old vehicles.

- Number of trips to the landfill: an average of 1.5 per truck per workday.
- Average tariffs: Q.12. high level; Q.7. medium level; Q.1. low level.

3.2.3 Supervision and Control of Concessions

The operation and performance of the private collection in the concessioned areas will be monitored, supervised, and controlled by the Private Collection Department of the DLP.

The fundamental aspects to watch daily will be the following:

(1) Total collection of the waste generated in the Zone by the concessionaire.

(2) Control that the vehicles owned by the commercial and individual companies are authorized by the DLP to transport solid waste.

(3) Prohibition to transport dangerous and/or toxic wastes by the concessionaire.

(4) Surveillance of the maximum tariffs that the users of service are charged.

(5) Surveillance so that the vehicles operate exclusively in the concessioned zone.

(6) control or the discharge of solid wastes in clandestine open dumps.

(7) Control of collectors operating in zones which are not concessioned to them.

4. Data Base

Contents

MANAGEMENT OF INFORMATION ABOUT MUNICIPAL SOLID WASTE SERVICES

4. Data Base

4.1 Introduction

Officials responsible for municipal solid waste management services in many countries have been facing an increasingly difficulties time due to adverse socioeconomic and physical developments as well as the rapid population growth being experienced in urban areas.

The problem is not simply associated with insufficient funds and equipment to cope with an increased level of service demands, but also stems from a lack of proper planning and operational management practices by municipal solid waste management authorities. The planning and operational management of solid waste collection and disposal services require reliable information which must be provided timely fashion to the officials who need it for their activities.

This document first discusses the importance of information management for planning, design, and operating municipal solid waste management systems. Then, this document considers the various factors that must be taken into account when designing an information management system.

4.2 The Role of Information Management

Information plays a vital role in the planning, design, and operation of solid waste management services. However, the importance of information regarding environmental aspects and its management has not received adequate attention from most of the municipal authorities responsible

for solid waste management.

Solid waste management is considered to be merely an activity in which collection vehicles and equipment are purchased and workers are employed to collect and transport solid wastes from households, institutions, commercial and industrial establishments, streets, etc. to dump sites. Vehicles and equipment are purchased and manpower is allocated as and when money is available.

The performance of solid waste management services can only be evaluated by the visual observation of streets and disposal sites.

The unsightliness observed and odors emitted from streets and disposal sites are often related to the lack of equipment, manpower, and planning, and a shortage of funds is almost always considered to be the most serious problem.

These planning and operation management activities require that information be collected and processed. In order to facilitate systematic collection, processing storage and dissemination, and the utilization of information for planning and operational management, an information management system must be established.

Such an information management system could collect information from the actual implementation of solid waste collection and disposal services and various other sources including socioeconomics studies. The stored information could also be categorized, which would lead to prompt retrieval of information retrieved and processed for the purposes of planning and operational management.

The information could be used to establish solid waste management goals and targets for the planning period, and to make decisions on resource investment for solid waste collection and disposal services.

The information could also be used to assess the efficacy of solid waste collection and disposal services and improve the performance of the solid waste management system. Such an analysis would require information on the operation and maintenance of vehicles and equipment, the productivity of workers, the performance of collection and disposal services as well as expenditures.

Fig. 1 presents the general flow of information from collection to processing, storage, and ultimately to the utilization of information in planning and operational management.

The information generated from the actual operation of solid waste management services could regularly (daily, monthly, yearly) be collected and input into the J-3100. Socioeconomic information relevant to solid waste management could also be collected and stored in the J-3100.

The pure data could then be processed to provide information in a useful form.

The processed information could be stored in the J-3100 or on paper, and could be used for planning and operational management.

This information would be controlled by the DLPM.

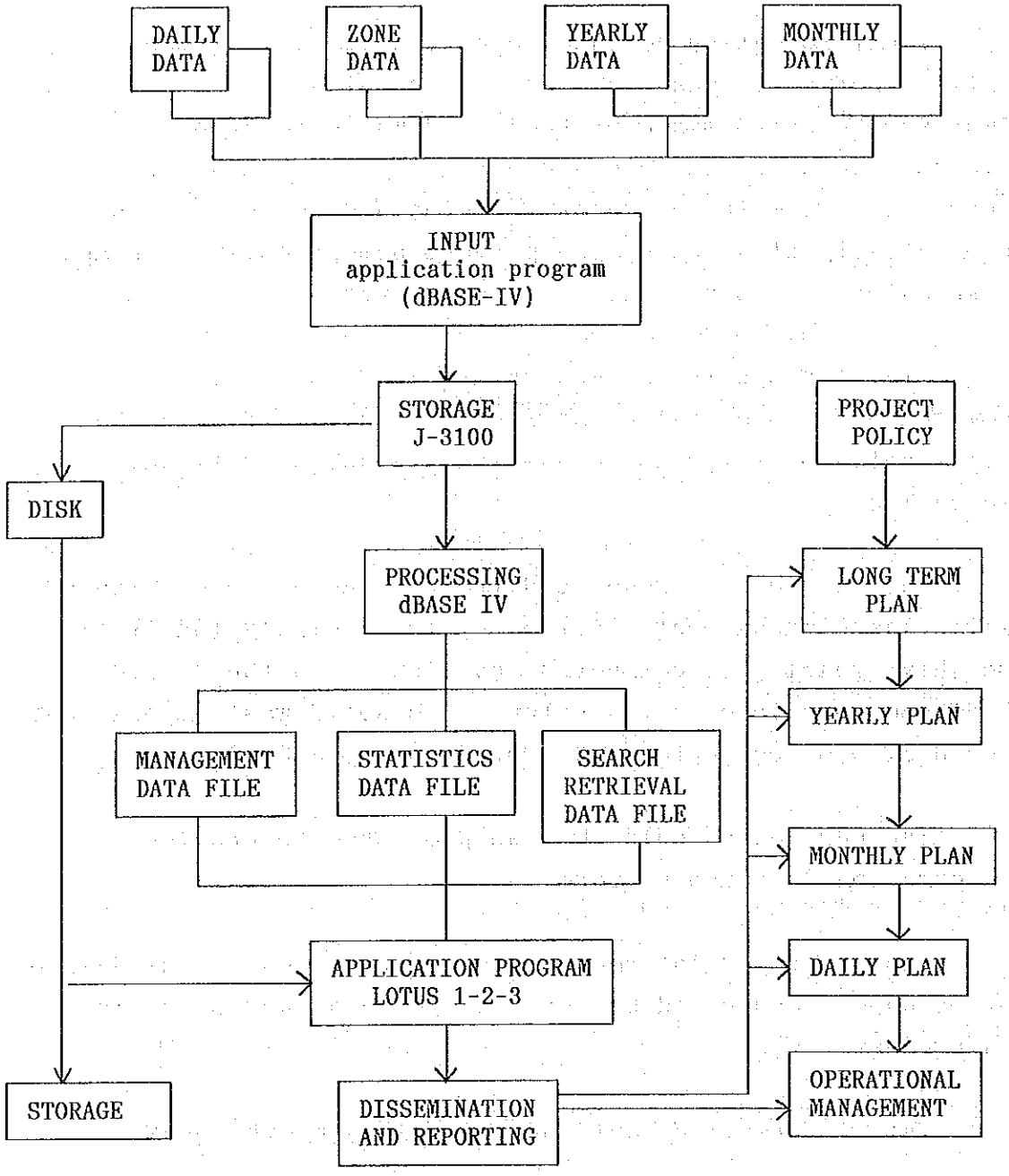


FIG. 1 FLOWS OF INFORMATION IN OPERATIONAL MANAGEMENT

Environmental data, such as that required for the environmental monitoring of solid waste processing and disposal facilities could be used in the planning, design, and operation of solid waste management systems.

However, this information would not easily get into the information management scheme mentioned above.

An information management system used for library operation could be applied to management which could be developed separately from the above-mentioned information management system.

Environmental data (water quality data) is generated daily and controlled by EMPAGUA. Therefore, this type of information would be controlled by EMPAGUA.

Fig. 2 presents the general flow of environment information (water quality data). The information generated from EMPAGUA's daily work would be regularly collected and input into the J-3100.

The pure data would then be processed to provide information in a useful form.

The processed information would be stored in the J-3100 and would be reported to DLPM. The DLPM, which is responsible for the controlled landfill, could be actively use the information for environmental supervision.

Fig. 3 presents the general flow of environmental data centering around the J-3100.

4.3 Operational Management Indicators

The previous section classified information required for the decision-making process in the planning and operational management of solid waste management into four

categories: socioeconomic and physical condition indicators, efficiency indicators, private service indicators, and environmental monitoring indicators.

The indicators were already prepared in the J-3100.

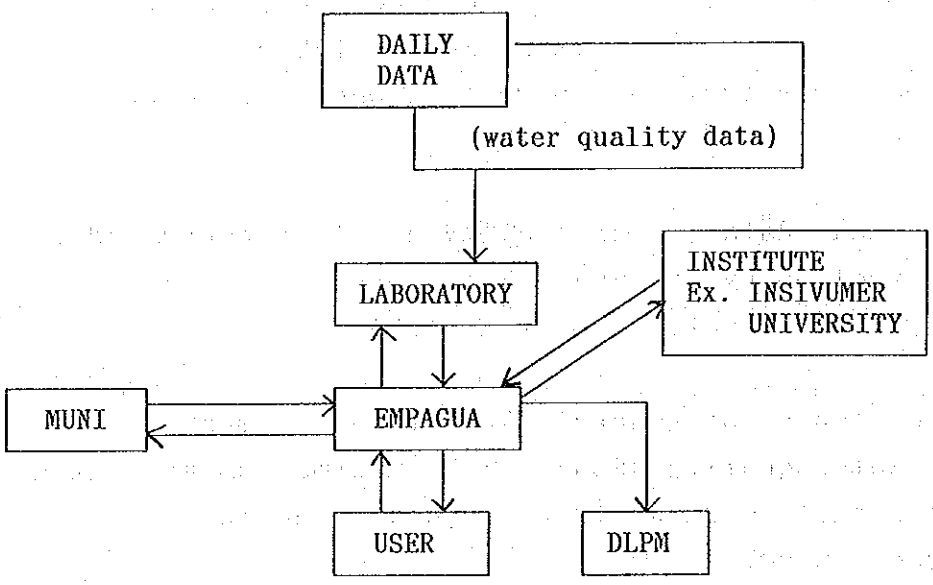


FIG. 2 FLOWS OF INFORMATION FOR WATER QUALITY DATA

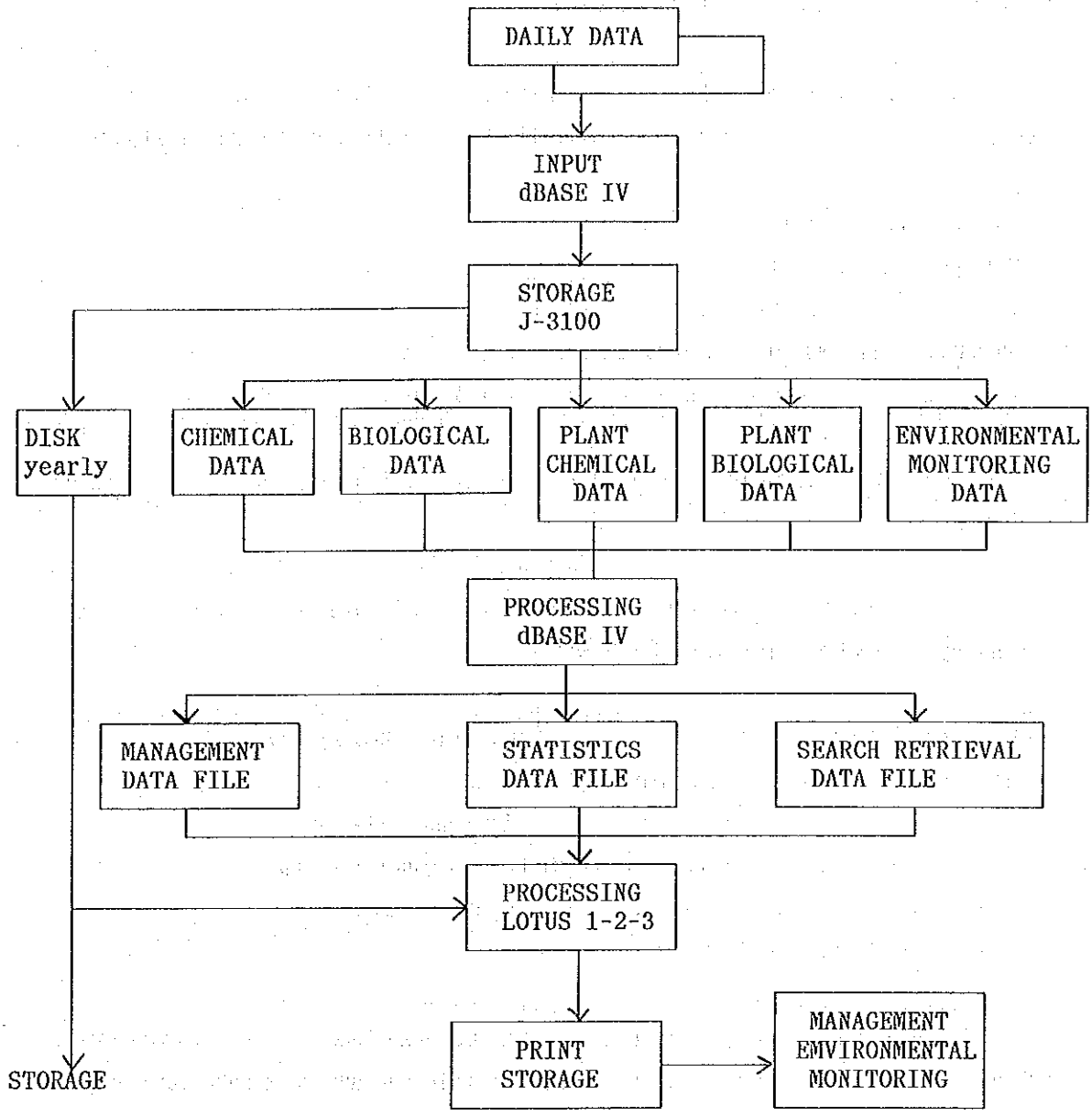


FIG. 3 FLOW OF WATER QUALITY DATA CENTERING AROUND J-3100

4.3.1 Waste Generation Amount

All indicators in this functional element belong to the socioeconomic and physical condition indicators as follows:

- Administrative area (km^2)
- Target area (km^2)
- Population in the target area
- Population within each zone
- Number of households within each zone
- Tariffs by zone
- Proportion of population with high, middle, and low income by zone

The quantity of waste from each of these sources is a primary service demand indicator.

- Household waste (ton/day, ton/month, ton/year)
- Household waste (kg/capita/day)
- Household waste from the high income class
- Household waste from the middle income class
- Household waste from the low income class
- Household waste from the slum

These indicators can be used to estimate the quantity of waste in a different setting, such as when the size of the population differs. Therefore, they are useful for predicting the future demand for solid waste management.

In addition to the quantities of waste generated, their physical and chemical compositions and densities provide essential information for determining appropriate collection, processing, and disposal methods.

- Physical composition
  Bones
  Paper
  Plastics

Wood and grass
Metals
Rubber and leather
Moisture content (%)
Lower calorific value (kcal/kg)
Chemical composition

4.3.2 Data from Truck Scales

4.3.2.1 Aspects considered

(1) Truck information

1) Ownership

The trucks are classified into six different groups, separated according to the institution to which they belong. To make them easy to handle, they have been assigned the following codes:

10 Code assigned to municipal trucks belonging to the Municipality of Guatemala and to nearby municipalities
20 Code assigned to public sector trucks
30 Code assigned to "La Cooperativa" private collection trucks
40 Code assigned to "La Asociacion" private collection trucks
50 Code assigned to private collection trucks which do not belong to the "La Cooperativa" nor the "La Asociacion". These trucks are referred to as "Independientes"
60 Code assigned to trucks and/or vehicles from factories, companies, private homes, etc. These trucks are referred to as "Particulares"

2) License plates

The license plate numbers of all the trucks and vehicles in written next to the ownership code, with the exception of those belonging to the Municipality of Guatemala, since due to their organization only the number of the corresponding municipal acronym is needed.

3) Type of material

The types of materials dumped in the landfill of El Trébol is entered here. For ease in handling, the materials have been classified, divided into six groups, and assigned the following codes:

01 Solid waste
02 Demolition and construction waste
03 Soil: from municipal markets and civil constructions, etc.
04 Select: material of good quality for compacting
05 Glass: waste from companies that bottle soft drinks, etc.
06 Others: materials not included under any of the other codes. For example, waste from tanneries, mud from marble factories, etc.

4) Route

The origin or destiny of the trucks that enter the scale is registered here. For ease in handling this item has been coded as follows:

100 Code assigned to zone one
101 Code assigned to zone two
102 Code assigned to zone three
103 Code assigned to zone four
104 Code assigned to zone five

105 Code assigned to zone six
106 Code assigned to zone seven
107 Code assigned to zone eight
108 Code assigned to zone nine
109 Code assigned to zone ten
110 Code assigned to zone eleven
111 Code assigned to zone twelve
112 Code assigned to zone thirteen
113 Code assigned to zone fourteen
114 Code assigned to zone fifteen
115 Code assigned to zone sixteen
116 Code assigned to zone seventeen
117 Code assigned to zone eighteen
118 Code assigned to zone nineteen
119 Code assigned to zone twenty-one
120-150 Code assigned to different work routes of the Municipality of Guatemala, solid waste collectors of the day shift of the DLPM
151 (market route) and 152 ("terminal" route) assigned to the day convoy of the DLPM
153 Code assigned to the night convoy of the DLPM
Note: Usually the trucks in the convoy unit are dump trucks or open trucks.
154-158 Code assigned to the night routes of DLPM solid waste collection trucks
159 Code assigned to all the different types of trucks of the municipality of Villa Nueva
160 Code assigned to all the different types of trucks of the municipality of Mexico
161 Code assigned to all the different types of trucks of the municipality of San Juan Sacatepéquez
162 Code assigned to all the different types of trucks of the municipality of Chinautla
163 Code assigned to all the different types of trucks of the municipality of Santa Catarina Pinula
164 Code assigned to all the different types of

trucks of the municipality of San Miguel Petapa

(2) Net weight (of materials) to be registered

1) Year

Scheduled period of time in which the truck was weighed. For example, year 1990, year 1991.

2) Month

Scheduled period of time in which the truck was weighed. For example, month of January, February, December, etc. This item is coded as follows:

01 January
02 February
03 March
04 April
05 May
06 June
07 July
08 August
09 September
10 October
11 November
12 December

3) Day

Scheduled period of time. This item has 30 or 31 days according to the month, with the exception of February, which has 28 days (in leap years 29).

4) Name of the day

The name of the day of the corresponding week is entered here. For example, Monday, Tuesday, etc.

5) Hour

Short period of time which ranges from 00 minutes to 60 minutes. This item has 24 hours, subdivided into minutes. The hour the truck's entry to the landfill ticket is issued is entered here. For example, 15:57.

6) Weight

The net weight of the material hauled by the truck is entered here.

7) The number of trips

The number of trips registered in the issued ticket which corresponds to the truck's entry to the landfill.

8) Operator

The person in charge of gathering the information and entering it in the computer. The following codes are used here:

300 Code assigned to the operator Alder Solís
301 Code assigned to the operator Otto García
302 Code to be assigned to a future operator

4.3.2.2 Data Base Design

(1) Truck information

Item Name	Width	Field Type	Dec	Index	Range
Ownership	02	Numeric	00	N	{10, 60}
License Plates	06	Numeric	00	N	{01, 999,999}
Material	01	Numeric	00	N	{01, 06}
Route	03	Numeric	00	N	{100, 200}

(2) Weight information

Item Name	Width	Field Type	Dec	Index	Range
Year	04	Numeric	00	N	>1,900
Month	02	Numeric	00	N	{01, 12}
Day	02	Numeric	00	N	{01, 31}
Name of Day	03	Characters		N	
Hour	05	Characters		N	
Weight	06	Characters	00	N	
Number of Trips	02	Numeric	00	N	
Operator	03	Numeric	00	N	

4.3.3 Water Quality Data

4.3.3.1 Chemical Analysis

(1) Aspects

- Sample number
- Place where sample was taken
- Zone
- Colony
- Date the sample was taken
- Hour
- Source
- Testing of sample
- Temperature °C
- Turbidness V.J.

- Cold
- Hot
- Unit color
- pH
- Residual chloride mg/l
- Flouride mg/l

(2) Design

Structure for database: C:\DBASE\QUIMICO.DBF
Number of data records: 0
Date of last update : 18/02/91

Field	Field Name	Type	Width	Dec	Index
1	SAMPLENUM	Numeric	3		N
2	LUGARCAPT	Character	50		N
3	ZONA	Numeric	2		N
4	COLONIA	Character	15		N
5	FECHACAP	Date	8		N
6	HORA	Numeric	5	2	N
7	FUENTE	Character	5		N
8	MUESTRA	Character	40		N
9	EXAMMEN	Date	8		N
10	TEMPERATUR	Numeric	2		N
11	TUREEDAD	Numeric	5	2	N
12	FRIO	Character	5		N
13	CALIENTE	Character	5		N
14	COLORUNIO	Numeric	5	2	N
15	PH	Numeric	5	2	N
16	CLOROMGL	Numeric	7	2	N
17	FLMGL	Numeric	7	2	N
18	EVALUATION	Logical	1		N
19	NOTE	Memo	10		N
** Total **			189		

4.3.3.2 Bacteriological Analysis

(1) Aspects

- Sample number
- Place sample was taken
- Zone
- Colony
- Date sample was taken
- Hour
- Source
- Person who took sample
- Transportation conditions
- Date test was started
- Hour test was started
- Residual chloride
- Taste
- Smell
- Aspect
- Suspended substances
- Incubation 35° C 10
- Incubation 35° C 1.0
- Incubation 35° C 0.1
- Incubation 35° C 0.01
- Incubation 20° C 10
- Incubation 20° C 1.0
- Incubation 20° C 0.1
- Incubation 20° C 0.01
- Number of bacteria per cc.
- Supposed form of gas 10
- Supposed form of gas 1.0
- Supposed form of gas 0.1
- Confirmed form of gas 10
- Confirmed form of gas 1.0
- Confirmed form of gas 0.1
- M.N.P. per 100cc.

(2) Design

Structure for database: C: DBASE BACTERIO.DBF
Number of data records: 113
Date of last update : 18/02/91

Field	Field Name	Type	Width	Dec	Index
1	SAMPLENUM	Numeric	3		N
2	LUGARCAPT	Character	50		N
3	ZONA	Numeric	2		N
4	COLONIA	Character	30		N
5	FECHACAP	Date	8		N
6	HORA	Numeric	5	2	N
7	FUENTE	Character	5		N
8	MUESTRACAP	Character	40		N
9	CONDICIONE	Character	40		N
10	FECHAINICI	Dateric	8		N
11	HORAPRIM	Numeric	5	2	N
12	HORASEGUN	Numeric	5	2	N
13	HORATERCER	Numeric	5	2	N
14	CLORO	Numeric	4	1	N
15	SABOR	Character	5		N
16	OLOR	Character	5		N
17	ASPECTO	Character	5		N
18	SUSTANCIAS	Character	20		N
19	INC3510	Numeric	3		N
20	INC35X	Numeric	3		N
21	INC35XX	Numeric	3		N
22	INC35XXX	Numeric	3		N
23	INC20X	Numeric	3		N
24	INC20XX	Numeric	3		N
25	INC20XXX	Numeric	3		N
26	INC20XXXX	Numeric	3		N
27	NODEDACT	Numeric	3		N
28	PRESUN10X	Numeric	3		N
29	PRESUN10XX	Numeric	3		N
30	PRESU10XXX	Numeric	3		N
31	CONFIR10X	Numeric	3		N

32	CONFIR10XX	Numeric	3		N
33	CONFI01XXX	Numeric	3		N
34	NNP100	Numeric	4	1	N
35	EVALUATION	Logical	1		N
36	NOTE	Character	100		N
** Total **			396		

4.3.3.3 Chemical Analysis of Plant

(1) Aspects

- O.T. No.
- Infomation No.
- Sample of:
- Taken by:
- Place
- Source
- Date and hour it was taken
- Date test was started
- Transportation conditions
- Aspect
- Color
- Turbidness
- Odor
- Taste
- PH
- Temperature (°C)
  (when taken)
- Hardness
- Albuminoid Nitrogen (mg/l)
- Ammonia NH_3 (mg/l)
- Nitrites NO_2 (mg/l)
- Nitrates NO_3 (mg/l)
- Oxygen consumed (mg/l)
- Chlorides CL (mg/l)
- Flourides F (mg/l)
- Total iron Fe (mg/l)
- Manganese Ma (mg/l)

- Residual cloride (mg/l)
- Sulphates SO_4 (mg/l)
- Total solids (mg/l)
- Ignition loss (mg/l)
- Fixed mineral sustances (mg/l)
- Solids in suspension (mg/l)
- Alkalinity Hydroxides
- Alkalinity Carbonates
- Alkalinity Bicorbonates
- Alkalinity Total
- Detergent
- Aluminum

(2) Design

Structure for database: C:\DBASE\PLANTAQI.DBF
Number of data records: 0
Date of last update : 12/02/91

Field	Field Name	Type	Width	Dec	Index
1	OTNO	Numeric	6		N
2	INFNO	Character	10		N
3	MUESTRA	Character	10		N
4	CAPTADA	Character	20		N
5	LUGAR	Character	20		N
6	FUENTE	Character	30		N
7	FECHACAPT	Date	8		N
8	HORACAPT	Numeric	5	2	N
9	FECHAAINIC	Date	8		N
10	HORAINIC	Numeric	5	2	N
11	CONDICIONE	Character	30		N
12	ASPECTO	Character	20		N
13	COLOR	Numeric	6	2	N
14	TURBIDEZ	Numeric	6	2	N
15	OLOR	Character	20		N
16	SABOR	Character	5		N
17	PH	Numeric	5	2	N
18	TEMPERATUR	Numeric	5		N

19	DUREZA	Numeric	8	2	N
20	NITROGENO	Numeric	8	2	N
21	NH3	Numeric	8	2	N
22	NO2	Numeric	8	2	N
23	NO3	Numeric	8	2	N
24	OXIGENO	Numeric	8	2	N
25	CL	Numeric	8	2	N
26	F	Numeric	8	2	N
27	FE	Numeric	8	2	N
28	MN	Numeric	8	2	N
29	CLORO	Numeric	8	2	N
30	SO4	Numeric	8	2	N
31	SOLIDOSTL	Numeric	8	2	N
32	PERDIDA	Numeric	8	2	N
33	SUSTMINE	Numeric	8	2	N
34	SUSPENSION	Numeric	8	2	N
35	HIDROXID	Numeric	8	2	N
36	CARBONAT	Numeric	8	2	N
37	BICARBON	Numeric	8	2	N
38	ALCALINE	Numeric	8	2	N
39	DETERGENT	Numeric	8	2	N
40	ALUMINIO	Numeric	8	2	N
41	EVALUATION	Logical	1		N
42	NOTE	Character	100		N
** Total **			497		

4.3.3.4 Bacteriological Analysis of Plant

(1) Aspects

- O.T. No.
- INF. No.
- Sample taken by:
- Sample taken in:
- Municipality:
- Department
- Branch office
- Date and hour sample was taken

- Date and hour sample reached the lab
- Transportation conditions
- Taste
- Odor
- Suspended substances
- Chloride residue
- Culture in agar-agar incubation 35° C 10cc
- Culture in agar-agar incubation 35° C 1.0cc
- Culture in agar-agar incubation 35° C 0.1cc
- Culture in agar-agar incubation 35° C 0.01cc
- Culture in agar-agar incubation 20° C 10cc
- Culture in agar-agar incubation 20° C 1.0cc
- Culture in agar-agar incubation 20° C 0.1cc
- Culture in agar-agar incubation 20° C 0.01cc

(2) Design

Structure for database: C:\DBASE\PLANTABA.DBF
Number of data records: 0
Date of last update : 12/02/91

Field	Field Name	Type	Width	Dec	Index
1	OTNO	Numeric	6		N
2	INFNO	Character	10		N
3	INTERESADA	Character	15		N
4	CAPTADAPOR	Character	20		N
5	CAPTADAEN	Character	20		N
6	LUGAR	Character	30		N
7	FUENTE	Character	30		N
8	FECHACAP	Date	8		N
9	HORACAP	Numeric	6	2	N
10	FECHA	Date	8		N
11	HORA	Numeric	6	2	N
12	CONDICION	Character	20		N
13	SABOR	Character	5		N
14	ASPECTO	Character	20		N
15	OLOR	Character	20		N
16	SUSPENSIO	Character	20		N

17	CLORO	Numeric	8	2	N
18	GERM35X	Numeric	8	2	N
19	GERM35XX	Numeric	8	2	N
20	GERM35XXX	Numeric	8	2	N
21	GERM35XXXX	Numeric	8	2	N
22	GERM20X	Numeric	8	2	N
23	GERM20XX	Numeric	8	2	N
24	GERM20XXX	Numeric	8	2	N
25	GERM20XXXX	Numeric	8	2	N
26	RESULT	Numeric	8	2	N
27	EVALUATION	Logical	1		N
28	NOTE	Character	100		N
** Total **			426		

5. Public Opinion

Contents

5. Public Opinion

5.1 Respondent's characteristics

(1) Number of Respondents ... 125 persons
(2) Men 28.8% ... Women 65.6%
(3) For age distribution, refer to the attached data.
(4) People living in the LAS GUACAMAYAS valley.
(5) More than 90% of the residents earn an income of less than Q800. (Excluding unknown data)
(6) The respondents' standard of living is from the middle of the lower class to the lower end of the middle class.
(7) For respondents' length of residency, refer to the attached data.

5.2 Present status

(1) About 88% of the people polled said they dispose of refuse at fixed places. About 60% of them also said that they throw trash into the valley.

(2) About 77% of the peoples expressed concern about trash being disposed of in areas around their homes. Of these, 74% expressed anxiety over this trash becoming the cause of disease.

(3) Only 30% of the respondents think that the environment around their homes is clean; the other 70% think that it is not clean.

These responses indicate that residents have a great interest in the illegal disposal of refuse.

(1) The majority of respondents acknowledge the need for reducing waste in a proper manner. Furthermore, they expressed a willingness to cooperate to resolve the problem.

(2) The residents do not seem to be receiving the benefits of municipal garbage collection services. About 13% of the respondents rated existing services satisfactory, while as many as 35% of these respondents expressed dissatisfaction with such services.

The city government provides the area with a bell-sounding trash collection service, which is apparently not adequate.

(1) About 38% of the respondents who reside in the valley, LAS GUACAMAYAS, responded that it is bad to throw trash away in the valley.

(2) The residents are becoming aware that trash is affecting them in some ways and specifically, they cited as first and foremost offensive odors, followed by smoke, water pollution, sopirote and noise, in that order.

Regarding the noise, it is likely that they are confusing this noise with traffic noise.

- Nevertheless, more than 90% of the residents living in nearby areas want waste disposal to be handled somewhere else.

5.3 Comments

(1) In short, in the survey carried out on Feb. 1991, many people mentioned sanitary and environmental problems related with illegal dumping of solid waste at Guacamayas.

(2) However, the surveyed people said they would cooperate with the Municipality to handle solid waste, in a way to improve the sanitary and environmental conditions in this area if a really sanitary landfill is constructed.

(3) From the abovementioned, most of the residents want the solid waste to be carried to far sites from residential areas, but the final disposal to be made in a sanitary way at the determinated site.

This means that the people will approve a sanitary landfill construction at a certain site of the city. In other hand, people may not want the landfill to be near their houses because of the actual conditions at El Trebol.

For this reason, the residents living in the surroundings of Guacamayas are aware of the need for a landfill in some other site of the city, but it is probable for them to oppose the new landfill construction at the Guacamayas. Therefore, it is necessary to improve first the actual situation at El Trebol, in a way they can feel the benefits of the Guacamayas sanitary landfill project.

5.4 Result

THE FIELD SURVEY TO CONFIRM THE EFFECTIVENESS
OF THE SOLID WASTE
FEBRUARY 1991

Q1 What is your sex?

1.	Man	36	28.8%
2.	Women	82	65.6
	Unknown	7	0.0
		125	100.0

Q2 How old are you?

1.	12 - 19	25	20.0%
2.	19 - 25	18	14.4
3.	35 - 32	9	7.2
4.	32 - 38	27	21.6
5.	38 - 45	13	10.4
6.	45 - 52	9	7.2
7.	52 - 58	5	4.0
8.	58 - 65	4	3.2
9.	65 - 71	5	4.0
10.	71 - 78	4	3.2
	Unknown	6	4.8
		125	100.0

Q3 How long have you been living in the suburb?

1.	2 - 5	8	6.4%
2.	5 - 9	11	8.8
3.	9 - 12	12	9.6
4.	12 - 15	14	11.2
5.	15 - 19	17	13.6
6.	19 - 22	18	14.4
7.	22 - 25	8	6.4
8.	25 - 28	1	0.8
9.	28 - 32	16	12.8
10.	32 - 35	6	4.8
	Unknown	14	11.2
		125	100.0

Q4 What is your family's total income?

1.	0 - 400 (Q)	31	24.8%
2.	400 - 800	49	39.2
3.	800 - 1,200	7	5.6
	Unknown	38	30.4
		125	100.0

Q5 Are you concerned with the-garbage generated within your house?

1.	Yes	125	100.0%
2.	No	0	0.0
	Unknown	0	0.0

Q6 What do you do with the garbage after clenaing the house?

1.	Bury it	42	33.6%
2.	Discard it at the edge of the road	8	6.4
3.	Discard it in the river	1	0.8
4.	Discard it in the ravine	74	59.2
5.	Discard it in the garbage dump located in the suburb	0	0.0
6.	Burn it	2	1.6
	Unknown	6	4.8
		125	100.0

Q7 Do you always discard your garbage at the same location?

1.	Yes, always at the same location	110	88.0%
2.	No, at different points	10	8.0
3.	Others	1	0.8
	Unknown	4	3.2
		125	100.0

Q8 How do you decide the place where to discard your garbage?

1.	I discard it near the house	76	60.8%
2.	I discard as far as possible from the house	35	28.0
3.	I discard at a designated location	9	7.2
	Unknown	6	4.8
		125	100.0

Q9 Why do you discard your garbage at the location indicated in the previous questions?

1.	Because it is convenient to be near the house	37	29.6%
2.	Because it does not soil my house since the garbage dump is far	31	24.8
3.	Because there is no other location where to discard the garbage	28	22.4
4.	Because this location was assigned to discard it	21	16.8
5.	Others	2	1.6
	Unknown	9	7.2
		125	100.0

Q10 Do you believe that the present method of discarding garbage is correct?

1.	I believe it is correct	86	68.8%
2.	I believe it is not correct	38	30.4
	Unknown	1	0.8
		125	100.0

Q11 Are you concerned with the garbage which is dumped in public areas of your suburb?

1.	Yes	96	76.8%
2.	No	28	22.4
	Unknown	1	0.8
		125	100.0

Q12 If you are concerned, why?-

1.	Because it is not good for the health of the suburb	74	59.2%
2.	Because it will cause illness	92	73.6
3.	Because it promotes flies	52	41.6
4.	Because it causes bad odors	3	2.4
5.	Because the suburb looks dirty más sucia	1	0.8
6.	Others	1	0.8
	Unknown	4	3.2
		125	100.0

Q13 Do you consider that the zone in which you live is clean?

1.	Yes	37	29.6%
2.	No	84	67.2
	Unknown	4	32.
		125	100.0

Q14. Do you consider it is necessary to reduce the quantity of garbage discarded throughout the zone in which you live?

1.	I definitely think yes	62	49.6%
2.	I believe yes	61	48.8
3.	No	1	0.8
	Unknown	1	0.8
		125	100.0

Q15 Do you cooperate to reduce-the garbage dumped in the suburb in which you live and to keep this clean?

1.	Definitely, yes	62	49.6%
2.	Yes	61	48.8
3.	No	0	0.0
	Unknown	2	1.6
		125	100.0

There are many methods to reduce garbate generated in your suburb and thus, improve the environment. We will mentione these in order that you indicate what opinion in regard to each:

Q16 Try not to discard as much garbage

1.	I believe that this definitely good	88	70.4%
2.	I believe, yes	33	26.4
3.	I believe, no	1	0.8
	Unknown	3	2.4
		125	100.0

Q17 Garbage should be discarded in assigned locations

1.	I believe that this is definitely good	88	70.4%
2.	I believe, yes	35	28.0
3.	I believe, no	0	0.0
	Unknown	2	1.6
		125	100.0

Q18 The garbage should be collected to take this outside the suburb.

1.	I believe that this is definitely good	86	68.8%
2.	I believe, yes	32	25.6
3.	I believe, no	0	0.0
	Unknown	7	5.6
		125	100.0

Q19 When you moved to the suburb, what do you think of the garbage dump at "Las Guacamayas" ravine?

1.	Good	16	12.8%
2.	No good	44	35.2
3.	Regular	25	20.0
	Unknown	40	32.0
		125	100

Q20 What do you think of the garbage dump now?

1.	Good	25	20.0%
2.	No good	47	37.6
3.	Regular	31	24.8
	Unknown	22	17.6
		125	100.0

Q21 How long have you felt uncomfortable about the existence of the garbage dump?

1.	Good	16	12.8%
2.	No good	64	51.2
3.	Regular	22	17.6
	Unknown	23	18.4
		125	100.0

Q22 Why do you feel uncomfortable?

1.	Noise	82	65.6%
2.	Bad odors	65	52.0
3.	Smoke	52	41.6
4.	Water contamination	38	30.4
5.	Zopilotes	18	14.4
6.	Insects	17	13.6
7.	Dogs	7	5.6
8.	Rats	2	1.6
9.	Others	1	0.8
	Unknown	25	10.0
		125	100.0

Q23 What factors have the most impact on you from the beginning of the garbage dump at "Las Guacamayas" ravine?

1.	Noise	31	24.8%
2.	Bad odors	61	48.8
3.	Smoke	38	30.4
4.	Water contamination	32	25.6
5.	Zopilotes	33	26.4
6.	Insects	17	13.6
7.	Dogs	6	4.8
8.	Rats	3	2.4
9.	Others	0	0.0
	Unknown	25	20.0
		125	100.0

Q24 What time of year is the most bothersome for you in connection with the garbage dump?

1.	Summer	50	40.0%
2.	Winter	34	27.2
3.	All season	17	13.6
	Unknown	24	19.2
		125	100.0

6. Final Disposal

Contents

6. Final Disposal Supporting Report

6.1 The Quantity of Solid Waste and Covering Material Hauled to the El Trebol Landfill Site and Las Guacamayas Sanitary Landfill Site

Tables 1 and 2 list the estimated amounts of waste disposal at the El Trebol and Las Guacamayas landfills in the year 2000. These estimations are based on data collected by a truck scale installed during the first field study and measured through the termination of the second field study, as well as data for waste collection and transportation in the Master Plan.

Since the Las Guacamayas Landfill will be placed into service in 1993, all waste will be disposed at the El Trebol Landfill from 1990 to 1992.

The estimated amounts of waste disposal at both landfills by the year 2000 are as shown Table 1, and Table 2.

The hauling quantity by the year 2000 by weight

Table 1 (Unit: Ton)

	Solid Waste	Construction Waste	Covering Material	Total
El Trebol	2,713,253	1,640,649	432,441	4,786,343
Las Guacamayas	1,563,693	0	664,571	2,228,264
Total	4,276,946	1,640,649	1,077,012	7,014,607

The hauling quantity by the year 2000 by volume

Table 2 (Unit: m^3)

	Solid Waste	Construction Waste	Covering Material	Total	Average per year
El Trebol	3,391,567	965,086	254,376	4,611,029	419,184
Las Guacamayas	1,954,617	0	390,924	2,345,541	293,193

Here, the specific gravity of the solid waste is 0.8 ton/m^3, and the specific gravity of the construction waste is 1.7 ton/m^3.

The specific gravity of the general waste is 1.7 ton/m^3 after compression by heavy machinery.

The following ratios of disposal amounts (Table 3) at both landfills were obtained from the population ratio in both areas, which is shown in Tables 4 - 6.

The distribution ratio of disposal amount in the El Trebol and Las Guacamayas Landfill sites

Table 3

	1990	1995	2000
El Trebol	100%	53%	54%
Las Guacamayas	0%	45%	46%

6.2 Usage Period of the El Trebol Controlled Landfill Site and the Las Guacamayas New Sanitary Landfill Site

Table 4

	Capacity	Usage Period
El Trebol controlled site	4,648,000m^3	11.1 years
Las Guacamayas new sanitary landfill site	4,898,000m^3	16.7 years

Usage period = Divide the capacity of each site by the average quantity of solid waste (cf. Table 2)

Table 5 The distribution ratio of the population for the El Trebol and the Las Guacamayas Landfill Site in the year 1990

	T. Ratio	G. Ratio	El Trebol T.Population	Las Guacamayas G.Population	Total	Easy	Possible
Zone 1	100(%)	0(%)	50,737	0	50,737	50,737	0
2	13	87	2,234	14,948	17,182	17,182	0
3	85	15	47,701	8,418	56,119	48,756	7,363
4	100	0	4,256	0	4,256	4,256	0
5	100	0	83,711	0	83,711	83,711	0
6	17	83	7,721	37,694	45,415	45,415	0
7	45	55	81,218	99,266	180,484	180,484	45,414
8	100	0	20,687	0	20,687	20,687	0
9	100	0	3,988	0	3,988	3,988	0
10	100	0	15,167	0	15,167	15,167	0
11	100	0	66,311	0	66,311	66,311	0
12	100	0	50,234	0	50,234	50,234	0
13	100	0	35,860	0	35,860	35,860	0
14	100	0	24,832	0	24,832	24,832	0
15	100	0	22,888	0	22,888	20,599	2,289
16	100	0	12,948	0	12,948	6,474	6,474
17	100	0	10,361	0	10,361	10,361	0
18	100	0	174,465	0	174,465	112,889	61,576
19	0	100	0	37,029	37,029	18,515	18,515
21	100	0	64,510	0	64,510	45,157	19,353
24	100	0	0	0	0	0	0
25	100	0	0	0	0	0	0
Sub total			779,829	242,769	1,022,598	861,615	160,983
MIXCO	0	100	0	328,854	328,854	46,475	282,379
VILLA NUEVA	63	37	29,384	17,258	46,642	0	46,642
S.C. Punula	100	0	0	0	0	0	0
CHINAUTLA	0	100	0	36,240	36,240	36,240	0
VILLA CANAL.	39	61	3,600	5,631	9,231	0	9,231
Sub total			32,984	387,983	420,967	82,715	338,252
Total			812,813	630,752	1,443,565	944,330	499,235
			56%	44%			

The T. ratio and G. ratio are obtained by the ratio of the zone area to the collection area of the El Trebol site and of the Las Guacamayas site.

Table 6 The distribution ratio of the population for the El Trebol and the Las Guacamayas Landfill Site in the year 1995

	T. Ratio	G. Ratio	El Trebol T.Population	Las Guacamayas G.Population	Total	Easy	Possible
Zone 1	100(%)	0%	46,180	0	46,180	46,180	0
2	13	87	3,612	24,169	27,781	27,781	0
3	85	15	41,132	7,259	48,391	48,391	0
4	100	0	4,079	0	4,079	4,079	0
5	100	0	84,601	0	84,601	84,601	0
6	17	83	16,054	78,384	94,438	94,438	0
7	45	55	92,159	112,638	204,797	204,797	0
8	100	0	19,848		19,848	19,848	0
9	100	0	3,495		3,495	3,495	0
10	100	0	14,837		14,837	14,837	0
11	100	0	75,176		75,176	75,176	0
12	100	0	55,632		55,632	55,632	0
13	100	0	39,941		39,941	39,941	0
14	100	0	28,924		28,924	28,924	0
15	100	0	28,702		28,702	28,702	0
16	100	0	22,983		22,983	12,317	10,666
17	100	0	23,941		23,941	19,488	4,453
18	100	0	202,488		202,488	142,886	59,602
19	0	100	0	38,524	38,524	20,263	18,261
21	100	0	74,776		74,776	54,469	20,307
24	100	0	0		0	0	0
25	100	0	0		0	0	0
Sub total			878,560	260,974	1,139,555	1,026,266	113,289
MIXCO	0	100	0	424,172	424,172	151,622	272,550
VILLA NUEVA	63	37	39,391	23,134	62,525	0	62,525
S.C. Punula	100	0	0	0	0	0	0
CHINAUTLA	0	100	0	43,318	43,318	43,318	0
VILLA CANAL.	39	61	8,597	13,446	22,043	0	22,043
Sub total			47,988	504,070	552,058	194,940	357,118
Total			926,548	765,044	1,691,613	1,221,206	470,407
			55%	45%			

The T. ratio and G. ratio are obtained by the ratio of the zone area to the collection area of the El Trebol site and of the Las Guacamayas site.

Table 7 The distribution ratio of the population for the El Trebol and the Las Guacamayas Landfill Site in the year 2000

	T. Ratio	G. Ratio	El Trebol T.Population	Las Guacamayas G.Population	Total	Easy	Possible
Zone 1	100(%)	0(%)	41,620	0	41,620	41,620	0
2	13	87	4,032	26,983	31,015	31,015	0
3	85	15	40,820	7,203	48,023	48,023	0
4	100	0	3,902	0	3,902	3,902	0
5	100	0	85,532	0	85,532	85,532	0
6	17	83	16,668	81,379	98,047	98,047	0
7	45	55	103,099	126,010	229,109	229,109	0
8	100	0	19,009	0	19,009	19,009	0
9	100	0	3,001		3,001	3,001	0
10	100	0	14,507		14,507	14,507	0
11	100	0	84,040		84,040	84,040	0
12	100	0	61,029		61,029	61,029	0
13	100	0	44,021		44,021	44,021	0
14	100	0	33,016		33,016	33,016	0
15	100	0	34,516		34,516	34,516	0
16	100	0	33,016		33,016	18,159	14,857
17	100	0	37,521		37,521	28,614	8,907
18	100	0	230,509		230,509	172,882	57,627
19	0	100	0	40,019	40,019	22,010	18,009
21	100	0	85,041		85,041	63,781	21,260
24	100	0	0		0	0	0
25	100	0	0		0	0	0
Sub total			974,899	281,594	1,256,493	1,135,833	120,660
MIXCO	0	100	0	519,590	519,590	311,950	207,640
VILLA NUEVA	63	37	49,397	29,011	78,408	0	78,408
S.C. Punula	100	0	0	0	0	0	0
CHINAUTLA	0	100	0	50,398	50,398	50,398	0
VILLA CANAL.	39	61	9,693	15,162	24,855	0	24,855
Sub total			59,090	614,161	673,251	362,348	310,903
Total			1,033,989	895,755	1,929,744	1,498,181	431,563
			54%	46%			

The T. ratio and G. ratio are obtained by the ratio of the zone area to the collection area of the El Trebol site and of the Las Guacamayas site.

Table 8 Quantity of Solid Waste and Covered Soil Hauled to the Landfill Sites

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Total Amount of S.W. to landfill (T/WD)	1,210.58	1,319.80	1,428.85	1,537.48	1,645.96	1,758.30	1,839.68	1,920.64	2,001.37	2,081.81	2,161.95
EL TREBOL (expressed in tons)											
1. Total Amount of S.W. (T/WD)	784.38	883.37	982.28	598.89	651.19	703.99	740.77	777.18	813.24	848.95	884.30
2. Total Amount of S.W. (T/Y)	245,511	276,495	307,454	187,453	203,822	220,349	231,861	243,257	254,544	265,721	276,786
3. Cumulative of S.W. (T)	245,511	522,006	829,460	1,016,913	1,220,735	1,441,084	1,672,945	1,916,202	2,170,746	2,436,467	2,713,253
4. Construction Waste (T/WD)	426.20	436.43	446.57	456.46	466.26	478.32	487.91	497.25	506.45	515.	524.35
5. Construction Waste (T/Y)	133,401	136,603	139,776	142,872	145,939	149,714	152,716	155,639	158,519	161,348	164,122
6. Cumulative C. Waste (T)	133,401	270,004	409,780	552,652	698,591	848,305	1,001,021	1,156,660	1,315,179	1,476,527	164,649
7. Covered Soil (T/Y)	0	0	48,049	48,049	48,049	48,049	48,049	48,049	48,049	48,049	48,049
8. Cumulative C.S. (T/Y)	0	0	48,049	96,098	144,147	192,196	240,245	288,294	336,343	384,392	432,441
9. Grand Total (T/Y) (3+6+8)	378,912	792,010	1,287,289	1,665,663	2,063,473	2,481,585	2,914,211	3,361,156	3,822,268	4,297,386	4,786,343
EL TREBOL (expressed in m^3)											
10. Total Amount of S.W. (m^3/Y)	306,889	345,619	384,318	234,316	254,778	275,436	289,826	304,071	318,180	332,151	345,983
11. Cumulative T.A. of S.W. (m^3)	306,889	652,508	1,036,826	1,271,142	1,525,920	1,801,356	2,091,182	2,395,253	2,713,433	3,045,584	3,391,567(0.8t/m^3)
12. Construction Waste (m^3)	78,471	80,355	82,221	84,042	85,846	88,067	89,833	91,552	93,246	94,911	96,542
13. Cumulative Const. Waste (m^3)	78,471	158,826	241,047	325,089	410,935	499,002	588,835	680,387	773,633	868,544	965,086(1.7t/m^3)
14. Covered Soil (m^3/Y)	0	0	28,264	28,264	28,264	28,264	28,264	28,264	28,264	28,264	28,264
15. Cumulative C.S. (m^3)	0	0	28,264	56,528	84,792	113,056	141,320	169,584	197,848	226,112	254,376
16. Grand Total (11+13+15)(m^3)	385,360	811,334	1,306,137	1,652,759	2,021,647	2,413,414	2,821,337	3,245,224	3,684,914	4,140,240	9,611,029
LAS GUACAMAYAS (expressed in tons)											
17. Total Amount of S.W. (T/WD)	0	0	0	482.13	528.13	575.99	611.00	646.22	681.68	717.37	753.30
18. Total Amount of S.W. (T/Y)	0	0	0	150,907	165,305	180,285	191,243	202,267	213,366	224,537	235,783
19. Cumulative A. of S.W. (T)	0	0	0	150,907	316,212	496,497	687,740	890,007	1,103,373	1,327,910	1,563,693
LAS GUACAMAYAS (expressed in m^3)											
20. Total Amount of S.W. (m^3/Y)				188,634	206,631	225,356	239,054	252,834	266,708	280,671	294,729
21. Cumulative A. of S.W. (m^3)	0	0	0	188,634	395,265	620,621	859,675	1,112,509	1,379,217	1,659,888	1,954,617(0.8t/m^3)
22. Covered Soil (m^3/Y)	0	0	0	37,727	41,326	45,071	47,811	50,567	53,342	56,134	58,946
23. Cumulative C. Soil. (m^3)	0	0	0	37,727	79,053	124,124	171,935	222,502	275,844	331,978	390,924(1.7t/m^3)
24. Grand Total (21+23)	0	0	0	226,361	474,381	744,745	1,030,610	1,335,011	1,655,061	1,991,866	2,395,541

365 x 6/7 ≒ 313 days/year

6.3 Dumping Methods at the El Trebol Controlled Site and Las Guacamayas New Sanitary Site

6.3.1 El Trebol controlled landfill site

6.3.1.1 Hauling quantity to the El Trebol site from the year 1992 to the year 1995 (Period of the feasibility study)

According to Table 8, from 1992 to 1995, the solid waste hauled to the El Trebol landfill site will be 1,148,848m³/4 years. This quantity amounts to 918m³/day.

Within the same period, construction waste hauled to the site will be 340,176m³/4 years. However, there will be some good material for covering solid waste at this site. It is possible to consider that the ratio of including good material for covering is 42%, since usable ratio of construction waste for covering may be set at 0.6, while the ratio of the volume hauled to site may be set at 0.7.

Therefore 0.6 x 0.7 = 0.42.

As a result, construction waste as solid waste will be obtained

340,176m³/4years x (1-0.7x0.6)=197,302m³/4years=158m³/day.

Accordingly, solid waste to the site will equal 918m³/day + 158m³/day = 1,076m³/day.

6.3.1.2 Covering Material

(1) The necessary quantity of covering material

If covering operations will be done once a week, then the volume of covering material can be calculated as follows:

The solid waste quantity each week will be
1,076m³/day x 6 days = 6,456m³/week.

This quantity of solid waste will be compacted to the thickness of 3m, making the necessary area about
2,150m² = 50m x 43m.

If the thickness of the covering is 0.5m, then the necessary volume of covering soil will be
2,150m² x 0.5m = 1,075m³/week.

(2) Securing the Covering Material

Within the above quantity of covering soil, the partial construction waste mentioned above can be used, that is
340,176m³ x 0.6 x 0.7 = 142,874m³/4 years
= 114m³/day = 684m³/week.
As a consequence of the above calculation,
1,075m³/week - 684m³/week = 391m³/week.
Accordingly, the annual amount of covering soil which will have to be purchased will be 28,264m³/year as covering material.

Therefore, the daily shoving operation of solid waste by the bulldozers will be 1,076m³/day, while the weekly shoving operation of covering material will be 1,075m³/week. These covering operations will take place once a week.

6.3.1.3 The landfilling method and the necessary number of bulldozers

The landfilling method used will requir that a slope with an inclination of 30% be constructed from the top of the flat area of the existing dumping site to the bottom, and that landfilling be carried out by bulldozers.

The shoving quantity of solid waste will be

Solid waste quantity = 1,076m³/day

Covering soil = 1,075m³/day

These solid waste and covering materials will be shoved by the existing 3 bulldozers and the 4 new bulldozers which will be purchased.

The necessary bulldozers are as follows:

A 32 ton bulldozer and a 15 ton bulldozer (existing) can shove quantities of 120m³/hour/one bulldozer and 45m³/hour one bulldozer, respectively, over a distance of 50m, since the slope on which waste will be shoved is inclined downward. This rate is expected to increase by 10% when the slope is flat.

In order to shove a quantity of 1,076m³/day over a distance of 200m, which is the distance of the inclined slope, for the first 50m, the 3 existing 15 ton bulldozers can be used effectively.

45m³/hour/bulldozer x 9 hours x 3 bulldozers

= 1,215m³/day

For the second, third and fourth 50m, one 32 ton bulldozer may be effectively used for this amount of solid waste.

120m³/hour/bulldozer x 9 hours = 1,080m³/day

For the compacting operations at the bottom of gully, one bulldozer is sufficient. Meanwhile the covering material can also be moved in the same way since the quantity of this covering material is 1,076m³/once a week.

6.3.2 Las Guacamayas New Sanitary Landfill Site

6.3.2.1 The Quantity of Hauling Solid Waste to the Las Guacamayas Landfill Site

Between 1993 and 1995, the quantity of solid waste to be hauled to the Las Guacamayas Landfill Site is shown in Table 8.

620,620m³/3 years = 661m³/day

Covering operations will take place daily. Covering soil is defined as consisting of 20% of solid waste, and its quantity will be 132m³/day. This soil will be able to be obtained from the construction of the sanitary landfill site, and from some areas where such soil remains.

6.3.2.3 The Landfilling Method

Bulldozer operations will shove 661m³/day of solid waste and 132m³/day of covering material, for a total of 793m³.

To move this much solid waste and covering material, over the first slope of 70m, two 32 ton bulldozers will be required.

97m³/one bulldozer/1 hour x 6 hours x 2 bulldozers
= 1,164m³

To handle the second slope which is 100m long two bulldozers will be required since the capacity of two bulldozers for a distance of 100m is

74m³/one bulldozer/1 hour x 6 hours x 2 bulldozers
= 888m³/day

The other two bulldozers can be used to shove and compact this solid waste and covering material at the bottom

of the slope.

By repeating this operation, the necessary site operations will be carried out effectively.

The necessary number of bulldozers to carry out the work down the slope

One 32 ton bulldozer and one 15 ton bulldozer (existing) can carry a quantity of 120m³/hour/one bulldozer and 45m³/hour/one bulldozer effectively over a distance of 50m, since the slope inclines downward. This quantity will be expected to increase 10% when the slope becomes flat. To shove a quantity of 1,076 m³/day over a distance of 200m, which is the distance of the inclined slope, for the first 50m, the existing three 15 ton bulldozers can be used effectively.

45m³/hour/bulldozer x 9 hours x 3 bulldozers
= 1,215m³/day

Only one 32 ton bulldozer is required for the second, third and fourth 50m stretch and can be used to shove above quantity of solid waste.

120m³/hour/bulldozer x 9 hours = 1,080m³/day

For compacting operations at the bottom of gully, one bulldozer is sufficient.

Assumption of Leachate Quantity at the Proposed Landfill Site at Las Guacamayas

1. Calculation Conditions

1) Precipitation quantity: 1,200mm/year (Rainy season May-Oct, 6 months)
Average daily precipitation quantity: 6.6mm

2) Run-off coefficient of leachate: 0.5

3) Run-off coefficient:
Catchment area (1) and (2): 0.15 (from the data in Table 201-6 on Guatemala city)
Catchment area (3): 0.3 (same as above)

4) Evaporation quantity: 720mm/year ≒ 2.0mm/day
(According to the feasibility study on the ground water development project conducted by JICA.)

2. Calculation of leachate quantity (Ref. attached)

Calculation for the landfill area of 12.2 ha

1) Leachate quantity at the landfill site (Landfill area of 12.2 ha)

Q_1 = C.I.A.
= 0.5 x 6.6 x 10^{-3} x 12.2 x 10^4
= 402.6m^3/day

2) Rain water inflow from the surrounding catchment area

Catchment area		Run-off coefficient
(1) 5.91 x 0.5 =	2.955	0.15
(2)	1.75	0.15
(3)	3.60	0.3
Total	8.305 ≒ 8.31	

As for catchment area (1), the building areas occupy 50% of the 5.91 ha, and the drainage from the building areas is discharged to the roads on the west side, and do not flow into the gully.

Accordingly,

Q_2 = C.I.A.

$Q_2 = (0.15 \times (2.96+1.75) \times 10^4 + 0.3 \times 3.6 \times 10^4) \times 6.6 \times 10^{-3}$

$= 117.9 m^3/day$

3) Infiltration quantity in the gully from the surrounding catchment area

Q_3 = (Annual average precipitation quantity - evaporation quantity) x catchment area - superficial run-off quantity.

This evaporation quantity is 720mm/year ≒ 2.0mm/day, according to feasibility study on the ground water development project conducted by JICA. The ground filtration quantity should totally flow into the gully to ensure safety.

Accordingly,

$Q_3 = (6.6 - 2.0) \times 10^{-3} \times 8.31 \times 10^4 - 117.9$

$= 264.4 m^3/day$

4) Present flow rate into the gully

Q_4 = 2,000m³/day = 0.023m³/sec

This flow rate is discharged downstream without coming into contact with the waste.

Accordingly, the leachate quantity Q is

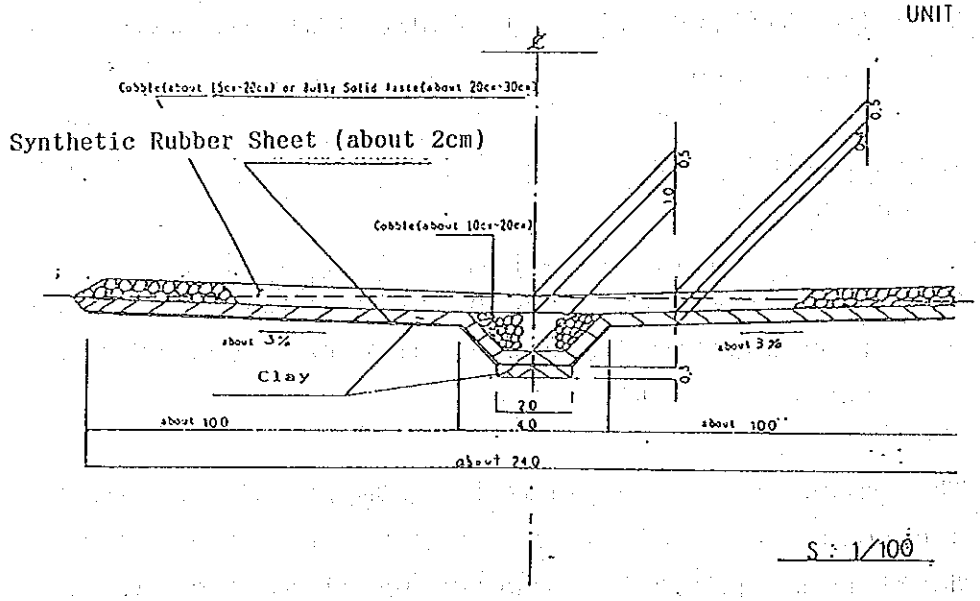
$Q = Q_1 + Q_2 + Q_3 = 402.6 + 117.9 + 264.4$

$= 784.9m^3/day$

3. Quantity of assumed leachate infiltration into the pit of the landfill site

STRUCTURE OF A STANDARD CROSS SECTION OF THE LEACHATE COLLECTION DITCH AT THE BOTTOM OF LAS GUACAMAYAS

UNIT



The bottom of landfill site is designed as in the above illustration. The filtration quantity of leachate is supported to be very little, since leachate collection ditch has the area occupied with cobble stones. Because, the filtration quantity of leachate is a function of static pressure of the leachate.

In general, though it is very difficult to obtain ground infiltration quantity, its quantity can be studied by

using the two kinds of ways of water balance and permeability coefficient.

1) Water balance study method

$I \cdot A = E \cdot A + G \cdot A + Q$

Here

I: The daily average precipitation quantity = 6.6mm

E: The daily average evaporation quantity = 2.0mm

Q: The run-off quantity of the leachate (from the above calculation) = $785m^3$/day

G: The ground infiltration quantity per unit area

A: The catchment area ((1)+(2)+(3)+(4)) = 12.2+8.31 = 20.51ha

The above calculation is formulated so that ground infiltration quantity can be discharged downstream to ensure safety.

Accordingly,

$6.6mm/day \times 10^{-3} \times 20.51ha \times 10^4$

$= 2.0mm/day \times 10^{-3} \times 20.51ha \times 10^4 + G/day$

$\therefore G \cdot A = (6.6-2.0) \times 10^3 \times 20.51 \times 104 - 785 = 158.46m^3/day$

2) Permeability coefficient study method

Suppose the width at the bottom of the gully is 50m and the distance up to the dam is 1,000m, then this area will measure $50,000m^2$. The leachate quantity is $785m^3$/day (as a result of the above calculation), and suppose that $785m^3$/day is stored in this area of $50,000m^2$, if the effective porosity is 0.4 of solid waste, then

$50,000m^2 \times h \times 0.4 = 785m^3$

$h = 3.9cm$

With a permeability coefficient $K = 10^{-4}cm/sec$

(according to the results of the geological survey)

Infiltration quantity $Q=A \cdot V=A \cdot KI=50,000 \times 10^{-4} \times 10^{-2} \times 0.039 = 0.00195 m^3/sec = 168.5 m^3/day$

Accordingly, the infiltration will be $160 m^3$ - $170 m^3$ per day.

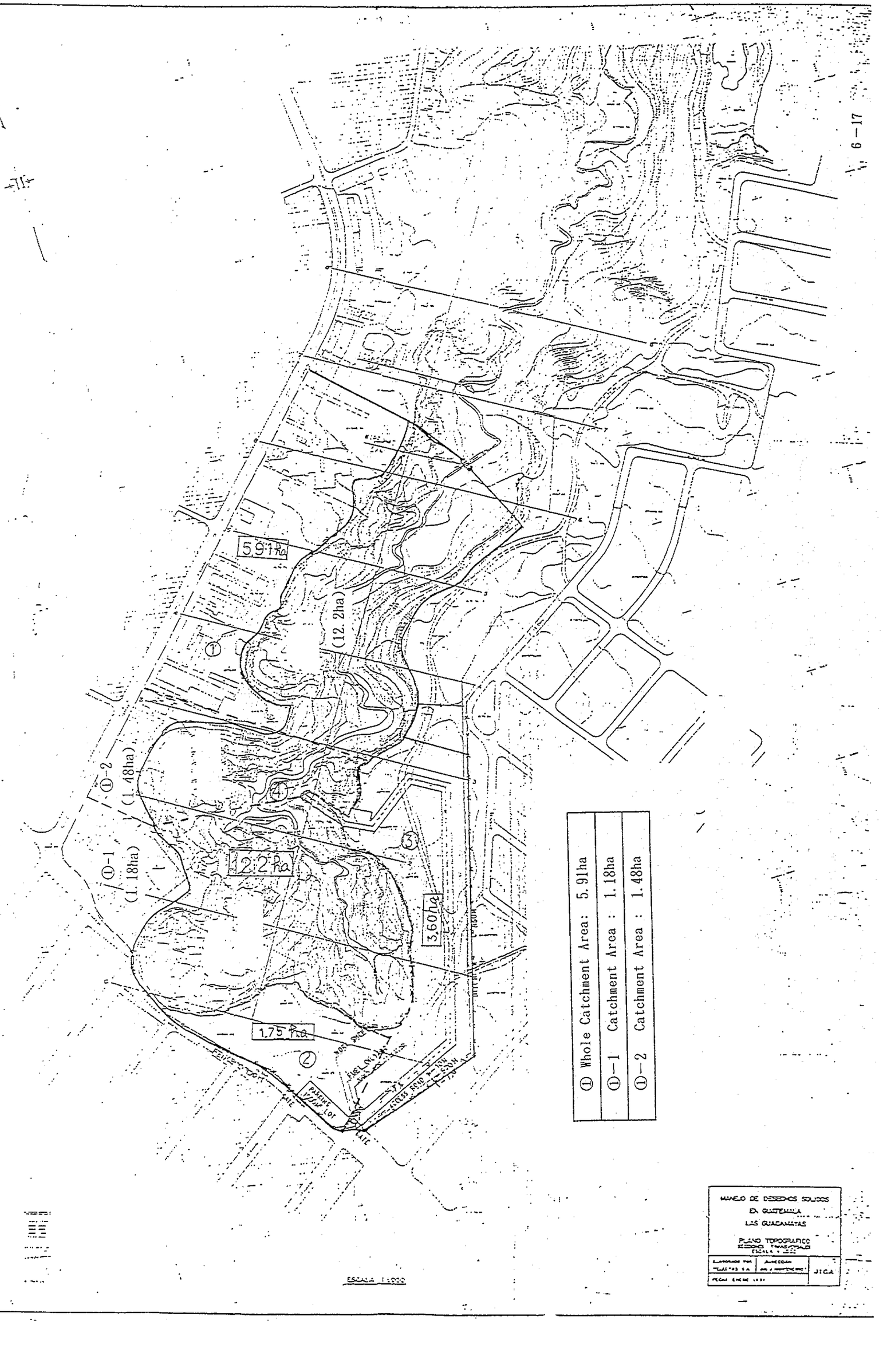
4. Comparison study of a case with a liner facility at the bottom and a case without it.

In the case of the construction of water insulation as per the above illustration the infiltration area will be:

$50,000 - 24 \times 1,000 = 26,000 m^2$

Accordingly, the infiltration quantity $Q = A \cdot KI = 26,000 \times 10^{-4} \times 10^{-2} \times 0.039 = 0.001014 m^3/sec = 87.6 m^3/day$

The infiltration reduction rate will become $(1 - 87.6/160\text{-}170) \times 100 = 45.3 - 48.5\%$



① Whole Catchment Area:	5.91ha
①-1 Catchment Area :	1.18ha
①-2 Catchment Area :	1.48ha

MANEJO DE DESECHOS SOLIDOS
EN GUATEMALA
LAS GUACAMAYAS
PLANO TOPOGRAFICO
ESCALA 1:1000
JICA

7. Environmental Evaluation

Contents

7.1 Introduction

Insufficient Solid Waste Management (SWM) has become a social and public health problem.

The Guatemala metropolitan area is suffering from growing pollution, which is currently exposing people to a wide variety of environmental hazards, especially waste pollution.

The rapid pace of growing population has brought about an increase in solid waste with little awareness of environmental conservation.

Under present conditions, expanding contamination and environmental degradation are contaminating the natural resources of the region, decreasing its productive potential for current and future generations, and threatening the health of people.

SWM has been given very low priority, and problems have been left to the Local Authorities to manage as best they can, with their limited financial and manpower resources, and without any form of technical or financial assistance from other sources.

The various Solid Waste pollution problems can be classified as follows:

(1) Clandestine open dumping
(2) Uncontrolled landfill

In order to solve all these problems, this project must be urgently implemented. Without this project, the City, especially its surrounding areas, will be overrun by Solid Waste, leading to unsanitary conditions and a general deterioration of the environment.

7.2 Clandestine Open Dumping

7.2.1 Present Condition

Clandestine open dumping sites are distributed throughout the entire study area.

The total number of open dumping sites in official records exceeds 500. Due to the lack of any sanitary control they are dangerous because of the exposure of residents to openly dumped waste.

The clandestine open dumping site seems to be one of the places that causes the transmission of disease such as digestive system infections etc., by flies, mosquitoes, and other worms gathering there.

7.2.2 Decrease in the Number of Clandestine Open-dumping Sites

(1) A decrease in the number of clandestine open-dumping sites can be realized by improving the collection service coverage and increasing concern for public health among residents.

The effect of this project is very great in that it will prevent deterioration of public health resulting from the negligence of dumped waste over long periods of time. Furthermore, it will decrease the number of opportunities for residents to be exposed to garbage, and contribute to environmental improvement.

(2) Without this project, the City, especially its surrounding areas, will be overrun by solid waste.

Generation Landfills Other place

1990	969 t/w.d	480 t/w.d	489 t/w.d
2000	1593	535	1058

If no improvements are implemented and the present collection system continues, by the year 2000, the daily quantity of illegally disposed waste will be 3500 m^3/w.d.

This quantity is equal to 1 cm-thick solid waste spreading over all of Guatemala City within approximately two years. This calculation indicates that, at this rate, solid waste measuring one meter in height would completely spread over a soccer field within 5 days.

7.3 El Trebol Disposal Site

7.3.1 The Present Environmental Condition

The evaluation on environment acceptability of El Trebol disposal site is summarized in Table 7-1

Table 7-1
Evaluation of El Trebol Disposal Site on Environmental Acceptability

El Trebol	Evaluation
Possibility of drinking water pollution	B
Impact of surface water pollution	C
Impact of flooding	C
Impact of ground water pollution	C
Distance from public facilities	B
Distance from densely populated areas	C
Dust hazard	C
Smog hazard	C
Noise hazard	B
Odor hazard	C
Landslides	C
Adjustability of a land use plan and neighboring land use	C

A: No damage
B: Slight damage
C: Damage

Air (HCl) quality, water qualities and noise hazard were measured for understanding present environmental condition on the disposal site.

(1) Air quality

Air is polluted by uncontrolled landfill method. Most of residents who live in El Trebol have already recognized that the uncontrolled landfill seriously affect the presence of odors.

El Trebol site is located at the top of the gully, situated in the center of Guatemala City. On that day, a part of the waste was burning and the gully was covered with smoke.

In order to describe the air pollution of El Trebol disposal site, atmospheric data (HCl) was undertaken, as follows.

Table 7-2
Atmospheric Data of the El Trebol Disposal Site

Position	Date		Wind Direction	Temp (C)	Humidity (%)	Air Volume (l)	C (mg/m3.N)
Center	10.Sep.	8:30-13:30	North	21-22	68-87	1286.1	0.705
Eastern	10.Sep.	14:30-18:30	South-west	20-22	78-82	1352.7	0.675
North	10.Sep.	15:30-18:00	South	20-22	78-80	636.1	2.925

Basically, this understanding depended on the presence of meteological conditions, such as wind direction, wind velocity, atmospheric pressure, and rainfall. These data are indicated in DATA-FILE.

(2) Previous study

Air contamination at Guatemala

A. Pedro Savaria Celis: "Study about air contamination in Guatemala's Metropolitan area."
Special Study ERIS-USAC; FAC ING Guatemala, August 1983

1. Parameters
   - SO_2
   - Sediment dust
   - Heavy metal determination

2. Levels

   Dust:
   Between 0.12 and 3.20 mg/cm² on 8 of the 10 study sites surpassed the reference level of 0.5 mg/cm²/ 30 days, having 3 lectures higher than 2.0 mg/cm² and 4 lectures between 1.0 and 2.0 mg/cm².

   Pb(Lead):
   Between 0.19 and 3.23 microg/m³ (first period), and from 0.15 to 3.50 microg/m³ (second period)

   * The levels of Pb near "La Terminal Zona 4" are equal as in Chicago and higher than many cities in the U.S.A. The levels of Pb at the end of "1 avenue Bolivar" are higher that the ones in many cities of the U.S.A. The rest of the Metropolitan area runs between 0.19 and 1.05 microg/m³.

   SO2(Sulfur):
   Its presence at the area is concentrated between 220 and 49 micrograms/m³ (0.77 and 0.017 ppm) area: Between 260 and 105 micrograms/m³. (0.091 and 0.037 ppm).

B. Zenon Much Santos: "Determination of air contamination by the Industries at Twen Uman City, San Marcos, Guatemala"

ERIS, USAC, FAC, Chemical Ingerier, Guatemala, April 1989.

1. Parameters

- Dust (Ps)
- Sulfur (SO2)
- Sediment Dust (PSD)

2. Levels:

PS:
The concentrations of dust in Barrio Verde, Tecum Uman, San Marcos, exceed the quality norms at OMS (World Health Organization)

SO2:
These concentrations also exceed these norms.

PSD:
Same

C. Short study of the quality of the air at Capitol City Weather Control Department, DSM June 1989.

1. Levels:

- At Capitol City (Guatemala) surpass the concentration of nitrogen (NO) and hydrocarbons (HC) of the reference levels.
- Carbon Oxide (CO) do not surpass the average levels.
- SO2 is between these levels at OMS.

(3) Water quality

The location and result of water quality analysis is indicated in Fig. 7-1 and Table 7-3, 7-4.

Leachate at the landfill site may pollute subterranean and surface water, and stench, noise, and dust in the site may cause traffic congestion. Furthermore, insufficient control is apt to generate rats and other vermin. Among examinations of the various effects on the environment at the final disposal site, the possibility of water pollution of public water systems, including subterranean water, by leachate should be considered most seriously.

From a geological point of view, the surroundings of the disposal site are located within the range of faults activated in 1976. As the geological structure is being extremely complicated, leachate is supposed to cause pollution.

The existence of double-layered ground water zones around the El Trebol disposal site was reported in a previous ground water study. At the point where the study team bored this time, the existence of an upper, shallow ground water zone was discovered. The coefficient permeability of the ash beds were $K = 2,928 \times 10^{-4}$ cm/sec, and therefore the effects on shallow ground water would be unavailable.

According to the recent survey of the surrounding wells, it seems that water levels have decreased and the water has become polluted from 4 or 5 years ago.

Even judging in general terms, the monitoring of water quality at this disposal site is indispensable for controlling the environmental effects and must be implemented. (refer to Table 7-3 and Table 7-4)

Table 7-3

Water Quality of El Trebol Disposal Site

	Downstream Slums	Upper Trebol	Under Trebol	Bore Point	East Trebol
Coliform count	1100	1100	34	460	-
SO4(mg/l)	28	45	16	12	
Pb (mg/l)	Trace	Trace	Trace	Trace	Trace
cd (mg/l)	ND	ND	ND	ND	ND
T-Cr(mg/l)	ND	ND	ND	ND	ND
As (mg/l)	0.02	0.05	0.05	0.02	0.03
Hg (mg/l)	ND	Trace	ND	0.02	ND
PH (mg/l)	7.47	7.54	7.94	9.88	6.77
Chlorine(mg/l)	66.5	5300	5400	7.1	10.6
T-N (mg/l)	2.8	114.1	-	1.7	10.6
COD (mg/l)	174	43500	38048	40	11.0
BOD (mg/l)	-	10000	11700	-	-

-: No date available

Table 7-3 and Table 7-4 result in indicating that these water samples have not included heavy metals.

Table 7-4 Water Quality Analysis

Well and Surface Water

1990

No.	E.Coli Nomber/100ml	SO_4^- mg/ℓ	Pb mg/ℓ	Cd mg/ℓ	T-Cr mg/ℓ	As mg/ℓ	Hg mg/ℓ	pH	COD mg/ℓ	Chlorine mg/ℓ	T-N mg/ℓ	BOD mg/ℓ
1	34	16	trace	ND	ND	0.05	ND	7.94	38,048	0.54	0.25%	11,700
2	1100	45	trace	ND	ND	0.05	trace	7.54	43,500	0.53	114.1mg/ℓ	10,000
3	1100	28	trace	ND	ND	0.02	ND	7.47	174	66.5	2.8	
4	0	16	trace	ND	ND	trace	ND	7.83	22	39.9	1.96	
5	0	8	trace	ND	ND	0.01	ND	7.44	15	19.5	2.52	
6		–	trace	trace	ND	0.01	ND	7.01	15	14.2	2.8	
7		–	–	trace	ND	0.01	ND	7.15	25	28.4	2.8	
8		46	0.02	ND	ND	ND	ND	7.06	182	35.5	1.4	
9		10	–	trace	ND	trace	ND	6.58	26	14.2	2.8	
10		8	–	trace	ND	0.02	ND	6.51	132	10.6	2.8	
11		8	–	trace	ND	0.01	ND	6.66	131	14.2	1.4	
12	0	56	trace	ND	ND	ND	ND	7.50	8	10.6	2.8	
13	0	55	0.01	ND	ND	ND	ND	7.35	4	8.8	2.8	
14	0	30	0.01	ND	ND	ND	ND	7.88	9	10.6	3.5	
15	0	62	trace	ND	ND	trace	ND	6.82	6	7.1	1.4	
16	0	48	trace	ND	ND	trace	ND	7.91	7	14.2	1.4	
17	0	52	trace	ND	ND	ND	ND	7.21	63	21.2	5.6	
18	0	73	trace	ND	ND	ND	ND	7.55	1	17.7	4.9	
19	0	25	trace	ND	ND	trace	ND	7.01	5	2.3	2.8	
20	0	–	ND	ND	ND	0.03	ND	9.49	76	10.6	2.8	
21	0	–	ND	ND	ND	0.04	ND	9.86	13	23.1	2.8	
22		–	ND	ND	ND	0.02	ND	6.36	4	31.9	31.9	
23		–	trace	ND	ND	0.03	trace	6.77	11	10.6	10.6	
24								7.86	11	10.6	10.6	
25	0	8	trace	ND	ND	ND	ND	6.33	18	7.1	2.1	
26	460	12	trace	ND	ND	0.02	0.02	9.88	40	7.1	1.7	

Fig. 7-1

Location map of Wells

(4) Noise

The Trebol dump site has two entrances, one is located in 13 Calle Zona 7, the other is in 30 Calle Zona 3. Most of solid waste transport has used the entrance in 30 Calle Zona 3. Exact location of measurement point is indicated such as A (Zona 3) and B (Zona 7) in Fig. 7-5.

These solid waste transports are considered to be with donkeys, compact loaders, carriages and trucks. This noise measurement is indicated in Fig. 7-2, 7-3.

The result clearly that the noise level at the entrance point B was generally higher than the recommended value by WHO.

Residents were exposed to an uncomfortable noise level for living.

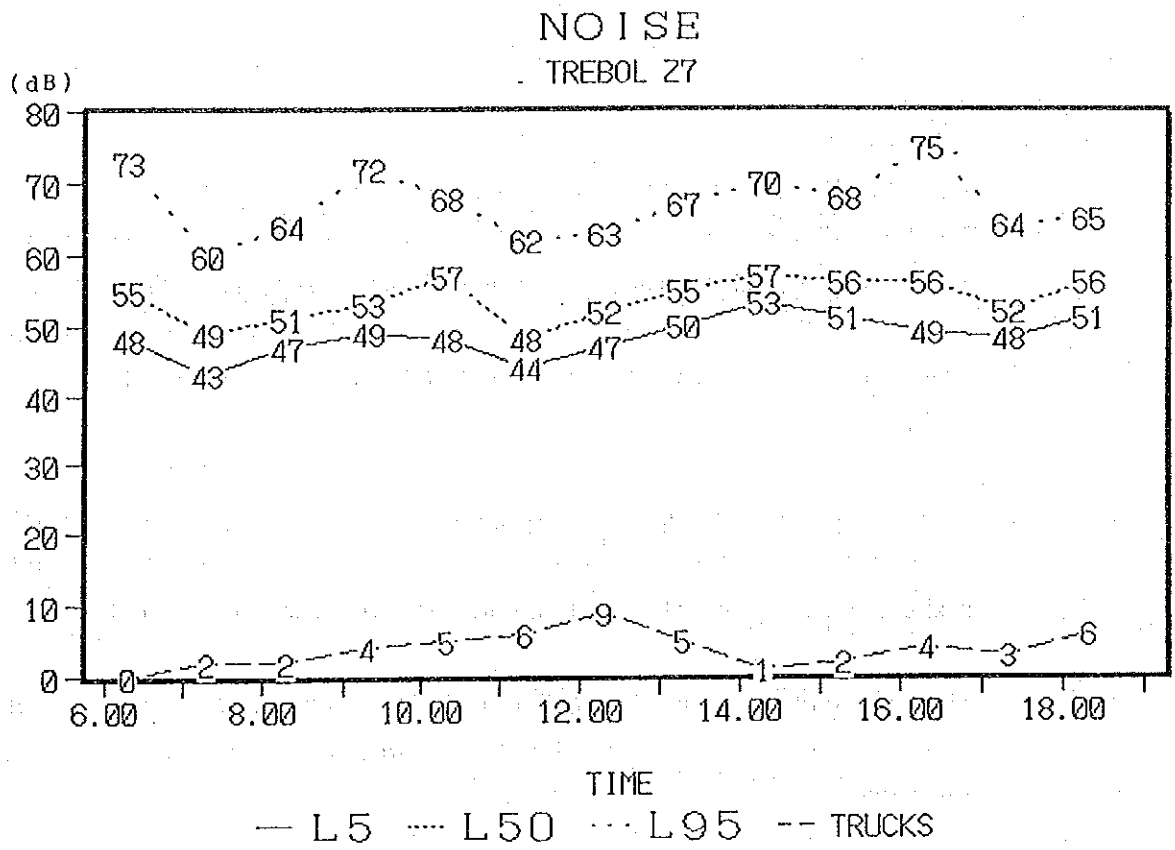


Fig. 7-2 NOSE LEVEL OF EL TREBOL

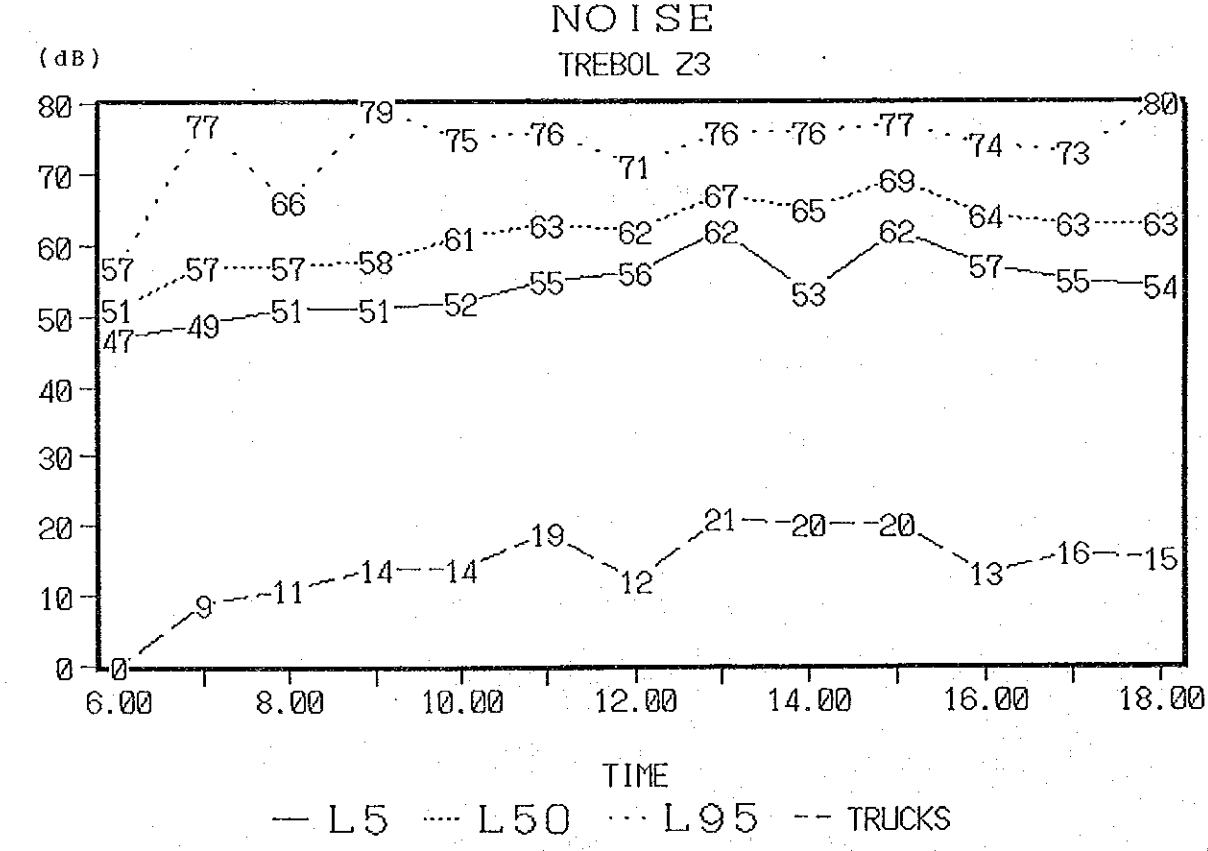


Fig. 7-3 NOISE LEVEL OF EL TREBOL Z3

7.3.2 Environmental protection

The following measures will be taken at El Trebol to protect the environment:

a. Air pollution

By means of covering the compacted waste with covering materials, air pollution to the neighboring residential areas, caused by spontaneous combustion, dust and odors will be prevented.

b. Ground water pollution

By means of tentative aeration of leachate with an aerator in a small pond, and a leachate circulation system reduction of ground water contamination can be expected.

c. Sanitary condition

With facilities such as fence, gates and improved access roads, sanitary conditions of the people living or working inside or outside of the site will be greatly improved.

7.3.3 Improvement of El Trebol Disposal Site

(1) Convert the El Trebol disposal site into a controlled landfill.

1) The use of natural soil to cover the dumped waste and to prevent fires and unpleasant odors which many originate from the dumped solid waste.

2) The construction of a leachate - recycling system, between a storage lagoon and the certain areas for the sanitary landfill site. With this, mainly organic content (BOD) of the leachate would be reduced and its quantity would be decreased by evaporation.

3) Opening of a new landfill site

Solid waste will be delivered both to the El Trebol disposal site and to the Las Guacamayas new landfill site so that the number of transportation vehicles will decrease from the current 71/hour to 41/hour in the future.

By the operation of the above items, bad environmental influence to El Trebol disposal site will be reduced.

Table 7-5
Evaluation of El Trebol Disposal Site on
Environmental Acceptability after Project

El Trebol	Evaluation
Possibility of drinking water pollution	B
Impact of surface water pollution	B
Impact of flooding	B
Impact of ground water pollution	B
Distance from public facilities	B
Distance from densely populated areas	C
Dust hazard	B
Smog hazard	B
Noise hazard	B
Odor hazard	B
Landslides	C
Adjustability of a land use plan and neighboring land use	C

A: No damage
B: Slight damage
C: Damage

7.4 Las Guacamayas New Disposal Site

7.4.1 Background

Las Guacamayas Gully is located adjacent to the Florida colony in Zona 19 of Guatemala City, and extends toward the north-northwest.

Government Institutions in La Florida Colony:

- Center of Child Welfare
  (12th Ave. between 5th and 6th Ave., Z19)
- Cultural Community Center
  (1st Street and 7th Ave. Z19)
- Municipal Dispensary
  (11th Ave. between 4th and 5th Street Z19)
- Auxiliary Mayor's Office, 19th zone
  (13th Ave. 0-91, 19th zone Florida)
- Auxiliary Mayor's Office, 5th zone Sat Maria
- Municipal Fiscal Receiver's Office
  (Monserrat Commercial Center)
- Municipal Firemen
  (12th Ave. and 6th Street Z10, La Florida Colony)
- National Police Sub-Station
  (11th Street and 5th Ave. 1 de Julio Colony)
- Health Station Sta. Marta Colony
  (end of 4th Street, Sta. Marta Colony)

Dumping site:

- Open dumping site (non sanitary) between I and II Monserrat Colony and Monte Verde Colony (2nd Ave.)
- Municipal dumping site (non sanitary) close to the Municipal Fire Station
- Zonas 19, 5 and 4 belonging to the 1 de Julio Health Center District, has the cleaning Municipal Service

of the Guatemala Municipality (and cleaning private service).

Schools:

- Number of schools (25)
- Number of teachers (377)
- Number of nursery students (116)
- Number of pre-kindergarten students (17)
- Number of kindergarten students (562)
- Number of small kids students (401)
- Number of pre-primary students (994)
- Number of elementary students (13)
- Number of primary students (6081)
- Number of public schools (12)
- Medical Clinic and Hospitals

Health Aspects

Among the 10 first causes of death, we can mention in priority order the following; light and strong choler, intestine parasites and skin diseases (Sarcoptiosis), and among dead causes we can find diarrhea and choler, this for children less than 5 years old.

Table 7-6
Works Memory 199
First Ten Causes of Sickness

NO	Diagnosys
1	Trichomoniasis
2	Intestinal parasitism
3	Arterial hypertension
4	Eczema
5	Myalgia
6	Arthralgia
7	Oral moniliasis
8	Peptic disease
9	Soft choler
10	Stress migraine

FIRST FIVE CAUSES OF CHILDREN SICKNESS
(LESS THAN ONE YEAR OLD)

NO	Diagnosys
1	Soft choler
2	Intestin parasitism
3	Sarcoptiosis
4	Peptic disease
5	Oral moniliasis

First Five Causes of Children Death
(Less Than One Year Old)

NO	Diagnosys
1	Premature birth
2	Congenital abnormalities
3	Septic shock
4	Others
5	

Table 7-7
Work Memory 199
Ten First Causes of Death

NO	Diagnosys
1	Chronic alcoholism
2	Intracranial hemorrhage
3	Hipovolemic shock
4	Acute lung edema
5	Hepatic cirrhosis
6	Mellitus diabetes
7	Renal incapacity
8	Chronic bronchitis
9	CA
10	
	REMAINING CAUSES
	TOTAL CAUSES

Number of deaths in those younger than 28 days	16
Number of deaths from 28 days to less than one year old	20
Number of deaths from 1 - 4 years old	15
Number of deaths from 5 - 14 years old	7
Number of mother deaths	0
Number of children born alive	1834

Environmental Condition

89% of the population receive water through pipes, the rest of the population get it from wells.

50% of the colonies have drainage and sewerage network for sewage water and excreted matters, which are released to nearby cliffs, which the rest lacks this service disposing on the ground.

Collection of garbage in residential colonies is made through the private sanitary train. The remaining part of the population uses empty land and cliffs - used as garbage disposal places, constituting this, contamination focuses, which promote an increase in the population of insects, rodents, which contaminate ambient health.

Education

The population is involved, and illiterate in 49.69%. In the marginal urban area, the educational level is low, and school students are 11,880 at the elementary school level.