled data and information will be extremely important to review and modify the M/P when in future it becomes necessary. At the same time, annual trends in respective SWM particulars can then be actually understood. Such data will possibly suggest a key for upgrading the SWM system of the DGSU.

c. Policy Approach for Recycling

It is estimated that recycling activities will be increased in line with the M/P. Resources recovered in SWM are increasingly distributed in the market. On the other hand in its consequence, it is anticipated that sales prices of recycled products may be lowered in response to increased supply of the products and it will contrarily impinge the recycling activities. Therefore, it is recommended that the policy approach (presented in Section 7.2.2 of the Main Report) to promote expanding markets of recycled products should be implemented.

7.2.1 Technical aspects

a. Discharge and Storage

Transformation from present "mixed discharge" to "source separation" requires understanding and cooperation by waste generators. Therefore, it is recommended that the public education program on waste management should be formulated and implemented with reference to the public education plan outlined in this report.

b. Collection

As collection is the delegations responsibility, the scope of the M/P regarding collection is limited in terms of "supervision and support" by the DGSU to the delegations. It is strongly recommended that

- Each delegation should formulate a workable long-term plan for separate collection.

c. Transfer Station and Transport

Transfer stations and transport play a crucially important role for controlling the waste flows in which respective wastes have to be delivered to proper destinations according to their categories. Therefore, it is recommended that the DGSU should further keep direct control and monitoring on transfer stations and transport in order to facilitate the integrity of all SWM components. In practice, a single common format for data compilation should be established and utilized in order to strengthen the control on transfer stations and transport. Track scales should be installed in every transfer station.

d. Intermediate Treatment

d.1 Selection Plant

Although currently mixed wastes are fed in the S/Ps for sub-products recovery, it is planned that from the year 2000 separately collected recyclable sub-products are started to be fed to S/Ps. Therefore, before that time, a modified operational mode of S/P to cope with "separated wastes" input should be carefully examined (for example, specification of reception and stockpile area of separate wastes, assignment

of one or some of sorting lines to separate wastes input and others to mixed wastes input, etc.) in order to establish optimized operation on time.

d.2 Composting Plant

It is strongly recommended that a pilot composting project on separated organic wastes from sub-system should be implemented in parallel with the basic design of the composting plant, in order to verify the design parameters (such as physical and chemical composition of the waste (organic waste of sub-system), quality of compost, etc.).

Meanwhile, as the success of a composting plant largely depends on (i) compost quality and (ii) size and stability of its market demand, it is recommended that, using the compost products from the pilot project, market promotion and experiment of agricultural application etc. should be tried.

e. Final Disposal

It will be anticipated that a future landfill site for disposing of the wastes after 2013 is very difficult to locate in the DF jurisdiction area or in the CNA land. Therefore, it will be inevitable to examine the possibility to locate the final disposal site on the land in the State of Mexico, and to examine the possibility of regional use of landfill by GDF, host municipality and others. As it is anticipated that coordination among those parties for future landfill establishment may require substantially long time of discussion before its implementation, the coordination for the future landfill (to be used after 2013) should be started at latest in the year 2007 or around by GDF and other entities.

7.2.2 Institutional Aspect

Contract-out is prevalent in various works of the SWM by the GDF, whose contract terms are all limited to be in a short period (from a several months to maximum two years) by the current budgetary process of the GDF. These contracts of short period have been introducing the GDF's financial demerits with following reasons.

- In case where a contractor uses machinery for the work, the contractor needs to purchase or rent the machinery. The shorter the contract period is, the shorter depreciation period is set by the contractor for the machine provided in the work. Consequently the shorter depreciation period raises the contract price of the work.
- In case where the laborers are employed in the shorter contract, they will not be accustomed to the work nor will their technical skill be improved. In consequence, work efficiency in total remains as low as that the work is initiated. It turns to be a higher labor cost compared with a contract of a longer period.

Therefore, either in case of contract-out or concession, it is recommended that the legal and budget authorization frame of GDF should be improved in order to extend the contract period as long as the useful life of machinery employed by the contractor.

7.2.3 Social Aspect

The following recommendations are proposed:

a. Public Health

- A Program for Solid Waste Separation at the Source should be implemented, which will benefit public health and thus improve the environment. This situation would lead to domestic sanitary management and will prevent the proliferation of harmful fauna at the source.
- Clear occupational health and safety requirements should be set for the GDF's Cleansing Service, for the contractors and concessionaires, and their compliance should be supervised and controlled by the GDF.

b. Community Education and Participation

- The proposed Public Educational Program should be implemented as one of the fundamental devices to suppress or mitigate critical social problems in the SWM of the DF; likewise, to foster community participation and their approach to the GDF's SWM administration.
- Additionally, the Educational Plan should be developed to facilitate the implementation of the three priority projects, whose feasibility was analyzed.
- Environmental education should be fostered and remarked, specially in elementary schools.
- Private sectors, NGOs and communal organizations should also be integrated in the solid waste reduction, reuse and recycling tasks.

c. Concertation

- Concertation should be driven among the participants in the SWM process, based on negotiation and consensus, as an additional instrument to solve critical and underlying social aspects.
- It should be acknowledged that, in the case of the DF, the separated recyclable material is a social and financial negotiation element within the organization process to be taken into account by the GDF.

d. Employment

- It should be stressed that the changes do not mean personnel layoffs; at least a balance in the total personnel engaged in SWM should be sought that, although position could be changed due to organizational or efficiency purposes.
- Besides, negotiation and concertation of innovative and modern proposals, that stand for positive changes for the promotion of informal personnel (volunteers and others) linked with the sweeping, collection and selection of solid wastes in the DF should be facilitated and supported.

e. **Legislative Arrangement and Enforcement**

- Laws to reduce the amount of packages and wrappings should be approved and enforced.
- A system to enforce the law, codes, standards and provisions on SWM should be encouraged, along with public education and the dissemination of the laws on SWM.

7.2.4 Environmental Aspect

The DGSU currently carries out environmental monitoring at final disposal sites and S/Ps. The range and frequency of data compiled through the monitoring are judged to be sufficient and important. Additional requirement for the environmental monitoring would be that format of data collection and compilation system should be improved so as to easily analyze the chronological changes, to detect atypical data, and to understand the reasons of chronological tendency and/or atypical data results.

7.2.5 Financial and Economic Aspect

If the following conditions are satisfied, the DGSU would be able to implement the priority projects by self-financing of the GDF without relying on the external funding, which will be the least cost solution from the financial viewpoint.

- The GDF in the year 1999 decides to commit an investment during 1999 to 2003 equivalent to 30 million US$ for the priority projects.
- The DGSU, after the construction of the priority projects, annually continues to allocate the budget for operation and maintenance of the priority projects, which should be about 10 to 17% of the DGSU's annual budget amount.

On the other hand, if the priority projects are to be implemented with external financing (such as from international banks), as financing options could mainly be categorized into the following two options (OECF type and World Bank (WB) type), merits and demerits of the two options should be carefully examined in view of GDF's present and future financial situation.

- OECF type: the repayment period is longer, annual repayment amount is smaller than WB type, total repayment amount is larger than the WB type.
- World Bank type: the repayment period is shorter, annual repayment amount is larger than the OECF type, total repayment amount is smaller than the OECF type.

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