L.1.5.2 Recommendations to Mitigate the Damage

a. Recommendation for Short Term Improvement

The following table shows countermeasures for each inundation prone area. The priority order was proposed by the municipality.

Table L-47: Recommendation for Short Term Improvement

No.	Name of Area	Priority	Recommendation
1	Villa Tepetate, Asentamiento Julián Quintana, Villa Sandino	1	· to make the scale of 'Arroyo Pancasan' bigger. · to construct drains in the next western area which go to 'Arroyo Pancasan' .
2	Reparto Bartolomé, Curva Chico Tripa	4	· to make the existing drain in the next eastern area bigger. · to construct drains in the next northwestern area which go to the above drain.
3	Barrio El Bolsón (next to the cemetery area)	2	· to construct drains in the next western area which go to 'Arroyo Zacatiligue'. However, a consolidated drainage plan is needed for improvement of 'Arroyo Zacatiligue'
4	Arellano Avenue	3	· to construct a drain at the lowest part of 'Arellano Avenue'. · to construct drains in the next western area.

To make the countermeasures efficiently, the followings should be done prior to executing the countermeasures.,

- to work out guidelines to control water storm,

  Guidelines should include following items:

  - responsibility sphere of each organization (See L.1.5.4 Institutional Requirement),
  - a technical guideline (ex. Capacity of the river should be calculated on the basis of once 10 year probable rainfall.),
  - and adjustment of laws and regulation regarding storm water management.

- to conduct basic investigation on the inundation prone areas according to the technical guideline (conduct topographical survey, design rivers and watercourses, etc.),
- to raise necessary funds for making the plan and executing it.

b. Recommendation for Middle and Long Term Improvement

A flood defense plan is needed for middle and long term improvement. A planning process of the plan is shown in the following section L.1.5.3. In this section, items which should be taken into account when a flood defense plan is made are described.

1) To investigate the present capacities of 'Arroyo Pancasan', 'Arroyo La Aduana', and 'Arroyo Zacatiligue'. If necessary according to the result of the investigation, to make a plan for improving the capacities of them.

2) To construct watercourses along the west periphery of the city for avoiding the water coming from the west into the city, and for having the water reach Lake Nicaragua or the rivers quickly through the watercourses.

3) To construct stormwater drains in the city for preventing the water from the west causing the inundation in the east, and for making the water reach the rivers immediately through the watercourses.

L.1.5.3 Planning Process for the Improvement

Figure L-22 shows a general flow of planning process of a flood defense plan.

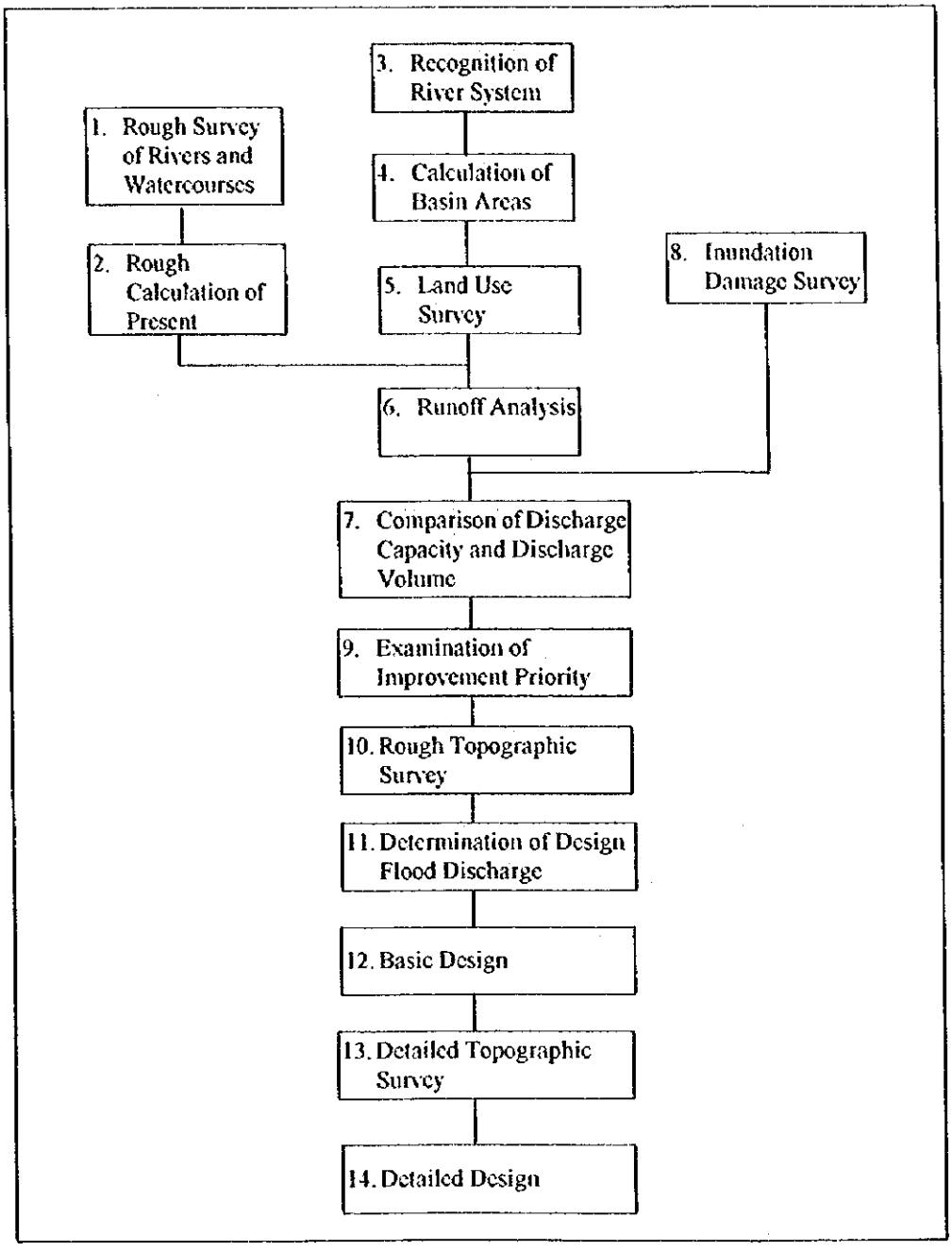


Figure L-22: Flow of Planning Process of Flood Defense Plan

1. Rough Survey of Rivers and Watercourses

To survey about three cross sections (a upstream point, a middle point, a downstream point) of rivers and watercourses.

2. Rough Calculation of Present Discharge Capacity

On the basis of the above survey result, present discharge capacity of rivers and watercourses are calculated by Manning's formula.

Manning's formula

$$V=1/n \times R^{2/3} \times I^{1/2}$$

V: flow velocity (m/s)
n: roughness coefficient
R: hydraulic radius (m)
I: gradient

$$Q=A \times V$$

Q: discharge capacity (m^3/s)
A: sectional area (m^2)

3. Recognition of River System

To recognize a relation ship of rivers (main rivers, tributaries).

4. Calculation of Basin Areas

According to the river system, to calculate the drainage areas which are divided by each tributary.

5. Land Use Survey

This survey is conducted in order to determine runoff coefficient, and the result of the survey is useful upon planning a river alignment.

6. Runoff Analysis

Although there are some runoff analysis methods, the rational formula method is recommendable for the rivers in the study area. Because the drainage areas of the rivers in the study area are comparatively small. In general, it can be said that the rational formula method is appropriate for a less than 200km^2 drainage area and shorter than 2 hours time of concentration.

$$Q=1/3.6 \times f \times r \times A$$

Q: design flood discharge (m3/sec)
f: runoff coefficient
r: average rainfall intensity (mm/hr) with in the time of flood concentration
A: drainage area (km^2)

7. Comparison of Discharge Capacity and Discharge Volume

To recognize parts of rivers which are needed to be improved by comparing the result of 2 and 7.

8. Inundation Damage Survey

To investigate actual inundation damages which have occurred, in order to mainly give priority order of improvement.

9. Examination of Improvement Priority

Upon considering the above items synthetically, priority order of improvement is examined.

10. Rough Topographic Survey]

According to the priority order, to conduct a rough topographic survey on a river for a basic design. The survey may consist of horizontal plan and vertical alignment.

11. Determination of Design Flood Discharge

To decide a design flood discharge of a river.

12. Basic Design

On the basis of the design flood discharge decided in 11, a basic design is made, which consists of horizontal, vertical and cross section plan, and rough design of structures.

13. Detailed Topographic Survey

To conduct a detailed topographic survey in order to conduct a detailed design.

14. Detailed Design

The detailed design is made for construction, which consists of horizontal, vertical and cross section design, and other necessary designs for construction.

L.1.5.4 Institutional requirements

The pluvial drainage is the municipal competence. Meanwhile it is not well defined who would be the responsible for the maintenance and protection of: permanent rivers and seasonal or temporal rivers inside and outside of municipal extension. Law No. 217-96 establishes the competence of MARENA taking water as "a natural resource". Whereas, MINSA should control its quality. Other entities are involved in the use and protection of water (e.g., the Agriculture Ministry and the National Commission of Water Resources).

It is recommended to carry out an ample and detailed evaluation study on the basin and the ditches that cross the municipality, especially in the urban area. The study should be in such a way as to identify:

- simply what is an urban drainage way (i.e., municipal competence); and
- what exceeds the above aspect and could cause effects to: groundwater and surface water (natural resources), to the public health, to the safety of persons and physical assets (floods, erosions, etc.).

Based on this study, it is recommended to classify ditches and other drainage ways in two systems:

- **micro-drainage** (municipal responsibility); and
- **macro-drainage** (responsibility shared by the municipality and the Central Government (MCT as operating agent)).

Because of its natural competence MARENA should lead this intersectorial study and should promote solution of:

- a local nature, through an agreement or treaty with the municipality; or
- a wider nature, by means of the Law.

The Annex N presents the recommendations on regulations and intersectorial actions in this regard.

L.1.6 Municipal Solid Waste management

L.1.6.1 Site Selection for Municipal SW Final Disposal Site

Background

The municipality has one landfill which locates in the southwest 5km away from the city center. The landfill has been used since 1976[3].

The landfill exists next to a southernmost crater which is one of three craters locating on the north of the landfill. A crater is a pass of rain to groundwater. It is, therefore, to be feared that leachate from the landfill may contaminate the groundwater flowing under the craters from which some of INAA's wells are taking water for tap water. This problem was also pointed out on the report: 'Inpacto Ambiental del Basurero Existente "La Joya" Granada', studied by Centro para la Investigacion de Recursos Acuaticos, (CIRA).

Consequently, the municipality has recognized the necessity of developing a new landfill to solve the above problem. So that, the municipality presented two candidate sites for landfill, one is 'Buena Vista' proposed in a study conducted by CIRA[4], and the other is 'San Jose de la Viuda'.

a. Presentation of Candidate Sites

a.1 Buena Vista (BV)

The proposed site "Buena Vista (BV)" is located at the northwestern part along a rural road. The site is about 6km northwest of the city center of Granada. The area is agricultural land where scattered bushes and trees, presently used for extensive agricultural cultivation. The coordinates of the site's center are approximately 11°58'50"N, 85°58'50"W. The altitude is about 70 meters above sea level (see Figure L-23).

a.2 San Jose de la Viuda (SJV)

The proposed site 'San Jose de la Viuda (SJV), is located about 4.5 km north from the city center of Granada, on the east side of the access road (Granada-Santa Rosa), and

[3] Impacto Ambiental del Basurero Existente "La Joya" Granada, CIRA, 1996
[4] Estudio del Manejo de los Desechos Solidos de la Ciudad de Granada, CIRA, 1996

about 1.3 km from the existing sewage oxidation pond. The coordinates of the site's center are approximately 11°58'30"N, 85°57'10"W. The altitude is about 40 meters above sea level (see Figure L-23).

b. Survey on the Sites

The survey on the candidate sites for a future landfill was conducted in accordance with the evaluation items which was shown in the Interim Report (1). The result of the survey are shown below.

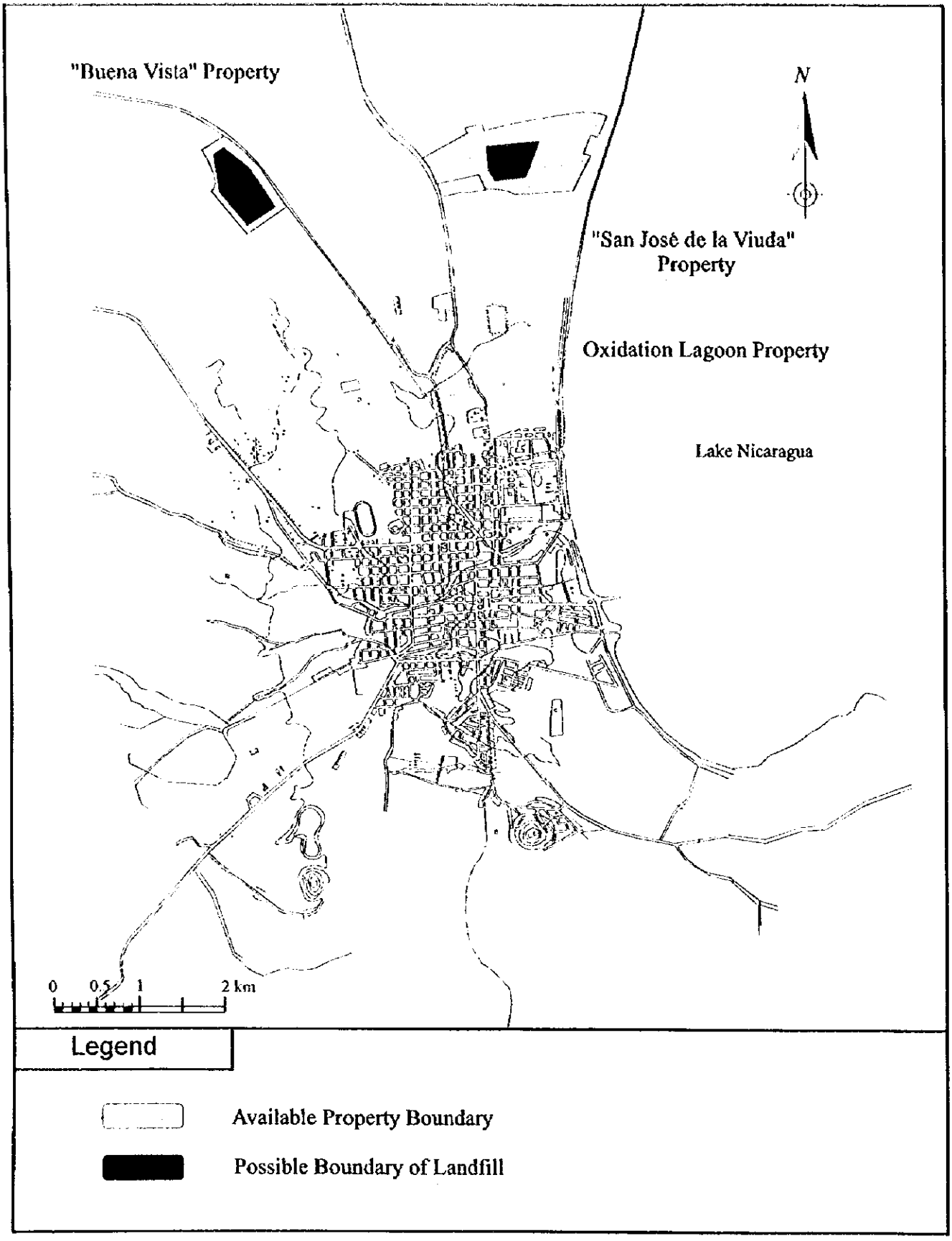


Figure L-23: Location of Candidate Sites

b.1 Buena Vista

b.1.1 Possibility of Land Acquisition

Present land use

It is mainly used for agricultural purposes (sorghum). The surrounding areas are used for similar purposes.

Land ownership

The land owner is one person.

Necessity of compensation

It is needed because the site is private land.

b.1.2 Possibility of Getting Neighborhood Consensus

Neighboring inhabitants

There are not towns nor villages around the proposed site.

Neighboring landowners

The NIMBY effect might be present in Nicaraguan society to some extent, it is accurate to say that its expression may be disorganized and dormant, although in reality, it is difficult to quantify it at this stage.

The neighboring landowners maintain crops farming. Measures to mitigate impacts from the landfill to the neighboring crops farming should be considered in the landfill operation practices (e.g., buffer zone and daily soil coverage of landfill operation face) in order to eliminate the crops damages by rodents etc..

"Neighborhood consensus" by adjacent crop farm owners might be necessary, and impact mitigation measures (i.e., daily soil coverage in sanitary landfilling operation) could possibly attain the consensus.

Residents along the access road

There are a considerable number of houses along the access road to "Buena Vista". The width of the road boundary of the access is very narrow in many places and many houses are situated very near to the road boundary. Therefore, it is impossible to obtain 2-way traffic in various places. Negative impact to roadside residents by the traffic of garbage trucks (noise, dust, vibration, increased danger of traffic accidents) are difficult to mitigate. An independent new access road to "Buena Vista" (however it is very costly) might be a solution for "neighborhood consensus" by residents along the road.

b.1.3 Compatibility with Development Plans

Compatibility with development plans

Granada does not have a superior development plan updated, only the Urban Development Regulatory Plan (UDRP) in 1982. This plan was begun to be elaborated by the consortium Esprinsa-Johnson on the request of the Vice-ministry of Urban Planning (VMPU) in 1978. This plan would substitute the one published in the official paper La Gaceta No. 97 in May 10 1973. The plan elaborated by Esprinsa-Johnson served as

basis for the Regulatory Plan Published in 1982. According to an officer in the Conservation Department of Granada municipality, this plan is still being used as a reference today.

With reference to the UDRP (1982), it is deemed that this site is compatible with city development plan.

Conformity with direction of urbanization

Urban development seems to be following the trend indicated by the 1982 Regulator Development Urban Plan. For instance, no large urban expansion is expected to the north in the proposed site direction. Largest urban expansion is expected along the highway that goes to Masaya-Managua (Northwest direction); and also along the highway that goes to Nandaime (Southwest direction).

Therefore, the site has conformity with the current urbanization direction.

b.1.4 Environmental Acceptability

Drinking water/Groundwater

There are no water supply wells in nor around the proposed site.

Although INAA, at this moment, does not plan groundwater exploitation in this area for the city's water supply system, the proposed site lies over an aquifer of great potential and hydro-geological conditions suitable for exploitation. Groundwater is of good mineral and bacteriological quality. It is suitable for drinking water purposes.

The proposed site lies west, upstream to an area selected for groundwater exploitation by a study sponsored by the United Nations Development Program in 1973. The other area selected is where Quinta Ena wells are located nowadays.

Surface runoff/Risk of flooding

There are no rivers in nor around the site. Natural drainage is deemed in good conditions in the area.

Topography

The site is basically plain, but it slightly rolls and slopes towards the Tisma plain.

Wind direction

Wind direction is toward the east and northeast (in the lake direction).

Precipitation, evaporation

The closest meteorological station with precipitation and evaporation values is located in Nandaime to 21 kms. to the southwest of Granada. These values are reliable to be applied to "Buena Vista". The mean values observed for the period from 1958 to 1994 are as follows:

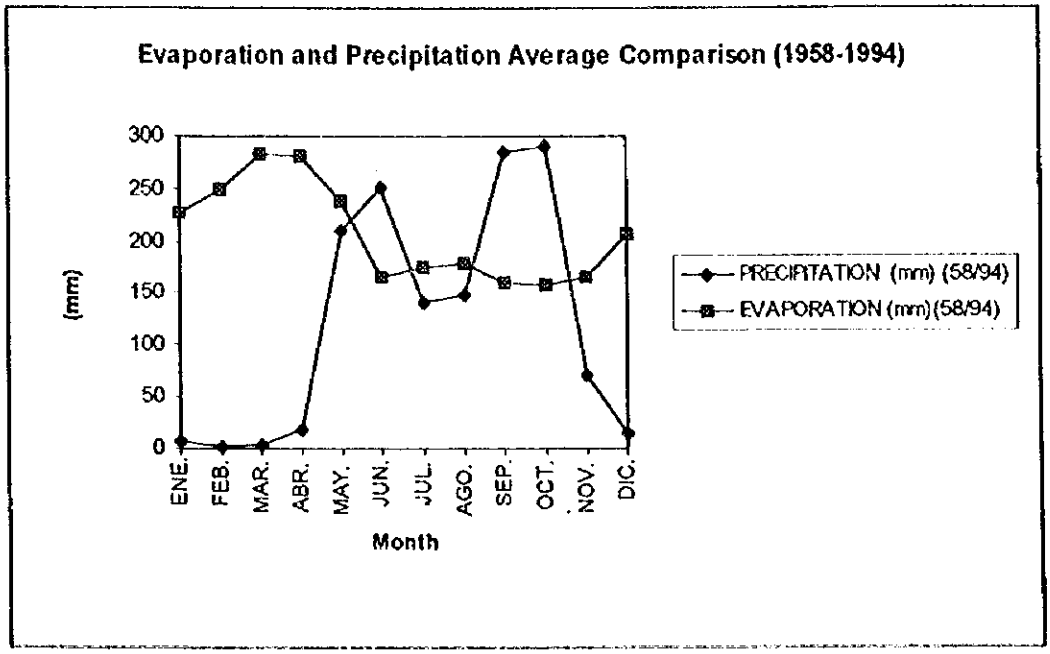
- Evaporation = 2271 mm
- Precipitation = 1407 mm

The monthly mean values obtained during the same span are given in the following table:

Parameter: Precipitation (mm.) for period 1958 to 1994

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Average	7	2	4	19	210	252	142	150	286	290	71	15	1407

Source : INETER



Land use of neighborhood

The land use of neighborhood is mostly for agricultural purposes, especially sorghum.

Distance to nearest village

There is not any village in the surroundings, however, a considerable number of houses is located along the access road to the site. The nearest house on the road is about 1 km apart from the site.

Distance to nearest house

The nearest house is 300 meters away from the site.

Distance to periphery of urbanized area

Distance to periphery of urbanized area is 4 km.

Access road passing residential area

The unpaved access road to the site "Buena Vista" is in poor road conditions (impassable during the rainy season). It is very narrow in many places and impossible to obtain 2-way traffic. There are about 100 houses along the road and are located very near to the road boundary. Social impacts (noise, dust, vibration, increased danger of traffic accidents, etc.) is considerably huge. If it is planned to maintain enough road width to mitigate these social impacts, another set of social impacts (e.g., resettlement of

many houses along the road) will be created, or substantially huge cost of constructing a new independent access road to "Buena Vista" will be required.

Distance to airport and other public facilities

There is an airport for crop dusting purposes near the site (around 1km to the southwest), but no other public facilities nearby are found.

Fauna and flora

In general terms, MARENA has declared three protected areas around Granada City. To the north, it is Laguna de Tisma (to 14 km); to the west, it is found Laguna de Apoyo (to 6 km); and to the south, it is found Volcan Mombacho (to 8 km), Río Manares, Juan Tallo, and Zapatera island. All these protected areas are located to considerable distance form the proposed landfill site.

Table L-48: Protected Areas Legally Established around Granada City

Name	Hectares	Decree	Date	Resources Protected
Laguna de Tisma	10,295	#1320	08/09/1983	Wetlands/Migratory Birds/Fishing Resources
Laguna de Apoyo	3,500	#42-91	04/11/1991	Scenery/Water Resources/Tropical Dry Fauna
Volcan Mombacho	2,487	#1320	08/09/1983	Fog - Forest/Forest
Laguna de Mecatepe	1,200	#1320	08/09/1983	Wetlands/Lagoon system/Associated Fauna
Río Manares	1,100	#1320	08/09/1983	Wetlands/River system/Associated Fauna
Archipielago de Zapatera*	5,227	#1194	05/02/1983	Insular system/Archeological Resources/Tropical Dry Forest/Associated Fauna

Source: MARENA
* All of them are Natural Reserves except Archipielago de Zapatera which is a National Park

Scenery

No tourist development is considered at this moment in the area.

Historic/Archeological sites

No historic or archeological sites are found in the surroundings of the proposed landfill site.

b.1.5 Economic Feasibility

Land area (ha)

The land area of the proposed farm "Buena Vista" has a total of 65 manzanas (approximately 45 hectares).

The land area of the proposed farm "Buena Vista" has a total of 37 manzanas or 26 hectares according to Register number, property No. 02100 (Hacienda BV). According to CIRA study the area is 25 manzanas or 17.6 hectares. The CIRA study might have not considered the land necessary for the buffer zone.

Land price

It is said that the price ranges from US$1,000 to US$1,200 per hectare in the area.

Expected life period (year)

Expected service life is 10-20 years.

Access road to the site

Present road conditions to "Buena Vista" requires substantially huge cost for improvement (grading, sub-base, base course construction and pavement, 2 bridges and several culverts for road-crossing drainage, etc.), even it maintains the same road boundary. If the road width needs to be widen in order to mitigate the social impacts mentioned, considerable costs of land acquisition for widening and resettlement will be additional. Or a new independent access road construction should be very costly with land acquisition cost in addition.

Availability of covering soil (for landfill site)

Covering soil for the sanitary landfill operation might be available from some borrow pits in a reasonable distance.

Availability of public service (water supply, sewage, electricity, telephone)

There is no tap water supply system, no sewage system, no telephone service. Electricity service line (probably 138 KV) is found to approximately 500 meters to the northwest in the location known as Santo Domingo. In order to be serviced by the electric line, one has to make a request to the Electricity company.

Distance to center of city

The distance to the city center is about 6 km.

Elevation of land

The elevation of the site is about 70m above the sea level and around 40m above Lake Nicaragua level.

Leachate Treatment and its Destination

Since the groundwater beneath the site has the potential and important value for future water supply and furthermore there is no receiving body (public water courses or sewer) of leachate treated effluent near the site, measures of contamination prevention should be complete (i.e., Decree 33-95 requires the effluent quality improvement to the level of: BOD 110mg/l and COD 220mg/l or below, for such case.). An independent leachate treatment and its operation should be necessary for the time duration of its service life (e.g., 10-20 years) and its maintenance period after the service (it could be 20-50 years). This could be a substantially heavy cost burden in operation and maintenance.

b.2 San Jose de la Viuda (SJV)

b.2.1 Possibility of Land Acquisition

Present land use

It is used mainly for cattle breeding and partially for agricultural purposes. The surrounding areas are used in similar way. In addition there is a poultry farm in the northern limit of the property.

Land ownership

At present the owner is basically represented by one person along with two other persons.

The owner originally was the Lacayo family (Bertha Argüello de Lacayo), but they were confiscated during the Sandinista revolution. The ownership during the 80's went to the cooperative "Walter Ferreti". The bank seized the property because of a debt. Alberto Vásquez Gómez and some of the cooperative members, repaid the debt; and nowadays, he is the owner along with Manuel Guido Gonzáles and Martha Talavera Siles.

Necessity of compensation

It is needed because the site is private land.

b.2.2 Possibility of Getting Neighborhood Consensus

Neighboring inhabitants

There are not towns nor villages around the proposed site.

Neighboring landowners

The NIMBY effect is present in Nicaraguan society to some extent; it is accurate to say that its expression may be disorganized and dormant. Although in reality, it is difficult to quantify it at this stage.

The neighboring landowner in the northern side has poultry farm operation. Measures to mitigate impacts from the landfill to the poultry farm should be considered in the design (e.g., buffer zone, daily soil coverage).

The major target of "neighborhood consensus" for "San Jose de la Viuda" might be the poultry farm in the northern neighbor, and impact mitigation measures (e.g., enough buffer zone) could possibly attain the consensus.

b.2.3 Compatibility with Development Plans

Compatibility with development plans

Granada does not have a superior development plan updated, only the Urban Development Regulatory Plan (UDRP) in 1982. This plan was begun to be elaborated by the consortium Esprinsa-Johnson on the request of the Vice-ministry of Urban Planning (VMPU) in 1978. This plan would substitute the one published in the official paper La Gaceta No. 97 in May 10 1973. The plan elaborated by Esprinsa-Johnson served as basis for the Regulator Plan Published in 1982. According to an officer in the Conservation Department of Granada Municipality, this plan is still being used as a reference today.

With reference to the UDRP (1982), it is deemed that this site is compatible with city development plan.

Conformity with direction of urbanization

Urban development seems to be following the trend indicated by the 1982 Regulator Development Urban Plan. For instance, no large urban expansion is expected to the north in the proposed site direction. Largest urban expansion is expected along the highway that goes to Masaya-Managua (Northwest direction); and also along the highway that goes to Nandaime (Southwest direction).

Therefore, the site has conformity with the current urbanization direction.

b.2.4 Environmental Acceptability

Drinking water/Groundwater

Around "San José de la Viuda", there are some drilled and excavated wells that are used for drinking water. In the poultry farm "San Felipe", there are two drilled wells which serve for drinking water purposes to the employees. In addition, water from those wells is used for chicken breeding and for chicken meat processing.

The proposed site lies most downstream over an aquifer (i.e., the same aquifer below "Buena Vista") of great potential and hydro-geological conditions suitable for exploitation. Groundwater is of good mineral and bacteriological quality. It is suitable for drinking water purposes.

The proposed site lies over an area selected for groundwater exploitation by a study sponsored by the United Nations Development Program in 1973. The other area selected is where Quinta Ena wells are located nowadays.

The inferior mineral quality groundwater found in the Apoyo crater side and central part of Granada urban sector might be due to saline water infiltrating through the lagoon's wall movement in the lake direction following the groundwater gradient. However, the good groundwater quality found in "San José de la Viuda" might be due dilution undergone because of stormwater infiltrated in the Apoyo lagoon side and the volcanic plain.

Surface runoff/Risk of flooding

There are no rivers in nor around the site. The site is located in a good distance from the Nicaragua lake (about 1,200m) and from the flood prone wetland in the east (about 700m).

Topography

The western part of the site is basically plain, but slightly rolling. The eastern part is flat and slopes slightly towards Lake Nicaragua.

Wind direction

Wind direction is toward the east and northeast (in the lake direction).

Precipitation, evaporation

The same as presented for "Buena Vista".

Land use of neighborhood

The land use of neighborhood is mostly for cattle breeding and partly for agricultural purposes. There is also a poultry farm located in the northern limit. The eastern limit is occupied by marshlands.

Distance to nearest village

There is not any village in the surroundings. The closest community is 'El Fortin' located 750m apart from the site.

Distance to nearest house

The poultry farm is located in the northern limit of the proposed landfill. And the next closest house is located to 500m.

Distance to periphery of urbanized area

The proposed landfill is located to 3 km to the periphery of the urbanized area.

Access road passing residential area

The access road to the site "San Jose de la Viuda" is unpaved, but it is in fairly good condition and is wide enough for 2-way traffic. It can be transited all the time even in the rainy season. It is an advantage that it does not cross any residential area, only a few scattered houses along the way are found.

Distance to airport and other public facilities

There is not an airport nor any other public facilities nearby. The closest public facility is the lagoon located to 1.4 km. This results in an advantage, given that the leachate from the landfill can be pumped and treated at such facility.

Fauna and flora

In general terms, MARENA has declared three protected areas around Granada City. To the north, it is Laguna de Tisma (to 14 km); to the west, it is found Laguna de Apoyo (to 6 km); and to the south, it is found Volcán Mombacho (to 8 km), Río Manares, Juan Tallo, and Zapatera island. All these protected areas are located to considerable distance form the proposed landfill site.

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Laguna de Apoyo	3,500	#42-91	04/11/1991	Scenery/Water Resources/Tropical Dry Fauna
Volcan Mombacho	2,487	#1320	08/09/1983	Fog - Forest/Forest
Laguna de Mecatepe	1,200	#1320	08/09/1983	Wetlands/Lagoon system/Associated Fauna
Río Manares	1,100	#1320	08/09/1983	Wetlands/River system/Associated Fauna
Archipielago de Zapatera*	5,227	#1194	05/02/1983	Insular system/Archeological Resources/Tropical Dry Forest/Associated Fauna

Source: MARENA
* All of them are Natural Reserves except Archipielago de Zapatera which is a National Park

Although the marshland along the lake Nicaragua is not a legally established protected area, it is an asset of fauna and flora in Nicaragua. In the meantime, it could be deemed that the marshland is not in the danger of species extinction, since the marshland extends more than 20 km along the lake Nicaragua.

Marshland areas usually host unique and important species, for that reason MARENA recommends to respect a land strip along the shore of around 400 meters. Tide fluctuations could also help to define the strip land. In the Regulator Plan of Granada (1982) in the Article 24, it is declared as Natural Reserve Zone of the lake shore. The proposed landfill is located to around 1,200 m from the shore.

World wide as the importance of wetlands has become increasingly understood, attention has been focused on how best to restore, enhance, or manage remaining wetlands. Wetlands usually work as traps of urban and agricultural runoff which contain nutrients, heavy metals, toxic organics, and sediments. wetland provide protection against shoreline erosion. They also may provide important base of support of food chains. Wetland restoration is seen as a useful approach to maintaining biological diversity (Jordan and others 1988).

Therefore, pollution prevention measures (sanitary operation and leachate treatment) should be proposed in the design of the new landfill as same as for "Buena Vista".

Scenery

Although lake Nicaragua can be distinguished in the east of the site, there will be no impact on the scenery, since the landfill access entrance will be planned on Granada-Santa Rosa road and substantial width of buffer zone (wetland, forest and land) will have to be reserved in the east side of the site.

Historic building

No historic or archeological sites are found in the surroundings of the proposed landfill site.

b.2.5 Economic Feasibility

Land area (ha)

Land area of the property is 223 manzanas or around 155 hectares. About 35ha in the middle of the property is sufficient for the landfill. The rest of the property can work as the buffer zone in its surrounding.

Land price

It is said that the price ranges from US$1,000 to US$1,200 per hectare.

Expected life period (year)

Expected service life is 10-20 years.

Access road to the site

The access road is wide enough for 2-way traffic and the condition is substantially good. The improvement works could be only grading of existing one and laying of asphalt pavement.

Availability of covering soil (for landfill site)

Covering soil for the sanitary landfill operation might be available from some borrow pits in a reasonable distance.

Availability of public service (water supply, sewage, electricity, telephone)

There is no water tap service nor sewage service in the area. There is no telephone, but there is electric service line crossing the property (probably 138 KV.). In order to be serviced by the electric line, one has to make a request to the Electricity company.

Distance to center of city

The distance to the city center is about 5 km.

Elevation of land

The elevation of the site is about 40m above the sea level and around 10m above Lake Nicaragua level.

Leachate Treatment and its Destination

The site has an advantage for reducing the leachate treatment cost (i.e., utilization of INAA's sewage treatment as the leachate destination). Since Decree 33-95 requires the effluent quality improvement to the level of: BOD 400mg/l and COD 900mg/l or below for such case, only a primary on-site treatment of leachate could be sufficient during its service life (e.g. 10-20 years).

c. Comparative Evaluation of the Sites and Site Selection

c.1 Evaluation

Major critical evaluation issues observed in the surveys are listed below in comparison of the 2 candidate sites.

c.1.1 Possibility of Land Acquisition

It could be considered that both sites have good possibility of land acquisition according to the counterpart's perception. It is deemed that the "Buena Vista" site has a little larger possibility of "land acquisition" than "San Jose de la Viuda".

The reasons are:

- Both of the sites are private land;
- "Buena Vista" is with one landowner, while "San Jose de la Viuda" is with plural (3) owners (and has the background as mentioned in b.2.1 above); and
- In case only 1 or 2 of 3 owners of "San Jose de la Viuda" is willing to sell the land, exact land extension available is not known at this moment.

In either case, "land acquisition possibility" and "exact boundary of the acquirable land" should be assured by the Granada City before the 3rd Study Work in Nicaragua.

c.1.2 Possibility of Getting Neighborhood Consensus

It is deemed that the "San Jose de la Viuda" site has a larger possibility of "neighborhood consensus" than "Buena Vista".

The reasons are:

- The major target of "neighborhood consensus" for "San Jose de la Viuda" might be the poultry farm in the northern neighbor, and impact mitigation measures (e.g., enough buffer zone) could possibly attain the consensus;
- There are a considerable number of houses along the access road to "Buena Vista". The width of the road boundary are very narrow in many places and impossible to obtain 2-way traffic. Negative impact to roadside residents by traffic of garbage trucks are difficult to mitigate in many places.

c.1.3 Compatibility with Development Plans

It is deemed that both "San Jose de la Viuda" site and "Buena Vista" site are samely "compatible with development plans".

The reasons are:

- No urban expansion is expected to the areas of both sites.

c.1.4 Environmental Acceptability

i. Risk of Water/Groundwater Contamination

The both sites are located on the aquifer which is suitable for tap water purposes. There are some wells located on the downstream area of the site "Buena Vista". It is considered that a new landfill in "Buena Vista" will affect the future exploitation of potable water sources in its downstream (such as the problem of La Joya location in the upstream of INAA wells). Therefore, **complete** measures of underground water protection are necessary for the case of "Buena Vista".

Meanwhile, although there is least possibility of groundwater exploitation in the downstream of "San Jose de la Viuda" site, the site lies near (about 1km) to the wetland along the Lake Nicaragua. Therefore, measures of contamination protection is necessary for the case of "San Jose de la Viuda" as well.

Both cases require measures of underground water protection.

ii. Flood Risk

The site "San Jose de la Viuda" extends next to low land, so that measures of inundation protection will be necessary. Although natural drainage in "Buena Vista" site is in good condition, flood protection measure should also be considered.

iii. Social Impact

The access road to the site "Buena Vista" is very narrow in many places and impossible to obtain 2-way traffic. There are about 100 houses along the road and are located very near to the road boundary. Social impacts (noise, dust, vibration, increased danger of traffic accidents, etc.) is considerably huge in the case of "Buena Vista". If it is planned to maintain enough road width to mitigate these social impacts, another set of social impacts (e.g., resettlement of many houses along the road) will be created, or substantially huge cost of constructing new independent access road to "Buena Vista" will be required.

The access road to the site "San Jose de la Viuda" is wide enough for 2-way traffic. Only a few houses are scattered along the road.

iv. Fauna and Flora

MARENA declared 3 protected areas around Granada City. All these areas are located to considerable distance from both "Buena Vista" and "San Jose de la Viuda" sites.

MARENA recommends to respect a land strip along the shore of around 400 meters in view of that wetlands usually host unique and important species. Tide fluctuations could also help to define the strip land. In the Granada Regulatory Plan(1982) in the Article 24, it is declared that the lake shore be as Natural Reserve Zone. However, The "San Jose de la Viuda" site is located far (around 1,200m) from the shore. Impacts on fauna and flora of the wetland and the Lake by "San Jose de la Viuda" site will be small, since appropriate measures of pollution prevention should be included in the design of the landfill for both cases of "San Jose de la Viuda" and "Buena Vista".

However in total , "Buena Vista" might have a little advantage to "San Jose de la Viuda" in view of fauna and flora protection.

c.1.5 Economic Feasibility

i. Land Area Available and Land Acquisition Cost

The land area size of both sites can be wide enough to be used for 10-20 years as a landfill. This means economically feasible to develop them as a landfill. Land acquisition cost might range the same for both sites.

ii. Access Road Improvement Cost

Present road conditions to "Buena Vista" requires substantially huge cost for improvement (grading, sub-base, base course construction and pavement, 2 bridges and several culverts for road-crossing drainage, etc.), even it maintains the same road boundary. If the road width needs to be widen in order to mitigate the social impacts mentioned, considerable costs of land acquisition for widening and resettlement will be additional. Or a new independent access road construction should be very costly with land acquisition cost in addition.

As for "San Jose de la Viuda", the access road is wide enough and the condition is substantially good. The improvement cost will be comparatively very small.

iii. Construction Cost

This could be deemed same for both sites at this moment.

iv. Operation and Maintenance Cost

"San Jose de la Viuda" has 2 advantages: one is shorter haulage distance than "Buena Vista"; and another is cheaper leachate treatment cost though possible utilization of INAA's sewage treatment plant.

An independent leachate treatment and its operation should be necessary for "Buena Vista" for the time duration of its service life (e.g., 10-20 years) and also for its maintenance period after the service (it could be 20-50 years). This could be a substantially heavy cost burden in operation and maintenance.

c.2 Site Selection

Comparative evaluation presented above are summarized in the table below.

Comparative Evaluation Item	"BV"	"SJV"	Remarks
1. Possibility of Land Acquisition	0	0	possibility of land acquisition should be assured before Phase III
2. Possibility of Neighborhood Consensus	- -	0	residents along the access road
3. Compatibility with Development Plan	0	0	
4. Environmental Acceptability			
i. groundwater contamination	-	0	prevention measures required
ii. flood risk	0	0	
iii. social impacts	- - -	0	residents along the access road
iv. Fauna and Flora	0	-	prevention measures required
5. Economic Feasibility			
i. Land Area Available and Acquisition Cost	0	0	
ii. Access Road Improvement Cost	- - -	0	bridges, culverts, pavement, etc.
iii. Construction Cost	0	0	
iv. Operation and Maintenance Cost	- - -	0	especially leachate treatment and its destination
TOTAL	2nd priority	1st priority	

Note: BV: Buena Vista
SJV: San Jose de la Viuda
0: equal to the other, or baseline to the other
-: disadvantage
- -: considerable disadvantage
- - -: extreme disadvantage

In view of above evaluation in total as summarized in the table above, The team proposes the site "San Jose de la Viuda" as the new landfill site. The main reasons are as follows:

- Neighborhood consensus from residents along the access road to the "Buena Vista" might be difficult to obtain;
- The development of the site "Buena Vista" has the great possibility to cause adverse effect in the future exploitation of groundwater (like La Joya), if complete groundwater protection measures are not included in the landfill facility. Meanwhile such facilities (i.e. leachate treatment) requires huge O&M costs;
- The traffic of waste collection vehicles will create huge social impacts on the residents along the road to the site "Buena Vista";
- The improvement of the access road to the site "Buena Vista" will need considerable cost; and
- Longer haulage distance to "Buena Vista" (than to "San Jose de la Viuda") and independent leachate treatment facilities in "Buena Vista" will continuously require huge O&M cost.

d. San Jose de la Viuda Site Selected

Granada Municipality, after examining the Team's proposal for the site selection presented in the P/R(2), decided to select the site-B (San Jose de la Viuda) as the candidate site for the new municipal SW.

L.1.6.2 Future Waste Amount and Composition

a. Waste Amount

a.1 Forecast Model

The Waste Amount and Composition Survey (WACS) carried out by the JICA Study Team both in rainy and dry seasons was used as a reference in the elaboration of the MSW amount estimate of the Study Area.

The forecast model will include interim estimates for the years 1996, 2000, 2005 and 2010 of the planning period. The types of waste to be forecasted are:

a.1.1 MSW

- Household waste
- Commercial waste
- Market waste
- Institutional waste
- Street sweeping waste
- Bulky waste

a.1.2 Other Wastes

a.2 Factors in Waste Amount Increase

The following factors will have an influence on the future generation of waste and its composition:

- Economic situation
- Social welfare and financial capacity of the single consumers/ families
- Industrial technology
- Import of products

Forecast of waste in the Study Area will be referred to the past data regarding waste amount and composition with the JICA Study Team had conducted for the Study on the Improvement of the Solid Waste Management System for the city of Managua in 1994-1995. Furthermore, from a financial view point (e.g., the GDP), the wastes of Nicaragua should identify with the developing state of the country.

a.3 Methodology for the Forecast-Model

For the type of wastes to be forecasted, the following assumptions were made

a.3.1 Household Waste

The weighed result for the residential areas will be used. Waste generation will be projected based on the number of inhabitants, with a margin for the increase in generation ratio as a result of a GDP increase. However, the ratio of garden waste (grass and wood, and others) will not increase.

a.3.2 Commercial Waste

Waste generation will be forecasted based on the number of shops which will increase in accordance with the increase in population, with a margin for the increase in generation ratio as a result of a GDP increase.

a.3.3 Institutional Waste

Waste generation will be forecasted based on the number of employees which will also increase with the population growth rate, with a margin for the increase in generation ratio as a result of a GDP increase.

a.3.4 Market Waste

Waste generation will be forecasted based on the number of shops in the market which will also increase with the population, with a margin for the increase in generation ratio as a result of a GDP increase.

a.3.5 Street Sweeping

Waste generation ratio will not change and generation will be projected based on the length of the street for sweeping services.

a.3.6 Bulky Waste

The bulky waste was observed at the disposal site in Granada for 2 times during WACS. But the Study Team could not find any bulky waste. In the future, bulky waste may increase gradually in accordance with the growth rate of GDP. However, the amount of bulky waste will be quite small. The Study Team, therefore, neglected the generation amount of bulky waste.

a.3.7 Other Waste

Other waste which directly hauled to disposal site will be forecasted based on the growth rate of GDP.

a.4 Increase in Population

The most direct influence on waste generation is the change in population. The projected population in the Study Area for the planning period are described in **Table L-3** Population Forecast in Granada.

a.5 Relation between GDP and Waste Generation

To determine the relation between GDP and the generation of waste, the increased amount of welfare was taken into account. A strict relation is not expected in advance, but some indication for further analysis may be identified.

An increase in the GDP is expected to have a big impact on the generation of waste per capita of developing countries more than developed countries. Also, at a certain welfare level, increase in GDP will remarkably change the composition of waste.

Japan has fine statistics allowing for the analysis of the relation of GDP and waste generation in a developing economy (1963-1970) and a developed economy (1975-1988). The years 1970-1975 are excluded due to fluctuations in data resulting from a new treatment law and economic recession and instability caused by the oil crisis.

Based on the data of Japan for the period 1963-1970, a developing economy can be characterized as follows:

- Average increase in waste generation per capita: 5.789%/year
- Average increase in GNP*: 10.438%/year

* GNP was used due to unavailability of a GDP.

Based on this figure, the Study Team assume that the change in GDP will affect waste generation as follows:

- Flexibility for a developing economy: 0.55 of GDP-change in %

The average GDP of the Study Area is supposed to develop as follows:

- 1996-1997 +5 %
- 1998-2000 +6%
- 2001-2005 +5%
- 2006-2010 +3.8%

The annual increase in GDP would result to increase in waste generation due to increased welfare. The increase in waste generation per capita per year is, therefore, estimated as:

- 1996-1997 5 x 0.55 = 2.75 %/year Say 2.8 %/year
- 1998-2000 6 x 0.55 = 3.30 %/year Say 3.3%/year
- 2001-2005 5.0 x 0.55 = 2.75 %/year Say 2.8 %/year
- 2006-2010 3.8 x 0.55 = 2.09 %/year Say 2.1 %/year

Accordingly, an average 2.7% increase in waste generation per capita per year will be constantly observed in the planning period 1997-2010.

On the other hand, the garden wastes (such as grass, wood) and cleaning waste (soils, etc.) share about 46% of MSW in Granada respectively) should not increase in future because urbanization and improvement of roads. The Study Team concluded, therefore, the increase in waste generation per capita per year in the planning period in Granada is :

Granada = 1.5% (2.7 x 0.54 = 1.458 say 1.5%)

a.6 Forecast on Waste Amount

Based on the above-mentioned assumption, the forecast on MSW and other wastes shall be presented. A temporary forecast on waste generation ratio in Granada is estimated based on the generation ratio in 1996 and tabulated in Table L-50.

Table L-50: Forecast on Waste Generation Ratio for Granada

Unit : g/unit/day

Year	Granada			
	1996	2000	2005	2010
1. MSW				
1.1 Household	675	716	772	831
1.2 Restaurant	15,109	16,036	17,275	18,611
1.3 Other Shop	1,676	1,779	1,916	2,064
1.4 Institution	98	104	112	121
1.5 Market	2,827	3,000	3,232	3,482
1.6 Street Swept	36,677	36,677	36,677	36,677
2. Other Waste (ton/day)	2.0	2.1	2.3	2.5

In addition, a temporary forecast on the increase of the number of generation source in the Study Area is also carried out based on that in 1996 and tabulated in Table L-51.

Table L-51: Forecast on the Number of Generation Sources in Granada

Year	Granada			
	1996	2000	2005	2010
1. MSW				
1.1 Household Waste	76,250	97,078	114,760	135,106
1.2 Restaurant	45	57	68	80
1.3 Other Shop Waste	471	600	709	835
1.4 Institutional Waste	1,692	2,154	2,547	2,998
1.5 Market Waste	933	1,188	1,404	1,653
1.6 Street Sweeping	35	35	40	47

The Study Team forecasts waste amount generation in Granada and tabulated in Table L-52.

Table L-52: Forecast on Waste Amount Generation in Granada

Unit : ton/day

Year	Granada			
	1996	2000	2005	2010
1. MSW				
1.1 Household Waste	51.5	68.7	87.4	110.5
1.2 Restaurant	0.7	0.9	1.2	1.5
1.3 Other Shop Waste	0.8	1.1	1/4	1.7
1.4 Institutional Waste	0.2	0.2	0.3	0.4
1.5 Market Waste	2.6	3.6	4.5	5.8
1.6 Street Sweeping	1.3	1.3	1.5	1.7
1.7 Bulky Waste*	0.0	0.8	1.2	1.8
Sub-total	57.1	76.6	97.5	123.4
2. Other Waste	2.0	2.1	2.3	2.5
Total	59.1	78.7	99.8	125.9

Note: * assumed 2% of the household waste.

b. Forecast on Future Waste Composition

A change in the composition of waste is expected due to new products, a different consumption pattern and changing lifestyle of people due to economic growth.

There is no data available in the Study Area. The analysis, therefore, focused on the comparison of the data provided by the WACS and other country including Managua, Nicaragua.

In Table L-53, results for household waste and MSW composition from WACS in Granada are compared with the data of Managua, Nicaragua by JICA Study Team in 1994, Rio de Janeiro in Brazil provided by the Applied Research Center of COMLURB (Rio de Janeiro Municipal Public Cleansing Company) in 1991.

To forecast the waste composition, therefore, the Study Team compare the data obtained from WACS with the data of Rio de Janeiro, Brazil because developed economy will be highly effected to the characteristic of wastes.

From Table L-53, there is a big difference in waste composition among 3 cities especially kitchen waste of MSW between Leon (27%), Chinandega (39%) and Granada (51%). As explained in 2.2.3b regarding results of the waste composition survey that all of sampling point in low income residences in Leon recycle their food waste by feeding their own animals or give to other persons. And this also happen in some sampling points of low income residences in Chinandega while a very few sampling point of low income in Granada use their food waste to feed animal. That's why the percentage of kitchen waste among 3 cities is quite difference. Due to this difference, the Study Team decided to use data of each city to forecast waste composition separately.

Referred to Table L-53, the frame of the waste composition in 2010 is set as follows:

- The ratio of combustible contents will decrease gradually. On the other hand, the ratio of incombustible contents will increase.
- The ratio of kitchen waste will decrease from 51% at present to 46% in year 2010 while the ratio of paper and plastic will increase to 10% and 9% respectively in year 2010.
- The ratio of grass and wood will decrease greatly from 23% at the time being to 19% in year 2010. Meanwhile, metal and glass ratios will increase from 1% to 3% in year 2010.
- For textile, ceramic and stone and others (soils, etc.), the percent of these contents are rather stabilized.

Table L-53 shows the forecast on waste composition of MSW in the Study Area.

Table L-53: Forecast on Composition of MSW in Granada

Unit : %

Composition	1996	2000	2005	2010
1. Combustible Content	**88.78**	**89**	**88**	**87**
Kitchen Waste	51.28	50	48	46
Paper	5.78	7	8	10
Textile	1.90	2	2	2
Plastic	6.09	7	8	9
Grass and Wood	23.32	22	21	19
Leather and Rubber	0.41	1	1	1
2. Incombustible Contents	**11.22**	**11**	**12**	**13**
Metal	1.15	2	2	3
Glass	1.14	2	3	3
Ceramic and Stone	4.96	4	4	4
Others (soils, etc.)	3.97	3	3	3
Total	**100.00**	**100**	**100**	**100**

c. Waste Stream

The main factors that will affect the changes in the future waste stream in Granada are:

- changes in waste generation amount;
- changes in waste collection system;
- changes in final disposal system.

The waste stream model below illustrates the flow of waste in Granada and shall also be used as a basis to forecast future waste flow.

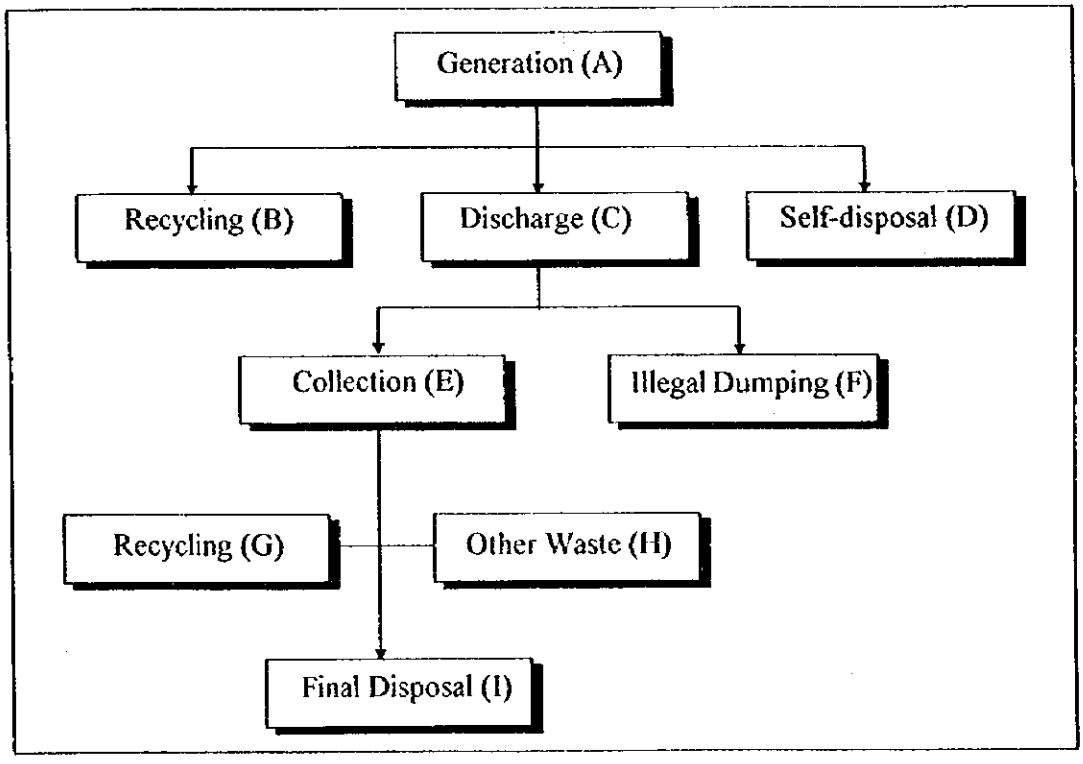


Figure L-24: Waste Stream Model

A: Waste Generation

The waste generation amount is as stipulated in section a.

B: Recycling at Generation Source

The ratio of the recycling amount at generation source to the waste generation amount will be remain until 2010.

$$Bn = An \times B_{1996}/A_{1996}$$

C: Discharge

The waste discharge amount shall be found by subtracting the recycling amount at generation source and the self-disposal amount from the waste generation amount.

$$Cn = An - (Bn + Dn)$$

D: Self-disposal at Generation

The ratio of self-disposal amount to the waste generation amount will decrease 0.5 % per year due to urbanization.

$$Dn = An \times (D_{1996}/A_{1996} - 0.005 \times (n - 1996)$$

E: Collection

The waste collection amount will increase according to the planned waste collection ratio in the master plan.

$$En = An \times \text{planned waste collection ratio}$$

F: Illegal Dumping

The illegal dumping amount will decrease with the increase in collection amount.

$$Fn = Cn - En$$

G: Recycling at Disposal Site

The ratio of recycling amount at disposal site to the collection amount will remain until 2000, but it will disappear from 2001 with the implementation of using the new landfill planned in the master plan.

- until 2000

  $$Gn = En \times G_{1996}/E_{1996}$$

- from 2001

  $$Gn = 0$$

H: Other Waste

Other waste which directly hauled to disposal site will be forecasted based on the growth rate of DGP.

I: Final Disposal

The final disposal amount shall be found out of the formula below.

$$In = En + HIn + Gn$$

From all of the above-explanation, finally, the Study Team concluded the amount of each component in waste stream as shown in Table L-54 and illustrated in Figure L-25 for year 2005 and Figure L-26 for year 2010.

Table L-54: Future Waste Stream in Granada in Year 2005 and 2010

Unit : ton/day

Items	1996	2000	2005	2010
Waste Generation	57.1	76.6	97.5	123.4
Recycling at Generation Source	5.0	6.7	8.5	10.8
Waste Discharge	43.2	59.5	78.2	102.0
Self-Disposal at Generation	8.9	10.4	10.8	10.6
Collection	35.4	48.8	70.4	102.0
Illegal Dumping	7.8	10.7	7.8	0.0
Recycling at Disposal Site	0.5	0.7	0.0	0.0
Other Wastes	2.0	2.1	2.3	2.5
Final Disposal	36.9	50.2	72.7	104.5

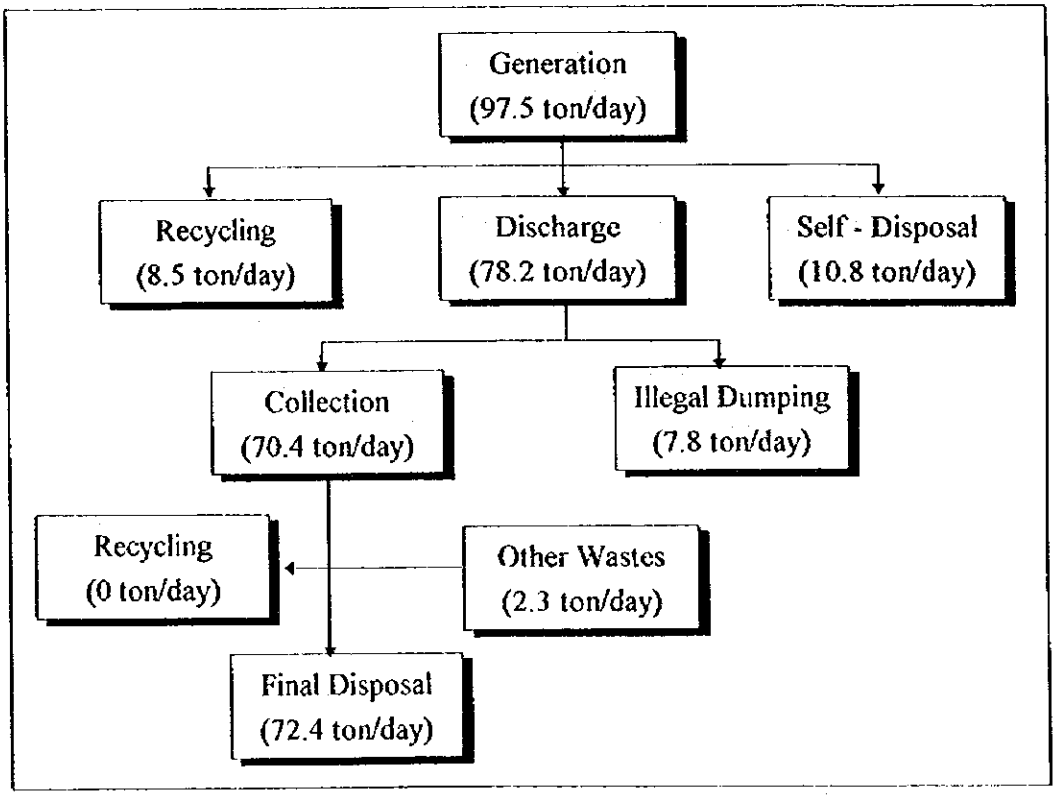


Figure L-25: Future Waste Stream of Granada in 2005

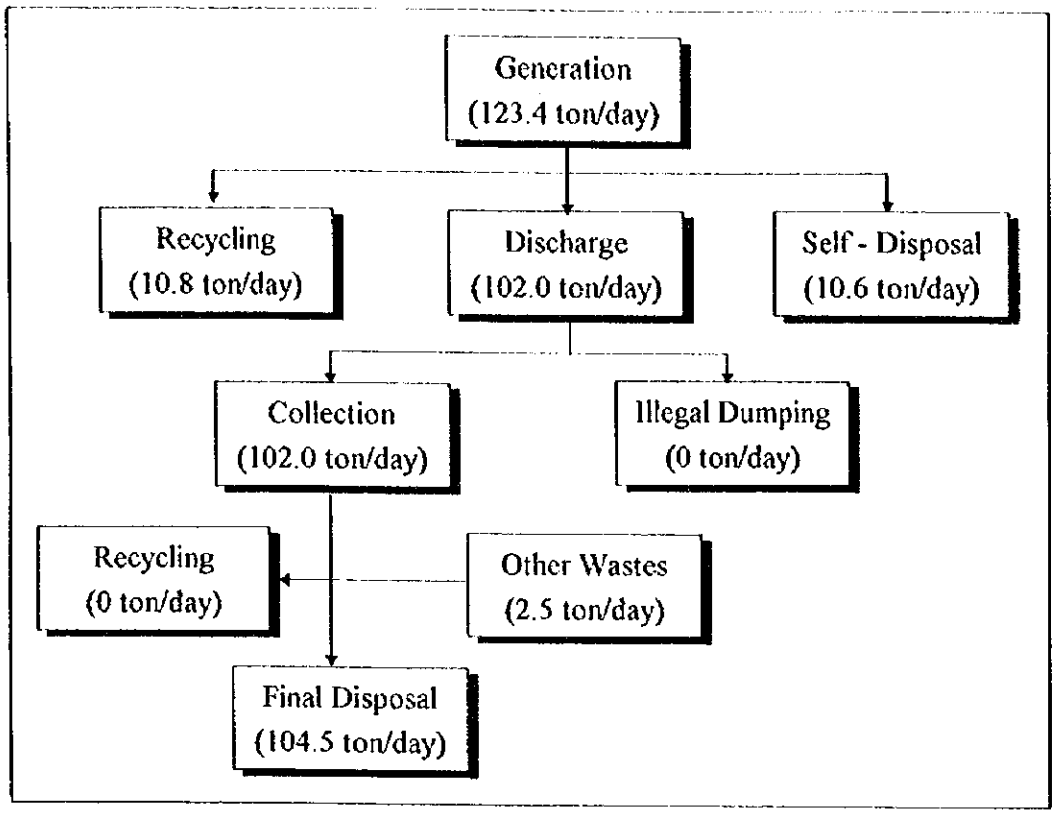


Figure L-26: Future Waste Stream of Granada in 2010

L.1.6.3 Selection of an Optimum Technical System

In this section, technical systems of MSWM is examined to select an optimum technical system which will be proposed in the Master Plan.

L.1.6.3.1 Policy for Selection of an Optimum Technical System

a. Criteria for Selection

Taking the current situation and background of SWM in Granada City into account, the policies for the selection of a technical system are as follows:

1) Systems and technologies to be adopted should be as simple as possible so that operation and maintenance would be easy and inexpensive.

2) The foreign currency requirements for the purchase, operation and maintenance of systems should be minimized. The use of locally available materials and services should be maximized.

3) The use of labor intensive rather than capital intensive techniques should be used where technically feasible and economically viable.

4) Technical system proposals have to be consistent with the institutional requirements should be maxim to ensure their efficiency.

b. Selection Procedure of an Optimum Technical System

An SWM technical system consists of various technical subsystems such as discharge and storage system, collection and transportation system, street sweeping system, intermediate treatment system, final disposal system, etc. A number of alternatives can be formed from the combination of these various subsystems. Hence, selection of the optimum technical system will be carried out according to the following procedure:

1. Preconditions for selection of subsystems
2. Identification of potential subsystem technologies for Granada City
3. Screening potential subsystem technologies
4. Candidate technical systems
5. Selection of an optimum technical system

L.1.6.3.2 Preconditions for Selection of Subsystems

Especially, location of a landfill and a workshop, and road conditions in Granada City should be considered for selecting subsystems.

a. Location of Landfill and Workshop

A site in the northern part of the city was selected for the future landfill. And it is proposed that the existing workshop is to be moved to the next to the new landfill.

These have to be taken into account especially when transportation subsystems are examined, because those location much affects them.

b. Road conditions

The road conditions in the areas located in the periphery of the city and along rivers are very bad. This obstructs a waste collection vehicle to enter those areas. The road conditions have to be taken into account, when a type of waste collection vehicle is selected.

L.1.6.3.3 Identification of Potential Subsystem for Granada

The screened potential subsystems for Granada are listed in the following table.

Table L-55: Potential Subsystems of SWM for Granada

Technical Systems	Technical Sub-systems	Sub-system Components
Discharge and Storage	• Source Separation	• Mixed discharge • Separate discharge
	• Type of Storage Equipment	• Nylon sacks • Plastic bags • Dustbins • On-site storage • Large containers
Primary Collection	• Type of Collection System	• Handcart • Animal cart
Secondary Collection and Transportation	• Collection Frequency • Collection Method	• Mixed collection • Separate collection
	• Type of Collection Service	• Curb collection • Door-to-door collection • Bell collection • Point collection • Public container collection
	• Collection Schedule	• Day collection • Night collection
	• Type of Collection Vehicle	• Compactor truck • Tractor and trailer • Tipper truck • Skip truck
	• Transportation System • Transfer Station	• Motor vehicle
Street Sweeping	• Cleaning Method	• Manual street sweeping • Mechanical cleaning
Intermediate treatment	• Composting	• Centralized composting plant • On-site/community based composting
Recycling	• Government Related • Private Sector Centered	
Final Disposal	Method of Sanitary Landfill	
Maintenance of Vehicles and Equipment	• Preventive Service Workshop • Full Service Workshop	

L.1.6.3.4Screening of Potential Subsystems

a. Discharge and Storage System

Generally, storage for solid waste is difficult to be controlled by the municipality because a way of waste storage vary with life style of people. But waste storage has to be done under good sanitary conditions, because it quite affects public health and aesthetic conditions.

Discharge much influence a subsequent technical system, or a collection system. The use of various kinds of receptacle and inadequate receptacles has the efficiency of collection and sanitary conditions decrease. And needless to say, waste has to be discharged at designated date and time for collection.

Consequently, discharge and storage should be done under a certain control by the municipality.

Present Situation

People are using various kind of receptacle for waste storage and discharge, e.g. nylon sack, plastic bag, plastic box, metal box, cardboard box, etc. This makes collection of household waste difficult very much. Although the municipality promote people to use plastic bag for reasons stipulated in the section of plastic bag, almost the low income people has still been using other receptacles because the price of a plastic bag is not affordable for them. It costs around 0.5C$.

For commercial waste and institutional waste, a plastic bag and a drum are well used.

In market places, a drum is considerably used. But waste scattered on roads is often observed even though drums are placed.

Potential Storage System

The applicability of the use of the following five storage systems which are commonly used in many countries and Granada are discussed hereinafter.

- Nylon sack
- Plastic bag
- Dustbin and Drum
- On-site refuse storage
- Large containers

There are a wide range of issues to be considered in the selection of the most appropriate storage system for Granada. The examples are as follows:

- amount of waste,
- composition of waste,
- collection frequency,
- a point where a receptacle is placed,
- workability for loading waste onto a vehicle,
- safety for a collection worker,
- durability of a receptacle to misuse, rough weather, and an animal,
- cost of a receptacle
- social custom.

a.1 Nylon sack

This subsystem, using a nylon sack as a receptacle of waste, can be often seen in Granada, especially for household waste. Its capacity is around 50 liters. And this is used as a reusable receptacle.

Advantage

- The receptacle is one of the most cost-effective ones due to reusable.

- The receptacle does not require much labor for loading onto a truck due to light in weight.

Disadvantage

- The subsystem requires considerable labor and time when waste is taken out of the receptacle.
- The subsystem exposes a collection crew to unsanitary conditions when waste is taken out.
- The receptacle requires periodical washing to preserve it sanitary.
- The receptacle can be torn by cats, dogs, etc., then, waste is scattered.

Applicability

The most strong point of the subsystem is cost-effective. The receptacle is cheep, or it can be often got without payment at a shop.

But it has to be taken into account that the subsystem requires a certain time for collection. This gives negative effect on a collection system.

Consequently, the subsystem is recommended at an early stage up to using plastic bags. Especially, the system is suitable for inhabitants who can not afford plastic bags.

a.2 Plastic bag

The subsystem, using a plastic bag as a receptacle of waste, has been increasingly seen in Granada. It has to be considered that the subsystem does not only affects a subsequent system, but also final disposal, because a plastic bag is taken to a landfill with waste.

Advantages

- The system is very sanitary because a plastic bag is collected with waste.
- The system is labor and time saving because a plastic bag are light in weight and disposable with waste.

Disadvantages

- The subsystem requires the continuous purchase of bags.
- The use of expendable slightly increases the waste generation amount.
- The receptacle can easily be torn by cats, dogs or when too full, then, waste is scattered.

Applicability

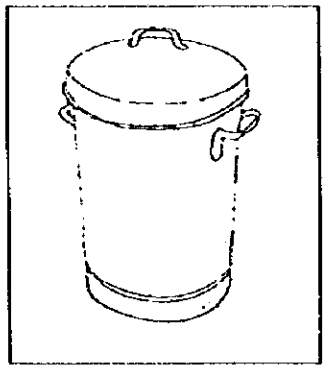
Although the receptacle requires less capital, the expenditure for its continuous purchase usually exceeds the expenses for acquisition and maintenance of a permanent container.

It has to be appreciated, however, that the subsystem is one of the most sanitary discharge and storage systems, if the receptacle is not tore. Especially, the system less risk a collection crew's health. And what the receptacle is tore can be prevented by an appropriate way of discharge, e.g. to discharge waste at designated date and time.

As a conclusion, the only point that is critical to the selection of this subsystem is cost. Although there may be difficulties in enforcing the use of this system in view of cost, it is recommended in case of affordable.

a.3 Dustbin and Drum

Dustbins herein refer to all small-size containers with lids, ranging from 30 liters to about 120 liters in size. One man can reasonably lift and empty containers weighing up to about 28 kg (70 liters), while two men are required to lift a 48 kg (120 liters) container.



The dustbins may be made of galvanized steel or high density polyethylene and must be weather resistant. In Granada, a simple half cut empty drum can be often seen as a dustbin.

Advantages

- The subsystem provides sanitary conditions because wastes stored can be completely covered.
- The subsystem maintains aesthetic conditions.
- The subsystem lasts for more than several years.

Disadvantages

- The subsystem requires a large initial investment for the purchase of dustbins.
- Dustbins require periodical washing to maintain their sanitary condition.
- Dustbins are easily stolen because of their usefulness.

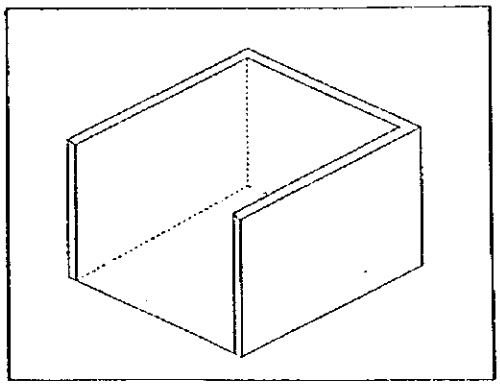
Applicability

In contrast with the use of a sack and a plastic bag, this system is less expensive in the long run, but initial investment is considerably expensive. This makes it difficult to introduce the subsystem into a household. But, taking the advantage of the subsystem into consideration, the subsystem is recommended for commercial waste in case of affordable.

Meanwhile, a simple half drum is recommended as a receptacle at a station for point collection in case that a community can well control the place, because it is fairly cheaper and well suited to a point collection subsystem.

a.4 On-site refuse storage

The on-site refuse storage is commonly made of bricks and mainly used to store communal refuse.



Advantages

- The subsystem is durable enough to last more than 20 years.
- The subsystem prevents large amount of waste from scattered.

Disadvantages

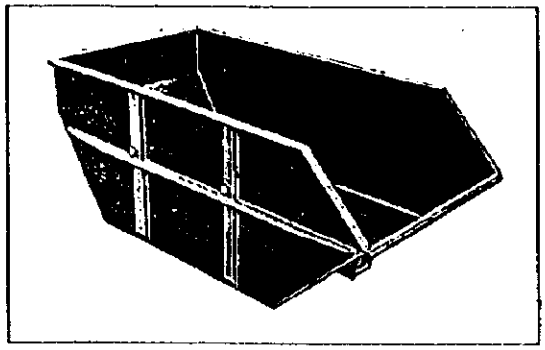
- The system requires a huge capital.
- The subsystem requires close monitoring for the maintenance of sanitary conditions and the prevention of squatting.
- The subsystem requires space.
- It is very difficult to select a location for on-site refuse storage because it is a permanent facility and it might cause public nuisance.
- The subsystem makes loading of waste on refuse collection trucks very difficult.

Applicability

The subsystem requires huge initial investment and sufficient maintenance. And the subsystem is well suitable for large amount of waste. It is, therefore, recommended for market waste.

a.5 Large containers

A container measuring 5 - 20 m^3 or bigger is suitable for an area generating large amount of waste. A special purpose vehicle is required for lifting, transporting and emptying a such container. And the subsystem requires sufficient room for vehicle to change a container to a empty one.



Advantages

- This system is durable enough to last more than several years.
- This system can curtail collection and transportation costs because it minimizes loading time.

Disadvantages

- This system requires a huge capital.
- This system requires special vehicles for lifting, transporting and emptying containers.
- This system requires space for placing and lifting containers.
- Irregular collection can cause unsanitary conditions i.e. huge amount of waste left is immediately spoiled, then this promote vectors to generate.
- The subsystem requires close monitoring for the maintenance of sanitary conditions and the prevention of squatting.
- The subsystem often makes it difficult due to its height that children discharge waste to the container.

Applicability

The required capital is too big as this subsystem does not only require containers but also special vehicles as well. This system would be financially too difficult to introduce to Granada by the municipality itself. It should be, however, appreciated that this subsystem makes collection and transportation costs reduced. Therefore, its introduction shall be taken into consideration together with the collection and transportation system.

a.6 Conclusion

- For household waste, a plastic bag is recommendable due to its contribution to sanitary conditions, especially what this subsystem less risk health of a collection worker is much appreciated. A nylon sack is also recommendable for people who can not afford plastic bags.
- For commercial waste, a plastic bag is recommendable for the same reason as the above. Besides a plastic bag, a dustbin is suitable to commercial activities with its sanitary advantage.
- For institutional waste, a suitable receptacle depends on amount of waste generated. It should be chosen out of a plastic bag, a dust bin and a container.
- For market waste, on-site storage and a container are recommendable due to huge amount of waste generated daily.

Although some subsystems are recommended for each waste generation source, they have to be further examined in view of an integrated system.

b. Primary Collection

In an inaccessible area for a collection truck, waste has to be carried to a designated point for collection.

Present Situation

At present in the market nearby 'Tallar Depot', handcarts are used well because many shops flood to the surrounding roads, this makes a collection truck obstructed to access the market. Waste generated in the market is carried by the handcarts to 'Tallar Depot', then it is transported to 'La Joya' landfill by trucks.

Handcarts are also used for collecting commercial waste. Many shops are concentrated at the central of the city where is not so far from 'Tallar Depot, and the roads often becomes congested. Therefore, handcarts are very suitable for a primary collection in the area.

Furthermore, handcarts are well used for street sweeping.

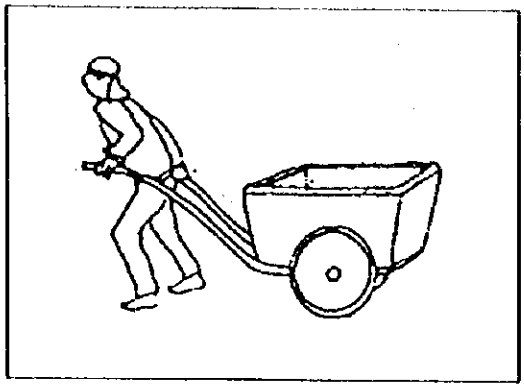
Potential Primary Collection System

Although there are some subsystems of primary collection system such as a handcart, an animal drawn cart, pedal cart, a motorized cart, a motorized tricycle and so on, only the following two subsystems are discussed in this section in view of the present situation.

- Handcart

- Animal Drawn Cart

b.1 Handcart



Handcarts are commonly used in developing countries for various purposes. In Granada, they are widely used to carry various kinds of loads. And actually, they are used for collecting waste .

Handcarts are used in developing countries for daily house-to-house collection, in particular, collection along very narrow streets. Typically, handcarts are made of open boxes that are attached to a frame, and the only way of emptying the cart is to discharge the load on the ground. The typical radius of operation of a handcart is about 1 km.

Advantage

- A handcart does not require high initial investment.
- Operation and maintenance of handcarts does not require special skill.
- Operation and maintenance cost is not expensive.

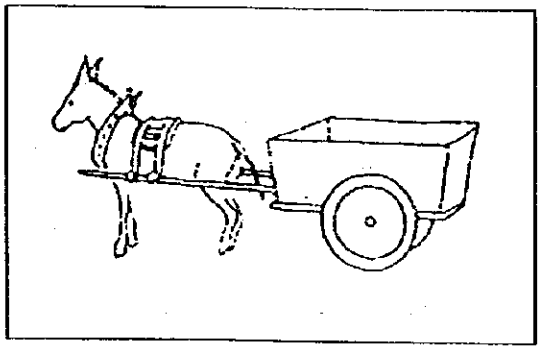
Disadvantage

- Operation radius is limited.
- Weight handcarts can deal with is limited.

Applicability

As actual usage shows, a handcart is suitable for the market, the commercial area and street sweeping in Granada. But, when it is introduced, a transfer station should be planed for collection and transportation.

b.2 Animal Drawn Carts



Horses were widely used in North America and in Europe for door-to-door refuse collection up until World War II. In Japan, cows were used for waste collection until the 1960s. Horses, mules, donkeys and cows are still used in several countries around the world. The capacity of draught animal carts generally ranges between 2 and 4 m^3. In some cases, the carts are equipped with bodies that can be tipped, by

either pivoting the body or by using a manually-operated worm and nut mechanism. The effective radius of operation is about 3 km[5]. Animal carts have the following advantages and disadvantages:

Advantages

- no consumption of fossil fuels
- quiet operation

Disadvantages

- It is less maneuverable than human handcarts.
- The required capital cost is higher than human handcarts.
- Animal carts may interfere with traffic.

Applicability

In the market, this subsystem can not apply because an animal drawn cart is too big to enter the market. And also the subsystem is inappropriate for the commercial area and street sweeping, as it may obstruct traffic.

This subsystem might be appropriate for the area in which the roads are very bad condition, so that a vehicle can not enter the area.

When this subsystem is introduced, a transfer station has also to be taken into account.

b.3 Conclusion

Although handcarts are suitable for the market of which the present unsanitary conditions require the subsystem, the conditions themselves should be improved. For commercial waste, handcarts are not always a good way as a primary collection service, because collection trips become so many times, this cause operation cost to be expensive.

The use of an animal drawn cart is not always an appropriate way for the same reason as the above.

Consequently, the usage of handcarts and animal drawn carts is considered inappropriate in view of long term. But in short term improvement, it should be taken into account.

c. Collection and Transportation

The objective of waste collection and transportation system is to collect and to transport waste from specific locations to a disposal site at regular intervals, at a minimal cost and in a reliable manner, with due considerations of sanitary conditions. It is very important to always bear in mind that the cost for the collection and transportation of waste is by far the most expensive part of the overall waste management system.

The collection and transportation system is mainly affected by the following aspects:

[5] "Solid Waste Management for Economically Developing Countries", L. F. Diaz et. al., ISWA and CalRecovery, 1996

- collection frequency
- collection method (mixed or separate)
- collection system
- collection schedule
- collection vehicle
- transfer system

c.1 Collection Frequency

Collection frequency is determined in view of sanitary conditions and operation and maintenance cost. As for organic waste, the more frequent collection is carried out the better in terms of sanitation. However, because this would mean more costs, collection frequency should be minimized as long as sanitation is maintained.

Considering its climate, high temperature and humidity (in the rainy season), and waste composition including high percentage of organic waste, a twice or thrice a week collection is recommended for Granada. Daily collection is inappropriate because of high cost.

c.2 Mixed or Separate Collection

A separate collection system is required by introducing intermediate treatment technologies. Introduction of incineration technology requires separate collection of combustibles and non-combustibles. Composting requires separate collection of organic and inorganic materials, while recycling requires separate collection of recyclable and unrecyclable materials.

The separate collection system requires additional costs because it necessitates more storage space, and reduces waste collection and transportation efficiency.

Another issue to be kept in mind is people's willingness to cooperate in source segregation. To promote people's consciousness on source segregation, it will be necessary to conduct public education and motivation programs.

In principle, mixed collection should be implemented in Granada because no intermediate treatment technologies are employed.

However, the study acknowledges the importance of conducting a separate discharge system, even without a separate collection system, to succeed in the introduction of a separate collection system at an early stage in the future.

c.3 Collection System

The town structure, and the present use of the area are the main factors to consider the appropriateness of the collection system.

Table L-56: Summary of Collection Systems

Collection System		Summary
Point Collection		Dischargers carry their own waste to specified waste collection points; discharged wastes are later collected by refuse trucks.
Curb Collection		Each household is responsible for placing the containers at the curb on collection day and for returning them to their storage location.
Door to Door Collection	Set-out - Set-back	Containers are set out from the premises and set back after being emptied by collection crews
	Set-out	Set out collection is essentially the same as set-out-set-back collection, except that residents are responsible for returning the containers to their storage location.
	Backyard Collection	The collection crew enters the premises and collects wastes from their storage location.
Bell Collection		The collector calls out to the residents to discharge their waste upon the arrival of collection vehicle at a given collection point.
Public Container Collection		Residents discharge waste regardless of collection day. This collection method produces a high collection efficiency.

In Granada, mainly a curb collection system are employed. However, this system is inappropriate in areas where road conditions are so bad that collection vehicles can not enter. Therefore, a point collection system is recommended to realize collection in those areas.

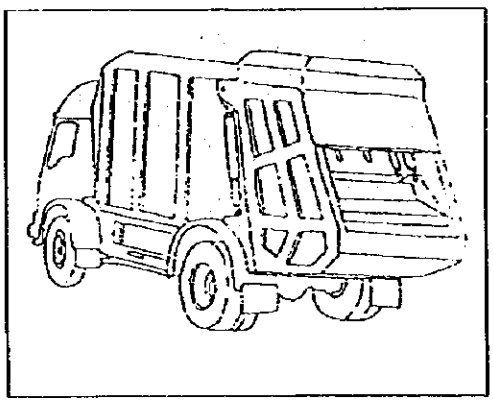
c.4 Collection Schedule

Setting a proper collection time is important to achieve an effective collection system. There are many factors to be considered to plan a collection schedule such as traffic, current town structure, social custom etc. Especially, traffic is a main factor as waste collection is carried out by vehicles mainly.

In Granada, traffic problems do not become conspicuous so much except the commercial area. Therefore, collection activity can conduct in the areas other than the commercial area in the daytime. In the commercial area, the center of the city, the collection schedule and system should be further examined, e.g. early morning collection or night collection.

c.5 Collection Vehicle

c.5.1 Compactor Truck



The use of rear end loading compaction vehicles have become the norm in many industrialized countries, where they are designed specifically for the following purposes:

- Maximization of productivity of highly paid labor force.
- Compaction of low density wastes to achieve higher payloads.

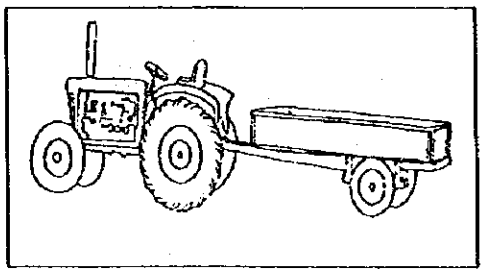
In industrialized countries, these compaction vehicles are used to haul 100 to 200 kg/m^3 density waste at collection points. The waste collected is compacted up to around 500kg/m^3 at the inside of the vehicle. To justify the introduction of such a vehicle, the volume of waste should be reduced to 1/2 to 1/4.

In Granada, the ASG's acquired out of WACS are 0.24-0.27 in household waste, 0.36-0.40 in restaurant waste, 0.43- 0.53 in market waste, 0.03- 0.04 in institution waste, and 0.07-0.08 in shop waste. Shop waste and institution waste are suitable for the vehicle due to its low density. The generation sources of those waste gather at the center of the city (the commercial area). Furthermore, the roads in the area are well paved, this contributes introduction of the vehicle because bad road conditions cause the vehicle to often be broken. Therefore, the vehicle is the one of the appropriate ones for the commercial area even though restaurants are located in the area.

One of the potential problems associated with using compactor trucks will be maintenance. The maintenance of compactor trucks require a higher level of technological skill. The present situation of the work shop can not meet with the demand. Therefore, the maintenance ability of Granada has to be improved when the vehicle introduced.

c.5.2 Non-Compaction Vehicle

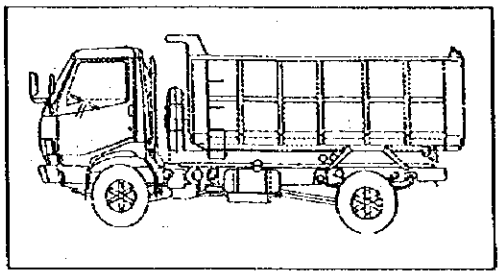
Tractor and Trailer



Tractors and trailers can be useful in certain areas close to a landfill. They can be useful for traveling over rough roads and can be used in connection with street sweeping services.

However, tractors is designed for multipurpose use in agricultural lands, not specified for the waste collection work in an urbanized area. Therefore, the efficiency of them is considered low compared with trucks.

Tipper Truck



Tipper trucks are fairly basic and do not incur excessive maintenance costs.

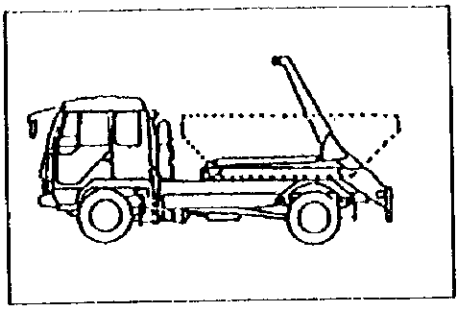
Tipper trucks are effective for loading large heaps of waste with a wheel loader. However, the accumulation of waste heaps in the streets is neither environment-friendly nor economical. The use of tipper trucks is less productive because of the considerable time consumed for waste loading activities.

Loading is normally carried out manually, hence it is extremely slow and tiring due to the considerably high loading elevation. When loading, waste is handed over from the ground to the workers inside the truck who pack the load. Further, the loading operation is unhygienic.

However, because of its wide applicability and ease in maintenance, tipper trucks should be consider to be introduced especially to bad road conditions' area, i.e. the periphery

areas and the areas along rivers. When the vehicle is introduced, a collection systems compensating for the disadvantage should be well examined.

Container Truck



A wide range of container trucks are available, handling containers from 1 to 30 m^3. These trucks are highly productive since they can load a container within a few minutes.

The container truck itself is cheaper than a compaction truck and can achieve a higher payload in the course of a day than any non-compaction vehicles.

The containers may be manufactured locally, the system is robust and can handle a wide range of wastes. The vehicles are easy to maintain compared with a compactor truck.

As mentioned above, the vehicle is very efficient for transportation especially in the economic aspect. However, the disadvantages of a container as a receptacle for storage have to be taken into account.

In view of amount of waste generated, this system is recommendable for markets and other sources which generate much amount of waste.

c.6 Transfer System

Generally, transfer of waste is considered when a transport distance is more than 20km (one way). The candidate site for landfill is located within 5km from the city center, so that it is not necessary to consider a transfer system in Granada.

c.7 Conclusion

Compactor trucks are recommendable for the central part of the city due to the well road conditions and density of waste collected in the area.

For the periphery areas and the area along rivers, tipper trucks are recommendable in view of road conditions.

For market waste, container trucks are recommendable due to its huge amount. But tipper trucks are suitable if on-site storage is chosen as a storage system.

However, various kinds of vehicles should not be introduced to not a so big city like Granada. It makes operation and maintenance of vehicles difficult and expensive, as they are hardly compatible and to storage a lot of kinds and a number of spare parts are required. Consequently, considering the above recommendations as basic ideas, types of trucks introduced should be further examined in view of a integrated system.

d. Street Sweeping

Street sweeping is one of the most visible services by municipalities. What whether street sweeping is done well or not influences the credibility of municipal leaders and local officials. Visitors instinctively rate municipalities based on their external conditions, i.e. cleanliness. Dirty cities cannot attract foreign investors and tourists. These ideas should be positively used to stimulate residents to build a better city.

Street sweeping programs were conducted mainly to remove litter and dirt so that streets appear presentable, and traffic will not create dust. In some areas particularly, regular street sweeping is necessary to prevent sewers from becoming clogged. It is also recognized that dirt is a potential pollutant of particulate matter.

For Granada, street sweeping is very important in view of tourism, because the city regard tourism as important industry. Therefore, street sweeping should be well conducted.

d.1 Manual Sweeping

Manual street sweeping is by far the oldest method. However, it still retains certain advantages as follows:

Advantages

- low capital
- great flexibility of operation
- applicable to cleansing of areas where debris accumulation is most frequent
- makes cleaning beneath parked vehicles possible
- makes cleaning rough cobble stone pavements possible
- produces less noise
- creates more job opportunities
- requires a minimum equipment repair and maintenance costs

Disadvantages

- difficulty in supervision
- dangerous under heavy traffic conditions

Applicability

As the present situation proves, i.e. the central part of the city covered with the municipality's street sweeping is well clean for its insufficient equipment, the manual sweeping functions effectively in Granada City.

d.2 Mechanical Sweeping

Typical sweeping vehicles are equipped with self-propelled sweepers and water sprinkler.

Advantages

- great productivity
- low manpower requirement
- ensures safe operation

Disadvantages

- huge capital
- high maintenance cost
- low flexibility of operation
- difficult to conduct in narrow areas
- produces lots of noise
- difficult to conduct under heavy traffic

Applicability

Mechanical Sweeping is generally the cheapest sweeping method for wide roads. This method is generally suitable for roads exceeding 6m in width. However, almost all the roads requiring street sweeping in the city are within 6m width. And the houses are not apart from the roads, this may bring residents' complaint about noise. Consequently, mechanical sweeping is not suitable for Granada.

d.3 Conclusion

Manual sweeping is recommendable because of the effectiveness of the existing way, i.e. manual sweeping using handcarts, and the feature of the roads in the city.

e. Intermediate Treatment

There are some options as intermediate treatment ways such as incineration, production of Refuse-Derived Fuel (RDF), pyrolysis, composting, size reduction, mechanical sorting and scavenging, etc. However, only composting is the subject of discussion in this section, because huge initial investment and O&M costs are required or valuable fractions are needed as compositions in the waste to realize other options practically.

e.1 Composting

Waste composting is a method to achieve microbiological degradation of organic matter (household and vegetable wastes, garden wastes, etc.), to produce a recycled organic product for use in agriculture, gardens, parks, etc.

The most important technical issue about composting concerns the precise nature of the product. Compost is not a fertilizer but a soil conditioner. It does contain some plant nutrients but its value lies primarily in that it improves the soil structure by introducing humus, promotes microbial activities, and can help to retain fertilizers and moisture in the soil. Before being offered for sale, it is important that the product is sterile and free from pathogens that could be harmful to crops and people. To achieve this, it is important to control temperature and moisture content to enable the necessary stages of decomposition to take place correctly, in order to sterilize the product.

The technology of composting municipal waste is well-established, and operating experience and information are available in great detail. Most essential for achieving success is that the waste is sorted in a "green fraction" e.g. organic waste and a fraction that is not appropriate for composting e.g. plastics, glass, metals, etc. Sorting may be conducted at a central composting plant or at the source.

Waste in Granada is clearly compostible, and this can be achieved by a simple windrow system or in some other mechanized plant, provided proper sorting is carried out prior to composting.

There are several composting methods. Most common are the following:

- Centralized composting plants
- On site composting

The methods are briefly described as follows.

e.1.1 Centralized Composting

Two main types of composting plants are as follows:

- Plants using open-air fermentation in windrows
- Plants using some kind of digester before being placed in windrows.

Both plants require the removal of non-compostable materials like metals, plastic, glass, stones, etc., prior to composting.

The two composting plants are briefly described below.

Windrow Composting

After sorting and before being placed in windrows, the waste is ground e.g. in a hammer-mill and the water content is adjusted to the optimum weight level of approximately 55 %.

The homogenized waste is placed in windrows which are approximately 2m high, for a period of up to 9 weeks. Every 2-3 weeks the windrows are turned and during this process the water content is adjusted. The operator must make sure that all materials in the windrow are exposed to its high temperature by checking whether materials previously on the surface of the windrow shift to the central part after turning. Turning can be performed either by front-end loaders or by special turning machines.

Depending on the final application, the mature compost may be sieved using screens with coarse or fine meshes.

Digester/Windrow Composting

After the sorting process, the compostable part of the waste is treated in a mechanical digester to provide optimum conditions, and hence accelerate the composting process.

A number of mechanical digesters are available in the market. Probably one of the most successful is the Dano-drum. This system involves the use of a large, slowly rotating drum and the required grinding, watering and aeration of the waste takes place in the horizontally rotating drum furnished with knives. Material is injected in one end and after one to three days of slow rotation is ejected from the opposite end of the machine where the material is sieved by a coarse screen. Air is injected into the interior of the drum to ensure constant supply of oxygen. The water may be subsidized by wet sewage sludge, increasing the nutrient content of the finished compost.

The homogenized waste is placed in windrows for a period of 1 to 2 months -- one month if the material is turned occasionally.

e.1.2 On Site/Community-Based Composting

Composting is a natural process which does not require sophisticated equipment. Any farmer or garden owner may produce compost by turning and watering a pile of organic wastes.

The pile must be sufficiently large to avoid rapid drying-up and small enough not to turn anaerobic. The pile must be mixed thoroughly three or four times a week or every other 3 weeks depending on the actual climatic conditions after which it may be used as a soil conditioner or as a fertilizer when mixed with manure or sewage sludge.

e.1.3 Market for Compost

A centralized composting plant is operated in Masaya, it is located next to the existing landfill of the city. According to the information from the supervisor of the plant, the present situation about the compost's market is as follows:

- Compost is sold at 15C$ per sack (100 pound), including the cost of the receptacle, excluding the transportation cost.
- O&M cost is around 17C$ per sack.
- The total sold number is around 12,000 sacks per year, especially in April and May it is well purchased.
- Advertisement of compost was done well, and the number of farmers who buy compost are increasing nowadays.

e.1.4 Recommendation on Composting

The use of a centralized, large mechanical composting plant like the ones adopted in Japan, Europe, and the United States, is currently considered inappropriate for Granada. It is not only extremely capital intensive, but also requires high operation costs as well as highly skilled labor force.

The introduction of a decentralized, community-based small composting units may be feasible in Granada due to the feature of the waste, i.e. the waste in Granada mainly consists of organic fractions.

However, it is difficult to make composting economically feasible, as the information from Masaya indicates. Therefore, it is necessary to conduct a small pilot facility for the production of compost on a limited scale for distribution before constructing community-based composting units.

e.2 Conclusion

No intermediate treatment technology is recommended for Granada in view of the city's current conditions. On-site/community based composting system may be adopted if there is a demand for compost. Promotion of on-site/community based composting for private use and not for sale may be a suitable means of promoting self disposal.

f. Recycling

The primary benefits of recycling are conservation of natural resources and landfill space; however, the collection and transport of materials requires substantial amounts of energy and labor. The requirements for a successful recycling activity are that a strong demand exist for recovered materials and that the market value of the materials be sufficient to pay for collection and transportation costs.

f.1 Composition of Recyclable Waste

Table L-57 shows the surveyed waste composition of Granada, the standard waste composition of industrialized countries and the United States. This comparison clearly shows that the present composition of recyclable waste in Granada is far less than that of industrialized countries: 16 % in Granada, 27-80 % in industrialized countries, and 67.5 % for the United States.

Table L-57: Comparison of Waste Composition

	Granada in 1996	Industrialized Countries	United States in 1990[b]
Kitchen	49.84 %	20-50 %	9.0 %
Paper	5.29 %	15-50 %	40.0 %
Textile	1.98 %	2-10 %	2.0 %
Plastic	6.11 %	2-10 %	7.0 %
Grass/Wood	24.90 %	-	20.5 %
Leather/Rubber	0.29 %	-	1.0 %
Metal	1.11 %	3-13 %	9.5 %
Glass	1.05 %	4-12 %	8.0 %
Ceramic/Stone	5.21 %	1-20 % (including others)	3.0 % (including others)
Others	4.22 %	-	-
Total	100.00 %	100.0 %	100.0 %

Note: Screened items are recyclable wastes.
Source:
[a]: "Integrated Resource Recovery, Recycling form Municipal Refuse: A state-of-the-art Review and Annotated Bibliography", UNDP Project Management Report Number 1, S. Cointreau, et. al. 1985
[b]: Integrated Solid Waste Management, Engineering Principles and Management Issues, G. Tchobanoglous, et al, McGraw-Hill, 1993

f.2 Recycling System

Recycling systems may be divided into two types in terms of executing bodies: government related recycling system and private sector centered recycling system.

f.2.1 Government Related Recycling System

Government related recycling system are carried out as a means of economically controlling solid waste generation. This system obliges dischargers and collectors to conduct additional work such as waste segregation and sorting, separate discharge, separate collection and transportation.

Therefore, this system can be adaptable for countries where the cost for developing a new landfill exceeds one for additional work. Namely, this can be applied for industrialized countries.

Consequently, this system is not the case in Granada.

f.2.2 Private Sector Centered Recycling System

The municipality has an indirect and limited role in the promotion of this recycling system. Private sectors operate the activity on their own responsibility. However, this can contribute the reduction of waste amount to be disposed, i.e. this makes the cost of waste disposal reduced.

f.3 Conclusion

As the recyclable compositions rate (17%) shows, the waste generated in Granada can not make the introduction of a government related recycling system feasible.

However, recycling should be encouraged in view of waste reduction and resource conservation.

g. Final Disposal

Upon consideration of the possible system alternatives for final disposal, the following aspects are to be taken into account:

- location and number of final disposal sites
- final disposal methods
- landfill structure
- level of sanitary landfill development and operation

g.1 Location and Number of Final Disposal Site

The candidate site for final disposal site is located in northern part of the city. The future landfill in Granada is this one only.

g.2 Final Disposal Method

The final disposal methods can be divided into the following three types:

- open dumping
- controlled tipping
- sanitary landfill

Although the open dumping method is generally employed in the existing disposal site, 'La Joya', this operation must not be adopted to the new landfill in view of its adverse effects on landscape, public health and the environment.

Sanitary landfill should be adopted as it has been proven to be the most economical final disposal method in terms of controlling environmental impacts within the acceptable level.

The advantages of sanitary landfill are as follows.

- Where land is available, sanitary landfill is usually the most economical solid waste disposal method.
- Sanitary landfill is not investment intensive compared with other disposal methods, i.e., composting and incineration.
- In contrast to incineration and composting, sanitary landfill does not require additional treatment or disposal operations for residue, quenching water, unusable materials, etc.
- A sanitary landfill can receive all types of solid wastes, eliminating the necessity for separate collections.
- A sanitary landfill is manageable; increased quantities of solid wastes can be disposed of with a minimum number of personnel and equipment.

- Submerged land may be reclaimed for use as parking lots, playgrounds, golf courses, botanical gardens, etc.

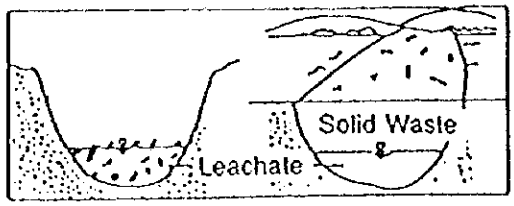
g.3 Landfill Structure

There are five types of landfill structure as shown below.

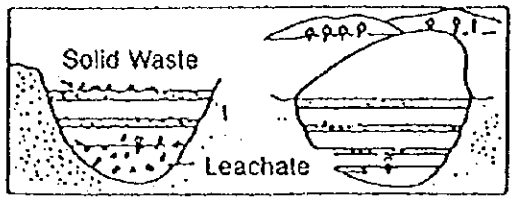
- anaerobic landfill
- anaerobic sanitary landfill
- improved anaerobic sanitary landfill
- semi-aerobic sanitary landfill
- aerobic sanitary landfill

Either of the above landfill structures contribute to the mitigation of environmental pollution. Figure L-27 illustrates each of the above landfill structures.

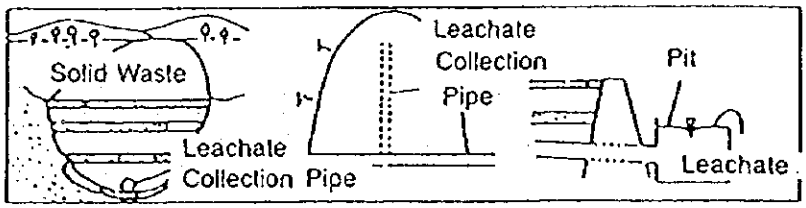
ANAEROBIC LANDFILL



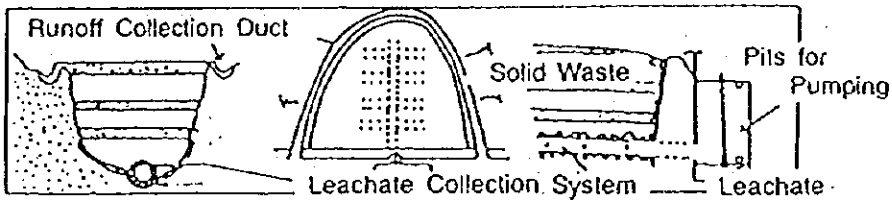
ANAEROBIC SANITARY LANDFILL



IMPROVED ANAEROBIC SANITARY LANDFILL
(IMPROVED SANITARY LANDFILL)



SEMI-AEROBIC LANDFILL



AEROBIC LANDFILL

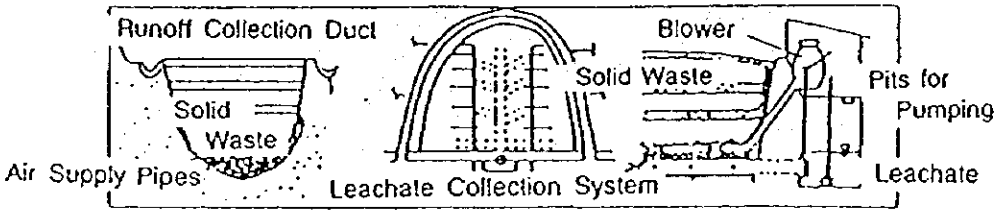


Figure L-27: Landfill Structure

Anaerobic landfill

As leachate generated in landfill layers is hardly drained, the landfill layers constantly maintain anaerobic condition. The quality of leachate is very poor, causing bad odor and propagating vectors and vermin.

Anaerobic sanitary landfill

Covering soil is applied on each layer of waste thereby preventing the outbreak of bad odor and incidental fires, and the propagation of harmful insects to a certain extent. However, leachate and gas generation problems remain.

As in anaerobic landfill, the landfill layers maintain anaerobic conditions.

Improved anaerobic sanitary landfill

In addition to covering soil, this landfill structure is constructed with a leachate drainage facility at the bottom of the disposal site. Leachate quality is improved and anaerobic conditions are maintained.

Semi-Aerobic sanitary landfill

Leachate quality is favorably improved with constant drainage. Drainage pipes stimulate natural ventilation, achieving aerobic conditions in the landfill layers and consequently accelerating solid waste decomposition.

Aerobic sanitary landfill

In addition to the drainage pipes used in semi-aerobic landfills, air supply pipes are introduced for forced air injection to achieve aerobic conditions in the layers, thereby accelerating solid waste decomposition and stabilization and improving leachate quality.

In view of the above advantages and disadvantages, the final disposal sites proposed in the Master Plan shall have a semi-aerobic sanitary landfill structure with leachate drain pipes.

g.4 Level of Sanitary Landfill Development and Operation

The sanitary landfill development and operation levels are classified as follows:

- Level 1, Controlled tipping
- Level 2, Sanitary landfill with dike and daily soil covering
- Level 3, Sanitary landfill with primary leachate circulation system
- Level 4, Sanitary landfill with leachate treatment system

The prospective sanitary landfill development and operation levels are illustrated in Figure L-28.

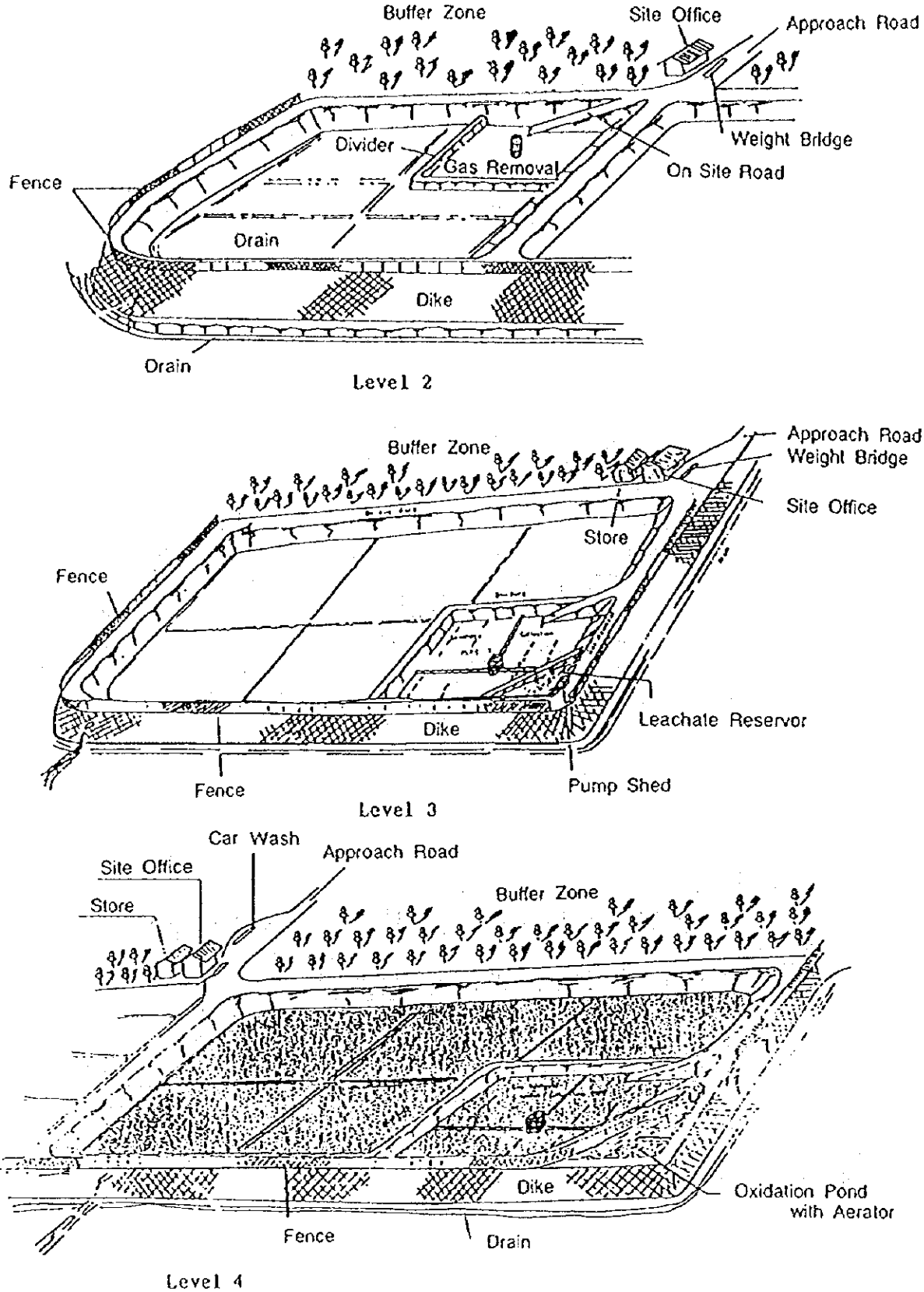


Figure L-28: Illustration of Prospective Sanitary Landfill Development and Operation Level 2, 3 and 4

The above mentioned sanitary landfill development and operation levels are described below.

Level 1: Controlled Tipping

Introduction of controlled tipping through:

- establishment of access to site;
- provision of cover materials for the prevention of fire outbreaks and the dispersion of rank odor;
- establishment of inspection, control and operational recording system for incoming waste.

Level 2: Sanitary Landfill with Dike and Daily Soil Covering

Introduction of sanitary landfill through:

- establishment of disposal site boundary to eliminate scavenging;
- execution of sufficient cover over waste disposed;
- enclosing the disposal area with a dike;
- construction of a divider between present and future landfill areas;
- establishment of a drainage system in order to divert storm water flow from surrounding areas away from the disposal site and to reduce leachate;
- construction of environmental protection facilities, such as buffer zone, litter control and gas removal facilities, to abate direct impact on surroundings;
- installation of gas removal facilities to achieve the conditions necessary for a semi-aerobic sanitary landfill;
- introduction of amenities for staff.

Level 3: Sanitary Landfill with Leachate Circulation

Establishment of leachate control through:

- installation of leachate collection, circulation and monitoring facilities;
- installation of liners for seepage control;
- construction of semi-aerobic sanitary landfill to accelerate waste decomposition and facilitate stabilization;
- introduction of water sprinkling for dust prevention.

Level 4: Sanitary Landfill with Leachate Treatment

Establishment of leachate treatment through:

- installation of an oxidation pond;

The above mentioned sanitary landfill development and operation levels are described and tabulated in Table L-58. Table L-59 shows the environmental standard each landfill level has to meet.

Table L-58: Outline of Sanitary landfill Development and Operation

Items		Level of Sanitary Landfill				Remarks
		1	2	3	4	
1	**Site Development**					
1.1	*Main Facilities*					
a.	Enclosing Structures					
	• Enclosing dikes		A	A	A	
	• Dividers		B	A	A	B means a dike made of refuse and soil
b.	Drainage System					
	• Surrounding drains		A	A	A	
	• On-site drains (surface water)		A	A	A	
	• On-site drains (spring)		A	A	A	If necessary
	• Drains for reclaimed area		A	A	A	
c.	Access					
	• Approach roads	A	A	A	A	
	• On-site roads	A	A	A	A	
	• Others	A	A	A	A	Improvement of existing road network to access the sites
1.2	*Environmental Protection Facilities*					
	Buffer zones		A	A	A	
	Litter control facilities		B	A	A	Movable fences, etc.
	Gas removal facilities		B	A	A	
	Leachate collection facilities			A	A	
	Leachate circulation facilities			A	A	
	Seepage control facilities			B	A	
	Leachate treatment facilities				A	
1.3	*Building and accessories*					
	Site office	B	A	A	A	
	Weighbridge	A	A	A	A	
	Store			A	A	
	Safety facilities		A	A	A	Gate, fence, lights, etc.
	Fire prevention facilities		B	A	A	Water tank, extinguisher, etc.
	Monitoring facilities			A	A	Monitoring well, etc.
	Car washer			A	A	
2	**Equipment**					
	Landfill Equipment	A	A	A	A	
	Others			A	A	Water truck, inspection vehicles, etc.
3	**Operation and Maintenance**					
3.1	*Operation*					
	a. Personnel					
	b. Cover material	B	A	A	A	B means insufficient soil cover.
	c. Utility					
	• Fuel tank	A	A	A	A	
	• Water		A	A	A	
	• Electricity	B	A	A	A	
	d. Chemicals					
	• Insecticide	A	A	A	A	
	• Monitering chemicals			A	A	
	e. Others		A	A	A	Divider, drain for reclaimed area, leachate collection pipes, etc.
3.2	*Maintenance*					
	• Main facilities		A	A	A	
	• Environmental protection facilities		A	A	A	
	• Building and accessories	A	A	A	A	
	• Equipment	A	A	A	A	

A: necessary
B: necessary under certain conditions, or may be omitted when budget is not enough

Table L-59: Environment Standards for Each Sanitary Landfill Development and Operation Level

Items		Sanitary Landfill Development and Operation Level			
		Level 1	Level 2	Level 3	Level 4
1	**Landfill Structure**				
1.1	Landfill Structure	Anaerobic Sanitary Landfill	Improved Anaerobic Sanitary Landfill	Semi-aerobic Sanitary Landfill	Semi-aerobic Sanitary Landfill
1.2	Achieved Condition	• Leachate generated in solid waste layers is seldom drained; an anaerobic state is maintained. Generally, the quality of leachate is poor. • Because of inactive decomposition of wastes, stabilization is slow.	• Through gas removal facilities, the quality of leachate is slightly better than in Level 1; an anaerobic state is maintained. • The rate of decomposition is slightly improved.	• Leachate accumulated at the bottom of landfills is promptly discharged through drain pipes (leachate collection pipes). The pipes also permit natural ventilation. • This structure facilitates decomposition of solid waste because a semi-aerobic condition is maintained. The quality of leachate is much improved and generation of offensive odour is further reduced. • Water content of solid wastes is lower than Level 2	• Leachate accumulated at the bottom of landfills is promptly discharged through drain pipes (leachate collection pipes). The pipes also permit natural ventilation. • This structure facilitates decomposition of solid waste because a semi-aerobic condition is maintained. The quality of leachate is much improved and generation of offensive odour is further reduced. • Water content of solid wastes is lower than Level 2
2	**Leachate and it's Impacts on Surroundings**				
2.1	Leachate Generation Amount	• Leachate is freely discharged outside of both landfilling and reclaimed areas because of the absence of an enclosing structure. • Stormwater flows into the landfill from catchment area and increases leachate amount.	• As for reclaimed areas, surface water is drained and discharged outside. • Stormwater from the catchment area is diverted into surrounding drains. • A divider separates the area for leachate generation from the working area. • The separation of the area for leachate generation reduces leachate amount.	• As for the reclaimed areas, surface water is drained and discharged outside. • Stormwater from the catchment area is diverted into surrounding drains. • A divider separates the area for leachate generation from the working area. • The separation of the area for leachate generation reduces leachate amount.	• As for the reclaimed areas, surface water is drained and discharged outside. • Stormwater from the catchment area is diverted into surrounding drains. • A divider separates the area for leachate generation from the working area. • The separation of the area for leachate generation reduces leachate amount.
2.2	Leachate Control Facilities	• None	Enclosing dike and divider prevents direct discharge of leachate.	• In addition to the facilities for Level 2 are leachate cycling and monitoring facilities. • Leachate is discharged only during heavy rain from regulating pond. Leachate discharged is therefore, diluted.	• Conditions are similar to Level 3 except for effluent which is constantly treated and discharged from oxidation pond.
2.3	Leachate Treatment Facilities	• None	• None	• Retention and regulation ponds may work as oxidation pond.	• Leachate is treated in an oxidation pond with aerator.
2.4	Leachate Quality	• High leachate content, and the quality is the poorest of all the landfill levels. The quality is also not expected to improve much even after a long period of time.	• Amount of leachate is limited because of dike and divider. However, leachate quality does not improve even after a certain period of time.	• Amount of leachate is limited as in Level 2. • The quality of leachate improves because of the semi-aerobic condition of the landfill. • Leachate circulation facilitates waste purification • Since leachate is discharged only during heavy rain, it is therefore, diluted.	• Amount of leachate is limited as in Level 2 • The quality of leachate will be treated in order to meet the effluent standards.

Items		Sanitary Landfill Development and Operation Level			
		Level 1	Level 2	Level 3	Level 4
2.5	Leachate Impact				
a.	Impacts on Undergroun d water	• The degree of the impact varies depending on the permeability of bottom soil. • If bottom soil is permeable, the impacts on underground water will be immense because of high pressure head and large amount of leachate.	• The degree of the impact varies depending on the permeability of bottom soil. • The amount of leachate is much less than Level 1. However, leachate would still have immense impact if bottom soil is permeable.	• Liner is laid to protect underground water from leachate seepage. • There is very little underground water contamination	• Liner is laid to protect underground water from leachate seepage. • There is very little underground water contamination.
b.	Impacts on Surface Water	• Because leachate is freely discharged from the landfill site, the impacts on surrounding water area is very high.	• Discharge of leachate may occur when the divider is submerged and through seepage. • Although leachate amount is limited, impacts on surrounding water area is high because of uncontrolled and unimproved leachate.	• Discharge of leachate occurs only during heavy rain • Leachate can be monitored. In case leachate to be discharged would affect the surroundings, the construction of leachate treatment facility is encouraged.	• Effluent from landfill site will satisfy the required effluent standards.
3	Others				
3.1	Vector control	• generates a large amount of flies, insects and rodents. • entices the huge gathering of crows • constant generation of rank	• Vector control is achieved and at a much improved level compared to Level 1.	• Vector control is achieved and at a much improved level compared to Level 1.	• Vector control is achieved and at a much improved level compared to Level 1.
3.2	Odours and Gas Production	• Occasional fires occur due to spontaneous ignition	• Conditions are much better than Level 1. • No fire outbreaks	• Due to semi-aerobic landfill structure, conditions are better than Level 2.	• Due to semi-aerobic landfill structure, conditions are better than Level 2.
3.3	Others	• scattering of wastes, dusty condition. • Deterioration of Landscape. • Noisy • Presence of scavengers.	• It is improved in all aspects.	• In addition to the condition achieved at Level 2, dust problems are mitigated with the use of a water sprinkler.	• Same as Level 3.

g.5 Conclusion

For the new landfill in Granada, a semi-anaerobic landfill structure and level 3 or 4 development stage landfill is recommendable.

h. Maintenance of Vehicles and Equipment

The present refuse collection vehicles maintenance and repair works are carried out at 'Plantelito' workshop, which is in a very poor state: lack of machinery and spare parts, unsuitable building for a workshop because it was built for a market.

There are basically two possible alternatives for the maintenance of vehicles and equipment. The first alternative would be the allocation of preventive services to a workshop operated by the municipality and of heavy maintenance services to private shops. The second alternative would be the allocation of all maintenance and repair works to a municipal workshop.

The first alternative would be inexpensive as it would only require basic facilities and a minimum number of mechanics and workers. The second alternative demands many

skilled mechanics, a large workshop, as well as sophisticated machinery. It is capital intensive and requires a lot of money for operation and maintenance.

For Granada, in view of the municipality's limited finance the first alternative is recommendable at an early stage, even though there are appropriate private shops.

Meanwhile, the location of the existing depot, 'Tallar Depot' for the collection vehicles is inappropriate. It is located next to the market, the shops flood the roads even in front of the entrance of the depot. This makes the operation of the depot very difficult. And the passing of the vehicles risks pedestrians coming shopping.

Usually, what a depot is located near a landfill or on the way between the waste collection point and a landfill reduce the operation cost of SWM. Therefore, to construct a new depot with a workshop next to the new landfill is proposed if there are an appropriate site.

L.1.6.3.5 Candidate Technical Systems

According to the procedure (1.Preconditions for selection of subsystems, 2.Identification of potential subsystem technologies, 3.Screening potential subsystem technologies) taken above, candidate technical systems are shown in the following table.

Table L-60: Candidate SWM's Technical Systems

System	Proposal
Discharge and Storage	• Source separation: Separates recyclable and non recyclable wastes • Type of storage: household waste: Nylon sack, Plastic bag commercial waste: Plastic bag, Dustbin institutional waste: Plastic bag, Dustbin, Container market waste: On-site storage, Container
Primary Collection	No primary collection (However, the existing handcart use in the market should be continued until the present market's unsanitary conditions is solved.)
Collection and Transportation system	• Collection frequency: More than twice a week • Collection method: Mixed collection for non-recyclable wastes • Type of collection: Curb collection, Point collection • Collection time: Day collection for most areas, and night and early morning collection for the city center • Type of collection vehicle: City center: Compactor truck Other area: Tipper truck Market: Container truck, Tipper truck • Transportation system: Direct transport by motor vehicle
Street sweeping	• Manual sweeping method
Intermediate treatment	• Only on-site/community based composting is encouraged.
Recycling	• Recycling activities are encouraged through institutional and educational programs.
Final Disposal	• Sanitary landfill with a certain leachate treatment system (Level 3 or 4).
Maintenance of Vehicle and Equipment	• for Preventive work mainly.

L.1.6.3.6 Selection of an Optimum Technical System

In order to select an optimum technical system, the items below out of the Candidate SWM's Technical Systems have to be examined further.

Discharge and Storage

- institutional waste: plastic bag, dustbin or container
- market waste: on-site storage or container

Collection and Transportation

- type of collection: curb collection or point collection
- type of collection vehicle:

  market waste container truck or tipper truck

  street waste container truck or tipper truck

Final Disposal

- sanitary landfill development and operation level: level 3 or 4

a. Discharge and Storage, and Collection and Transportation

Upon considering 'Discharge and Storage' and 'Collection and Transportation' , a type of vehicle introduced for the services is main factor affecting them. Therefore, it is examined in the following section.

a.1 Type of Vehicle

Cost Comparison on the type of vehicle

The Table L-61 shows the required number of vehicles for the each type, and the unit costs per waste ton. The required number of trucks is calculated on the basis of the amount of waste collected in 2010 which is estimated to be 101.6 ton/day.

Table L-61: Collection Cost Comparison by Vehicle Type

Item	unit	Compactor Truck			Tipper Truck		Container Truck		
1. Conditions									
Capacity in weight	t	4	6	8	4	6	4	6	8
Capacity in volume	m3	8	12	15	10	15	5	8	10
Required number of trucks	unit	11	9	8	14	12	13	8	7
Required containers	unit						237	150	120
2. Investment									
Investment cost per waste (a)	C$/ton	31	30	34	32	32	62	45	45
3. O&M cost									
3.1 Fuel cost per waste (b)	C$/ton	9	9	12	11	12	24	19	25
3.2 Labor cost per waste (c)	C$/ton	38	31	28	48	41	25	15	13
3.3 M&R cost per waste	C$/ton	6	6	7	6	6	12	9	9
O&M cost per waste (b+c+d)	C$/ton	53	46	47	65	59	61	43	47
4. Unit rate									
a + b + c + d	C$/ton	84	76	81	97	91	123	88	92

As the table shows, the $12m^3$ compactor truck is the most advantageous in view of reducing costs. The first to the third are dominated by compactor trucks. The $5m^3$ container truck is the most disadvantageous because a great number of containers are required, the second worst is the $10m^3$ tipper truck.

Road Conditions

Considering a type of vehicle used for collection service, road conditions can be physical restrictions. As a matter of fact, the causes why the present collection service is insufficient are not only the lack of vehicle, but also bad road condition. Especially in the peripheral areas and along the rivers, there are many areas not to be provided the service due to road conditions. For the areas, although the costs are low, compactor and container trucks are not suitable because the such road conditions must cause compactor trucks damage and make container trucks trouble when they put and load containers. Tipper trucks are the most suitable for the such areas out of the vehicles, although the costs must be high.

Institutional, Market and Street Waste

Introducing containers for institutional and market wastes also has to be examined due to their huge generation at a generation source. The amount of waste generated from institutions and markets are 0.4ton/day and 5.8ton/day in 2010 respectively. The total amount, 6.2ton/day, requires only one truck (6.2 ton is to be $21.6m^3$. A $5m^3$ container truck can deal with $35m^3$ per day, a $8m^3$ container truck can $56m^3$ and a $10m^3$ container truck can $70m^3$.). Introducing only one container truck is very risky, because there is no substitution when the truck is out of order or under repair. The service must stop in such cases. Therefore, to introduce a container truck is not a realistic plan.

On the other hand, the ASG of market and street wastes has to be examined. As a result of the WACS, ASG of market waste is about 0.5. And the ASG of street waste is usually regarded as considerably high because the waste includes sand and soil. When ASG is high, the compactor truck is not effectively. Furthermore, sand and soil make the hydraulic system of the truck damage. Therefore, the tipper truck is recommendable for those wastes due to its durability against sand and soil, and its wide use character.

Conclusion

According to the above examination, compactor trucks are the most recommendable type of vehicle if the problem of road conditions is solved. Therefore, suppose no problem on road conditions, the compactor truck is selected as a type of vehicle for waste collection. And the tipper truck is selected for market and street waste.

The road conditions will be a key on considering the near future plan.

a.2 Discharge and Storage

In accordance with the type of vehicle, discharge and storage technical systems in 2010 for institutional and market wastes are recommended as follows:

- institutional waste: plastic bag, dustbin
- market waste: on-site storage

a.3 Collection and Transportation

Type of Collection

Point collection system should be introduced as far as possible in order to reduce costs. In general, collection time of the point collection is shorter than the curb collection because wastes are put together at certain points. In areas where the road conditions are in poor shape, the point collection system should be used, because it can overcome the road conditions. In case of this, wastes should be taken to the points by waste generators.

However, point collection requires certain spaces for putting waste. This must be a obstacle on introducing the system to the city center. Therefore, the curb collection system should remain in the city center.

Consequently, the following types of collection are recommended in 2010:

- city center: curb collection
- other areas: point collection

b. Final Disposal

In order to not have bad influence on the environment around the final disposal site, the level 3 which has leachate collection facilities is recommended for the landfill in 2010.

c. Optimum Technical System

According to the above examination, the following technical system in 2010 is selected as an Optimum one.

Table L-62: SWM's Technical Systems in 2010

System	Proposal	
Discharge and Storage	• Source separation:	Separates recyclable and non recyclable wastes
	• Type of storage:	
	household waste	Nylon sack, Plastic bag
	commercial waste	Plastic bag, Dustbin
	institutional waste	Plastic bag, Dustbin
	market waste	On-site storage
Primary Collection	No primary collection (However, the existing handcart use in the market should be continued until the present market's unsanitary conditions is solved.)	
Collection and Transportation system	• Collection frequency:	More than twice a week
	• Collection method:	Mixed collection for non-recyclable wastes
	• Type of collection:	
	City center	Curb collection
	Other areas	Point collection
	• Collection time:	Day collection for most areas, and night and early morning collection for the city center
	• Type of collection vehicle:	
	Compactor truck	Household waste, Commercial waste, Institutional waste
	Tipper truck	Market waste, Street waste
	• Transportation system:	Direct transport by motor vehicle

System	Proposal
Street sweeping	• Manual sweeping method
Intermediate treatment	• Only on-site/community based composting is encouraged.
Recycling	• Recycling activities are encouraged through institutional and educational programs.
Final Disposal	• Sanitary landfill with leachate collection facilities (Level 3).
Maintenance of Vehicle and Equipment	• for Preventive work mainly.

L.1.6.4 Institutional Requirements

Urban cleaning is essentially a municipal duty, given that it is the result of the citizens' livelihood and the Law No. 40-88 defines those services as municipal obligation. It lacks a **Regulation of Urban Cleaning**, which would establish the rights and duties of the citizen and the municipality regarding the urban cleaning, including the municipal competence to penalize transgressors. Today, MINSA has the prerogative (Decree No. 432-89) regarding sanitary aspects.

The Regulation is an executive document. Only when at the same time better municipal services are introduced and the community is motivated to comply with the burden, the use of the regulation becomes viable, and as a result, there will be an improvement in the environment and citizens will increase their trust for the municipality. At that moment, the citizens accept to pay for the services, and a tax plan to pay for the services could be introduced. Urban cleaning will not be derived from separated actions and investments, but from the integration of them. Therefore, in order to organize this integrity, trained persons and an adequate organization are needed. Meanwhile in order to introduce and develop the trained persons and adequate organization, a control system based on a prior planning is indispensable.

In short, the **institutional training** by the municipality will comprise at least:

- An Operational Plan with resources and costs dimensioned or estimated;
- An Urban Cleaning Regulation coherent with the Operational Plan;
- A Tax Plan coherent with the costs and economic capacity of the citizens. It should be considered that **everybody** should receive services and **pay** for the services according to the "viable quality" of the services and the economic capability of the citizens. The Tax Plan should consider averages for the social-economic segments;
- The organizational improvement and human resource training for the departments of Waste Collection, Public Cleaning, and Vehicles and Equipment will provide indispensable support to achieve the regularity of the services; and
- Community involvement should be implemented in proportion to the "improved and regular" services in order to attain the burden sharing by citizens. Meanwhile, the areas subject to the community participatory projects should be gradually expanded, but the contents of the participation should be full and complete in respective community.

Before it is decided whether to "privatize" those services partially or totally, it is considered that the waste collection services, street cleaning and landfill disposal should be being operated by the municipality until when the operation department and its staff are trained to be able to plan and control the operation results and costs.

Annex N presents recommendations on "Instructions and/or Regulations (as well as Tables with Strategies and Intersectorial Integration)".

The Main Report for F/S of Volume III includes (item 4.3.2) the proposed Regulation on SWM for Granada, that might be the same for the other municipalities.

L.1.6.5 The Municipal SWM Master Plan

The following table shows the outline of the Master Plan.

Table L-63: Outline of M/P for Municipal SWM in Granada

Item	Present (1996)	2000	F/S (2005)	M/P (2010)
FORECAST ON KEY ELEMENTS				
Service projected area	14.3 km^2	14.3 km^2	14.3 km^2	14.3 km^2
Population in the study area	76,250	97,078	114,760	135,106
Waste generation amount	57.1 ton/day	76.6 ton/day	97.5 ton/day	123.4 ton/day
Waste discharge amount	43.2 ton/day	59.5 ton/day	78.2 ton/day	102.0 ton/day
Waste collection amount	35.4 ton/day	48.8 ton/day	70.4 ton/day	102.0 ton/day
Final disposal amount	36.9 ton/day	50.2 ton/day	72.7 ton/day	104.5 ton/day
Coverage rate(to waste amount)	82.0 %	82 %	90 %	100 %
Coverage rate(to population)	63.0 %	63 %	89 %	100 %
Served population	48,037	61,159	101,843	135,106
non-served population	28,213	35,919	12,917	0
Length of road swept	35 km	35 km	40 km	47 km
PARTICULARS OF THE PLAN				
1.Collection & Transport				
Collection system	Curb collection	Curb collection	Curb, Point collection	Curb, Point collection
No. of collection vehicles	Tractor:2, Dump truck : 1, Truck:3	Tractor:2, Dump truck : 1, Truck:3	Compactor Truck: 7 Tipper truck: 1 Wheel loader: 1	Compactor Truck: 9 Tipper truck: 1 Wheel loader: 1
Transportation system	Direct transport	Direct transport	Direct transport	Direct transport
Responsible authority	Municipal Services Department	Municipal Services Department	Urban Environment Maintenance	Urban Environment Maintenance
No. of personnel	32	32	34	42
Unit cost of collection	C$110.2/ton	C$ 99.8/ton	C$ 100.4/ton	C$ 92.6/ton
2. Street sweeping				
Cleaning method	Manual	Manual	Manual	Manual
Length of road	49 km	-	-	-
Length of road swept	35 km	35 km	40 km	47 km
Responsible authority	Municipal Service Department	Municipal Service Department	Urban Environment Maintenance	Urban Environment Maintenance
Number of personnel	30	30	30	30
Unit cost of street sweeping	C$ 1.09/m	C$ 21/km	C$ 21/km	C$ 21/km

Item	Present (1996)	2000	F/S (2005)	M/P (2010)
Equipment used	Broom, shovel, handcart	Broom, shovel, handcart	Broom, shovel, handcart	Broom, shovel, handcart
3. Intermediate treatment	None in particular	None in particular	No requirement other than on-site & community based ones.	No requirement other than on-site & community based ones.
4. Recycling				
Recycling Amount				
At generation point	5.0 ton/day	6.7 ton/day	8.5 ton/day	10.8 ton/day
At landfill	0.5 ton/day	0.7 ton/day	0.0 ton/day	0.0 ton/day
Recycling system	No organized recycling	No organized recycling	Segregation of wastes for recycling is promoted.	Segregation of wastes for recycling is promoted.
5. Final disposal				
Disposal method/level	Open Dumping	Controlled Tipping (Level 1)	Sanitary Landfill (Level 4)	Sanitary Landfill (Level 4)
Disposal site	La Joya	La Joya	San Jose de la Viuda	San Jose de la Viuda
Area of the site	3 ha	3 ha	6 ha	6 ha
Final disposal site from generation center	5 km	5 km	5 km	5 km
Responsible authority	Municipal Services Department	Municipal Services Department	Urban Environment Maintenance	Urban Environment Maintenance
No. of personnel	1	2	10	10
Charge for Disposal	C$ 24 /ton	-	-	-
Unit disposal cost	C$ 4.26/ton	C$ 7.9/ton	C$ 153.8/ton	C$ 143.2/ton
Main equipment	Bulldozer: 1 (rental : occasional use)	Bulldozer: 1	Bulldozer: 1 Tipper truck: 1 Excavator: 1 Sprinkler truck: 1	Bulldozer: 1 Tipper truck: 1 Excavator: 1 Sprinkler truck: 1
6. Maintenance of Vehicles and Equipment				
Maintenance shop	1	1	1	1
Responsible authority	Municipal Shop	Municipal Shop	a new workshop	a new workshop
No. of employees	3	3	-	-
7. Operation				
Responsible authority	Municipal Services Department	Municipal Services Department	Urban Environment Maintenance	Urban Environment Maintenance
Number of persons	63	-	-	-
Type of operation	Municipal operation	Municipal operation	Municipal operation	Municipal operation
8. Finances				
City budget	C$ 14,327,000	C$ 17,957,000	C$ 22,918,000	C$ 27,617,000
Cleansing department budget	C$ 1,431,000	C$ 1,479,000	C$ 4,226,000	C$ 5,479,000
Management of service recipients	Existence of a register	existing system	Department of Administration and Finances	Department of Administration and Finances
Fee collection method	door to door	-	-	-
Rate of fee collection	16.3 %	70.0 %	82.5 %	95.0 %
Revenue	C$ 106,000	C$ 532,000	C$ 2,419,000	C$ 3,394,000
9. Privatization				
SWM services privatized	None	None	To be examined	To be examined
Method of contract				