H.6.2 EIA for the Composting Plant

H.6.2.1 Description of the Composting Plant Project

Table H-85 shows the summarized outline of the composting plant project.

Table H-85: Description of the Composting Plant Project

Aspects	Description
Basic Features	
Project Location	The Federal Zone, ex-Lake Texcoco area.
Land Area	Around 36 ha occupied by the plant
Activity	Treating organic waste by a controlled aerobic decomposition to produce compost product which is used as soil conditioner and/or cover soil for waste landfill.
Type of waste accepted	Separated organic waste in the sub-system. Estimated composition is organic (dry) 13.6-23.6% and water 68.0-78.0%.
Structure of the plant	
Access	Entrance from Periferico (the Peripheral Ring Road).
Internal road	One outer road and one center road
Construction Procedure	
Construction stage	in 2001 750 ton/day capacity composting section 240 ton/day capacity curing section 300 ton/day capacity separation section in 2002 250 ton/day capacity composting section 80 ton/day capacity curing section in 2003 250 ton/day capacity composting section 80 ton/day capacity curing section
Land preparation in 1999 to 2000	Construction waste compacted up to 2m height, gravel of 0.5m thickness, then sandy soil of 0.5m thickness.
Operation	
Operation stages	Operation starts in 2002 with capacity of 750 ton/day composting section, 240 ton/day curing section and 300 ton/day separation section. Operation size rises to 1,000 ton/day in 2002, and 1,250 ton/day from 2003 onwards.
Operation sequence	Waste is shredded into pieces by a shredder and formed into windrows, undergoing aerobic decomposition for 28days. Young compost is transferred to curing to be decomposed by fungi. After 120days, impurities are removed from the mature compost and the product is shipped out. Rejected waste is disposed of at Etapa IV or V.
Rejected waste	96 ton/day to be disposed of (assuming 1,250 ton/day input).
Products amount	167.9 ton/day (assuming 1,250 ton/day input)
Sub-products amount	1.7 ton/day of metal to be recovered (assuming 1,250 ton/day input)

H.6.2.2 Analysis of the Environmental Impacts

Through the process of IEE shown earlier, it was concluded that the environmental impact would be identified in the following aspects.

- Public health.
- Accidents/Risks.
- Groundwater.
- Air Pollution.
- Water Pollution.

- Soil Contamination.
- Noise.
- Odor.

Examining the current site condition and the construction and operation process, IEE was reconsidered and concluded that the other environmental items, i.e. those which were ranked as D in the IEE, will not be affected by the project. The reasons for their exclusion are shown in a table in Section G.7 of this report. The exception is about fauna because ecologically valuable species are found, hence this aspect is included in analysis.

a. Public Health

Public health can be adversely affected by the composting plant project for the following reasons.

1. Waste scattered from the waste trailers which deliver waste from its origins to the plant due to the mismanagement of waste delivery.
2. Offensive odor emitted from putrescible waste.
3. Proliferation of vectors.
4. Loud noise emitted by the use of machinery.
5. Dust caused in the turning process and machinery.

Items 1 and 3 are examined below, and the others will appear in the later sections.

a.1 Mismanagement of Waste Delivery

Careless delivery of waste may allow waste to be scattered along the transportation routes and around the composting plant, resulting into the degradation of city beauty and public health.

Meanwhile, the DGSU has been using tarpaulin to cover waste on the trailers in order to avoid waste scattering. It is observed that the tarpaulin has been achieving a satisfactory result to overcome this problem.

Since this practice is continued, waste will not be significantly scattered to degrade the city cleanness or public health. **It is ensured by regular monitoring that the tarpaulin does not have large holes or tears though which waste might escape from the trailers.**

a.2 Vectors Proliferation

Organic waste attracts wide range of vermin (or disease vectors such as fly, mosquitoes, rats, etc. which transmit pathogens) and hence can potentially increase the incidence of diseases in surrounding population and the plant workers.

It is intended that waste is first subject to aerobic decomposition in the proposed composting plant. In the aerobic decomposition process, easily biodegradable organic matter, which is also the source attracting vermin, is quickly decomposed. They are no longer readily available for those harmful fauna.

Aerobic decomposition will also raise the temperature of waste about 55 degrees centigrade. Since most pathogens are susceptible to heat, it is expected that the number of pathogens decreases significantly as aerobic decomposition proceeds, and vermin will not approach to such hot material.

Therefore, **aerobic decomposition, if successfully controlled,** will minimize the population of disease vectors and limit the spread of diseases. Furthermore, residents live sufficiently far from the plant, thus they are unlikely to be affected by the annoying animals from the plant. Nevertheless, the newly delivered waste will attract pathogens and vermin, and there should be a certain amount of such young waste in the plant at any time. Therefore, **the plant workers working near the raw material are instructed to wear appropriate clothes and equipment** to prevent from being exposed to disease vectors.

b. Accidents/Risks

Methane is explosive when it accounts for 5% of air. Methane associated with waste management, however, originates in methanogenic decomposition taking place in an anaerobic process. In the windrows which operate aerobic decomposition, it is unlikely to produce methane. If it should be produced, it will be easily dispersed into the air. During curing, anaerobic decomposition may take place in the deep section, but decomposition process is very slow. Thus gas generation will not significant.

Carbon dioxide is formed as a result of aerobic decomposition of organic matter and hence the plant will produce it. Human being will be asphyxiated if exposed to high concentration of carbon dioxide for hours. At the composting plant, however, carbon dioxide is produced at the windrows in open air and immediately diffused.

Therefore, the said risks or accidents should be unlikely to happen.

c. Groundwater

Groundwater contamination is anticipated to occur under a situation where leachate infiltrates into the soil and reaches to an aquifer.

Leachate intrusion into the aquifer, however, is only probable when there is enough leachate to fill all available pore space in the subsoil above the aquifer. In other words, leachate quantity matters. Although it is significantly difficult to numerically express the amount of leachate to be produced, the proposed composting plant will not yield much leachate for the following reasons[17].

- Meteorological data shows that precipitation is about 600 mm/year and evaporation is about 1,800 mm/year on average near the ex-Lake Texcoco area. The latter is by far greater than the former. Unlike a waste landfill which utilizes cover soil, waste in windrows is directly exposed to the air, hence waste is always prone to be dry.
- **Moisture content is strictly monitored and controlled to maintain the most favorable condition for decomposition, either by spraying water or encouraging evaporation using a turner.** It is noteworthy that turning was proved to be an exclusively effective countermeasure against flooded compost in the DGSU's existing composting plant during the rainy season of 1998, when abnormally much rainfall was recorded.

Nevertheless, taking the very high water table in the site into account, once leachate, even small amount, seeps into soil, it will readily meet with superficial groundwater.

[17] It is empirically known that a windrow composting plant produces little leachate and it commonly operates without being provided with impermeabilization.

Although the environmental impact given by this leachate may not be simply ignored, it is to be reminded that this groundwater is not used by people.

Generally speaking, the concerns of leachate are (i) its high concentration of organic matter (or high BOD or COD), (ii) its aggressiveness (i.e. low pH), and (iii) the contaminants carried by leachate.

Contaminants are those which are originally contained in inorganic waste and dissolved into acid leachate. Acidity is mainly a result of the dissolution of carbon dioxide and organic acids: the former is produced by aerobic decomposition and anaerobic fermentation, and the latter is produced by anaerobic fermentation.

In the case of the proposed composting plant, the following should be pointed out.

- The plant uses waste which is **separated as "organic waste" by waste generators.** Organic content is expected to be as high as 90%, while it is 38% in normal municipal waste in the DF. Therefore, there is **no or significantly few sources of noxious contaminants in waste.** Leachate contaminants in the composting plant are mostly food origin and should be highly biodegradable organic matter and nitrogen (either ammonia, nitrate or nitrite).
- The leachate will show low pH. Since groundwater contains high alkalinity, in other words it has high capacity to act as a buffer against the ingress of hydrogen ions, acid leachate will not lower the pH of groundwater.
- It is disputable whether there is a biogas which breaks up the organic matter in groundwater in the ex-Lake Texcoco area because of its atypically high salinity. It can not be considered, however, that biological activity is totally absent, and decomposable organics may be degraded into inorganics even at a limited rate.
- Since permeability of the clay subsoil is at the order of 10^{-5}cm/sec or could be lower, the groundwater and contaminants, if any, move slowly.
- Groundwater in the shallow aquifer is not for human use because of the extreme salinity. Therefore, contamination with organics and nitrogen, if any, does not show any serious implication. Groundwater in the deep aquifer, which is used as potable water, is far below from the ground surface and slow flow of leachate within the shallow aquifer should by no means environmentally affect it.

In summary, it is considered that leachate seepage into the soil will probably be a small amount; it does not contain toxic substances but high concentrations of organic matter; it will only very slowly flow with groundwater which is not used by humans; and groundwater in the deeper aquifer unlikely will be polluted.

d. Flora and Fauna

Field investigation revealed that flora of the area is not of particular interest, while its fauna includes important species to which special attention should be paid. Environmental impact on those species is anticipated.

Therefore, those environmentally valuable species are carefully transferred outside of the site, so that the reduction in their population is avoided.

e. Air Pollution

Air is anticipated to be polluted by traffic of waste trailers, dust raised from windrows when the shredder and the turner are used, and biogas generation. The latter was already discussed in Section b. Pollution due to the first two would increase the incidents of respiratory diseases and eyes irritation.

Regarding the traffic of waste trailers, the proposed project does not largely change the current traffic mode, thus the increase in pollutants emission attributable to the project should be minimum. At present, it is well known that the road traffic is the major cause of the air pollution in the DF, but the contribution of waste trailers traffic is negligible.

As for dust from windrows, the problem is highly local and the recipients are exclusively the plant workers. To minimize the dust effect, the workers are urged to use appropriate clothes, masks and eye protectors and the site managers take care of their health condition.

f. Water Pollution

Water pollution could be found in groundwater and surface water, and the groundwater issue has already been discussed.

The adjacent surface water is *Brazo Izquierdo Río Churubusco*. The effect on it by leachate is to be considered in terms of quantity and quality, as shown in the section of groundwater.

The migration of leachate to the canal will be through groundwater or via ground surface. Regarding the first route, groundwater contamination with leachate will not be significant as discussed earlier, therefore groundwater will not contaminate the canal.

On the other hand, surface runoff which might contain organic matter and probably surface soil and compost particles may flow into the River Churubusco when it rains hard. However, the problem will be insignificant since this will be an occasional event when the runoff exceeds the water absorption capacity of the platform. Moreover, the runoff is intercepted at the embankment along the river and eventually evaporated.

g. Soil Contamination

Soil contamination is a concern because it may cause groundwater pollution, degrade ecosystem within the soil, and restrict the future land use resulting in land devaluation.

The first issue has already been discussed under the title of groundwater.

As for the ecosystem, there are three items to be considered. One is that the leachate infiltration occurs only when the control of moisture content is not successful. Another is an effect by toxic material. Leachate produced at the proposed composting plant should not contain toxic substances that may impact the ecosystem, since waste handled at the plant should contain few sources of toxicity. The other is an effect by organic matter. Leachate containing high concentrations of organic matter may change the living environment for microorganisms in the subsoil and, in turn, change the structure of ecosystem. This change, if any, should not be negative.

In regard to the restriction of future land use, there are two key issues to be taken into account. Firstly, the land use in the project site is already restricted by its high salt content. Secondly, soil will be contaminated not by hazardous substances but by organics, which will be decomposed slowly but partly accumulated in soil for years little by little.

Generally speaking, soil containing excessive organic matter may fall in short of oxygen, then produce gases such as methane and hydrogen sulfide. Thus, excavation before construction works could be risky. But it is only the case where exist commonly expected biological activities. In the present case of the composting plant site, however, **leachate seepage is limited in volume, and organic matter will be degraded only in a slow manner.** Therefore, soil contamination with organic leachate would not restrict the land use options. Even if it should do so, the extent of restriction should be by far smaller than that due to salinity.

h. Noise

The plant will use a shredder to shred waste and a turner to turn waste in windrows to supply oxygen. These equipment can be a source of loud noise which might disturb the daily life of adjacent residents and/or have an adverse health effect on the plant workers.

Regulations in Mexico in regard to noise stipulate the following.

- Noise in the environment should not be louder than 68dB giving care to the surrounding residents and fauna (NOM-081-ECOL-1994).
- Noise in the working areas to protect the health of workers is defined by NOM-011-STPS-1994 which establishes the permissible maximum time of exposure to noise expressed by Continuous Sound Level Equivalent (NSCE)[18] as follows.

Table H-86: Permissible Maximum Time of Exposure to NSCE

Time (Hours)	NSCE (dB)
8	90
4	93
2	96
1	99
0.5	102
0.25	105

Both the shredder and the turner produce noise of 85dB from 1m away at the 1.5m height according to the technical specification. Background noise level is assumed to be at 50dB.

The following equation is given.

[18] NOM-011-STPS-1994 gives a guide to obtain Continuos Sound Level Equivalent (NSCE: Nivel Sonoro Continuo Equivalente) in case where the workers are exposed to noises with different intensity for different period in their work day.

$$Lp = Lw - 20 \log_{10} r - 8 \cdots\cdots\cdots\cdots\cdots\cdots (i)$$

where Lw = Noise level at source (dB).

r = Distance between noise source and receiving point (m).

Lp = Noise level at receiving point r meters away from the source (dB).

In case where several noise sources exist, the following equation is to be used.

$$P = 10 \log_{10} \Sigma 10^{Pi/10} \cdots\cdots\cdots\cdots\cdots\cdots (ii)$$

where P = Resulting noise level (dB) from plural noise sources.

Pi = Noise level from noise source i.

If the shredder and the turner are working very closely, the noise level from the two will be 88.01 dB by using equation (ii). Since **the buffer area has 100m width**, the noise level at the periphery of the plant will be 50 dB using equation (i). Combining this and background noise, the resulted noise level is 53dB.[19] It is sufficiently below the permissible limit of 68dB.

As regards the second standard, the noise level of machinery, i.e. 85dB, combined with the background noise level, can be assumed to be the NSCE for the machine operators who work near the turner or shredder for eight hours. The synthetic noise still remains 85dB[20] and exposure to 85dB noise for eight hours is within the permissible limit set by the norm, thus no health hazard is anticipated. Even when the shredder and the turner come close each other, the combined noise level will be 88dB, which should not be a serious problem.

Nevertheless, some plant workers may be vulnerable to noise less louder than the permissible level. **Putting appropriate clothes and protectors and regular health consultation are recommended.**

i. Offensive Odor Emission

Offensive odor is nearly unavoidable in solid waste management. It will be a minor issue for the majority, but can be extremely serious for limited population.

Culprits of offensive odor emitted from waste are gases such as ammonia (NH_4), hydrogen sulfide (H_2S) and methyl mercaptan (CH_3SH) which are mostly generated as the end products of the anaerobic decomposition of readily decomposable organic matter.

On the other hand, the plant is planned to operate a windrow system of aerobic decomposition. Waste will be mixed with air by periodical turning to maintain oxygen in waste. Therefore, **well managed aerobic decomposition minimizes the production of malodorous gases.**

However, anaerobic decomposition can not be totally eliminated particularly during the first week of the whole process. This is because the waste younger than about one week is biochemically active due to the high proportion of easily decomposable

[19] Letting two noise levels A(dB) and B(dB) (A>=B), and when the disparity A-B is given, the value d=C-A is empirically known, where C(dB) is the compound noise level of A and B. In this case, A-B=0(dB) and d=3(dB).
[20] Following the above, A-B=35(dB) and d=0(dB)

matter, and oxygen is quickly consumed inside the waste. Therefore, odor will be the most problematic at the stages of unloading, shredding and first turning of the raw material.

In the curing section, although oxygen is not deliberately provided, natural oxygen diffusion into the young compost can be expected because it is porous. Furthermore, organics contained in the young compost are those which are difficult to be degraded such as cellulose and lignin, and undergo a decomposition process only at a very slow rate. Thus gas production is not significant.

A worry might be release of malodorous gases when the compost products after curing are turned when they are transported, because of the possibility of oxygen depletion in the deep portion of the mature compost. However, anaerobic process will cease due to the drop in moisture content within the shorter period than the planned curing period. Therefore, sufficient time is allowed for slowly produced odor to be dispersed into the air, probably not remaining within the compost at the end of the curing.

In conclusion, odor produced in the early stage of composting is the most significant. Since the plant design shows that a curing area with much less odor is laid out in a portion closest to the residential area, odor will not affect the adjacent residents. The plant workers are instructed to wear appropriate clothes and masks.

H.6.2.3 Conclusion

The previous section described the possible causes and effects on the environment given by the composting plant and the extent of the problems. Figure H-34 is a diagram to show the discussion schematically.

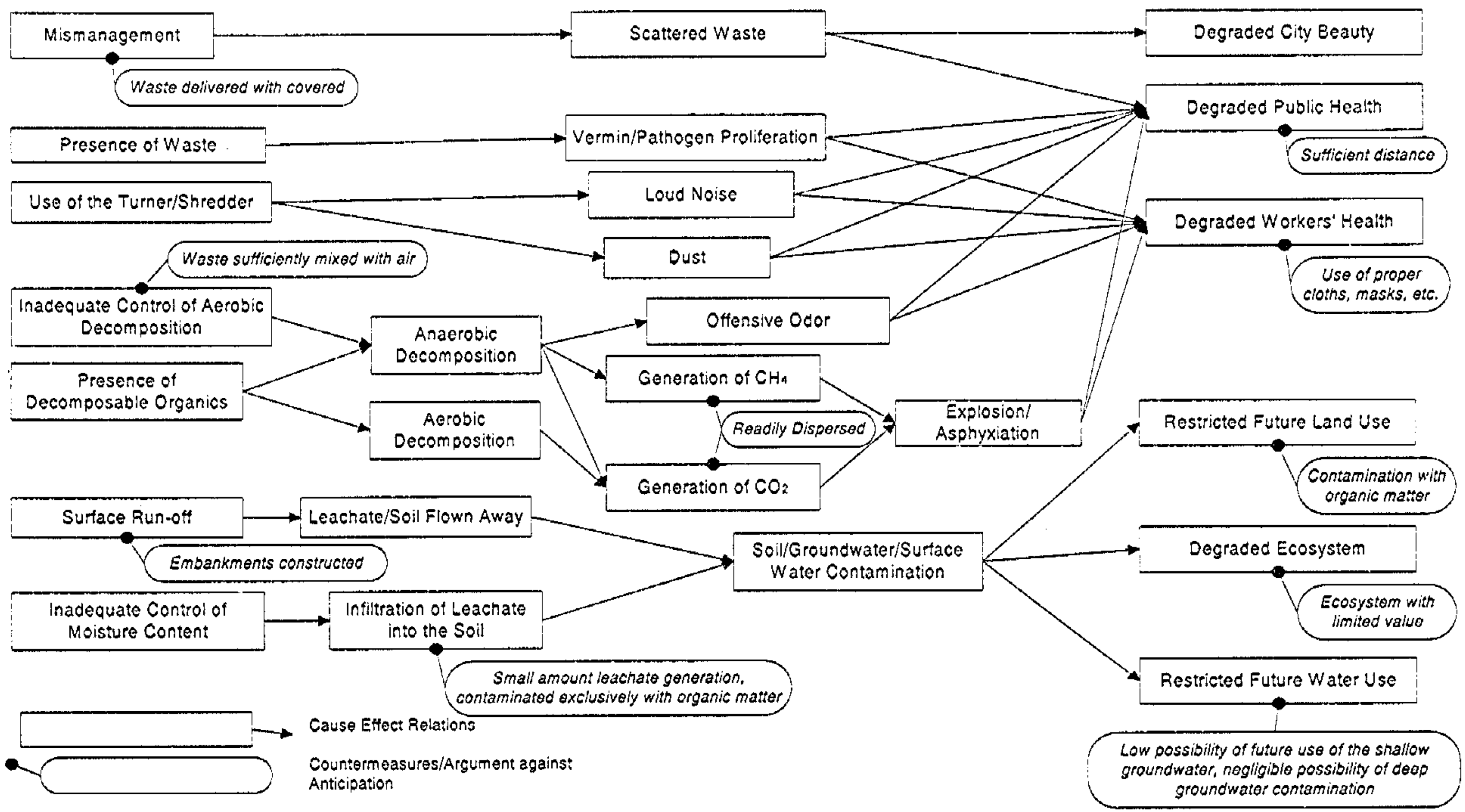

Figure H-34: Cause Effect Relations (Composting Plant Project)

In conclusion, any major environmental adverse effect is not anticipated. This is, however, based on the several preconditions which were indicated with bold letters. The failure to meet them may result in serious environmental impacts. Compliance with those preconditions and recommendations has to be ensured by controlled operation. These are shown in Table H-87.

Table H-87: 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.

H.6.3 EIA for the Etapa V Project

H.6.3.1 Description of the Etapa V Project

The description of the Etapa V new landfill project is summarized in Table H-88 below. Detailed descriptions are presented in Section H.2.2.2.

Table H-88: Description of the Final Disposal Site Project at Etapa V

Aspects	Description
Basic features	
Location	The Federal zone of ex-Lake Texcoco area
Land Area	About 250 ha in total
Activity	Final disposal of municipal waste collected in the DF and part of State of Mexico
Type of waste accepted	Waste from household and institutions, disinfected medical waste.
Structure	
Access	Accessed from the toll road (*Autopista*) connecting the DF and Texcoco.
Outer ring road	Asphalt paved: width 20.0m, length app. 6km
Inner roads	Width 10.0m, length app. 20km in total for the first lift.
Landfill area	First lift: 194ha, Second lift: 130ha, Third lift: 74ha
Landfill bottom liner	HDPE 1mm thick liner
Leachate collection	Submerged pumps are installed in leachate extraction wells.
Leachate handling	Pumped leachate sprayed over the landfill.
Gas removal	Passive control through ventilation wells.
Construction Procedure	
Construction stage	In 2001 Roads and cells for the first lift In 2006 Roads and cells for the second lift In 2010 Roads and cells for the third lift
Operation	
Operation stage	From 2002 to 2004 Up to 8m From 2007 to 2008 Up to 16m From 2011 to 2012 Up to 24m
Waste disposal amount	3,609,000 ton/year in 2002 and 3,278,000 ton/year in 2010 assuming the implementation of the M/P.
Waste trailers traffic	About 700 trailers per day.
Method of landfilling	Waste is unloaded from the trailers, compacted, piled up to 8m height, and covered with soil. After the first lift of 8m, the second lift is made 100m inner from the edge of the first lift and up to 16m height. The third is similarly made up to 24m.

H.6.3.2 Analysis of the Environmental Impacts

The following environmental items were deemed to be negatively affected through the IEE process.

- Public health.
- Accidents/Risks.
- Groundwater.
- Flora and Fauna.
- Landscape.
- Air Pollution.
- Water Pollution.
- Soil Contamination.
- Odor.

IEE was attempted again with taking into account of the design features of the landfill and environmental condition of the site, and it was confirmed that the other items ranked "D" will not be affected adversely. The reasons for their exclusion from the EIA are described in a table in Section G.7 of this report. Only one exception is traffic. Initially, the project was not thought to bring any change in traffic to the current situation. Since the Autopista is to be used by waste trailers, however, the issue would require examination in terms of accident and risk. Consequently, it will be discussed under the item of accidents/risks.

a. Public Health

Public health might be affected by the project for the following reasons.

1. Waste scattered from the waste trailers which deliver waste from its origins to the plant due to the mismanagement of waste delivery.
2. Offensive odor emitted from putrescible waste.
3. Proliferation of vermin.
4. Dust caused by waste tipping, trailers movement on site, or from cover soil.

Items 1 and 3 are examined below, and the others will appear in the later sections.

a.1 Mismanagement of Waste Delivery

Careless delivery of waste may allow waste to be scattered along the transportation routes and around the landfill site, resulting into the degradation of city beauty and public health.

Meanwhile, the DGSU has been using the tarpaulin to cover waste on the trailers in order to avoid waste scattering. It is observed that the tarpaulin has been achieving satisfactory result to overcome this problem.

Since **this practice is continued,** waste will not be significantly scattered to degrade the city cleanness or public health. **It is ensured by regular monitoring that the tarpaulin does not have large holes or tears though which waste might escape from the trailers.**

a.2 Vermin Proliferation

Organic waste attracts wide range of vermin (or disease vectors such as fly, mosquitoes, rats, etc. which transmit pathogens) and hence can potentially increase the incidence of diseases in surrounding population and the site workers.

Waste is continuously landfilled (i.e. 24 hours a day) and covered with soil within 24 hours. Cover soil is widely practiced to prevent the population increase of noxious fauna.

Therefore, vermin proliferation should be minimum, without posing health hazards to the public. The workers working at the landfill front **are instructed to put appropriate clothes and equipment to avoid any exposure to health hazards.**

b. Accidents/Risks

Landfill operation can lead to an unexpected incident due to (i) problematic site management and waste collection management, (ii) problematic traffic, (iii) waste load pressure (such as landfill slope slides and lateral movement of soil) and (iv) gas generation.

b.1 Problems of Management

Incidents caused by careless site management can be expected during both the construction and operation phases.

During construction, the operation of construction equipment and machine such as dump trucks, bulldozers and loaders may be a danger to the site workers. **Instructing good site operation to the workers, control of their movement and appropriate site supervision by experienced personnel minimize the potential risk.**

During the operation, waste itself can pose serious risk. Hazardous, chemically active, and/or radioactive wastes are particularly dangerous for the workers and could bring long term risks open to the general public. Since the BP V is not supposed to accept those waste, **proper waste disposal manner will be thoroughly instructed to the generators of such waste.** At the site, **waste is inspected periodically on arrival, and visually monitored by the site workers at the tipping front.**

Even household waste can be hazardous. The site workers may be injured with sharp material and broken glass. Containers with spray cans with remaining gas is explosive. **The site workers are equipped with adequate clothes and protectors such as gloves and boots in case of such event.**

Glass material is also dangerous setting spontaneous fire to waste under the sunlight. **Soil cover** should minimize this risk.

The general public is prohibited from entering the site as practiced in Etapa IV, thus danger to them will be also minimized.

b.2 Problems of Traffic

Change in traffic mode near the site is expected during the construction and operation along the Autopista México-Texcoco and a peripheral ring road called *Periferico.*.

The Periferico and Avenue Peñon-Texcoco are currently used for waste delivery to the BP IV. Therefore traffic load along them will remain the same with slight increase brought by traffic for construction. The increase in traffic load on the Periferico should be negligible.

The Autopista is not used for waste transport at present and should have an increased traffic during the construction and operation. The current traffic load of the Autopista is presumed to be moderately high considering the fact that this Autopista is one of the major roads connecting the DF and the state of Mexico, although reliable data is absent. Therefore, traffic increase in terms of proportion will be small. Furthermore, the Autopista can be considered to have a capacity to absorb the traffic increase brought by the project. What should be stressed is that the impact by the project is not permanent but restricted in the construction and operation period, and that economic development and population growth particularly in the state of Mexico sill bring a much larger impact on the traffic load than the landfill project.

Caution should be exercised to the junction of the Autopista and the Periferico, and the junction of the Autopista and the newly built access road. Since vehicles run the Autopista relatively high speed, any actions which interrupt the traffic flow such as altering lanes and turning of long vehicles should be carefully controlled. **Expansion of roads at the junctions and other traffic control measures such as providing**

clear signs to call for drivers' attention to the movement of waste trailers are carried out. In considering those, examination on the fluctuation of traffic loads of normal vehicles and that of waste trailers in a day is taken into account with particular attention.

b.3 Waste Load Impact

As waste is accumulated, its gravitational force turns to be a significant stress to the land. The EIA study[21] previously carried out prior to the construction of BP IV stressed a possible risk of land subsidence by the waste landfill and impact on the canals running in and around the ex-Lake Texcoco area.

On the other hand, the impact which may be caused by waste load at vertically expanded Etapa IV has been already discussed in Section II.2.2.2. Considering the similarity of the projects and soil character at Etapa IV and Etapa V, the conclusion derived from the said discussion will hold in the case of Etapa V.

The other possible concerns in regard to the compression effect are derived from the presence of wells within the site, which were previously used to extract salty groundwater. Without properly dealing with those wells, the following is anticipated.

- The impermeable liner at the bottom of the landfill is pressed down, scratched with the sealed wells, and damaged. It may have a fault, or may become susceptible to a fault.
- Change in subsoil structure by weight pressure may result in cracks or fissures of the wells. If leachate should be leaked into groundwater, such cracks or fissures would act as a migration pathway towards underlying strata.

The landfill plan states that **the well casings are totally removed and the boreholes are filled with bentonite.** If the work is successfully done, the worry mentioned above can be ignored.

b.4 Gas Generation

The biological process taking place in a landfill with municipal solid waste results in the generation of so-called "landfill gas" or "biogas" which contains CH_4, CO_2, and small quantities of CO, N_2, O_2, ammonia, sulfide and other trace gases. Primary concern regarding the biogas is CH_4 and CO_2. The proportion of these varies with the composition of waste and the age of the landfill, but in general, CO_2 becomes the principal gas (about 60% on dry volume bases) in the earlier stage of anaerobic decomposition. After this, CH_4 exceeds CO_2, remaining about 60% for a fairly long period.

CH_4 is, if present in the air in concentrations between 5 and 15 %, explosive. Within a landfill, oxygen depletion acts as an impedance of CH_4 explosion. Once CH_4 migrates to the outside of the landfill and meet with air, however, there is a large risk of explosion.

CO_2, being a heavier than air, tends to migrate downwards and remain in the lower portion of the landfill for long time. When there is a chance of migration and contact

[21] ABC Estudios y Proyectos, S.A. de C.V., *Estudio de Impacto Ambiental del Sistema Integral de Manejo de Desechos Solidos Bordo Poniente*, Contract N. SU-2-31-1-800, March 1993

with groundwater, it will be partly solved or precipitated as calcium carbonate on soil. However, if it finds a pathway to enclosed sections (houses and/or buildings), CO_2 will be concentrated up to over 0.5% and it is asphyxiant.

Migration pathways for those gases can be geological formation (fissures, joints, caves, etc.) and man-made structures (boreholes, wells, sewer, etc.), and also can be found on site such as monitoring sumps, ventilation facilities and cracks created by settlement at site margins.

The proposed landfill design incorporates **passive ventilation facilities** in order to prevent unexpected gas migration. As far as the ventilation is exercised in a controlled manner, landfill gas will be trapped and dispersed before migrating and risks due to the landfill gas will be minimal.

Besides, due to the presence of the geomembrane liner on the bottom of the landfill, the chance of biogas migration through underground pathways is also minimal. Further, as for CO_2, there is a sufficient distance between its source and the residential area, which is an anticipated target of CO_2 impact.

It should be stressed that landfill gas formation generally lasts for nearly 15 years or more after the site closure, depending on the decomposition speed of waste. Therefore, **ventilation facilities are kept maintained and regular monitoring of gas composition is carried out.**

c. Groundwater

The possible environmental impact on groundwater is twofold: change in the phreatic water level and change in groundwater quality.

c.1 Groundwater Table Level

Change in the groundwater table level may have a serious imprecation for the hydraulic structures owned by CNA in ex-Lake Texcoco area.

One of the priority issues of the BP V landfill design is to minimize the volume of leachate by minimizing rainwater infiltration. As a result, water recharge into the shallow groundwater will decrease, then water table will be lowered. However, the landfill site is only a small portion of the whole ex-Lake Texcoco area from which groundwater recharge takes place.

Therefore, the decrease in the water table level will be too small to give any influence to the local groundwater hydrology, and an adverse impact is null.

c.2 Groundwater Quality

When water passes through waste which is under biological decomposition, a wide variety of substances present in waste, of which heavy metals are of particular concern, will be dissolved into water. As the decomposition of relatively young waste produces carbon dioxide and organic acids, pH of water drops and toxic constituents, particularly heavy metals, become readily soluble. The impact of leachate on underlying groundwater should be considered in terms of quantity and quality of leaked leachate.

In general, origins of water (or leachate) can be waste itself, rain, surface water body, or groundwater, but the first one is usually negligible. In the present case of BP V, neither surface water nor groundwater will be the source of leachate as there is no major surface water body around, and groundwater infiltration into the landfill is to be cut off by an impermeable liner laid at the landfill bottom. The remaining possible origin of leachate is rainfall, but its percolation into the waste is considered to be small. This is because cover soil and intermediate cover soil will act as waterproofing. Therefore, leachate generation amount is controlled in first place.

Generated leachate will gradually travel downwards through waste, reaching a inpermeabilization system. The system consists of a synthetic liner (1mm thickness), and the original clay formation of with about 0.5 m thickness, below which exists the shallow groundwater. As far as the liner functions in a normal manner, the system should be enough to prevent leachate from leaking, hence preventing groundwater contamination.

Abnormal function of the liner can be anticipated in case where the liner gets damaged by hard objects or pressure given by waste and/or accumulated leachate. The proposed design attempts to protect the liner from physical damage by providing a 0.5 m thick tepetate layer over the liner, and to control the water head of leachate by extracting it. Waste load will not cause land subsidence large enough to make a fault to the liner (see above). Therefore, the possibility of leachate leakage is substantially small.

In conclusion, the possibility of contaminated groundwater will be negligibly low.

ABC study (1993) pointed out that the abandoned wells existing in the surrounding area might act as a migration pathway for leachate. It would be problematic only if a certain amount of leachate with significant contaminants reached one of the wells. However, because of what has considered above, such event is implausible.

d. Flora and Fauna

Field investigation revealed that flora of the area is not of particular interest, while its fauna includes important species to which special attention should be paid. Environmental impact on those species is anticipated.

Therefore, those environmentally valuable species are carefully transferred outside of the site, so that the reduction in their population is avoided.

e. Landscape

As the project site is almost flat, the presence of 24m high landfill must be a significant change in the appearance of the area.

In considering an issue of landscape, however, not only the simple appearance but also, or with higher attention, how the appearance appeals to peoples' perception should be taken into account.

Although the latter is highly subjective and difficult to be discussed in general terms, a good attempt will be to employ a photomontage technique to compare the landscape before and after the project. The results are found in the EIA report prepared by the JICA team. It can be deemed that since the ex-Lago Texcoco area is vast, the elevation of 24m is not significant. Further, vegetation developed on the landfill is expected to improve the aesthetics of the area.

As the landfill is 2.2km away from the nearest residential area, it is not be well seen by the residents. It will be most visible from the Autopista, hence the car drivers and passengers will be those who perceive the landscape. Since the site is not regarded as a scenic spot, it is considered that any impact to the drivers and passengers given by the change in landscape will be relatively small.

f. Air Pollution

Air pollution may be caused by two factors: traffic and site operation.

f.1 Air Pollution by Traffic

It is generally known that vehicle transportation pollute the atmosphere due to the exhaust gas containing SOx, NOx and CO. The presence of these may increase the occurrence of respiratory diseases or eye irritation in population and damage vegetation.

Since Etapa V is to be used as an alternative to Etapa IV, waste trailers will be simply diverted from the present access road to the Autopista and a new access road. Although the travel distance will increase by about 10km for one round trip, the increase of pollutants emission in populous areas due to the project will be only slight.

f.2 Air Pollution by Operation

Air pollution caused by landfill operation is attributed to the generation of noxious gases and dust.

Regarding the former, the concern is twofold. One is major biogas components, namely methane and carbon dioxide, and already discussed earlier. The other is about trace gases with offensive odor, which will be independently considered later.

In respect of dust problem at the site, it is anticipated that dust will be raised at the tipping front, from the soil cover, and/or from the inner roads when a vehicle passes (the outer road, paved with asphalt, will not be a dust source). For the first issue, it will be more or less inevitable due to the nature of the operation, but the problem is very local and the impact can be minimized by workers' using appropriate masks. Dust from the soil cover will be insignificant since the proposed project sprays leachate and/or water over the landfill. Spraying leachate and the control of vehicle movement within the site will limit the dust form the inner roads.

g. Water Pollution

Water pollution could be found in groundwater and surface water, and the former was already discussed.

There are three canals along the west, east and south sides of Etapa V. Possible effect on surface water will be caused by the following.

- Overflowed leachate migrates over the land surface to reach the canals.
- Infiltrated leachate migrates via unsaturated pore spaces toward the canals.
- Infiltrated leachate migrates to the shallow groundwater and contaminated groundwater reaches the canal.

On the other hand, the design of the Etapa V landfill includes **the soil cover over the waste and an impermeable HDPE liner at the bottom of the landfill**. Therefore, leachate generation within the landfill and migration out of the landfill should be well controlled. It is unlikely for leachate to cause surface water contamination.

However, surface water pollution might be also occurred by the ingress of runoff. It is unlikely that runoff water becomes contaminated with leachate or particles of the soil cover. This is because firstly runoff water does not have a contact with leachate doe to the presence of the soil cover, and secondly the final cover is firmly compacted not to be eroded. Further, since rainfall in the region is few, the problem will be only occasional. Therefore, the impact of surface runoff on the surrounding canals is insignificant.

h. Soil Contamination

Soil contamination matters because if it occurs, groundwater will be degraded, soil ecosystems will be affected and the future land use will be restricted.

Soil contamination is probable only if substances present in the leachate from the tipped waste intrude into the soil. However, **there is an HDPE liner** to confine leachate within the landfill, hence it is very unlikely that leachate finds a way to the soil.

In regard to the land use, the site is currently already restricted due to the high salinity. The landfill development may even improve the land condition since vegetation will be introduced on closure.

i. Odor

Although organic waste generated in the sub-system is to be separately collected and delivered to the composting plant, organic waste will still be a large proportion of waste to be disposed of at Etapa V. Therefore, production of offensive odor is anticipated.

However, it is observed that the dry climate of the Mexico City helps decrease odor. Further, once tipped at the landfill, **waste is compacted and covered with soil at fairly short interval**. These practices should minimize odor problems.

Offensive odor may also result from the production of landfill gas. However, landfill gas should not cause a significant odor problem as they will be ventilated in a controlled manner and will be adequately treated.

H.6.3.3 Conclusion

The previous section described the possible causes and effects on the environment given by the landfill development at Etapa V and the extent of the problems. Figure H-35 is a diagram to show the discussion schematically.

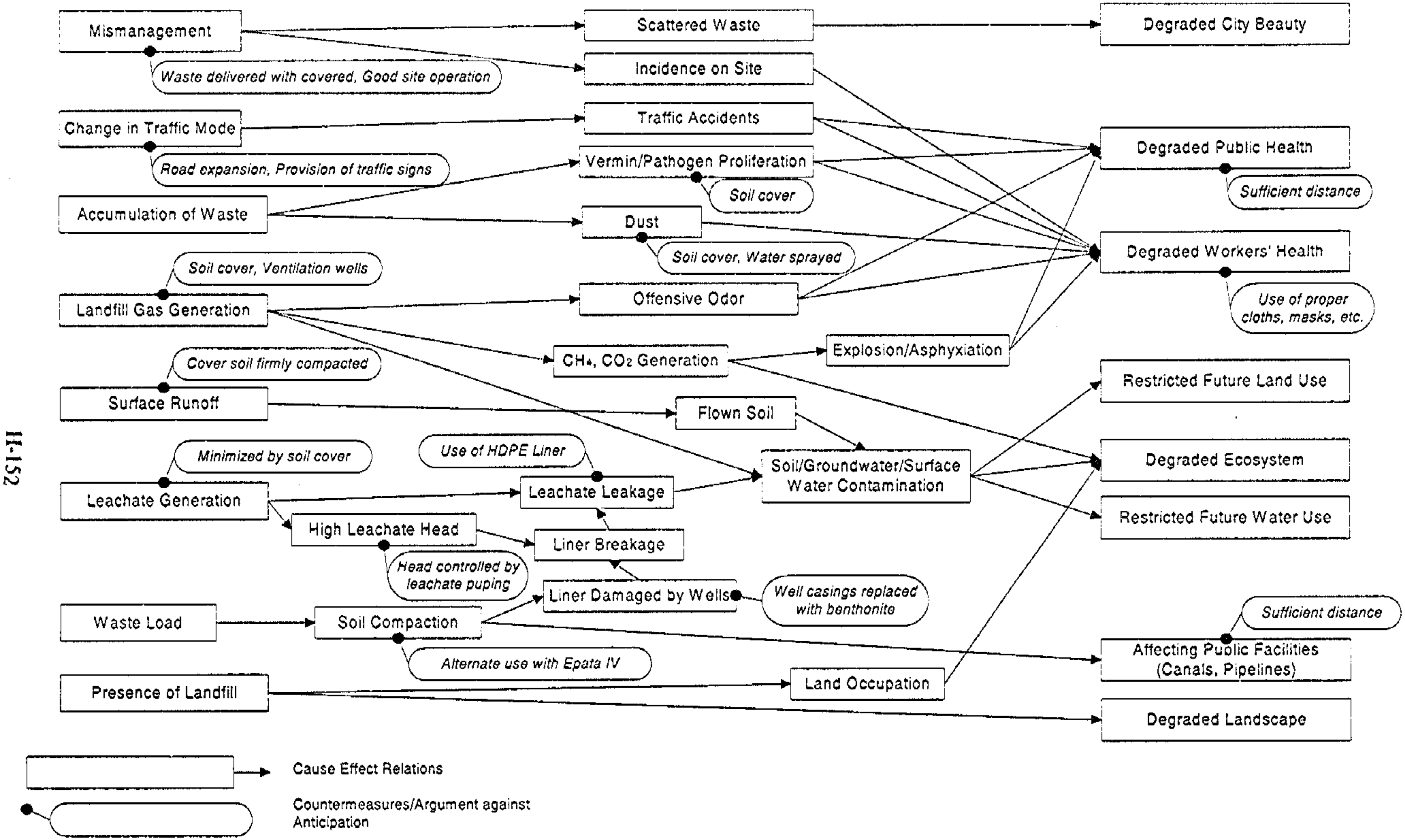

Figure H-35: Cause Effect Relations (Etapa V Landfill Project)

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 H-89 presents such preconditions, consequence of their failure, and method to ensure the preconditions.

Table H-89: 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.

H.7 Project Evaluation

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

H.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**
- **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.

Major factors to decide success or not of a composting plant are:

- quality.
- market demand of compost product.

The compost plant owned by the delegation Gustavo A. Madero was fed with mixed municipal waste, consequently the compost product from the plant was of inferior quality as it contained high impurities, where market demand for such low quality compost was so small that the plant was finally shut down.

Since the compost plant in the study is planned to treat organic waste separately collected, it is expected that compost products of good quality are to be produced.

Although the market demand of compost products in the DF is not well known, if the compost products are of high quality, it is very possible to be used as soil conditioner for:

- gardening in place of natural fertile soil presently exploited from forest areas.

- greening of ex-lake Texcoco area where high salinity in the original ground impinges the growth of vegetation.
- greening the Bordo Poniente final disposal sites.

Therefore, the mistake experienced by the Gustavo A. Madero compost plant will not be repeated by this composting plant project.

On the other hand, it is anticipated that the market demand of compost product might sometimes become smaller with seasonal factors. Therefore, it will sometimes be necessary to consume the compost products with lesser costs, rather than over-stockpiling. In targeting cost reduced compost consumption, it can be an alternative to utilize mature compost before separation for such as cover soil for landfills (as cost of separation process could be saved). In this light, it will be necessary to investigate and develop a market of:

- low quality compost.

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.

H.7.2 Institutional Evaluation

Alternatives of institutional settings for priority projects can be: "DGSU", "parastatal entity" or "private entity". However, an alternative that a "private entity" be an owner of any of the three priority projects seems to be very difficult to be realized. This is because all the priority projects are located on the federal territory managed by the CNA, where the guarantee of long term environmental protection by an eligible project proponent (such as GDF) is necessary. In other words, two-parties (CNA and a private entity) negotiation regarding a SWM project in which the DGSU being absent will unlikely be accepted by the CNA.

Meanwhile, in any case, responsibilities of the project should always be placed on the DGSU where three parties intervene in the project (i.e., the land owner CNA, a project proponent, and DGSU who assumes the responsibility against CNA).

Furthermore, 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.

H.7.3 Social Evaluation of Priority Projects

The following components are remarkable in the social evaluation of the three priority projects, whose feasibility studies were carried out.

a. Public Health

The construction and operation of the composting plant will carry the following public health results:

- Separation and processing of the organic material will be beneficial, as it will considerably reduce the proliferation of disease-carrying vectors (flies, cockroaches, mosquitoes, rodents).
- Likewise, a decrease in a number of illegal dumping sites, yet significantly less.
- There will be no adverse impacts -represented by noise or offensive odors- for the surrounding population due to the location of the plant, as long as it will be operated efficiently.

Regarding the operation of Etapa IV and the construction of Etapa V, the effects on public health will be the following:

- Significant reduction in the proliferation of harmful, disease-carrying fauna (vectors).
- Less illegal dumping sites.
- No negative impact caused by noise and offensive odors.
- Possible adverse effects by dust, noise and accident, due to the intense truck traffic; this fact would lead to the adoption of mitigation measures, though the supervision and control of transportation and public education.

b. Employment

Composting Plant:

- It is estimated that 250 jobs will be created during the construction of the plant in year 2001.
- It is considered that 80 new jobs will also be created for the years 2002-2003, amount that will rise to 120 jobs for the period of 2004 to 2010.

Sanitary Landfill (Etapa IV and V)

- It is estimated that 50 jobs would be created during Etapa V planning, designing and construction phase in years 2000 and 2001.

- Creation of new jobs during the operation stage of landfills IV and V from year 2001 to 2010. Since the works in Etapa IV and V will be held alternatively, it is estimated that the same staff will be used, with slight increments of around 100 new jobs.

Separated Collection:

- For the subsystem collection, which is to be contracted out or operated by concessionaire, it is estimated that 530 jobs would be created as of 1999.
- The separated collection to be contracted out and/or operated by concessionaire granted in the areas in which such service is currently rendered by the delegations is estimated to begin gradually in the year 2002. With the possible participation of worker associations currently linked with this service, a balance between the number of jobs is expected without dismissal, since the staff will be rotated to more advanced phases of collection, processing, haulage and recycling tasks of the separated material. All the aforementioned process would generate around 11,000 new jobs by the year 2010, which in turn would cover the possible displacements of voluntary and informal personnel (see Table H-90).

Yet, it should be pointed out that the latter estimate staff comprised for recycling is merely hypothetical, being subject to diverse factors that might reduce such figure indicated.

c. Occupational Health

- The adverse effects of dust and odors on the composting plant workers will be prevented and controlled through the compliance of standards and laws on occupational and security environment, established by the corresponding labor and health legislation bodies.
- Regarding the adverse effects of dust, noise and exposure to hazardous factors due to harmful agents contained in the solid wastes of Etapa IV and V, they are to be controlled or mitigated through the supervision and monitoring by the GDF on the landfill operators, by the reinforcement of the existing laws on workers' protection.
- Likewise, supervision and control must be exercised with respect to the safety of workers at the unloading zones and the internal landfill roads, so as to avoid accidents due to the operation of the equipment and heavy trucks. These methods will prevent negative impacts that the uncontrolled operation of heavy machinery might cause.
- In addition, all the adverse impacts previously mentioned will be mitigated through training courses on occupational health and safety at work for the GDF staff and contractors.

d. Continuity of the Service

The operation of a sanitary landfill is continuous. This fact is even more critical for the DF, whose only final disposal site is represented at Bordo Poniente sanitary landfill. Without any other available alternative, this site must run permanently; this means that the operators (contractors, concessionaires or parastatal entity) must ensure its proper functioning throughout the year. For this purpose, clear contracts will be helpful, stating the punitive clauses in case of a breach, the measures to be followed should a interruption of the service occur, and even insurance policies to guarantee the continuous operation of the landfill.

Other items related to the social evaluation of the three projects are shown in Table II-91. In summary, the social evaluation of such projects does not show significant problems, and hence certain benefits -such as more jobs- will be present. In addition, it should be pointed out that the most important health and environmental problems for the urban population of Ecatepec and Nezahualcoyotl municipalities arise from the open wastewater canal (Canal de Sales), which is adjacent to the urban concentration along a distance of 7 km and are not related to the three priority projects.

Table H-90: Estimation of Jobs Required for Processing Recyclable Material (1999-2010)

(From delivery of selected material to the final presentation of the product for its consumption)

Items	% from Total	Man/day per processed ton[24]	Recyclable Material (1000 ton/year)				Number of Jobs[23]			
			Current 1998	Phase 1 1999-2001	Phase 2 2002-2004	Phase 3 2005-2010	Current 1998	Phase 1 1999-2001	Phase 2 2002-2004	Phase 3 2005-2010
Paper/Cardboard	46.0	3.0	83	83-103	127-175	188-272	800	800-1,000	1,300-1,800	1,900-2,700
Plastics	21.0	3.0	38	38-47	58-80	86-124	2,000	2,000-2,500	3,100-4,300	4,600-6,600
Ferrous Metal	9.5	16.0	17	17-21	26-36	39-56	900	900-1,100	1,300-1,900	2,000-3,000
Aluminum	1.5	10.0[25]	3	3-3	4-6	6-9	100	100-100	200-300	300-300
Glass	19.0	11.0	34	34-43	53-72	78-112	1,300	1,300-1,600	1,900-2,600	2,900-4,100
Others	3.0	9.0	6	6-7	9-11	12-18	200	200-200	300-300	400-500
Total	100.0		181	181-224	277-380	409-591	5,300	5,300-6,500	8,100-11,200	12,100-17,200

Source: Prepared by the Study Team, based on researches conducted.

[23] 300 working days/ year are considered
[24] Preliminary estimations
[25] Material exported for its recycling overseas

Table H-91: 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, 80 new jobs during the operation stage in years the 2002 and 2003, and 120 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.

H.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.

H.7.5 Financial Evaluation

a. Introductory Remarks

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" [25]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. Thus by using FIRR, the analysis will numerically elucidate the rung of financial vulnerability associated with, and amongst each of the "benefits" as numerated above. In preparation of FIRR analysis, current household income and entity revenues in DF have duly been investigated to provide a baseline conditions in estimation of WTP in pecuniary term.

Details of income distribution of households and revenues of entities, its estimation in Mexico City, as well as the work outcomes of the Public Opinion Survey (POS) that was carried out in 1998 level are provided in Data M. Further, the theoretical background and the *state-of-the-art* estimation of long-run marginal cost (LRMC) are instructed as reflected in Data M to provide a briefing on the underlying economics concept in search of financial viability, and economic feasibility as well, as borne out by FIRR and Economic Internal Rate of Return (EIRR).

b. Household Income and Entity's Revenue

In preparing the measurement of project benefits in terms of willingness to pay (WTP) of people to pay for the public service in concern, current households income and entity's revenue in DF are estimated while utilizing the Public Opinion Survey (POS) and macroeconomic data, as appropriate.

b.1 Household Income

<u>Income Distribution in Mexico</u>

Distribution of income in Mexico worsened notably as some of the economics index reveal. For example, the Gini coefficient of Mexico's total income distribution increased from 0.43 to 0.48 over the decade of 1984 to 1994. This deterioration took place prior to the 1995 currency crisis-induce recession, as such it could not attribute to business cycle effects. Alternatively, the increase in overall income inequality

[25] 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.

appears to be closely related to an increase in the dispersion of wages and salaries across different schooling levels. While the average wage as denoted by monetary income increased by 8.1 percent in real term arising from P.7.00 per hour to P. 7.57 per hour over the same period of time, 83 percent of workers experienced a significant decline in their wages.[26]

Estimation by Macroeconomic Information

The 1997 revenue from the Payroll tax (*Impuesto sobre la Nomina*) in DF was projected at P.2,434.9 million[27] with the registered tax payers of 2.833 million[28], thereby leading to an estimate of per capita payroll tax at P. 859.7 in the year. With this, combined with the payroll tax rate of 2 percent[29], the total amount of payroll checks each earner received in 1997 was P.42,973.8, or P.3,581 per month[30]. Also considering the total population of 8.62 million in DF, the ratio of payroll workers to the total population in DF will be 3.04. Let's take it as given that the average number of a household is 4.75[31], the number of payroll wage earners per household is 1.56, thus making the estimated household income at P.5,586 per month, or US$ 613.8 per month.

Public Opinion Survey, *(POS)*

For 388 effective responses, the average monthly income was found at P. 4,697.2 that is equivalent to US$ 516.2 per household, with an average of 1.7 permanent job holders per household. Of the gross household income, P.4054.9 percent, or 86.3 percent, has been the actual expenses, as such the aforementioned assumption of deductibles of 15 percent as taxes and others is in harmony with this outcome and would be considered acceptable. Distribution of income revealed by these effective respondents is illustrated and given below as Figure II-36[32]. As clearly depicted, a distribution of sample will be overlapped in shape with that of the country as a whole.

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[26] Reference: Ulrich Lachler, *Education and Earning Inequality in Mexico,* World Bank Research Working Paper 1949, 1998, p5

[27] Source: Congress Report, *Cuaderno Estadistico de las Finanzas Publicas del Distrito Federal*, 1997. The total tax revenue in DF was projected to be P.15,914 million, of which 15.3 percent was from the payroll tax.

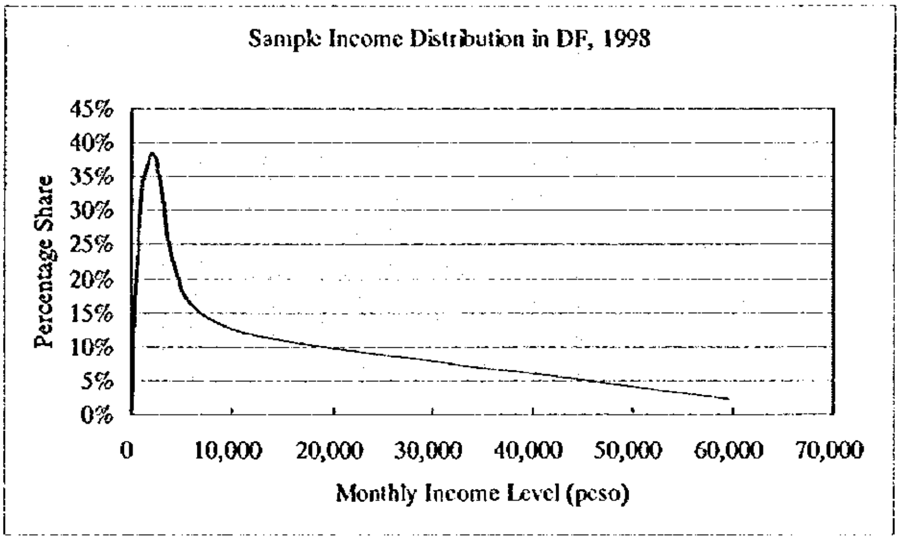
[28] The number of payroll workers in DF both in the public and private sectors is estimated from that of 2.765 million in 1994 and its proportional increase with the annual average population growth of 0.6 percent in DF. (Source: INEGI, *XIV Censo Industrial, XI Comercial y XI Censo de Servicios Censos Economicos 1994 DF*, p.6) In aggregate, economically active population in Mexico is around 36 million in 1997.

[29] Source: CALIDAD ISEF, *Codigo Financiero de Distrito Federal 98*, p.85

[30] This estimate is perceived to be somewhat equivalent to around 20 to 25 percent less amount of those for Manager class people in the public sector. (Reference, Interview to the Financial Advisor (Asesora) at the government of DF, 1998)

[31] Source: *POS* carried out by JICA team in 1998

[32] Evidently in the light of stochastic, the sample estimate of average income can not be used either for point estimation, or interval estimation in search of the population parameters simply because the population sampled is not, as previously seen *in Fig. 8.7.5.xx*, normally distributed. Neither does nonparametric, or distribution-free, statistics where no assumptions about the populations except continuity of a random variable specify figures in point or interval estimation of parameters. In the face of binding conditions in place, the sample estimate would best be understood as a good deal of benchmark income level or supporting information for the previous estimate derived from macroeconomic data.



Data: *POS*, 1998

Figure H-36: Sample Income Distribution in DF, 1998

b.2 Entity Revenue

Currently in DF, the statistical data and other numerical information on the financial position of entities in DF are of no avail. With this in view, macroeconomic data is alternatively used in estimation of gross revenues and per unit operational/non-operational revenue internally generated by the entities in DF. The 1997 gross regional product (GRP) in DF was US$ 97.0 billion, around a quarter of GDP. Deducting depreciation and indirect taxes from GRP, regional income is now inferred to 80 percent of the aggregate production of goods and services in DF, of which the share of return to production factors, or economic agencies, corresponding to the private business/firms sector is presumably set at 45 percent. With this, combined with 330,000 entities registered in DF, the gross and per unit revenues attributed to entities are estimated at US$ 34,920 million and US$ 0.105 million per year, respectively. Provided that 35 percent of taxable income are subject to the fiscal obligation of corporate tax and other indispensable payments for allowances, disposable incomes, or net profits for appropriation will be approximated at US$ 22,698 million and US$0.068 million per annum for the entities in aggregate and unit, respectively.

c. Willingness to Pay (WTP) – People's Perceptive "*Bid Price*" for Service

Firstly, a kind of "bidding prices" rendered by the direct beneficiaries (categorically divided to households and entities herewith) in DF for the public services in concern are compiled as a proxy measure for their willingness to pay[33]. Subsequently, the empirical WTP currently in use for the analyses by the international lending

[33] WTP is presumably demonstrating people's normative judgement in terms of maximum amount to pay for the services concerned, with an assumption that beneficiaries do make decisions on how much they allocate their scarce resource under their specific constraints and preference. Alternatively saying, WTP is the "bidding price" for solid wastes management services that people reveal with a view to maximizing their welfare without meeting financial hardship.

institutions and aid agencies is set forth in a bid to delineate the difference between the world perception and the WTP currently in place in Mexico City.

c.1 Deliverables of *POS* – Revealed WTP and Money Transferred

With the *POS* outcomes compiled, willingness of each of the households and entities, vis-à-vis, factories, offices, markets, and schools, to pay for the service turned out to be respective of P.12.5 per week (US$59.4/year), P.0.016 per kg, P.0.047 per kg, P.0.024 per kg, and P.0.03 kg, while *tips* and *fincas* actually paid were P.7.07 per week (US$33.6/year), P.0.018/kg, P.0.012/kg, P.0.051/kg, and P.0.458/kg[34], in that order. In aggregate, willingness of households to pay for and actual transfer imparted the indicatives of US$ 123.2 million and US$ 69.7 million per annum. Also, the weighed average[35] WTP and money transactions actually took place for the collective entities in DF are indicated reaching P.0.03/kg and P.0.02/kg, or, US$ 3.4 and US$ 2.2 per ton, combining to the aggregates of US$ 7.6 million and US$ 5.0 million per annum, respectively.

With the above, combined with the observations regarding the disposable income estimates as previously given, WTP and the pecuniary transfer actually took place for the households account for 1.22 percent and 0.69 percent, respectively. In respect of the entities in aggregate, those shares stand remarkably low for their economic size at respective of 0.03 percent and 0.02 percent, with 53.8 percent of the total 4,169,000 ton of wastes (*i.e.*, 2,243,000 tons) being generated by the entities in the area.

The results figured out thus far are summarized in Table H-92 and Table H-93 below.

Table H-92: Gross and Disposable Income by Beneficiary

	Gross Income	Disposable Income
Average Household (US$/year)	6,194 (or 516.2/month)	5,347 (or 445.6/month)
Entities in Aggregate (US$ mil/year)	34,920	22,698
Entities per Unit (US$ million/year)	0.105	0.068

[34] This "extraordinary" statistic appears in one of the schools and universities samples in GAM *Delegacion*. The value seems likely to have shifted the weighed mean value of willingness of entities a little bit higher, thus by being excluded in the succeeding processing of estimation.

[35] Each of the WTP and *ficas* attributed to factories, offices, markets, and schools are weighed by the sample numbers that count respective of 20, 40, 40, and 40, combining to a total of 140 entities.

Table H-93: WTP and Actual Money Transactions by Beneficiary

	Willingness to Pay (WTP)		Actual Transactions	
	Amounts	Share in Disposable Income (%)	Amounts	Share in Disposable Income (%)
Household per Unit (US$/year)	65.3	1.22	36.9	0.69
Household in Total (US$ mil/year) 1/	123.2	1.22	69.7	0.69
Entities in Total (US$ mil/year) 2/	7.6	0.03	5.0	0.02
Entities' Bid Price (US$/ton)	3.4	0.014	2.2	0.009

1/ 1.9 million households are assumed in DF, with the total population of 8.6 million and 4.7 household members in average.

2/ Weighed Average. 2,243,000 tons of wastes generated from entities per annum is assumed.

With the foregoing in view, the weighed averages of *tips* and *fincas* revealed as WTP and actually paid in DF worked out respective of US$ 61.5 million and US$ 34.9 million per annum in gross term, while applying the waste amounts generated by each of the beneficiaries.

c.2 Empirical WTP – An Intuition of Mark-Up Expenses

It would be useful to make some accepted measures of people's ability to pay available for reference herewith. In this connection, international lending institutions presumably assume, as a kind of mark-up expenditures, that the percentage share of household disposable income for the service of solid waste management remain around 2 percent, in line with other major services, notably, water, sanitation (drainage, street cleaning), urban transport being set at 4 percent, 1 percent, and 3-8 percent, respectively[36].

With this, the mark-up expenses for the households and entities currently in DF are estimated at US$ 211.6 million and US$ 499.4 million per annum in gross term, and US$ 111.4 and US$ 1,496 per annum per unit for the households and entities currently in DF, respectively. Once weighed by wastes generated by each of the beneficiary category, the average (weighed average) WTP is figured out at US$ 366.4 million in gross and US$ 856.2 per year per unit. Aggregates of revealed WTP, actual money transfer, and empirical WTP estimated from the sample statistics in DF in 1998 are summarized in Table H-94 below.

Table H-94: Aggregates of Revealed WTP, Actual Money Transfer, and Empirical WTP in DF, 1998

All Beneficiaries in DF, 1998	Revealed WTP	Transfer	Empirical WTP
Weighed Average (US$ million)	61.5	34.9	366.4

d. Benefits Measured by Long-Run Marginal Cost (LRMC) Pricing

In order that the analysis provide financial sustainability directly corresponding to the efficient allocation of scarce resources in the society, the project benefits are measured by way of estimating the Long-Run Marginal Cost pricing. Against the financial back data conveying the project costs of each of the project components, the

[36] Source: World Bank, *Institutionalization of Integrated Urban Development*, 1994, p.9

marginal costs (levelized annuity costs of construction and maintenance) of an incremental and new units and facilities are estimated.

The summary of marginal costs associated with each of the project components by institutional framework is shown in the following Table H-95.

Table H-95: LRMCs by Project Component and Institutional Framework

	Landfill	Compost	BP E-IV		BP E-V		Compost		Total	
			CRF	LRMC	CRF	LRMC	CRF	LRMC	CRF	LRMC
Alternative 1	Case 1	Case 1	0.33	7.4	0.33	7.6	0.28	4.6	0.24	17.4
Alternative 2	Case 1	Case 2	0.33	7.4	0.33	7.6	0.28	4.6	0.24	17.7
Alternative 3	Case 2	Case 1	0.33	6.2	0.33	7.6	0.28	4.6	0.24	17.7
Alternative 4	Case 2	Case 2	0.33	6.2	0.33	7.6	0.28	4.6	0.24	18.0

Note: Case 1: Internalized DGSU
Case 2: Constructed by DGSU and O/M on contract-out basis by the private sector
duration: 12 years, social discount rate: 20%
CRF: Capital Recovery Factor
LRMC: Long-Run Marginal Costs (US$ million/year)

e. Financial Internal Rate of Return (FIRR) Analysis and Financial Evaluation

Initiated by the outline view of the analytical framework and presumptions as reflected above, the numerical results are given with the variation of "*benefits*" considered. Subsequently, the sensitivity analysis will be carried out in a bid to simulate the financial viability with changes in the major variables of the model.

Against the background of model configuration and parameters as reflected in Data M, 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 H-96 down below.

Table H-96: 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 H-97: 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

Table H-98: 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 H-99: 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.

As compared to a mark-up price level to pay for the service, both alternatives with actual money transaction and revealed WTP as project benefits sequentially showed off people's affordability as well as financial sustainability with all the cost shares rest far below the bottom-line. FIRRs could not be calculated due to extraordinary low profiles of benefits-"revenue" attributable to the cases. With this, coupled with the ever-increasing cost of waste disposal, DGSU would encounter difficulties in the face of financial vulnerability and fragility in sound management of the concerned public service in the days to come. The entire financial burden is, and will be into the future, on the shoulder of the DGSU's public unless any policy alternative is initiated.

Summary net cash-flow tables for the whole project and by sub-projects are shown in Table H-100 as attached.

Table H-100: Summary Financial Costs by Alternative

US$ million

Alternative 1

Aggregate Initial Investment Cost Table

	BP-ETAPA IV			BP-ETAPA V			Compost Plant			AGGREGATE		
	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total
Land Lease					0.23	0.23		0.10	0.10		0.33	0.33
Design&Supervsision	0.35	0.49	0.84	0.03	0.30	0.33		0.38	0.38	0.38	1.17	1.55
Pilot project												
Civil&Construction	1.42	4.91	6.32	0.29	2.97	3.25	0.00	0.02	0.02	2.51	7.89	9.60
Equipment	2.22		2.22					3.48	3.48	0.80	3.48	5.70
Equipment Lease												
Tax and Duties	0.80	0.54	1.34	0.06	0.35	0.41	0.61	0.39	1.00	1.16	1.28	2.75
Base Cost	4.79	5.94	10.72	0.38	3.84	4.22	3.69	4.36	8.05	9.33	14.14	22.99
Physical Conti	0.48	0.59	1.07	0.04	0.38	0.42	0.37	0.44	0.80	0.74	1.41	2.30
BaseC+PhyConti	5.27	6.53	11.80	0.42	4.23	4.65	4.06	4.80	8.85	5.05	15.55	25.29
Price Contingency	0.33	1.22	1.55	0.04	1.22	1.26	0.41	1.64	2.05	6.63	4.08	4.86
IDC	0.58	1.55	2.13	0.03	1.09	1.12	0.31	1.34	1.65	5.94	3.98	4.90
Aggregate Cost	6.2	9.3	15.5	0.5	6.5	7.0	4.8	7.8	12.5	17.6	23.6	35.1
Agg Cost exc.IDC	5.6	7.8	13.3	0.5	5.5	5.9	4.5	6.4	10.9	11.7	19.6	30.2

Operation & Maintenance Investment Cash Flow of the Project by Sub-Components

	BP-ETAPA IV			BP-ETAPA V			Compost Plant			AGGREGATE		
	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total
1999												
2000												
2001	0.09	2.65	2.74							0.09	2.65	2.74
2002	0.07	0.44	0.51	1.60	5.17	6.77	0.13	0.56	0.70	1.80	6.18	7.98
2003		0.44	0.44	1.55	5.03	6.57	0.16	0.69	0.85	1.71	6.16	7.87
2004	0.07	0.44	0.51	1.58	4.89	6.47	0.16	0.69	0.85	1.81	6.02	7.84
2005	0.09	2.42	2.51		0.01	0.01	0.16	0.69	0.85	0.25	3.12	3.37
2006	0.16	2.42	2.58	0.05	0.01	0.06	0.16	0.69	0.85	0.37	3.12	3.49
2007		0.44	0.44	2.96	3.31	6.27	0.16	0.69	0.85	3.12	4.44	7.56
2008	0.07	0.44	0.51	0.13	2.34	2.47	2.61	0.69	3.29	2.81	3.47	6.28
2009	0.09	2.34	2.43		0.01	0.01	0.68	0.69	1.37	0.77	3.04	3.81
2010	0.16	2.14	2.30	0.05	0.01	0.06	0.16	0.69	0.85	0.37	2.84	3.21
Total	0.8	14.2	15.0	7.9	20.8	28.7	4.4	6.1	10.5	13.1	41.0	54.1

Averall Cash Flow for the Project

	BP-ETAPA IV			BP-ETAPA V			Compost Plant			AGGREGATE		
	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total
1999	0.05	0.06	0.11	0.00	0.04	0.04	0.00	0.07	0.07	0.05	0.17	0.22
2000	5.22	6.47	11.69	0.02	0.18	0.20	0.003	0.21	0.21	5.24	6.86	12.10
2001	0.09	2.65	2.74	0.39	4.01	4.41	3.36	3.08	6.44	3.84	9.74	13.59
2002	0.07	0.44	0.51	1.60	5.17	6.77	0.82	1.28	2.10	2.49	6.89	9.38
2003		0.44	0.44	1.55	5.03	6.57	0.16	1.41	1.57	1.71	6.87	8.59
2004	0.07	0.44	0.51	1.58	4.89	6.47	0.16	0.69	0.85	1.81	6.02	7.84
2005	0.09	2.42	2.51		0.01	0.01	0.16	0.69	0.85	0.25	3.12	3.37
2006	0.16	2.42	2.58	0.05	0.01	0.06	0.16	0.69	0.85	0.37	3.12	3.49
2007		0.44	0.44	2.96	3.31	6.27	0.16	0.69	0.85	3.12	4.44	7.56
2008	0.07	0.44	0.51	0.13	2.34	2.47	2.61	0.69	3.29	2.81	3.47	6.28
2009	0.09	2.34	2.43		0.01	0.01	0.68	0.69	1.37	0.77	3.04	3.81
2010	0.16	2.14	2.30	0.05	0.01	0.06	0.16	0.69	0.85	0.37	2.84	3.21
Total	6.1	20.7	26.8	8.3	25.0	33.3	8.5	10.9	19.3	22.8	56.6	79.4

Alternative 2
Aggregate Initial Investment Cost Table

Aggregate Initial Investment Cost Table

	BP-ETAPA IV			BP-ETAPA V			Compost Plant			AGGREGATE		
	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total
Land Lease					0.23	0.23		0.10	0.10		0.33	0.33
Design&Supervsision	0.35	0.49	0.84	0.03	0.30	0.33		0.36	0.36	0.38	1.15	1.53
Pilot project							0.00	0.02	0.02	0.00	0.02	0.02
Civil&Construction	1.42	4.91	6.32	0.29	2.97	3.25		3.48	3.48	1.70	11.35	13.05
Equipment	2.22		2.22				1.44		1.44	3.66		3.66
Equipment Lease								0.98	0.98		0.98	0.98
Tax and Duties	0.80	0.54	1.34	0.06	0.35	0.41	0.29	0.49	0.78	1.15	1.38	2.53
Base Cost	4.79	5.94	10.72	0.38	3.84	4.22	1.73	5.43	7.16	6.90	15.21	22.10
Physical Conti	0.48	0.59	1.07	0.04	0.38	0.42	0.17	0.44	0.62	0.69	1.42	2.11
BaseC+PhyConti	5.27	6.53	11.80	0.42	4.23	4.65	1.90	5.87	7.77	7.58	16.63	24.21
Price Contingency	0.33	1.22	1.55	0.04	1.22	1.26	0.19	2.17	2.37	0.56	4.62	5.18
IDC	0.58	1.55	2.13	0.03	1.09	1.12	0.14	1.66	1.80	0.75	4.30	5.05
Aggregate Cost	6.2	9.3	15.5	0.5	6.5	7.0	2.2	9.7	11.9	8.9	25.5	34.4
Agg Cost exc.IDC	5.6	7.8	13.3	0.5	5.5	5.9	2.1	8.0	10.1	8.1	21.2	29.4

Operation & Maintenance Investment Cash Flow of the Project by Sub-Components

	BP-ETAPA IV			BP-ETAPA V			Compost Plant			AGGREGATE		
	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total
1999												
2000												
2001	0.09	2.65	2.74							0.09	2.65	2.74
2002	0.07	0.44	0.51	1.60	5.17	6.77	0.13	0.56	0.70	1.80	6.18	7.98
2003		0.44	0.44	1.55	5.03	6.57	0.16	0.69	0.85	1.71	6.16	7.87
2004	0.07	0.44	0.51	1.58	4.89	6.47	0.16	1.18	1.34	1.81	6.51	8.33
2005	0.09	2.42	2.51		0.01	0.01	0.16	1.18	1.34	0.25	3.61	3.86
2006	0.16	2.42	2.58	0.05	0.01	0.06	0.16	1.18	1.34	0.37	3.61	3.98
2007		0.44	0.44	2.96	3.31	6.27	0.16	1.18	1.34	3.12	4.93	8.05
2008	0.07	0.44	0.51	0.13	2.34	2.47	1.31	1.18	2.49	1.51	3.96	5.47
2009	0.09	2.34	2.43		0.01	0.01	0.34	1.18	1.52	0.43	3.53	3.96
2010	0.16	2.14	2.30	0.05	0.01	0.06	0.16	1.18	1.34	0.37	3.33	3.70
Total	0.8	14.2	15.0	7.9	20.8	28.7	2.8	9.5	12.3	11.5	44.5	55.9

Averall Cash Flow for the Project

	BP-ETAPA IV			BP-ETAPA V			Compost Plant			AGGREGATE		
	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total
1999	0.05	0.06	0.11	0.00	0.04	0.04	0.00	0.06	0.06	0.05	0.15	0.21
2000	5.22	6.47	11.69	0.02	0.18	0.20	0.002	0.20	0.20	5.24	6.85	12.09
2001	0.09	2.65	2.74	0.39	4.01	4.41	1.52	2.98	4.50	2.00	9.65	11.64
2002	0.07	0.44	0.51	1.60	5.17	6.77	0.51	1.88	2.39	2.18	7.49	9.67
2003		0.44	0.44	1.55	5.03	6.57	0.16	2.00	2.17	1.71	7.47	9.18
2004	0.07	0.44	0.51	1.58	4.89	6.47	0.16	1.18	1.34	1.81	6.51	8.33
2005	0.09	2.42	2.51		0.01	0.01	0.16	1.18	1.34	0.25	3.61	3.86
2006	0.16	2.42	2.58	0.05	0.01	0.06	0.16	1.18	1.34	0.37	3.61	3.98
2007		0.44	0.44	2.96	3.31	6.27	0.16	1.18	1.34	3.12	4.93	8.05
2008	0.07	0.44	0.51	0.13	2.34	2.47	1.31	1.18	2.49	1.51	3.96	5.47
2009	0.09	2.34	2.43		0.01	0.01	0.34	1.18	1.52	0.43	3.53	3.96
2010	0.16	2.14	2.30	0.05	0.01	0.06	0.16	1.18	1.34	0.37	3.33	3.70
Total	6.1	20.7	26.8	8.3	25.0	33.3	4.7	15.4	20.0	19.0	61.1	80.1

Alternative 3
Aggregate Initial Investment Cost Table

Aggregate Initial Investment Cost Table

	BP-ETAPA IV			BP-ETAPA V			Compost Plant			AGGREGATE		
	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total
Land Lease								0.10	0.10		0.10	0.10
Design&Supervsision	0.13	0.49	0.62	0.13	0.49	0.62		0.38	0.38	0.26	1.36	1.62
Pilot Project							0.00	0.02		0.00	0.02	
Civil&Construction	1.42	4.90	6.32	1.42	4.90	6.32		3.48	3.48	2.83	13.28	16.11
Equipment							3.07		3.07	3.07		3.07
Equipment Lease												
Tax and Duties 3/	0.31	0.54	0.85	0.31	0.54	0.85	0.61	0.40	1.01	1.23	1.48	2.71
Base Cost	1.86	5.93	7.79	1.86	5.93	7.79	3.69	4.37	8.06	7.40	16.23	23.63
Physical Conti	0.19	0.59	0.78	0.19	0.59	0.78	0.37	0.44	0.81	0.74	1.62	2.36
BaseC+PhyConti	2.04	6.52	8.56	2.04	6.53	8.57	4.06	4.81	8.86	8.14	17.86	26.00
Price Contingency	0.13	1.23	1.35	0.19	1.88	2.07	0.41	1.64	2.05	0.73	4.75	5.48
IDC 4/	0.22	1.55	1.77	0.15	1.68	1.84	0.31	1.35	1.65	0.69	4.58	5.26
Aggregate Cost	2.4	9.3	11.7	2.4	10.1	12.5	4.8	7.8	12.6	9.6	27.2	36.7
Agg Cost exc.IDC	2.2	7.7	9.9	2.2	8.4	10.6	4.5	6.4	10.9	8.9	22.6	31.5

Operation & Maintenance Investment Cash Flow of the Project by Sub-Components

	BP-ETAPA IV			BP-ETAPA V			Compost Plant			AGGREGATE		
	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total
1999												
2000												
2001		0.92	0.92								0.92	0.92
2002	0.07	0.44	0.51	1.51	5.89	7.40	0.13	0.56	0.70	1.71	6.90	8.61
2003		0.44	0.44	1.46	5.75	7.21	0.16	0.69	0.85	1.62	6.88	8.50
2004	0.07	0.44	0.51	1.49	5.61	7.10	0.16	0.69	0.85	1.73	6.74	8.47
2005		2.72	2.72		0.24	0.24	0.16	0.69	0.85	0.16	3.65	3.81
2006	0.07	2.22	2.29	0.05	0.24	0.29	0.16	0.69	0.85	0.28	3.15	3.43
2007		0.44	0.44	0.54	4.03	4.57	0.16	0.69	0.85	0.70	5.16	5.86
2008	0.07	0.44	0.51	0.05	3.06	3.10	2.61	0.69	3.29	2.72	4.19	6.90
2009		3.06	3.06		0.24	0.24	0.68	0.69	1.37	0.68	3.99	4.67
2010	0.07	2.86	2.93	0.05	0.24	0.29	0.16	0.69	0.85	0.28	3.79	4.07
Total	0.4	14.0	14.4	5.1	25.3	30.4	4.4	6.1	10.5	9.9	45.4	55.2

Averall Cash Flow for the Project

	BP-ETAPA IV			BP-ETAPA V			Compost Plant			AGGREGATE		
	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total
1999	0.02	0.06	0.08	0.02	0.06	0.08	0.003	0.07	0.07	0.04	0.19	0.22
2000	2.02	6.50	8.53	0.09	0.30	0.39	0.00	0.21	0.21	2.12	7.01	9.13
2001		0.92	0.92	1.93	6.17	8.10	3.36	3.09	6.45	5.29	10.18	15.47
2002	0.07	0.44	0.51	1.51	5.89	7.40	0.82	1.28	2.10	2.40	7.62	10.01
2003		0.44	0.44	1.46	5.75	7.21	0.16	1.41	1.57	1.62	7.60	9.22
2004	0.07	0.44	0.51	1.49	5.61	7.10	0.16	0.69	0.85	1.73	6.74	8.46
2005		2.72	2.72		0.24	0.24	0.16	0.69	0.85	0.16	3.65	3.81
2006	0.07	2.22	2.29	0.05	0.24	0.29	0.16	0.69	0.85	0.28	3.15	3.43
2007		0.44	0.44	0.54	4.03	4.57	0.16	0.69	0.85	0.70	5.16	5.86
2008	0.07	0.44	0.51	0.05	3.06	3.10	2.61	0.69	3.29	2.72	4.19	6.90
2009		3.06	3.06		0.24	0.24	0.68	0.69	1.37	0.68	3.99	4.67
2010	0.07	2.86	2.93	0.05	0.24	0.29	0.16	0.69	0.85	0.28	3.76	4.04
Total	2.4	20.5	22.9	7.2	31.8	39.0	8.5	10.9	19.3	18.0	63.2	81.2

Alternative 4

Aggregate Initial Investment Cost Table

	BP-ETAPA IV			BP-ETAPA V			Compost Plant			AGGREGATE		
	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total
Land Lease								0.10	0.10		0.10	0.10
Design&Supervsision	0.13	0.49	0.62	0.13	0.49	0.62		0.36	0.36	0.26	1.34	1.60
Pilot Project							0.00	0.02				
Civil&Construction	1.42	4.90	6.32	1.42	4.90	6.32		3.48	3.48	2.83	13.29	16.12
Equipment							1.43		1.43	1.43		1.43
Equipment Lease								0.98				
Tax and Duties 3/	0.31	0.54	0.85	0.31	0.54	0.85	0.29	0.49	0.78	0.90	1.57	2.48
Base Cost	1.86	5.93	7.79	1.86	5.93	7.79	1.72	5.43	7.15	5.43	17.30	22.73
Physical Conti	0.19	0.59	0.78	0.19	0.59	0.78	0.17	0.44	0.61	0.54	1.63	2.17
BaseC+PhyConti	2.04	6.53	8.57	2.04	6.53	8.57	1.89	5.87	7.76	5.97	18.93	24.90
Price Contingency	0.13	1.22	1.35	0.19	1.88	2.07	0.19	2.17	2.37	0.51	5.28	5.79
IDC 4/	0.22	1.55	1.77	0.15	1.68	1.84	0.14	1.66	1.80	0.52	4.89	5.41
Aggregate Cost	2.4	9.3	11.7	2.4	10.1	12.5	2.2	9.7	11.9	7.0	29.1	36.1
Agg Cost exc.IDC	2.2	7.7	9.9	2.2	8.4	10.6	2.1	8.0	10.1	6.5	24.2	30.7

Operation & Maintenance Investment Cash Flow of the Project by Sub-Components

	BP-ETAPA IV			BP-ETAPA V			Compost Plant			AGGREGATE		
	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total
1999												
2000												
2001		0.92	0.92							0.13	0.92	0.92
2002	0.07	0.44	0.51	1.51	5.89	7.40	0.13	0.56	0.70	1.74	6.90	8.61
2003		0.44	0.44	1.46	5.75	7.21	0.16	0.69	0.85	1.62	6.88	8.50
2004	0.07	0.44	0.51	1.49	5.61	7.10	0.16	1.18	1.34	1.73	7.23	8.95
2005		2.72	2.72		0.24	0.24	0.16	1.18	1.34	0.16	4.14	4.30
2006	0.07	2.22	2.29	0.05	0.24	0.29	0.16	1.18	1.34	0.28	3.64	3.92
2007		0.44	0.44	0.54	4.03	4.57	0.16	1.18	1.34	1.85	5.65	6.35
2008	0.07	0.44	0.51	0.05	3.06	3.10	1.31	1.18	2.48	0.46	4.68	6.09
2009		3.06	3.06		0.24	0.24	0.34	1.18	1.52	0.16	4.48	4.82
2010	0.07	2.86	2.93	0.05	0.24	0.29	0.16	1.18	1.34	0.28	4.28	4.56
Total	0.4	14.0	14.4	5.1	25.3	30.4	2.8	9.5	12.3	8.3	48.8	57.0

Averall Cash Flow for the Project

	BP-ETAPA IV			BP-ETAPA V			Compost Plant			AGGREGATE		
	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total
1999	0.02	0.06	0.08	0.02	0.06	0.08	0.00	0.06	0.06	0.04	0.18	0.22
2000	2.02	6.47	8.49	0.09	0.30	0.39	0.002	0.20	0.20	2.12	6.97	9.08
2001		0.92	0.92	1.93	6.17	8.10	1.51	2.98	4.49	3.57	10.07	13.51
2002	0.07	0.44	0.51	1.51	5.89	7.40	0.51	1.88	2.39	2.12	8.21	10.30
2003		0.44	0.44	1.46	5.75	7.21	0.16	2.00	2.17	1.62	8.19	9.82
2004	0.07	0.44	0.51	1.49	5.61	7.10	0.16	1.18	1.34	1.73	7.23	8.95
2005		2.72	2.72		0.24	0.24	0.16	1.18	1.34	0.16	4.14	4.30
2006	0.07	2.22	2.29	0.05	0.24	0.29	0.16	1.18	1.34	0.28	3.64	3.92
2007		0.44	0.44	0.54	4.03	4.57	0.16	1.18	1.34	1.85	5.65	6.35
2008	0.07	0.44	0.51	0.05	3.06	3.10	1.31	1.18	2.48	0.46	4.68	6.09
2009		3.06	3.06		0.24	0.24	0.34	1.18	1.52	0.16	4.48	4.82
2010	0.07	2.86	2.93	0.05	0.24	0.29	0.16	1.18	1.34	0.28	4.28	4.56
Total	2.4	20.5	22.9	7.2	31.8	39.0	4.7	15.4	20.0	14.4	67.7	81.9

H.7.6 Economic Evaluation

H.7.6.1 Proposition

Economic analysis of the prospective SWM investment project was undertaken while using benefits and costs as measured in terms of scarcity of resources and allocative efficiency in the national economy as a whole. As regards 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. In practice, the cost of the prospective investment plan for the new final disposal site that needs to be established as soonest. Economic cost was revalued from the financial costs while excluding the incorporated imperfections due to non-competitive pricing, externality of the economy, and fiscal distortions such as taxes and duties levied on goods and services in the markets. Specifically, Standard Conversion Factor (SCF) in use for the analysis was 0.95, while considering the low tariff rates on the imports and subsidies on the exports, as well as those recently applied in the investment projects in Mexico under the auspices of the World Bank. Should the quantification of costs and benefits accrued be undertaken in terms of the local currency, shadow exchange rate would be considered to stray at around 1.05[37].

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

H.7.6.2 Findings

Economic feasibility of the proposed investment plan as borne out by ENPV has been estimated in line with the foregoing guiding principles and the operational parameters as given below. To be noted that economic evaluation for ENPV has only been carried out for the project component of final disposal sites (FDSs), notably, Etapa IV and V, because final disposal site(s) is certainly necessary whether intermediate processing exists or not.

a. Economic Benefit

The benefit as replaced by the cost saved is assumed to be the unpaid cost otherwise accrued to the construction of the new final disposal site that is to be located in a far distance than the existing ones. Although indicative, the prospective investment cost is envisaged to reach US$ 70 million[38], with the scheduled disbursement of capital investment consecutively taking place at 28.6 percent, 42.8 percent, and again 28.6 percent over the three years commencing in 1999. In the currency term, direct

[37] As easily understood, shadow exchange rate (SXR) is numerically expressed as an inverse of SCF.

[38] It is estimated that US$70 million of initial investment is needed for construction of a new landfill at Ixtapaluca that was evaluated as a secondary prospective candidate site following BP-V in "Annex D Comparative Evaluation of Candidate Sites for Final Disposal of Solid Waste." About 35million tons of waste are needed to be disposed of by 2010. The site at Ixtapaluca is located at a hillside and the aquifer under the site has good quality of groundwater. Therefore, a bank to protect the waste from flowing out to the downstream and leachate collection/treatment system to protect the groundwater from being contaminated are surely necessary when the new landfill is constructed. The study team assumed the initial cost of such a landfill to be US$2 per ton of waste, i.e., 35 million tons of waste multiplied US$2 equals to US$70 million.

benefits, therefore, is assumed to be US$ 20.0 million, US$ 30 million, and US$ 20.0 million in the said initial investment period.

b. Economic Cost

The aggregate economic costs of initial investment accrued to supply one additional tonnage solid waste management and disposal in the forthcoming years till 2010 have been figured out to be US$ US$ 21.9 million, US$ 21.0 million, US$ 22.2 million, and US$ 20.8 million for the Alternatives 1,2,3,and 4, respectively. Of this, the economic costs of FDSs in use for the estimation of economic feasibility are respective of 14.4 million and US$ 14.1 million for the Alternatives 1,2 (Case 1) and the Alternatives 3,4 (Case 2), while accounting for around 65 percent for both of the cases. The economic costs of operation and maintenance are also converted from the financial to the economic cost, reflecting the true value of goods and services employed in the project. These recurrent economic costs turned out to be US$ 52.1 million, US$ 53.7 million, US$ 52.6 million, and US$ 54.2 million for Alternatives 1, 2, 3, and 4, respectively.

In aggregate, the economic costs accrued to the project as a whole worked out US$ 74.0 million, US$ 74.7 million, US$ 75.2 million, and US$ 76.6 million for the Alternatives 1, 2, 3, and 4, respectively. Of this, the economic costs in concern for economic feasibility study, vis-à-vis, Etapa IV and Etapa V, reached respective of US$ 56.3 million and US$ 57.5 million for Case 1 and Case 2, while accounting for around three quarters of the total for both of the cases.

c. Economic Net Present Value (ENPV)

Economic Net Present Value (ENPV) was calculated on the basis of the new and the incremental cost and benefit streams associated with the proposed investment outlays over the period of maximum 3 years with the commencement in 1999. All the costs are shadow priced, being adjusted to convert market prices to shadow prices expressed in terms of border currency unit (US dollar).

With the methodology and the numerical assumptions as noted immediately above, 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 II-103 below. Detailed cost breakdown of the capital investment and recurrent costs for the Alternatives are in Table II-101 as attached. Further, summary net cash-flow tables for FDSs in aggregate and by component are shown in Table II-102.

Table H-101: Summary Economic Costs

US$ million

Alternative 1

Aggregate Economic Costs of Initial Investment

	BP-ETAPA IV			BP-ETAPA V			Compost Plant			AGGREGATE		
	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total
Land Lease					0.22	0.22		0.09	0.09		0.31	0.31
Design&Supervsisio	0.35	0.47	0.82	0.03	0.29	0.31		0.38	0.38	0.38	1.13	1.51
Pilot project												
Civil&Construction	1.42	4.66	6.07	0.29	3.14	3.42	0.00	0.02	0.02	2.51	7.00	9.51
Equipment	2.22		2.22					3.33	3.33	2.22	3.33	5.55
Equipment Lease												
Tax and Duties 3/												
Base Cost	3.99	5.12	9.11	0.32	3.64	3.95	3.07	3.81	6.89	7.78	12.58	19.95
Physical Conti	0.40	0.51	0.91	0.03	0.36	0.40	0.31	0.38	0.69	0.34	1.26	1.90
BaseC+PhyConti	4.39	5.63	10.02	0.35	4.00	4.35	3.38	4.20	7.57	3.73	13.83	21.95
Price Contingency												
IDC 4/												
Aggregate Cost	4.4	5.6	10.0	0.3	4.0	4.3	3.4	4.2	7.6	3.7	13.8	21.9

Operation & Maintenance Investment Cash Flow of the Project by Sub-Components (Base Cost)

	BP-ETAPA IV			BP-ETAPA V			Compost Plant			AGGREGATE		
	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total
1999												
2000												
2001	0.09	2.52	2.61							0.09	2.52	2.61
2002	0.07	0.42	0.49	1.60	4.91	6.51	0.13	0.54	0.67	1.80	5.87	7.67
2003		0.42	0.42	1.55	4.78	6.32	0.16	0.65	0.82	1.71	5.85	7.56
2004	0.07	0.42	0.49	1.58	4.65	6.23	0.16	0.65	0.82	1.81	5.72	7.54
2005	0.09	2.30	2.39		0.01	0.01	0.16	0.65	0.82	0.25	2.96	3.21
2006	0.16	2.30	2.46	0.05	0.01	0.06	0.16	0.65	0.82	0.37	2.96	3.33
2007		0.42	0.42	2.96	3.15	6.10	0.16	0.65	0.82	3.12	4.22	7.34
2008	0.07	0.42	0.49	0.13	2.22	2.35	2.61	0.65	3.26	2.81	3.29	6.10
2009	0.09	2.22	2.31		0.01	0.01	0.68	0.65	1.34	0.77	2.89	3.66
2010	0.16	2.03	2.19	0.05	0.01	0.06	0.16	0.65	0.82	0.37	2.70	3.07
Total	0.8	13.5	14.3	7.9	19.7	27.6	4.4	5.8	10.2	13.1	39.0	52.1

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

	BP-ETAPA IV			BP-ETAPA V			Compost Plant			AGGREGATE		
	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total
1999	0.04	0.05	0.09	0.004	0.03	0.04	0.002	0.06	0.06	0.04	0.15	0.19
2000	4.35	5.58	9.93	0.02	0.17	0.19	0.002	0.18	0.19	4.37	5.94	10.31
2001	0.09	2.52	2.61	0.33	3.80	4.13	2.80	2.69	5.50	3.22	9.01	12.23
2002	0.07	0.42	0.49	1.60	4.91	6.51	0.71	1.16	1.87	2.37	6.50	8.87
2003		0.42	0.42	1.55	4.78	6.32	0.16	1.28	1.45	1.71	6.48	8.19
2004	0.07	0.42	0.49	1.58	4.65	6.23	0.16	0.65	0.82	1.81	5.72	7.54
2005	0.09	2.30	2.39		0.01	0.01	0.16	0.65	0.82	0.25	2.96	3.21
2006	0.16	2.30	2.46	0.05	0.01	0.06	0.16	0.65	0.82	0.37	2.96	3.33
2007		0.42	0.42	2.96	3.15	6.10	0.16	0.65	0.82	3.12	4.22	7.34
2008	0.07	0.42	0.49	0.13	2.22	2.35	2.61	0.65	3.26	2.81	3.29	6.10
2009	0.09	2.22	2.31		0.01	0.01	0.68	0.65	1.34	0.77	2.89	3.66
2010	0.16	2.03	2.19	0.05	0.01	0.06	0.16	0.65	0.82	0.37	2.70	3.07
Total	5.2	19.1	24.3	8.2	23.7	32.0	7.8	10.0	17.8	21.2	52.8	74.0

Alternative 2

Aggregate Initial Investment Cost Table

	BP-ETAPA IV			BP-ETAPA V			Compost Plant			AGGREGATE		
	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total
Land Lease					0.22	0.22		0.09	0.09		0.31	0.31
Design&Supervsisio	0.35	0.49	0.84	0.03	0.28	0.31		0.34	0.34	0.38	1.12	1.50
Pilot project							0.00	0.02	0.02	0.00	0.02	0.02
Civil&Construction	1.42	4.91	6.32	0.29	2.82	3.11		3.30	3.30	1.70	11.03	12.73
Equipment	2.22		2.22				1.44		1.44	3.66		3.66
Equipment Lease								0.93	0.93		0.93	0.93
Tax and Duties 3/												
Base Cost	3.99	5.40	9.39	0.32	3.32	3.64	1.44	4.69	6.13	5.75	13.40	19.15
Physical Conti	0.40	0.54	0.94	0.03	0.33	0.36	0.14	0.37	0.52	0.57	1.25	1.82
BaseC+PhyConti	4.39	5.94	10.32	0.35	3.65	4.00	1.58	5.06	6.65	6.32	14.65	20.97
Price Contingency												
IDC 4/												
Aggregate Cost	4.4	5.9	10.3	0.3	3.7	4.0	1.6	5.1	6.6	6.3	14.7	21.0

Operation & Maintenance Investment Cash Flow of the Project by Sub-Components (Base Cost)

	BP-ETAPA IV			BP-ETAPA V			Compost Plant			AGGREGATE		
	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total
1999												
2000												
2001	0.09	2.52	2.61							0.09	2.52	2.61
2002	0.07	0.42	0.49	1.60	4.91	6.51	0.13	0.54	0.67	1.80	5.87	7.67
2003		0.42	0.42	1.55	4.78	6.32	0.16	0.65	0.82	1.71	5.85	7.56
2004	0.07	0.42	0.49	1.58	4.65	6.23	0.16	1.12	1.28	1.81	6.19	8.00
2005	0.09	2.30	2.39		0.01	0.01	0.16	1.12	1.28	0.25	3.43	3.68
2006	0.16	2.30	2.46	0.05	0.01	0.06	0.16	1.12	1.28	0.37	3.43	3.80
2007		0.42	0.42	2.96	3.15	6.10	0.16	1.12	1.28	3.12	4.69	7.81
2008	0.07	0.42	0.49	0.13	2.22	2.35	1.31	1.12	2.43	1.51	3.76	5.27
2009	0.09	2.22	2.31		0.01	0.01	0.34	1.12	1.46	0.43	3.35	3.78
2010	0.16	2.03	2.19	0.05	0.01	0.06	0.16	1.12	1.28	0.37	3.16	3.53
Total	0.8	13.5	14.3	7.9	19.7	27.6	2.8	9.0	11.8	11.5	42.2	53.7

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

	BP-ETAPA IV			BP-ETAPA V			Compost Plant			AGGREGATE		
	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total
1999	0.04	0.05	0.09	0.004	0.03	0.03	0.002	0.05	0.05	0.04	0.14	0.18
2000	4.35	5.88	10.23	0.02	0.16	0.17	0.002	0.17	0.17	4.37	6.21	10.58
2001	0.09	2.52	2.61	0.33	3.47	3.79	1.27	2.57	3.84	1.68	8.55	10.24
2002	0.07	0.42	0.49	1.60	4.91	6.51	0.45	1.67	2.12	2.12	7.00	9.12
2003		0.42	0.42	1.55	4.78	6.32	0.16	1.79	1.95	1.71	6.98	8.70
2004	0.07	0.42	0.49	1.58	4.65	6.23	0.16	1.12	1.28	1.81	6.19	8.00
2005	0.09	2.30	2.39		0.01	0.01	0.16	1.12	1.28	0.25	3.43	3.68
2006	0.16	2.30	2.46	0.05	0.01	0.06	0.16	1.12	1.28	0.37	3.43	3.80
2007		0.42	0.42	2.96	3.15	6.10	0.16	1.12	1.28	3.12	4.69	7.81
2008	0.07	0.42	0.49	0.13	2.22	2.35	1.31	1.12	2.43	1.51	3.76	5.27
2009	0.09	2.22	2.31		0.01	0.01	0.34	1.12	1.46	0.43	3.35	3.78
2010	0.16	2.03	2.19	0.05	0.01	0.06	0.16	1.12	1.28	0.37	3.16	3.53
Total	5.2	19.4	24.6	8.2	23.4	31.6	4.3	14.1	18.4	17.8	56.9	74.7

Alternative 3

Aggregate Initial Investment Cost Table

	BP-ETAPA IV			BP-ETAPA V			Compost Plant			AGGREGATE		
	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total
Land Lease								0.09	0.09		0.09	0.09
Design&Supervsisio	0.13	0.47	0.60	0.13	0.47	0.60		0.36	0.36	0.26	1.29	1.55
Pilot Project							0.00	0.02	0.02	0.00	0.02	0.02
Civil&Construction	1.42	4.66	6.07	1.42	4.66	6.07		3.30	3.30	2.83	12.62	15.45
Equipment							3.07		3.07	3.07		3.07
Equipment Lease												
Tax and Duties 3/											-	
Base Cost	1.55	5.12	6.67	1.55	5.13	6.67	3.07	3.77	6.85	6.17	14.02	20.19
Physical Conti	0.15	0.51	0.67	0.15	0.51	0.67	0.31	0.38	0.68	0.62	1.40	2.02
BaseC+PhyConti	1.70	5.63	7.34	1.70	5.64	7.34	3.38	4.15	7.53	6.78	15.42	22.20
Price Contingency												
IDC 4/												
Aggregate Cost	1.7	5.6	7.3	1.7	5.6	7.3	3.4	4.2	7.5	6.8	15.4	22.2

Operation & Maintenance Investment Cash Flow of the Project by Sub-Components (Base Cost)

	BP-ETAPA IV			BP-ETAPA V			Compost Plant			AGGREGATE		
	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total
1999												
2000												
2001		0.87	0.87								0.87	0.87
2002	0.07	0.42	0.49	1.51	5.60	7.10	0.13	0.54	0.67	1.71	6.55	8.26
2003		0.42	0.42	1.46	5.46	6.92	0.16	0.65	0.82	1.62	6.53	8.16
2004	0.07	0.42	0.49	1.49	5.33	6.82	0.16	0.65	0.82	1.73	6.41	8.14
2005		2.58	2.58		0.23	0.23	0.16	0.65	0.82	0.16	3.47	3.63
2006	0.07	2.11	2.18	0.05	0.23	0.27	0.16	0.65	0.82	0.28	2.99	3.27
2007		0.42	0.42	0.54	3.83	4.37	0.16	0.65	0.82	0.70	4.90	5.61
2008	0.07	0.42	0.49	0.05	2.90	2.95	2.61	0.65	3.26	2.72	3.98	6.70
2009		2.91	2.91		0.23	0.23	0.68	0.65	1.34	0.68	3.79	4.47
2010	0.07	2.72	2.79	0.05	0.23	0.27	0.16	0.65	0.82	0.28	3.60	3.88
Total	0.4	13.3	13.7	5.1	24.0	29.2	4.4	5.8	10.2	9.9	43.1	53.0

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

	BP-ETAPA IV			BP-ETAPA V			Compost Plant			AGGREGATE		
	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total
1999	0.01	0.02	0.03	0.016	0.05	0.07	0.002	0.06	0.06	0.03	0.13	0.16
2000	1.69	5.62	7.30	0.08	0.26	0.33	0.002	0.18	0.18	1.77	6.06	7.82
2001		0.87	0.87	1.61	5.33	6.94	2.80	2.67	5.47	4.41	8.87	13.28
2002	0.07	0.42	0.49	1.51	5.60	7.10	0.71	1.16	1.86	2.29	7.17	9.46
2003		0.42	0.42	1.46	5.46	6.92	0.16	1.27	1.44	1.62	7.15	8.78
2004	0.07	0.42	0.49	1.49	5.33	6.82	0.16	0.65	0.82	1.73	6.41	8.14
2005		2.58	2.58		0.23	0.23	0.16	0.65	0.82	0.16	3.47	3.63
2006	0.07	2.11	2.18	0.05	0.23	0.27	0.16	0.65	0.82	0.28	2.99	3.27
2007		0.42	0.42	0.54	3.83	4.37	0.16	0.65	0.82	0.70	4.90	5.61
2008	0.07	0.42	0.49	0.05	2.90	2.95	2.61	0.65	3.26	2.72	3.98	6.70
2009		2.91	2.91		0.23	0.23	0.68	0.65	1.34	0.68	3.79	4.47
2010	0.07	2.72	2.79	0.05	0.23	0.27	0.16	0.65	0.82	0.28	3.60	3.88
Total	2.1	18.9	21.0	6.8	29.7	36.5	7.8	9.9	17.7	16.7	58.5	75.2

Alternative 4

Aggregate Initial Investment Cost Table

	BP-ETAPA IV			BP-ETAPA V			Compost Plant			AGGREGATE		
	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total
Land Lease		0.47	0.47					0.09	0.09		0.56	0.56
Design&Supervisio	0.13	4.66	4.79	0.13	0.47	0.60		0.34	0.34	0.26	5.47	5.73
Pilot Project							0.00	0.02	0.02	0.00	0.02	0.02
Civil&Construction	1.42		1.42	1.42	4.66	6.07		3.30	3.30	2.83	7.96	10.79
Equipment							1.43		1.43	1.43		1.43
Equipment Lease								0.93				
Tax and Duties 3/												
Base Cost	1.55	4.66	6.21	1.55	5.13	6.67	1.43	4.69	6.12	4.52	14.47	19.00
Physical Conti	0.15	0.51	0.67	0.15	0.51	0.67	0.14	0.37	0.52	0.45	1.40	1.85
BaseC+PhyConti	1.70	5.17	6.87	1.70	5.64	7.34	1.57	5.06	6.64	4.98	15.87	20.85
Price Contingency												
IDC 4/												
Aggregate Cost	1.7	5.2	6.9	1.7	5.6	7.3	1.6	5.1	6.6	5.0	15.9	20.8

Operation & Maintenance Investment Cash Flow of the Project by Sub-Components (Base Cost)

	BP-ETAPA IV			BP-ETAPA V			Compost Plant			AGGREGATE		
	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total
1999												
2000												
2001		0.87	0.87								0.87	0.87
2002	0.07	0.42	0.49	1.51	5.60	7.10	0.13	0.54	0.67	1.74	6.55	8.29
2003		0.42	0.42	1.46	5.46	6.92	0.16	0.65	0.82	1.62	6.53	8.16
2004	0.07	0.42	0.49	1.49	5.33	6.82	0.16	1.12	1.28	1.73	6.87	8.60
2005		2.58	2.58		0.23	0.23	0.16	1.12	1.28	0.16	3.93	4.10
2006	0.07	2.11	2.18	0.05	0.23	0.27	0.16	1.12	1.28	0.28	3.46	3.74
2007		0.42	0.42	0.54	3.83	4.37	0.16	1.12	1.28	1.85	5.37	7.22
2008	0.07	0.42	0.49	0.05	2.90	2.95	1.31	1.12	2.43	1.43	4.44	5.87
2009		2.91	2.91		0.23	0.23	0.34	1.12	1.46	0.16	4.25	4.59
2010	0.07	2.72	2.79	0.05	0.23	0.27	0.16	1.12	1.28	0.28	4.07	4.35
Total	0.4	13.3	13.7	5.1	24.0	29.2	2.8	9.0	11.8	9.25	46.4	55.7

Averall Cash Flow for the Project (IniInv-BCPhyC, O/M-Base)

	BP-ETAPA IV			BP-ETAPA V			Compost Plant			AGGREGATE		
	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total
1999	0.01	0.05	0.06	0.016	0.05	0.07	0.002	0.05	0.05	0.03	0.15	0.18
2000	1.69	5.12	6.81	0.08	0.26	0.33	0.002	0.17	0.17	1.77	5.55	7.32
2001		0.87	0.87	1.61	5.33	6.94	1.26	2.57	3.83	3.00	8.77	11.64
2002	0.07	0.42	0.49	1.51	5.60	7.10	0.44	1.67	2.12	2.06	7.69	9.75
2003		0.42	0.42	1.46	5.46	6.92	0.16	1.79	1.95	1.62	7.67	9.29
2004	0.07	0.42	0.49	1.49	5.33	6.82	0.16	1.12	1.28	1.73	6.87	8.60
2005		2.58	2.58		0.23	0.23	0.16	1.12	1.28	0.16	3.93	4.10
2006	0.07	2.11	2.18	0.05	0.23	0.27	0.16	1.12	1.28	0.28	3.45	3.74
2007		0.42	0.42	0.54	3.83	4.37	0.16	1.12	1.28	1.43	5.37	7.22
2008	0.07	0.42	0.49	0.05	2.90	2.95	1.31	1.12	2.43	0.46	4.44	5.87
2009		2.91	2.91		0.23	0.23	0.34	1.12	1.46	0.16	4.25	4.59
2010	0.07	2.72	2.79	0.05	0.23	0.27	0.16	1.12	1.28	0.28	4.07	4.35
Total	2.1	18.5	20.6	6.8	29.7	36.5	4.3	14.1	18.4	14.4	62.2	76.6

Table H-102: Summary Net Cash-Flow for ENPV

US$ million

Alternative 1 & 2 (Case 1)

Averall 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)

Averall 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		-2.45
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 H-103: Summary of Economic Feasibility by Components and Measurement Indices

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

H.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.

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