### Q.5.1.16 Rainfall of the Influence Area

According to the 17 year rainfall data registered by INETER from 1969 to 1985, in Granada City, the annual average rainfall is 1,475 mm; the lowest value recorded was 1,000 mm in 1977 and the highest 1,919 mm in 1979.

Two different seasons are observed during the year, the rainy season (May - October), when approximately 96% of the total annual rainfall occurs and the dry season (November - April) in which brief, low intensity sporadic rainfall is registered. The annual rainfall varies notably from one year to another and even from one month to another with in the same year.

The months with the highest of greater rainfall are June, September and October. The driest months are December, January, February, March and April. November is a transition period between the rainy and dry seasons.

### Q.5.1.17 Evaporation of the Influence Area

The total monthly evaporation registered by INETER, between 1969 to 1985, fluctuates between 150 mm (September) and 315 mm (April). The annual average evaporation is 2337 mm. In general, the evaporation rate peaks in March and April, and is the lowest in the September, October and November. (See data of INETER in Chapter 5 of Data Book: Volume V)

### Q.5.1.18 Evapotranspiration of the Influence Area

There are no evapotranspiration data registered by INETER, at the Granada meteorological station.

### Q.5.1.19 Wind Velocity and Direction

The estimated monthly average wind velocity vary between 0.7 m/sec (October) and 2.7 m/sec (February). The annual average velocity is estimated as 1.6 m/sec. The highest average wind velocities are recorded in February, March and April and are the lowest in October and November. The prevailing wind direction, all year is from the east.

## Q.5.2 The Biotic Environment

### Q.5.2.1 The Flora in the Area

#### Q.5.2.1.1 Introduction

The study area is located four kilometers to the north of the city of Granada, exactly on the property known as San Jose de la Viuda. The flora survey was performed within a 1.5 kilometer radius from the center of the proposed landfill site.

The type of native vegetation in the area is of **Dry Tropical Forest (BTS: Bosque Tropical Seco)**, the deciduous trees shed their leaves during the dry season. The east of the area (toward the lake) is protected by a public forest with soils that are flooded temporarily, which allows the vegetation to maintain its leafage even during the dry season.

The principal economic activity of the area is cattle-raising, followed by chicken production and some fruit production by perennial cultivation (jocote *Spondias purpurea*, mangos *Mangifera indicates*, tamarind *Tamarindus indicates*, papaw *Meliccocus bijugatus*, tart lemons *Citrus aurantifolia*, and the barnanas *Musa spp.* (banana, plantain and filipito). At a smaller scale or experimental level corn *Zea Mays*, yuca *Manihot esculenta* and mung beans *Vigna radiata* are grown at El Carmen and sugar canes *Saccharum officinarum* at "San Jose de las Animas".

### Q.5.2.1.2 Methodology

The flora survey consisted of field investigations through out the study area for the identification of various habitats. The various species were identified in their national habitat; samples of flora which were found to be in full at the bloom time as well as species which were not possible to identify on-site were collected. The collected samples were registered, preserved and identified subsequently at the National Herbarium of Nicaragua, which is also the botanical depository that supports this study.

### Q.5.2.1.3 Ecosystems

In the study site three ecosystems can be determined:

- Arable and grazing land (pasture)
- Seasonal swamp with trees and shrubbery (grove).
- Marshland with low-lying vegetation (wetland or swamp).

#### a. Arable and Grazing Land (Pasture)

This ecosystem (i.e., arable land and pasture) occupies a little more than 70% of the total area and all the area proposed for the sanitary landfill is included. At present sorghum wheet *Sorghum X bicolor* is grown as fodder. This ecosystem in addition covers a small meadow to the east. All this area belongs to the property of San Jose de la Viuda.

Within this same ecosystem the following properties are also located to the North: Santa Rosa; San Ignacio; Las Mercedes; El Carmen; San Jose de las Animas and part of Santa Rita y Dolores. To the South, Las Porras and the West, La Porra and El Fortin are also located.

The principal economic activity in the area, is cattle-rearing, for the reason of natural pasture land management, with, the use of trees as fencing posts. Within the pasture land, there are various: fruit-bearing, timber yielding or "native" trees (see photos in Chapter 8 of the Data Book: Volume V).

Among the **native species** the following were identified:

Giant trees of: ceiba *Ceiba pentandra;* panama *Sterculia apetala;* espino de playa *Pithecellobium dulce;* coyol *Mexican Acrocomia;* guanacaste white *Albizia niopoides;* espavel *Anacardium excelsum;* anona *Annona reticulata;* jinocuabo *Bursera simaruba;* guarumo *Cecropia peltata;* papalon *Coccoloba caracasana;* poroporo *Cochlospermum vitifolium;* Laurel *Cordia alliodora;* jicaro sabanero *Crescentia alata;* guachipilin *American Diphysa*; black guanacaste *Enterolobium cyclocarpum;* talalate *Gyrocarpus americanus;* medlar *Manilkara chicle;* jaboncillo *Sapindus saponaria;* tempisque *Sideroxylon capiri;* acetuno *Simarouba amara;* huevo de chancho *Stemmadenia obovata;* palo de piojo *American Trichilia*; and cornizuelo *Acacia collinsii*.

Among the **native species** cultivated for their fruits, wood or for its aesthetic value, the following were identified:

Nancite *Byrsonima crassifolia;* papaya *Carica papaya;* laurel *Cordia alliodora;* tiguilote *Crdia dentata;* jicaro sabanero *Crescentia alata;* jicaro *Crescentia ujete;* madero negro *Gliricidia sepium;* guacimo de ternero *Guazuma ulmifolia;* guaicum *Guaiacum sanctum;* pitahaya *Hylocereus polyrhyzus;* mamey *American Mammea;* leucaena *Leucaena leucocephala;* yuca *Manihot esculenta;* mamon *Meliccocus bijugatus;* sapodilla *Pouteria mammosa;* guava *Psidium guajava;* spanish plum *Spondias purpurea;* mahogany *Swietenia humilis;* cortes *Tabebuia chrysantha;* and oak *Tabebuia rosea;* and cocoa *Theobroma cocoa*.

Among the **exotic/rare species** cultivated for their fruits, woods for its aesthetic value, the following were identified:

Nim *Azadirachta indicates;* Casuarina *Casuarina equisetifolia;* caimito *Chrysophyllum caimito;* tart lemon *Citrus aurantifolia;* sweet orange *Citrus sinensis;* coconuts *Coconut nucifera;* malinche *regal Delonix;* eucalyptus *Eucalyptus camaldulense;* rubber *Ficus elastica;* quinceanera *Jatropha hastata;* mango *Mangifera indicates;* bananas *Muse spp;* narciso *Nerium oleander;* Tamarind *Tamarindus indicates;*and almond *Terminalia catappa*.

Among the **species used as natural fencing** the following were identified:

Teonoste *Acanthocereus pentagonus;* spanish plum *Spondias purpurea;* jinocuabo *Bursera imaruba;* madero negro *Gliricidia sepium;* chilamate *Ficus morazaniana;* espino de playa *Pithecellobium dulce*.

Among the **herbaceous** were determined:

Yellow flower *honest Baltimora;* ledo *Amaranthus spinosus;* escoba dulce *Scoparia dulcis;* viborana *Asclepias curassavica; Blechum pyramidatum; Capraria biflora;* Chili pepper *Capsicum annum.; Cleome spinosa;* pegajosita *viscous Cleome*; quelite del fraile *Cnidoscolus aconitifolius;* achopaste *Cordia curassavica;* chischis *Crotalaria retusa; Croton lobatus;* pelotitas *Cucumis anguria;* zacate de gallina *Cynodon dactylon;* coyolillo *Cyperus rotundus; Desmodium spp.;* pringa mosca *Gronovia scandens;* cola de alacran *Heliotropium indicum;* guasquito *Lantana camara;* una de gato *Martynia annua;* manzanita *Momordica charantia;* verdolaga *Portulaca oleracea; Achyranthes aspera;* and *Rauvolfia tetraphylla*.

In the proposed landfill site area, all the properties are cattle ranches except for El Carmen farm. In all the properties, a high percentage of the pasture land is overgrown with weed (meadows). The following species are found in abundance on pasture land:

Gamba hay *Andropogon gallanus* and Estrella hay *Cynodon nlemfuensis;* followed by fodder sorghum forrajero *Sorghum X bicolor* and taiwanese hay *Pennisetum purpureum*.(see the photo in the Chapter 8 of Data Book: Volume V)

In the new sanitary landfill disposal site at San Jose de la Viuda, there is a total of 14 hectares of these different pastures. At the Santa Rosa and San Ignacio farms the meadows are mainly overgrown with yacate gamba *Andropogon gallanus*.

### b. Seasonal Swamp with Trees and Shrubbery

This area is located to the east of the landfill site area, and it is situated between the wetlands and the arable and grazing lands. In this zone seasonal floods occur. This habitat presents the characteristic of being the area which is found to be better preserved in relationship to the total area.

The surface vegetation is made up of woody species, most of which reach heights of up to 12 meters, especially the ceibas stands out with heights of up to 20 meters.

The following were identified as species abundant in the swamp: elequeme *Erytrina fusca* (the most common species), followed by the gigantic ceiba trees *Ceiba pentandra;* guanacaste *Enterolobium cyclocarpum;* tiguilote *Cordia dentata;* lagarto *Zanthoxylum sp.;* oak *Tabebuia rosea;* zapote de mico *Couroupita nicaraguense,* a **rare species**, and is the only kind of its genus found in Nicaragua in Nicaragua, genizaro *Albizia saman;* ojoche *Brosimum alicastrum*, panama *Sterculia apetala*, guacimo *Guazuma ulmifolia*, guarumo *Cecropia peltata;* espavel *Anacardium excelsum;* Jaboncillo *Sapindus saponaria;* in some sites with lot of regeneration, leucaena *Leucaena leucocephala;* papaturro *Coccoloba caracasana;* sweet orange *Citrus sinensis* (harvested), cocoa *Theobroma cocoa* (harvested); guava *Psidium guajava;* jicaro sabanero *Crescentia alata* and *Crescentia cujete* (haevested) acetuno *Simarouba amara;* spanish plum *Spondias purpurea;* jinocuabo *Bursera simaruba;* river almond-tree *Andira inermis;* anona de charco *Annona glabra;* chilamate *Ficus ovalis;* manzano *Crateva wall;* espino de playa *Pithecellobium dulce;* cornizuelo *Acacia collinsii;* palma *Eleais oleifera* (which was only observed in at San Jose de las Animas, although it is a native species to swampy zones), corozo *Scheelea rostrata* (the only species of this genus, also observed in the property of San Ignacio. This species is also a narive to swampy zones), quesillo or amapola *Malvaviscus arboreus;* aromo *cacia farnesiana.*(see photos in Chapter 8 of the Data Book: Volume V)

Among the **herbaceous species** the following were observed:

Ave del paraiso *Heliconia latisphata;* pringa moya *Gronovia scandens;* coralillo *Rivina humilis;* escoba manga *Scoparia dulcis; Capraria biflora; Corchorus orinocensis;* zacate de gallina *Cynodon dactylon;* verdolaga *Portulacca oleracea;* yellow flower *Baltimora recfat; Crotalaria rugosa; Cleome spinosa; Cyperus articulatus; Ludwigia octovalvis; glaucous Canna* (this species is rare in Nicaragua but it is common within this area), *Lippia nodosa.; Kosteletskya pentasperma.; Boerhavia erecta; viscous Cleome* and *Cyperus articulatus*.

Growing on the stems of the trees, two species of climbing /trailing plants (gen. Araceae) were identified: *Monstera adansonii* and *Syngonium angustatum,* and on the branches, the hemiparasites of the genus Loranthaceae: *Struthanthus quercicola* and *Struthanthus orbicularis*.

The creek/riverbed that is located east of the in the farm of San Jose de la Viuda, is totally covered by the aquatic fern *Ceratopteris pteriodoides*. In this area and as well as in the area of the wetland, the cattle is left to graze.

### c. Marshlands with Low-lying Vegetation

The marshland, composed mainly of low-lying vegetation, is located within the influence area, to the east of the projected landfill area. This place is known by the locals as **El**

**Canal (The Channel)** and is located approximately one kilometer from the farmhouse San Jose de la Viuda up to about forty meters off the coast of Lake Nicaragua.

Within this ecosystem, the number of some dominant plant species prevails, and is ranked can be observed in the following from damp to wettest: (1) *Cyperus articulatus*, (2) *Thalia geniculata* and (3) *glaucous Canna*, also gramineous *Echinocloa cruspavonis; Oryza latifolia*, *Thalia geniculata*, *Brachiaria mutica* and *Thalia geniculata* can be found. In the most submerged part tule *Typha dominguense* followed by reeds *Phragmites australis* and bramble *Mimosa pigra*, and finally floating and covering the water surface, the water hyacinth *Echhornia crassipes*, water lettuce *Pistia stratiotes*, *Salvinia auriculata* and *Ceratopteris pterioloides* (the later two species are ferns).

Some natural species of **espino de playa** *Pithecellobium dulce*, chichicaste *Cnidoscolus urens* (a herbaceous plant within urticating properties) *Ipomoea pesca-prae*, an herbaceous of *Crotalaria spp.* grown in the coastal area and on the sandy beach. It is common to observe the growth of (catapanza) *Passiflora foetida* and (manzanita) *Momordica charantia*.

Among those vegetation cultivated are coconut *Cocos nucifera* and almond *Terminalia catappa*.

Among the **herbaceous** present in the area the following species were identified: escoba lisa *Sida acuta*, bledo espinoso *Amaranthus spinosus*, quelite del fraile *Jatropha gossipiifolia*, pegajosita *Cleome viscosa*, guasquito *Lantana camara*, sorosi *Momordica charantia*, uña de gato *Martynia annua*, coyolillo *Cyperus rotundus* and *Cleome spinosa*.

### Q.5.2.1.4 Results of Flora Survey

A total of 69 florae families, comprising 130 genera with a total of 149 species were identified.

Three (3) ecosystems were determined and identified in the entire area:

- Arable and grazing land.
- Seasonal swamp with trees an shrubbery.
- Marshland with low-lying vegetation.

The arable and grazing land is the richest habitat for florae, therefore 107 species were identified; in the second place the seasonal swamp with trees and shrubbery has 64 species and in the last place the wetland with only 17 species. The differences in the number of species is because only the wetland plants are very robust and can adapt to the extremely hersh conditions of the marshland.

The large variety of species in the arable and meadow habitat is partly due to the introduction of natural species from other zones and of exotic species, especially among the ornamental and edible species, and also due to the environmental conditions in which development of those species is allowed.

Two individual species, which are locally rare but not endangered species, were found in the flora survey of the SJV site :

One specie is of the Lecythidaceae family bala de cañon *Couroupita nicaraguense*, and the another is of the Anacardiaceae family, espavel *Anacardium excelsum*. These species are common in other areas, but they are rare locally. Both species are located to the east of the farm house San Jose de la Viuda, the former in the seasonal swamp area and the latter in the meadow habitats.

Two more species of the Arecaceae or Palmae family exist. Each species was found to exist uniquely. These species are: *Elaeis oleifera* and *Scheelea rostrata*, the two are native to swampy areas. The former species was observed in the San Jose de las Animas Farm and the latter in the Santa Rosa Farm both in the seasonal swamp habitat with trees and shrubbery.

### Q.5.2.1.5 Conclusions of Flora Survey

**Within the area of research, which was the area of 1.5 km radius around the center of the project, no plant species in danger of extinction was found.**

It is considered that the project of a sanitary landfill with leachate control and treatment, daily soil covering over the waste disposed in cells and buffer zone of tall trees (e.g., eucalyptus), will not affect the local vegetation, because the chosen site is an area used presently for cultivation and the only matter at hand regarding vegetation is the cultivation itself and some weeds that normally grow on it.

On the other hand, it will be possible that some newer unique species may emerge if the soil cover material over the disposed waste are completely attired from the soils near the project site. A way of minimizing this effect is, to try to use the soil surrounding the landfill area to cover the disposed waste and not bring soil from distant places, because seeds of other species that would compete with the local species could be contained in the soil.

This project design proposing borrow pit for cover soil in the project site already paid attention to this matter and mitigated the problem.

### Q.5.2.1.6 References Used for the Flora Survey


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## Q.5.2.2 The Fauna in the Area

### Q.5.2.2.1 Introduction

This study was carried out in order to indicate the species of faunae that exist within a 1.5 km radius from the center of the future sanitary landfill site, to establish some criteria with respect to these components, and to view the effect this project could have on the ecosystem.

### Q.5.2.2.2 Methodology

The sampling and the observations were carried out from the 9th to the 12th of July at 3 points located within the property of San Jose de la Viuda and in the wetlands, next to the gravel road to Malacatoya. Furthermore, recognition in all the property above mentioned was executed as well as in the bordering properties. Because of the habits and differentiated use of the space on the part of the fauna, the methodology was variable.

**a. Birds**

Ornithological surveys were conducted in the morning from 5:30 am until 9:30 am and in the evening from 4:00 p.m. until 7:00 p.m.. Simultaneously 2 capture nets, 12 meters long and 2 meters wide were installed for the captivation of specimens. Counting of Zopilotes *Coragyps atratus* was carried out on Wednesday 9th of July and Saturday 12th of July in the surroundings of the wastewater disposal site of poultry farm San Felipe. Furthermore, the locals were interviewed to understand the presence of migrant birds in the different seasons of the year.

**b. Mammals**

During the night, traps for small-mammals were installed at 3 sampling sites. Night watches were simultaneously carried out in search of land mammals. In the case of bats a net was installed to capture and subsequently identify them. Also the locals were interviewed about the land mammals present in the area.

**c. Amphibians**

Daytime and night watches were made around 3 sampling points within the wetlands adjacent to the road to Malacatoya. Furthermore, interviews to the locals about the amphibians presence were made.

**d. Other**

Interviews to obtain information on other aspects such as the economic activities in the area and the existence of particular fauna species were carried out. Also, collections of mollusk shells for their identification were carried out.

### Q.5.2.2.3 Results

Through visual observation, 47 species of birds were identified, apart from capturing: 1 rodent, 4 chiropterans, 2 amphibians and a reptile. Also, 4 species of reptiles were seen. The inhabitants reported 1 additional species of bird, 8 mammals, 11 reptiles, 6 fishes (see the general list of fauna in Chapter 8 in the Data Book: Volume V).

The population of Zopilotes *Coragyps atratus* that currently inhabits the surroundings of the poultry farm San Felipe is estimated to number between 500 and 800. In the nocturnal and daytime tours no mammals were detected. Two types of mollusks in the tour were found, however, in the total research area 13 species of these animals were reported.

The birds species observed the most were: *Quiscalus mexicanus*, *Q. nicaraguensis*, *Crotophaga sulcirostris*, *Campylorhynchus rufinucha* and *Calocitta formosa*. On the other hand the most abundant species in the open swamp were: *Jacana spinoza* and *Casmerodius albus*. According to some inhabitants, the area of the swamp is used by some species which migrate locally at some time of the year. These species are: *Cairina moschata*, *Columbina Inca*, *Columbina talpacoti*, *Zenaida asiatica*, *Dendrocygna autumnalis*, *American Mycteria*. Furthermore the *Myiodynastes maculatus* was observed which is a species that migrates locally.

The inhabitants of the zone reiterated that many species of aquatic birds build their nests in the swampy area; such is the case of herons and ducks among others. They also pointed out that many birds such as the *Cairina moschata*, arrive for a certain period of the year and feed on seeds of wetland plants, others feed on mollusks which are very abundant in the swampy area. Among the mollusks, samples of *Pomacea flagelata* could be collected however, on other occasions other species have been collected in the same zone (see the mollusks list in Chapter 8 of the Data Book: Volume V).

The inhabitants pointed out the existence of Cuajipla (*Caiman crocodilus*) and black alligator (*Crocodilus acutus*) which are listed the categories managed by CITES (Convention on International Trade of Endangered Species). Furthermore they mentioned the Iguana population (*Iguana rhinolopha*) and the Gallego was observed (*Basilisk vittatus*) and *Mabuya unimarginata* which are commodities.

Some people indicated that in the fishing takes place in some parts of the swamp mainly for four species: guapote, mojarra, tilapia and barbudo (common names).

Concerning mosquitoes, the inhabitants indicate that only one species exists and that the number of these increases in the rainy season. In the days of the field research mosquitoes were not observed. On the other hand, large quantities of flies in the area of the farmhouse of the San Jose de la Viuda property were observed.

### Q.5.2.2.4 Discussion of Results

The distribution of the fauna in the area indicates that 3 types of habitats currently exist as a result of the human activity:

- cultivation and grazing land area
- seasonal swamp trees and shrubbery
- open wetlands with low-lying vegetation

During the sampling period 3 events, that elucidate the current status of the fauna within the area of interest, were observed:

1. In the first two sampling points, no chiropterans (bats), nor birds were captured by the installed nets.
2. Chiropterans in the seasonal swamp area were captured.
3. No mammals were observed during the daytime and nocturnal observation tours.

These events reveal that not many mammalian species live in the landfill project area. However, in the area of the wetland there is a large number of species of animals like, bats, fish, amphibians and mollusks that depend on the remainder of the seasonal swamp with tall and shrubs and of the open perennial swamp with low-lying vegetation.

By counting the Zopilotes *Coragyps atratus*, it was determined that between 500 and 800 live near the poultry farm San Felipe, however it is probable that the number of Zopilote could be larger since the inhabitants of the area indicated that in other occasions the number was much greater.

Traps to capture rats and smaller vermin were used. One roof rat *Rattus rattus* was captured near the poultry farm San Felipe.

#### Q.5.2.2.5 Conclusions

**Within the area under research, which was a 1.5 km radius from the center of the project, no animal species was found in danger of extinction, upon execution the sanitary landfill construction.**

Within the research area, the part where there is currently cultivation and grazing land is the one that has less fauna abundance. The area of the open wetland of gramineous plants, trees and shrubs, makes up an ecosystem of abundant faunae.

### Q.5.3 The Socio-economic Environment

#### Q.5.3.1 Current Land Use

Land uses in the surrounding areas of the project site are mainly: cattle rearing and/or fallow agriculture. There is a little perennial harvesting of fruit trees, such as the spanish plum, mango, tamarind, papaw, tart lemon, banana, plantain and filipito. One specific economic activity in the surrounding area is the San Felipe poultry farm.

#### Q.5.3.2 Current Utilization of the Ground Water Sources

In the property San Jose de la Viuda there are several wells, whose water is given to cattle for drinking and it is not consumed by the inhabitants, they assure the consumption of water brought from Granada City, as the contamination of the water wells in very likely.

In the San Felipe Poultry Farm there are two wells, which serve as a potable water source for the workers. Furthermore, the water of these wells is given to the chickens in growth stage and it is used for their plucking and washing in the slaughter process.

### Q.5.3.3 Current Utilization of the Surface Waters

The surface water near the project site (i.e., wetland water) is not utilized for any specific economic activities. Meanwhile, the Lake Nicaragua is located to the east of the property, which is used by the population for their personal bathing. In the small village Kauloa, some people use its water for consumption. Furthermore, it is used as a resort by people who visit the city. On the other hand, certain properties and estates located on the border of the lake, use water of the lake for irrigation.

## Q.6 Analysis of the Environmental Impacts

### Q.6.1 Atmospheric pollution

Negative impact by atmospheric pollution will not be produced in the construction stage as well as the operation stage. This is because when the earth movement works take place, a water tanker will be used, which is equipped with a hose and sprinklers to control the dust. As for the operation stage, since a landfill gas removal facility will be installed, atmospheric pollution will be minimal as the structure of the sanitary landfill proposed prohibits open burning of waste disposed. On the other hand, due to the daily covering of the solid waste there will be no bad spreading.

### Q.6.2 Dust Increase

There will be no dust increase either from the traffic of the waste collection vehicles, or from the sanitary landfill operation proposed (e.g., disposal, compaction and soil coverage), since the access road (from the city to the SJV site) will be paved. Likewise, the approach road in the site to the landfilling face will be gravel paved.

The pavement of the access road will be a positive impact for the neighboring zone, due to the reduction of the dust, noise and the vibration caused by the traffic on the road, etc. Furthermore, a water tanker will be used for dust control, when sanitary landfill operations are carried out in the site.

### Q.6.3 Pollution Risk for the Subsoil and Ground Water Sources

There will be minimal impact to the subsoil and ground water sources because the bottom of the SJV sanitary landfill site and of the leachate treatment lagoon, will be properly waterproofed by a clay liner.

### Q.6.4 Impacts Provoked by the Gaseous Emission of $CH_4$ and $CO_2$

There will be no negative impacts due to gaseous emissions in the zone, because the installation of a landfill gas removal facility will create the appropriate ventilation conditions to avoid the accumulation and possible explosion of the landfill gas (e.g., $CH_4$), as well as the underground lateral migration of the emissions, avoiding $CH_4$ to accumulate in confined spaces.

Meanwhile, $CO_2$ being 1.5 times heavier than the air, will sink and be vented out through the perforated leachate collection pipes which are laid at the bottom of the landfill cells. Hence, $CO_2$ accumulation in closed spaces will be avoided.

### Q.6.5 Risks of human exposure to volatile chemicals and pathogenic microorganisms

In the sanitary landfill, with practices of daily soil coverage on disposed waste, human exposure to pathogenic microorganisms will be minimal and insignificant. Likewise, there will not be human exposure to volatile chemicals. To avoid personnel being affected, by pathogenis, workers will receive a supply of protective gear such as boots, gloves and masks, as well as toiletries, such as soap, for hand washing.

On the other hand, as hazardous industrial waste and/or hazardous/infectious medical waste (such as syringes) are not allowed to be disposed of at this landfill site, human exposure to volatile chemicals is not expected.

### Q.6.6 Proliferation of Diseases Vectors

In the sanitary landfill, daily soil coverage on waste will be carried out and therefore, proliferation of disease transmitting vectors could substantially be controlled and avoided. Therefore, it is not expected that the sanitary landfill project would produce any impacts the poultry farm San Felipe due to disease vectors proliferation.

On the other hand, as for the San Felipe poultry farm, present activities and poor hygiene practices already attract some disease vectors (e.g., roof rats *Rattus rattus* are attracted to poultry feeds, Zopilotes *Coragyps atratus* are attracted to residues from fowl meat processing). (see pictures in Section 8.10 of Chapter 8 in the Data Book: Volume V)

Therefore, it is important to confirm that the **present environmental quality of the poultry farm** is such that some disease vectors are attracted to its unsanitary conditions.

### Q.6.7 Fire Risks

Fires are not expected to be produced in the sanitary landfill, since the waste compaction and the daily soil covering on waste are methods that minimize the possibility of spontaneous fires occurrences.

### Q.6.8 Impacts on the Flora and Fauna

With respect to the ecosystems in the project site (i.e., Cultivation and grazing land), the area where the sanitary landfill is projected is presently used for cattle rearing and no kind of flora and fauna in danger of extinction are found therein. Although surface vegetation of the project area will be removed at the construction period, since trees will be planted as the buffer zone, there will be no negative impacts such as loss of florae. Likewise, there will be no negative impacts such as reduction in fauna.

With respect to the ecosystems in the forest and wetland area (i.e., Seasonal swamp with trees and shrubs, and Wetlands with low-lying vegetation), although the area makes up an ecosystem of abundant species, no florae and faunae in danger of extinction are found therein.

Furthermore, the forest and wetland area is beyond the reach of construction activities and as for landfill operation stages, a buffer zone of fast growing trees will protect the local ecosystem. Meanwhile, leachate from the landfill is collected and treated to a permissible level before discharging to the wetland, it could be judged that the impact

will be insignificant. Even in if the effluent should pose a negative impact on the ecosystem, the impact will only be limited to a small focused area, in comparison to the rest of the vast area of the wetland and its huge biodegradation capacity and toxicant removal/retention functions.

### Q.6.9 Noise impacts in the zone

The area bordering the sanitary landfill will not be influenced by the noise generated by the heavy machinery operating in the site, since with the construction of the buffer zone (fast growing trees, e.g., eucalyptus), the noise impact will be mitigated.

### Q.6.10 Change in the Land Use

The impacts of land use changes will only be limited to the 40 hectares that will be developed for the SJV sanitary landfill project site (i.e., landfill area, area for treatment lagoons, borrow pit for cover soil, buffer zone, office etc.), as good sanitary landfill operation practices (e.g., daily soil coverage), environmental protection facilities (e.g., impermeable liner and leachate treatment lagoons), buffer zone with tall trees will limit the influence area to the 40 ha project area.

### Q.6.11 Landscape Alterations

The 40 ha project site will suffer landscape alterations, however, the landfill shape and its operation will not be noticeable because of the buffer zone (plantation with fast growing trees) around the project site. It will be judged that the landscape alteration will not create negative impacts but rather a favorable scenic view.

The project site, after its service life and the closure process, will be used as an ecological park. It will further give a favorable landscape which will be accessible by citizens at that time.

### Q.6.12 Damages to Archaeological and Paleontologic Points of Interest

Within and around the project site there are no archaeological and paleontologic points of interest.

### Q.6.13 Changes to the Property Values

On the part of the land owners of the project site, there is a willingness to sell the necessary area. The negotiation of land purchase between the project proponent (i.e., Granada Municipality) and land owners will begin after the Environmental Permit (Permiso Ambiental) for the project is issued by MARENA, because it would be impractical to do so beforehand. This means that at the moment of the EIA elaboration it is difficult to predict whether the land price will increase due to the Environmental Permit given or not, and in that case how much it will cost.

Meanwhile, there will not be a negative impact on property value changes of the project neighboring areas, because the project will employ sufficient measures of environmental mitigation and furthermore, asphalt pavement on the access road will be beneficial to the neighboring land uses and to the users of the access road.

# Q.7 Mitigation Measures

## Q.7.1 Design of the Mitigation Measures

Some of the mitigation measures were already included in the conceptual design of the SJV landfill site project. Most of those measures are related to:

- security of the sanitary landfill.
- good sanitary practices of landfill operation.
- adequate functioning of facilities proposed in the project.
- monitoring of important parameters.

Table Q-22 below summarizes the mitigation measures to be developed, in which it can be observed that some mitigation measures are common to several environmental factors.

On the other hand, an operation handbook will be prepared which will be given to all the staff of the landfill project, as well as to the managers and the corresponding authorities, before the operation stage begins, thereinafter it will be given to those new workers who are hired. In this handbook all daily activities will be described, as well as the actions to be taken in the event of emergencies, for example, breakdown of equipment, fires, accidents, etc.

## Table Q-22: Mitigation Measures

| Activity | Description | Public Health | Hazards, Risks | Ground water | Flora & Fauna | Landscape, waste scatter | Air Pollution | Soil Contam. | Noise, Vibration |
|---|---|---|---|---|---|---|---|---|---|
| Security of the Project Site | Access Control (scavenger, etc.) | X | X | | | X | | | |
| | Fire Safety | X | X | | | | | | |
| Sanitary Practices of Landfill Operation, Adequate Functioning of Facilities | Fencing of the Site | X | X | | | X | | | |
| | Construction of Buffer Zone | | | | X | X | | | X |
| | Use of Compactor Trucks for Waste Collection | | | | | X | X | | X |
| | Inspection of Incoming Waste | X | X | | | | | | |
| | Waste Compaction and Daily Soil Coverage | X | X | | X | X | X | | |
| | Impermeable Clay Liner | X | | X | | | | X | |
| | Elimination of Stagnant Water | X | X | | X | | | | |
| | Waste Scatter Control | | | | | X | | | |
| | Tire Wash Basin and Washing Area for Vehicles | X | | | | X | X | | |
| | Preventive Maintenance of Vehicles and Equipment | | | | | | X | | X |
| | Access Road Asphalt Pavement, Gravel Approach Road | X | X | | | | X | | X |
| | Dust Control by Water Tanker | X | X | | | | X | | |
| | Surface Water Drainage | X | | X | X | | | X | |
| | Leachate Control | X | X | X | X | | | X | |
| | Control of Gaseous Emissions | X | X | | X | | X | | |
| | Closure of the Landfill Site | X | X | X | X | | X | X | |
| Workers' Safety | Supply of Protection Equipment | X | X | | | | | | |
| | Operation Manual | X | X | X | X | X | X | X | X |
| Monitoring | Water Quality | X | | X | X | | | X | |
| | Air Quality | X | | | | | X | | |

Note: X marked means the mitigation measure will reduce the environmental impact for the indicated factor.

## Q.7.2 Evaluation of the Efficiency of each Mitigation Measure

### Q.7.2.1 Security of the Project Site

Access of unauthorized persons to the project site, including the firewood collectors will be fully restricted.

### Q.7.2.2 Good Sanitary Practices of Landfill Operation, Adequate Functioning of Facilities

**a. Fencing of the Site**

The fencing of the site will not permit the access of unauthorized persons, thus protecting their health. Also, the light solid waste scattering out of the site will be avoided.

**b. Construction of the Buffer Zone (Tree Planting)**

With the plantation of trees the constant micro-climate of the area will be maintained, the landscape aesthetics will be preserved and the effects of the noise and vibration toward the surrounding areas will be minimal.

**c. Utilization of Compactor Trucks for Waste Collection**

With the utilization of compactor trucks, air pollution in the access road will be considerably reduced an to insignificant level, because the number of trips necessary for waste collection from the service areas to the site will be reduced by the employment of compactor trucks. There will be no diffusion of offensive odors, either.

**d. Inspection of the Incoming Waste**

With the inspection of the waste, disposal of hazardous, toxic, infectious or radioactive wastes will be restricted. With this, occupational health of the site workers and environmental settings therein and nearby (e.g., water quality of the lake, the wetland, ecology of present fauna and flora) will be protected.

**e. Waste Compaction and Daily Soil Coverage**

The waste will be extended and compressed into layers of about 30cm in order to achieve the optimum compaction in the area of the landfill, by a bulldozer. This work will be carried out repeatedly until a height of 3 m is reached. Each day a cell will be formed and covered with 10 - 15 cm of soil at the end of the day with a slope of 3:1. The material for the daily covering will be excavated from the on-site borrow pit designated within the site boundary.

The daily compaction of waste and soil covering over the disposed waste in the site will avoid the proliferation of disease transmitting vectors, thus public health is protected. Air pollution by foul odors will be avoided and scattering of the light solid waste at the boundaries will be avoided.

Therefore, daily soil coverage practices with the landfill gas removal facility and the buffer zone, will never cause adverse impacts on other environmental features (e.g., flora/fauna, agricultural production, poultry farm activities).

**f. Impermeable Bottom Liner with Clay**

Since the infiltration of the leachate to the subsoil is not permitted by the impermeable bottom clay liner of the landfill cells and lagoons, the subsoil and groundwater of the site are fully protected.

**g. Elimination of Stagnant Waters**

Stagnant water as a potential mosquito proliferation area will be eliminated by the site surface gradient and drainage designed and appropriate operational practices in the site, negative impacts on health by stagnant water will be reduced to nil. The only place with stagnant water that can not be avoided, will be the wash basin for the truck tires. However, vector proliferation therein will be avoided by periodical drain out of the water in the basin.

**h. Control of Waste Scattering**

With the mobile fence to be placed near the landfill face, the scatter of waste (e.g., plastic bags) out from the active cell will be restricted significantly. Furthermore, buffer zone with tall tree planting will restrict the scatter and finally the fence with mesh on the site boundary stops the scatter.

**i. Tire Wash Basin and Washing Area for Vehicles**

The tire washing basin will contribute to eliminate waste that could adhere to the tires which could make the access road (Granada-Santa Rosa) dirty and disperse bad odors along the road.

**j. Preventive Maintenance of Vehicles and Equipment**

With preventive maintenance of the waste collection vehicles and on-site equipment, the air pollution caused by inappropriate machine maintenance (e.g., smoke expel due to wrong operation of the injector pump, dirt in the air filters, etc.) will be avoided. Also, the noise increase caused by inappropriately maintained equipment will be avoided.

**k. Access Road Asphalt Pavement and Approach Road Gravel Pavement**

Asphalt pavement on the access road and gravel pavement and water sprinkling by a water tanker on approach road will significantly eliminate the air pollution caused by dust and it will contribute to the safety and health of the drivers, on-site workers and neighboring residents and others.

**l. Dust Control by Water Tanker**

Water sprinkling over dusty work site will eliminate the negative impacts of dust. Meanwhile, amount of water sprinkled will be controlled to an optimum level in order not to generate excessive leachate from the disposed waste.

**m. Surface Water Drainage**

The surface drainage system is designed to restrict the stormwater flowing to the active landfill cell in order to avoid increase of leachate generation. It is designed that the surface water originated from rainfalls on other than active cell will be separately gathered in a drainage channel and routed to the off-site area.

**n. Leachate Control**

With the leachate collection system and its treatment in the lagoons, treated effluent will be maintained to a quality of permissible level. Negative impacts of contamination to the subsoil and the groundwater will be almost nil at the project site and will be very minor (i.e., permissible level) at the outflow point (the wetland area). Impact of treated leachate effluent will be insignificant with regard to: public health, water resource quality (underground and Lake), and flora and fauna of the project influence area.

**o. Control of the Gaseous Emissions**

With the installation of the landfill gas removal facility (i.e., perforated chimneys), control on the ventilation will be created to avoid the impacts of gaseous emissions to public health and workers safety. The risk for methane to reach explosive levels and/or causing fire is eliminated by the gas removal facility and by the practices of daily soil coverage on disposed waste. On the other hand, enough space around the gas removal chimneys should be restricted as "off limits" in order to prevent the risk of burn for the on-site workers in case that the landfill gas chimney catches incidental fire.

**p. Final Coverage of the Site and Restoration of the Landscape**

The operation of a section (3.5 ha) of the landfill will be completed in 5 years. After the 5 years operation, the final covering will be placed on the section. Which will be: clay material of 60 cm thickness; and vegetation soil enough for the re-vegetation of the area. This final covering of the section will avoid the stormwater infiltration and in this manner the production of leachate in the section will be substantially restricted. Furthermore, the landscape with small size vegetation will be restored as an environmental setting.

### Q.7.2.3 Workers' Safety

**a. Supply of Protection Equipment**

Risk of catching diseases due to contact or inhalation of hazardous and/or infectious substances during the landfill operation will be avoided by the provision of the protection equipment. With these protection measures and practices, workers' safety and health will be protected.

**b. Operation Manual**

Provision and use of such manual will lead to protection of all environmental factors. The manual contains: principles of sanitary landfill works; restrictions regarding reception of waste materials; waste handling procedures in practice; operation and maintenance procedures; monitoring process; precautions to prevent negative impact on the environment; actions necessary in case of accident; etc.

### Q.7.2.4 Monitoring

**a. Water Quality**

By monitoring ground water, functioning of impermeable liner can be verified. By monitoring leachate generated and effluents of the leachate treatment lagoons, quality control on the treatment will be available. The monitoring will give notice for taking necessary measures, in case any abnormal behavior is shown. In such manner,

underground water body and consequently all environmental settings including human health will be protected.

**b. Air Quality**

By monitoring air quality, any necessary action to protect it can be implemented, in case altered concentrations of the control parameters are determined.

## Q.7.3 Mitigation Effects

In view of the above clauses, it can be evident that, with construction and operation of the sanitary landfill, impacts which could not be mitigated are very few. They are: change of land use; traffic volume increase on the access road due to waste collection vehicle; increase of noise levels.

Change of land use, which will be from present cattle breeding/agricultural production to landfill use, can limit its impact only for the project site by the buffer zone, planting native species of trees such as leucaena, eucalyptus and acacia, which happen to be fast growing kinds and give environmental integration to the site in a short period. After the project life, change of land use of the project site will give beneficial impacts to the city and citizens. The project site after the closure could give an environmental asset as ecological park and/or timber production from the buffer zone trees.

In the event of traffic increase, the impact will be compensated with the asphalt pavement of the road. This will produce positive impacts: for the surrounding areas by reducing dust, noise and vibration; for the road users by giving a better road condition.

Increase of noise level around the site, will be muffled off with the plantation of trees around the area (buffer zone), preventing impact on surrounding areas.

## Q.7.4 Occurrence of Impacts that cannot be Lessened

The increase of traffic on the area will take place from Monday trough Saturday, from 8:00 a.m. to 5:00 p.m. Assuming that 5 compactor trucks make 3 trips/day and 1 dump truck makes 4 trips/day in year 2001, the net traffic increase will be 19 trips/day on Monday to Saturday and it will count for about 13% increase to the present (year 1997) traffic at the entrance point to the project site. Such percentage represents a small negative impact on the traffic volume.

Modification of current land use will be during a 30 year span (which is also the useful life of the filling).

## Q.7.5 Plan of the Project Closure

Once the useful life of the sanitary Landfill is over, a final covering of the area will be carried out with 60 cm of clay and vegetation soil prepared for re-vegetation of the area. The site can have a future potential use in recreational purposes (such as ecological park) with or without planting more trees.

Meanwhile, monitoring of landfill gas generation after the project closure will be necessary until it is secured that the risk of landfill gas fire disappears. And enough space around the gas removal chimneys should be kept as restricted area of "off limits" when the project site is used for recreational purposes for the citizen.

# Q.8 Environmental Management Program

## Q.8.1 Monitoring Plan

To assure that the landfill operation does not represent any negative impact to the surroundings, monitoring of environmental factors (e.g., groundwater quality) will have to be carried out.

### Q.8.1.1 Respective Impact Indicators

With respect to the wetland and groundwater quality, it is indicated that a certain level of negative impact is presently recorded. Those parameters should be periodically surveyed as part of the monitoring plan.

As mentioned previously, with the landfill operation at the project site, there will be noise increase caused by the traffic of the waste collection vehicles and the works of the heavy machinery in the site, which will be mitigated by the buffer zone. However, noise measurements will be implemented after installation of the buffer zone in order to verify whether the buffer zone mitigates increased noise to surrounding areas.

Although the landfill is designed to avoid lateral emissions of landfill gases (e.g., by gas removal facility), in order to verify the good functioning of the gas removal facilities, visual inspection of vegetation including count ups of survival percentage of the trees in buffer zone will be done.

### Q.8.1.2 Results of the Measurements before the Beginning of the Project

The results of the measurements of the respective impact indicators such as air quality, noise levels, vibration, traffic, groundwater quality, water quality in the wetland, etc., are presented as the baseline of the present environmental settings. (see Chapter 8 of the Data Book: Volume V)

### Q.8.1.3 Frequency of the Future Measurements of the Impact Indicators

Quality of: groundwater (4 monitoring wells); leachate generated; and leachate treated effluent will be monitored periodically in order to secure the appropriate functioning of the environmental protection measures incorporated in the project. With regard to monitoring items, Table Q-23 lists parameters and the frequency to be surveyed.

Table Q-23: Monitoring parameters

| Parameter | Ground water | Frequency (per year) |
|---|---|---|
| pH | x | 1 |
| BOD | x | 1 |
| COD | x | 1 |
| Conductivity | x | 1 |
| $Cl^-$ | x | 1 |
| $SO_4$ | x | 1 |
| Fe | x | 1 |

### Q.8.1.4 Sampling and Laboratory Analysis

The municipality will be in charge of the monitoring of those impact indicators, therefore it will be the municipality who will choose the laboratory or the institution that will make the samplings. Hence, the laboratory or the institution chosen will decide the techniques to be used for the sampling as well as for the analysis in the laboratory.

## Q.8.2 Maintenance and Control of the Equipment

The preventive maintenance of the equipment (e.g., waste collection vehicles, heavy machinery at the landfill site, and a weigh bridge ), will be carried out once a week, in order to avoid the equipment to be damaged and thus affecting the operations in the landfill site. This maintenance will be carried out by staff of the maintenance shop of the Municipality.

## Q.8.3 Cleansing and Maintenance Plan of the Facilities

The cleansing of the bordering areas to the sanitary landfill, as well as the area surrounding the leachate treatment lagoons will be carried out once every other week, to avoid the growth of weeds. On the other hand, those facilities that require structural maintenance (road surface, etc.) should be periodically inspected and repaired.

## Q.8.4 Safety plans

The measures to be taken to protect the health of the on-site workers are already included as the mitigation measures of the project.

## Q.8.5 Risk Control in Different Execution Stages of the Project

The control of accident risks for the workers, in the construction stage of the sanitary landfill project, will be the responsibility of the company contracted for the construction, who will have to inform the staff under its command about a security regulation.

For the operation stage, the measures to be taken to protect the health of the on-site workers are already included as the mitigation measures of the project.

Risk control after the site closure should ensure that the area around the gas removal facility (chimney) should be restricted as "off-limits" in view of a fire risk.

## Q.8.6 Contingency Plans in Case of Emergencies

In the operation handbook that will be given to the workers, the measures to be taken will be indicated in the case of emergency. Furthermore, there will always be a vehicle available at the site in case it is necessary to take a worker to a hospital when having an accident, which is unlikely due to the safety measures that will be taken at the project site.

# Q.9 Forecast of the Environmental Quality of the Influence Area

The environmental quality of the influence area is forecast for respective environmental items as follows:

- public health;
- hazards and risks (including exposure to volatile chemicals and pathogens);
- fire risks;
- air pollution including dust increase;
- gaseous emmision of $CH_4$ and $CO_2$
- Disease vectors
- soil and groundwater contamination;
- flora and fauna;
- landscape aesthetic;
- noise and vibration;
- archeologic and paleontologic points of interest; and
- economic activities including land use changes and land prices increase.

It is expected that due to the mitigation measures to be carried out in respective stage (i.e., construction, operation and closure and after closure stages) of the project, the environmental quality during and after the project is maintained equal to the current conditions.

## Q.10 Conclusion of EIA

### a. Outcome of EIA

SJV A New Municipal SW Disposal Site is planned with level 4. In order to minimize its impacts to the surrounding areas, various mitigation measures were formulated. This will mitigate most of the adverse impact caused by the construction, operation and closure of the disposal site to a permissible level. Particularly, amount of the leachate generated from the disposal site shall be minimized as much as possible and furthermore, an impermeable liner shall prevent it from permeate the ground water and then collected through leachate collecting pipes to regulation pond and then treated at a facultative lagoon and a maturation pond to permissible concentration level. Therefore, no possibility can be envisaged for the newly proposed disposal site to be a cause for ground water contamination as was in the case with a present La Joya disposal site.

Negative impact (occurrence of dust, vibration, noise, and increase of traffic volume) caused by the traffic of collection vehicles will be improved than it is now by the asphalt pavement of the present access road (Granada-Santa Rosa Road).

During the landfill operation period and after its closure, the landscape of the site is changed as landfill work involves topographical alteration. However, it can not be seen by the buffer zone, and after the landfill is completed, re-vegetation over the final covering of the landfill improve the landscape. Therefore, no negative impact of landscape alteration will be envisaged. Regarding the plan for land use after the closure, an ecological park construction is proposed by integrating surrounding natural resources such as a hill of about 7.5m formed by waste, existing wetland, forests, and Lake Nicaragua. This will bring not only environmental improvement, but also benefits residents in the neighboring areas and all residents in Granada Municipality.

In the sanitary landfill, daily soil coverage on waste will be carried out and therefore, proliferation of disease transmitting vectors could substantially be controlled and avoided. Therefore, it is not expected that the sanitary landfill project produces impacts of disease vectors proliferation toward the poultry farm, San Felipe. On the other hand,

as for the poultry farm, present activities and sanitation situation is already attracting some disease vectors (e.g., roof rats *Rattus rattus* are attracted by poultry feeds, Zopilotes *Coragyps atratus* are attracted by untreated residues from fowl meat processing).

The policy of prohibiting scavenging at the new disposal site will result in a loss of income and livelihood for scavengers and middlemen currently operating at La Joya disposal site, a decrease in the amount of waste materials recycled, and a little upset to the recycling system in the city. However, the negative impacts will be minor because the number of scavengers affected will be less than 30. Furthermore, it is recommended to promote recycling by segregation at the source in order to mitigate these negative impacts and also to improve the recycling rate.

The important points regarding the positive impacts of the project are that present La Joya disposal site (although it is substantially improved by the pilot project) , of which untreated leachate is currently permeating the ground will be closed and will become level 4 sanitary landfill disposal site with leachate treatment facility. Above all, since present La Joya disposal site is located upstream of the INAA's wells, which is the main water supply source in Granada City today, its closure and the shift to the new final disposal site, which does not influence ground water, is urgent. Accordingly, the benefit brought from this plan is very high.

It is expected that due to mitigation measures to be carried out in respective stages (i.e., construction, operation and closure and after closure stages) of the project, the environmental quality during and after the project is maintained equal to the current conditions.

**b. Getting an Environmental Permit**

As was stated in the EIA report, the negative impact brought by the implementation of SJV A New Municipal SW Disposal Site Development Project is within permissible level and minimal. On the other hand, there are numbers of positive impact for USE in Granada City, such as closure of the La Joya disposal site which has a high potential of giving serious negative impact to the environment through contamination of the ground water source. Therefore, the project shall be carried out based on the work process stated in the Implementation Plan. Granada Municipality, which is the proponent of SJV A New Municipal SW Disposal Site Development Project, needs to submit this EIA report and obtain an environmental permit in accordance with "EIA and Regulation to obtain an Environmental Permit (Decree No. 45-94)" in order to carry out the project promptly.

# ANNEX R

## F/S - 2:

## Model Community Integrated USE Improvement Project

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# R F/S-2: Model Community Integrated USE Improvement Project

Urban fringe area (UFA) faces a set of sanitation problems such as: absence of waste collection service and consequently illegal waste dumping; domestic wastewater flowing and stagnation; frequent inundation; etc. Even one of these problems is solved with community efforts or with an external assistance, sanitary condition in the area will not easily be improved due to other problems. An integrated approach for the solution must be necessary.

Thus, approximately 200 ha areas of communities developed in the south of the city, which are not included in the INAA's sewerage project for the year 2010 were selected as candidate areas for Model Community. Investigation including a topographical survey were carried out in order to examine the situation of the areas. Consequently, C1, C2, C3 areas were selected as Model Community areas, with the reasons prescribed in the planning framework of F/S. "Model Community Integrated USE Improvement Project" is detailed below.

## R.1 Water Supply System Improvement Project

### a. Water Supply System Improvement

As was prescribed in the planning framework, water supply system improvement project is not subject to priority projects in this Study. However, the following cost were taken into account as the project cost for "Model Community Integrated USE Improvement Project".

1. The model community (C1, C2 and C3 areas) is situated within the areas where water supply system has been already established. Therefore, water supply coverage of the area is 100% at present and in future. Water supply improvement works will be carried out to cope with the increased population in the areas. Hence, the cost for the improvement of the water supply system to deal with the increased population (from year 2000 to 2005) in the model community is calculated as the project cost. The cost is calculated based on the INAA's Pre-F/S report.
2. Rectification works of shallow buried existing water pipe shall be carried out together with the domestic wastewater facility construction works. Therefore, the cost for rectification works is assumed in the contingency cost for domestic wastewater treatment facility construction.

### b. Project Cost

Table R-1 shows the project cost calculated based on the method stated above.

Table R-1: Project Cost for Water Supply System Improvement in the Model District

| | C1 | C2 | C3 | Total |
|---|---|---|---|---|
| Facility Construction Cost (thousand C$) | 1,289 | 1,786 | 1,864 | 4,939 |
| Operation & Maintenance Cost (thousand C$) | 124 | 172 | 179 | 475 |
| Total | 1,413 | 1,958 | 2,043 | 5,414 |

## R.2 Refuse Collection Improvement Project

### a. Conclusion Deduced from Pilot Projects

As was prescribed in the planning framework, refuse collection improvement project in the model community is formulated based on the result of the pilot projects. The important conclusion deduced from the pilot projects are as follows;

1. Even though residents have will to pay refuse collection fee, the amount of the fee they can afford to pay is extremely limited. WTP amount averages from 3.3C$/month/household to 3.9 C$/month/household.
2. Therefore, cost for the collection service in the model community shall be minimized as much as possible and it is necessary to examine the measures to minimize the cost burden by the residents.
3. Point collection system which reduces the refuse collection cost through residents cooperation is fully acceptable to the residents. However, waste collection bays have to be installed within 50m from the respective households.
4. Waste collection bay is sufficient if it is made of concrete floor and the notice boards is put up.
5. Refuse collection frequency can be twice a week.

### b. Refuse Collection System Improvement

The outline of the refuse collection system improvement for the model community is as follows;

**Served Population:** 24,658 in year 2005

**Projected Collection Amount:** 19 ton/day

**Collection System:** Point collection system with waste collection bays. The collection cost of point collection system is cheaper than that of the curb collection system.

**Collection Vehicles:** Compactor truck

**Collection Frequency:** Twice a week

### c. Project Cost

The project cost of the refuse collection system improvement for the model community is included in that of F/S-1: Municipal Solid Waste Management System Improvement Project.

## R.3 On-Site Domestic Waste Water Treatment System Improvement Project

### R.3.1 Technical System

#### a. Service Projected Area and Population

The on-site domestic wastewater treatment system will be established for areas C1, C2, and C3. The conditions observed in these areas are as follows:

- According to INAA[1], In 1995, the C1, C2 and C3 areas had a population density exceeding 100 persons/ha and the population density of C1 and C2 is estimated to exceed 200 persons/ha in 2010.
- C1, C2 and C3 have streets along which the construction of on-site domestic wastewater treatment facilities, e.g. pipelines and wastewater treatment facility, can be planned.

Accordingly, C1, C2, C3 (population of approximately 23,000) where the 1995 population density of more than 100 persons/ha is forecast to further increase in 2010, will be given priority for the installation of the on-site domestic wastewater treatment system. Realistic planning of the on-site system is possible for these areas as streets are already established in these areas.

Accordingly, C1, C2 and C3 are subject to the M/P of on-site domestic wastewater treatment system. M/P assumes construction of on-site treatment facility by 2010 for these areas. The areas where the improvement of the facility will be completed by 2005, starting in 2001 are subject to F/S. This is based on the assumptions that the improvement ratio increases regularly by 2010.

Table R-2: Population and Population Density of On-site Treatment System Area

| Zone | Area (ha) | 1995 | | 2000 | | 2005 | | 2010 | |
|---|---|---|---|---|---|---|---|---|---|
| | | Pop. (per.) | Dens. (p/ha) | Pop. (per.) | Dens. (p/ha) | Pop. (per.) | Dens. (p/ha) | Pop. (per.) | Dens. (p/ha) |
| C1 | 33 | 4,997 | 153 | 5,466 | 167 | 5,979 | 183 | 6,658 | 204 |
| C2 | 31 | 3,992 | 130 | 4,608 | 150 | 5,319 | 173 | 6,251 | 204 |
| C3 | 67 | 7,789 | 117 | 8,471 | 127 | 9,213 | 138 | 10,201 | 153 |
| C4 | 60 | 868 | 14 | 1,899 | 31 | 4,147 | 69 | 9,224 | 153 |
| **Total** | **191** | **17,646** | **92** | **20,444** | **107** | **24,658** | **129** | **32,334** | **169** |
| Off-site Area | 559 | 53,525 | 96 | 59,652 | 107 | 66,698 | 119 | 74,266 | 133 |

[1] ESTUDIO DE PRIORIZACION DE INVERSIONES EN SECTOR DE AGUA POTABOLE Y ALCANTARILLADO SANITARIO, ALCANTARILLADO SANITARIO DE LA CIUDAD DE GRANADA, DICIEMBRE 1996, I.N.A.A. ITS, Lotti, Iamsa

However, on-site domestic wastewater treatment facility (pipeline, wastewater treatment facility) needs to be constructed per a small sized community as a treatment block (composed of a group of several to several tens of households). Construction of the facility becomes possible only if the consensus is reached per treatment block.

The items necessary to have residents' consensus on are;

- Securing the site for treatment facility (it is desirable that the community localizes the candidate site offers the site voluntarily)
- Agreement on the implementation of facility construction works (pipeline, wastewater treatment facility)
- Each household shall have a responsibility to connect their wastewater to the catchpit.
- Cooperation for operation and maintenance of the facility by the residents n the community (cleaning, etc.).
- Removal of illegal squatters on the public land designated for the facility construction (including public road for community sewer).

Compared with off-site treatment system, there are more items to be agreed on with residents in the community in the on-site treatment system. Facility shall be constructed one after another starting with the community agreement with residents has obtained.

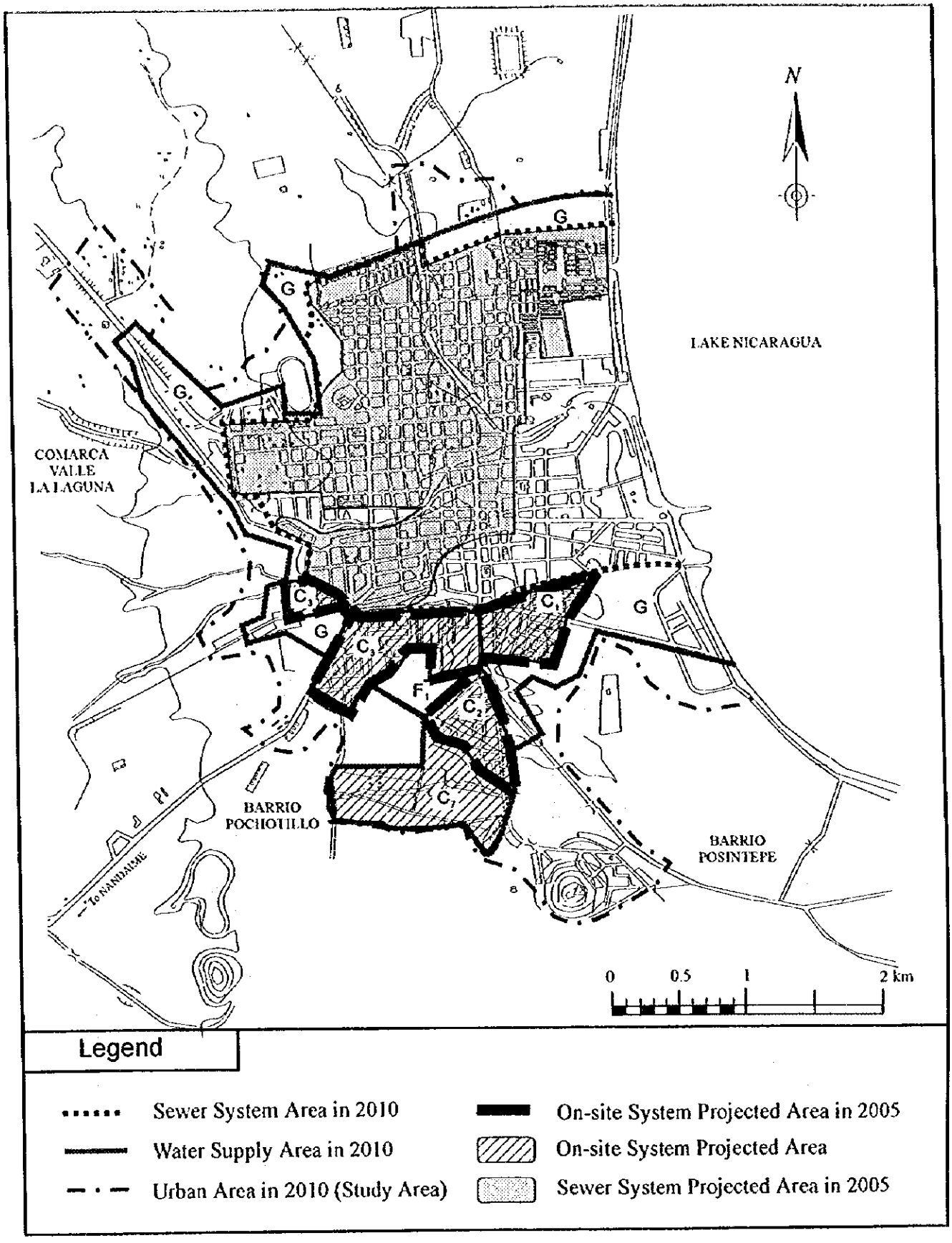



Figure R-1 : On-site System Projected Area

### b. Facilities Localization

#### b.1 Key Principles for the Facilities Localization

Localization of on-site system facilities should be determined depending upon: numbers of houses; layout of the respective houses; topographic conditions, etc. of the areas subject to the on-site system.

Key principles for the facilities localization are listed below and the concept of localization of on-site facilities are shown in Figure R-2.

- Sewer should be located away from vehicle roads;
- Gradient of sewer should follow the site gradient;
- Basically the sewer should not cross vehicle road in order to maintain the overburden depth shallow; and
- Numbers of households subject to an on-site system should be about 5 to 50, and the treatment facilities should be located in such a place that the above principles are satisfied.

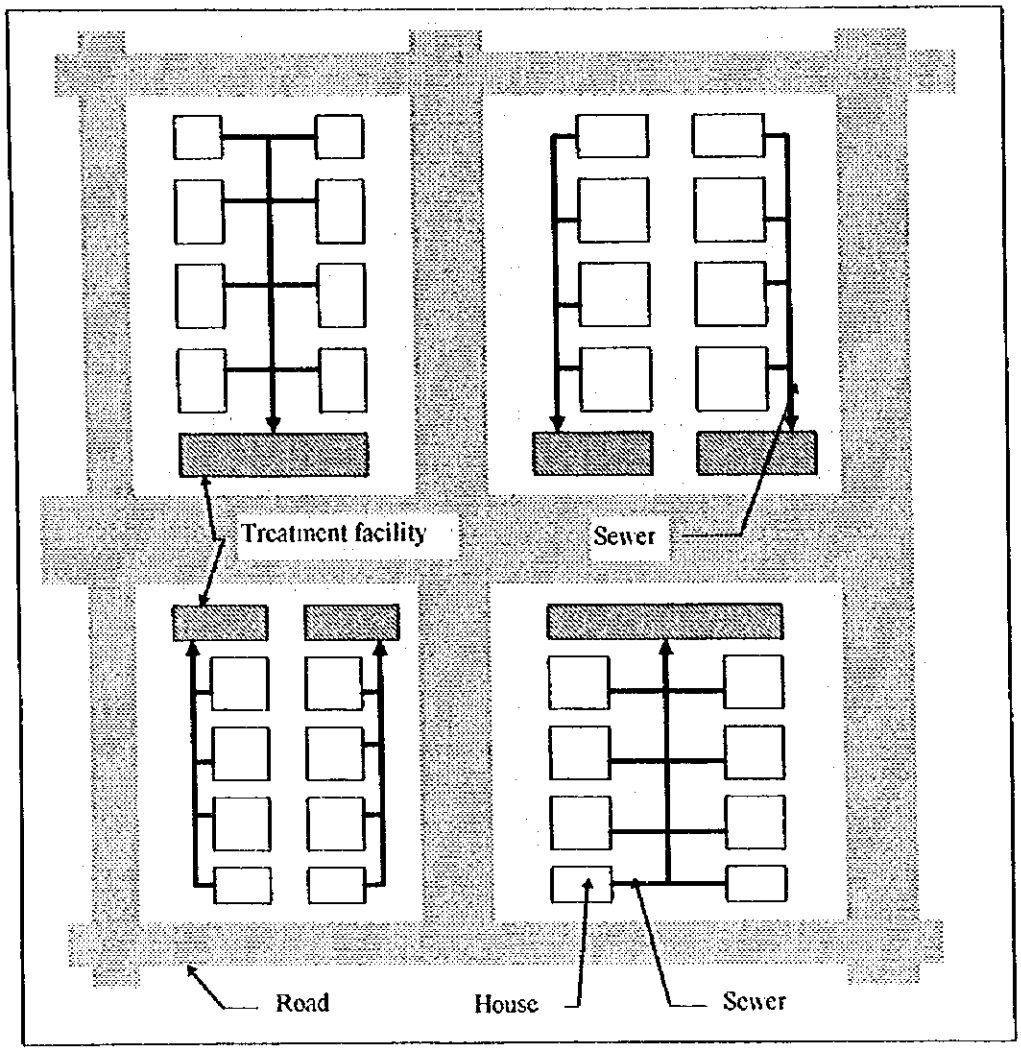



Figure R-2: Concept of On-site System Localization

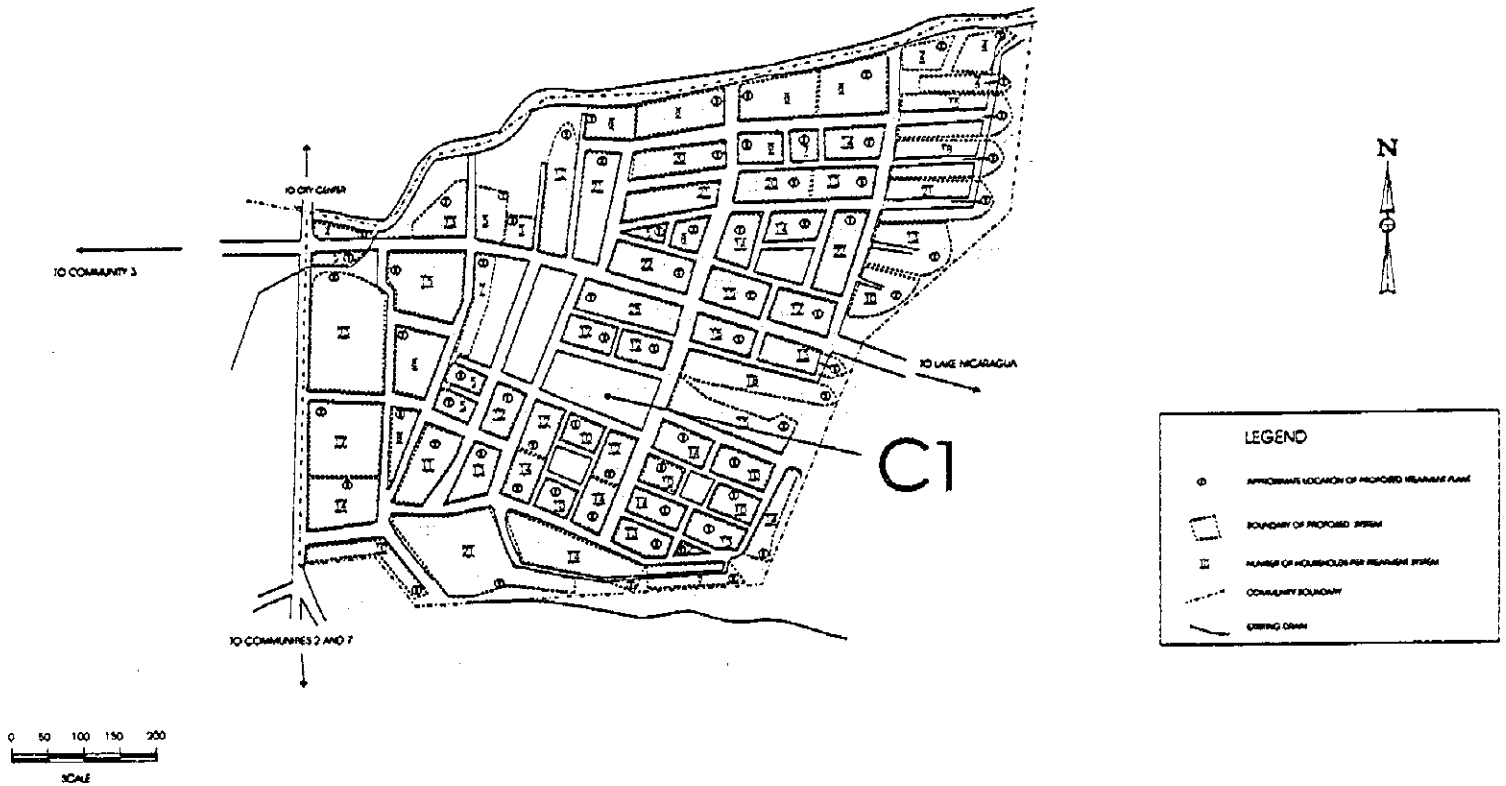
### b.2 Facilities Localization

Based on the Key Principles mentioned above and survey results, district C1,C2, and C3 are divided into sub-districts, a smallest unit for on-site treatment, and the served population per respective sub-districts are shown in Table R-2 and Table R-4. The on-site systems arrangement plan are shown in Figure R-3 and Figure R-5.

Table R-3: Future Population of the Zone "C1"

| Sub-district code number | Population | | | Sub-district code number | Population | | |
|---|---|---|---|---|---|---|---|
| | 1997 | 2005 | 2010 | | 1997 | 2005 | 2010 |
| 1 | 24 | 28 | 31 | 36 | 83 | 95 | 106 |
| 2 | 134 | 156 | 174 | 37 | 47 | 54 | 60 |
| 3 | 99 | 114 | 127 | 38 | 53 | 61 | 68 |
| 4 | 83 | 95 | 106 | 39 | 116 | 135 | 151 |
| 5 | 59 | 68 | 76 | 40 | 41 | 47 | 53 |
| 6 | 77 | 88 | 98 | 41 | 47 | 54 | 60 |
| 7 | 88 | 102 | 113 | 42 | 83 | 95 | 106 |
| 8 | 47 | 54 | 60 | 43 | 77 | 88 | 98 |
| 9 | 47 | 54 | 60 | 44 | 83 | 95 | 106 |
| 10 | 30 | 35 | 39 | 45 | 83 | 95 | 106 |
| 11 | 41 | 47 | 53 | 46 | 128 | 149 | 166 |
| 12 | 30 | 35 | 39 | 47 | 88 | 102 | 113 |
| 13 | 30 | 35 | 39 | 48 | 99 | 114 | 127 |
| 14 | 99 | 114 | 127 | 49 | 88 | 102 | 113 |
| 15 | 71 | 81 | 90 | 50 | 77 | 88 | 98 |
| 16 | 77 | 88 | 98 | 51 | 104 | 121 | 135 |
| 17 | 122 | 142 | 158 | 52 | 88 | 102 | 113 |
| 18 | 18 | 21 | 23 | 53 | 83 | 95 | 106 |
| 19 | 71 | 81 | 90 | 54 | 59 | 68 | 76 |
| 20 | 71 | 81 | 90 | 55 | 59 | 68 | 76 |
| 21 | 83 | 95 | 106 | 56 | 59 | 68 | 76 |
| 22 | 47 | 54 | 60 | 57 | 83 | 95 | 106 |
| 23 | 122 | 142 | 158 | 58 | 88 | 102 | 113 |
| 24 | 47 | 54 | 60 | 59 | 77 | 88 | 98 |
| 25 | 116 | 135 | 151 | 60 | 83 | 95 | 106 |
| 26 | 122 | 142 | 158 | 61 | 12 | 14 | 15 |
| 27 | 30 | 35 | 39 | 62 | 53 | 61 | 68 |
| 28 | 47 | 54 | 60 | 63 | 24 | 28 | 31 |
| 29 | 128 | 149 | 166 | 64 | 24 | 28 | 31 |
| 30 | 146 | 170 | 189 | 65 | 24 | 28 | 31 |
| 31 | 71 | 81 | 90 | 66 | 88 | 102 | 113 |
| 32 | 71 | 81 | 90 | 67 | 105 | 121 | 135 |
| 33 | 59 | 68 | 76 | 68 | 123 | 142 | 158 |
| 34 | 59 | 68 | 76 | 69 | 77 | 88 | 98 |
| 35 | 71 | 81 | 90 | 70 | 59 | 68 | 76 |
| | | | | 71 | 83 | 95 | 106 |
| Sub-total | 2,537 | 2,928 | 3,260 | Sub-total | 2,648 | 3,051 | 3,398 |
| Total | 5185 | 5979 | 6658 | | | | |

Note: Upon consideration of community consensus and O&M system of a DWW treatment system, one block which is the smallest neighborhood community is planned as one treatment community. If several blocks manage to create a treatment community, the unit construction cost(per household) for a treatment facility can be reduced though the cost of connection to the pipeline can not be reduced(See Annex R). Therefore, if consensus among multiple communities and O&M system can be established, it is desirable to have a DWW treatment system for several blocks in order to reduce the cost.



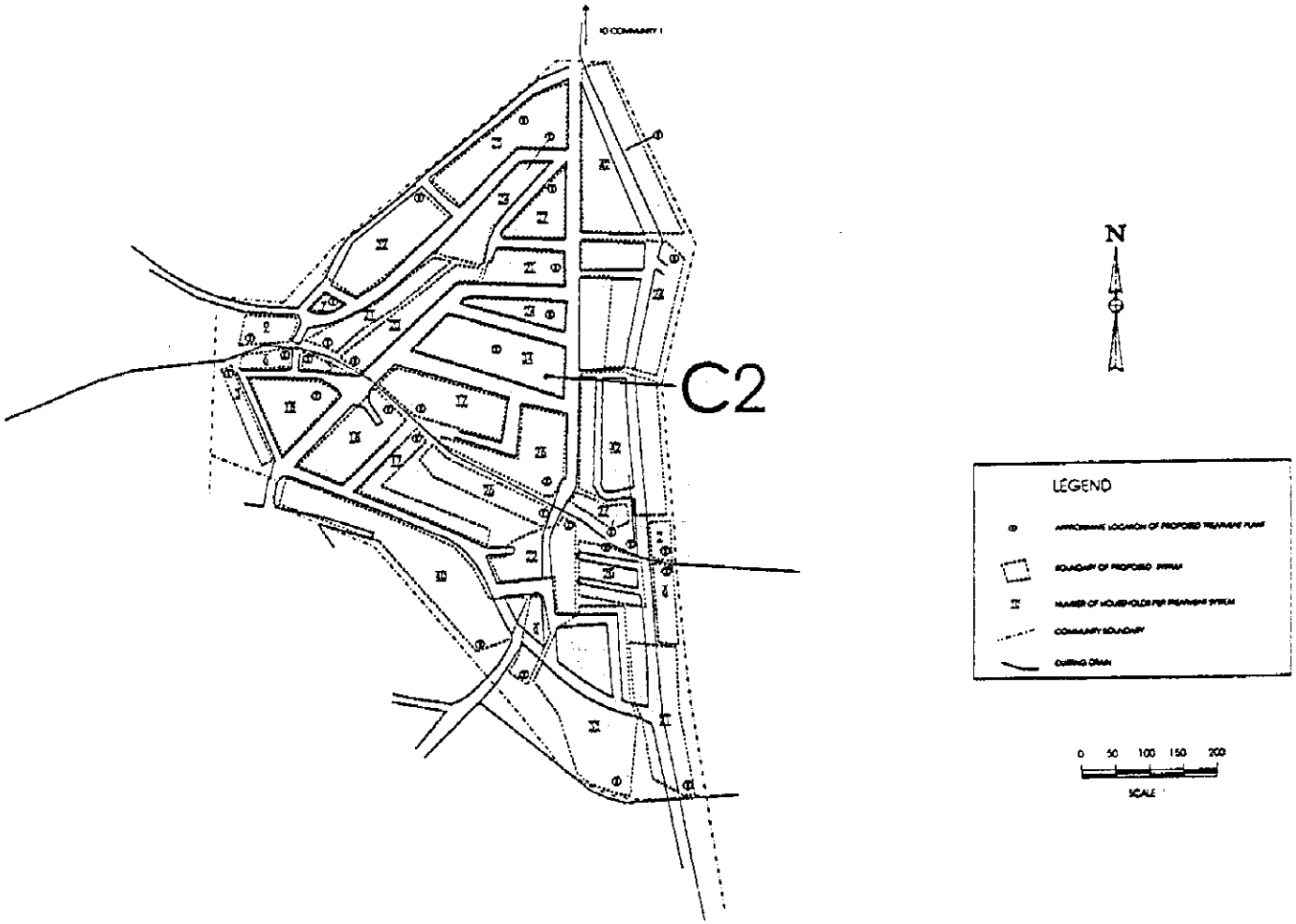

DOMESTIC WASTEWATER TREATMENT SYSTEMS IN COMMUNITY 1 OF
THE MODEL COMMUNITY INTEGRATED U.S.E. IMPROVEMENT AREA

Figure R-3 : On-site Systems Arrangement Plan (Zone C1)

## Table R-4: Future Population of the Zone "C2"

| Sub-district code number | Population | | | Sub-district code number | Population | | |
|---|---|---|---|---|---|---|---|
| | 1997 | 2005 | 2010 | | 1997 | 2005 | 2010 |
| 1 | 277 | 348 | 409 | 17 | 172 | 216 | 254 |
| 2 | 158 | 198 | 233 | 18 | 278 | 351 | 408 |
| 3 | 165 | 207 | 243 | 19 | 26 | 33 | 38 |
| 4 | 178 | 223 | 263 | 20 | 13 | 16 | 19 |
| 5 | 211 | 265 | 311 | 21 | 20 | 25 | 30 |
| 6 | 139 | 174 | 205 | 22 | 119 | 149 | 176 |
| 7 | 158 | 198 | 233 | 23 | 119 | 149 | 176 |
| 8 | 158 | 198 | 233 | 24 | 112 | 141 | 165 |
| 9 | 46 | 58 | 68 | 25 | 172 | 216 | 254 |
| 10 | 139 | 174 | 205 | 26 | 145 | 182 | 214 |
| 11 | 132 | 166 | 195 | 27 | 132 | 166 | 195 |
| 12 | 59 | 74 | 87 | 28 | 40 | 50 | 59 |
| 13 | 40 | 50 | 59 | 29 | 264 | 331 | 389 |
| 14 | 33 | 41 | 49 | 30 | 40 | 50 | 59 |
| 15 | 224 | 281 | 330 | 31 | 218 | 274 | 322 |
| 16 | 112 | 141 | 165 | 32 | 139 | 174 | 205 |
| Sub-total | 2,229 | 2,796 | 3,288 | | 2,009 | 2,523 | 2,963 |
| Total | 4,238 | 5,319 | 6,251 | | | | |

Note: Upon consideration of community consensus and O&M system of a DWW treatment system, one block which is the smallest neighborhood community is planned as one treatment community. If several blocks manage to create a treatment community, the unit construction cost(per household) for a treatment facility can be reduced though the cost of connection to the pipeline can not be reduced(See Annex R). Therefore, if consensus among multiple communities and O&M system can be established, it is desirable to have a DWW treatment system for several blocks in order to reduce the cost.



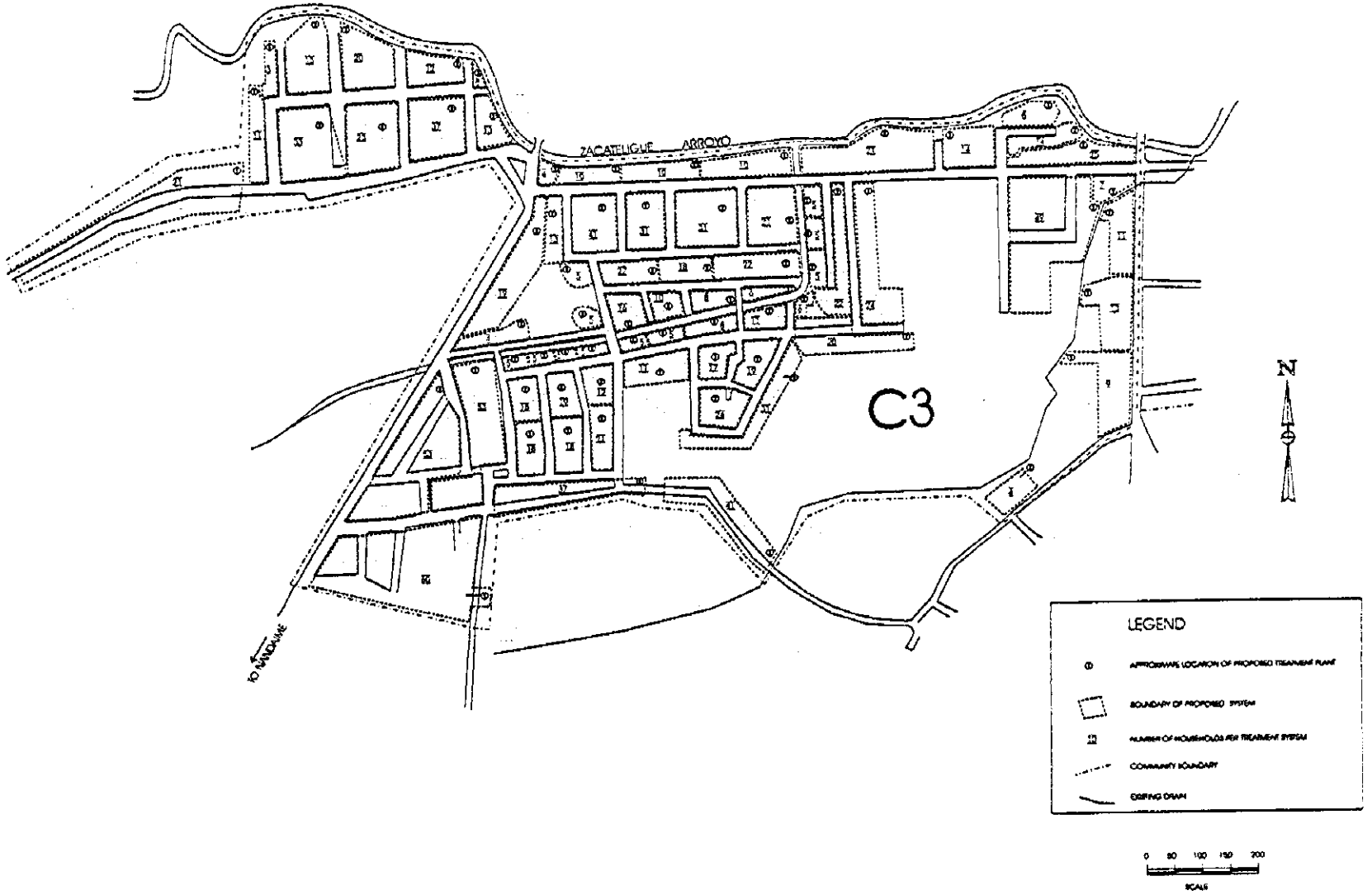

DOMESTIC WASTEWATER TREATMENT SYSTEMS IN COMMUNITY 2 OF
THE MODEL COMMUNITY INTEGRATED U.S.E. IMPROVEMENT AREA

Figure R-4 : On-site Systems Arrangement Plan (Zone C2)

## Table R-5 : Future Population of the Zone "C3"

| Sub-district code number | Population | | | Sub-district code number | Population | | |
|---|---|---|---|---|---|---|---|
| | 1997 | 2005 | 2010 | | 1997 | 2005 | 2010 |
| 1 | 136 | 155 | 171 | 38 | 58 | 66 | 74 |
| 2 | 71 | 81 | 90 | 39 | 84 | 96 | 107 |
| 3 | 213 | 244 | 269 | 40 | 71 | 81 | 90 |
| 4 | 20 | 23 | 25 | 41 | 46 | 52 | 57 |
| 5 | 97 | 111 | 123 | 42 | 316 | 361 | 400 |
| 6 | 149 | 169 | 188 | 43 | 154 | 176 | 195 |
| 7 | 129 | 148 | 162 | 44 | 129 | 148 | 162 |
| 8 | 239 | 272 | 302 | 45 | 142 | 161 | 179 |
| 9 | 77 | 88 | 98 | 46 | 33 | 38 | 42 |
| 10 | 84 | 96 | 107 | 47 | 33 | 38 | 42 |
| 11 | 51 | 58 | 65 | 48 | 33 | 38 | 42 |
| 12 | 26 | 30 | 33 | 49 | 200 | 229 | 254 |
| 13 | 123 | 141 | 155 | 50 | 154 | 176 | 195 |
| 14 | 84 | 96 | 107 | 51 | 103 | 118 | 131 |
| 15 | 33 | 38 | 42 | 52 | 123 | 141 | 155 |
| 16 | 33 | 38 | 42 | 53 | 110 | 126 | 139 |
| 17 | 103 | 118 | 131 | 54 | 71 | 81 | 90 |
| 18 | 174 | 199 | 221 | 55 | 51 | 58 | 65 |
| 19 | 264 | 302 | 335 | 56 | 33 | 38 | 42 |
| 20 | 64 | 73 | 81 | 57 | 33 | 38 | 42 |
| 21 | 116 | 133 | 147 | 58 | 71 | 81 | 90 |
| 22 | 200 | 229 | 254 | 59 | 239 | 272 | 302 |
| 23 | 51 | 58 | 65 | 60 | 136 | 155 | 171 |
| 24 | 39 | 45 | 49 | 61 | 77 | 88 | 98 |
| 25 | 142 | 161 | 179 | 62 | 116 | 133 | 147 |
| 26 | 200 | 229 | 254 | 63 | 123 | 141 | 155 |
| 27 | 129 | 148 | 162 | 64 | 123 | 141 | 155 |
| 28 | 26 | 30 | 33 | 65 | 116 | 133 | 147 |
| 29 | 64 | 73 | 81 | 66 | 33 | 38 | 42 |
| 30 | 64 | 73 | 81 | 67 | 33 | 38 | 42 |
| 31 | 64 | 73 | 81 | 68 | 33 | 38 | 42 |
| 32 | 64 | 73 | 81 | 69 | 33 | 38 | 42 |
| 33 | 136 | 155 | 171 | 70 | 384 | 439 | 486 |
| 34 | 90 | 103 | 114 | 71 | 342 | 390 | 432 |
| 35 | 161 | 184 | 204 | 72 | 342 | 390 | 432 |
| 36 | 90 | 103 | 114 | 73 | 26 | 30 | 33 |
| 37 | 51 | 58 | 65 | | | | |
| Sub-total | 3,857 | 4,408 | 4,882 | | 4,204 | 4,805 | 5,319 |
| Total | 8,061 | 9,213 | 10,201 | | | | |

Note: Upon consideration of community consensus and O&M system of a DWW treatment system, one block which is the smallest neighborhood community is planned as one treatment community. If several blocks manage to create a treatment community, the unit construction cost(per household) for a treatment facility can be reduced though the cost of connection to the pipeline can not be reduced(See Annex R). Therefore, if consensus among multiple communities and O&M system can be established, it is desirable to have a DWW treatment system for several blocks in order to reduce the cost.




DOMESTIC WASTEWATER TREATMENT SYSTEMS IN COMMUNITY 3 OF
MODEL COMMUNITY INTEGRATED U.S.E. IMPROVEMENT AREA

Figure R-5 : On-site Systems Arrangement Plan (Zone C3)

## c. Facility Planning

### c.1 Pipeline

The design of the pipe was carried out by utilizing design parameter in based on the results of the pilot project.

Table R-6 : Basic Design Conditions for Pipeline

| Item | Design Parameter |
|---|---|
| Type of collection system | Separate system |
| Material of pipe | PVC |
| Minimum diameter of pipeline | 100 (mm) |
| Formula of flow rate | Manning formula |
| Roughness coefficient | n=0.01 |
| Maximum velocity of flow | 3.0 (m/sec) |
| Minimum velocity of flow | 0.6 (m/sec) |
| Maximum length of manhole to manhole | 80 (m) |
| Minimum earth depth | 600 (mm) |

The curtailment of construction expenses was considered by installing the pipes parallel to the ground surface gradient.

### c.2 Treatment Facilities

#### c.2.1 Intake Water Quality and Amount

Influent quality shall be the value set in the M/P. Influent amount shall be calculated on a wastewater discharge ratio 100 (liter/person/day), referring to the result of the pilot projects.

Table R-7 : Influent Water Quality

| | BOD (mg/l) | COD (mg/l) | SS (mg/l) |
|---|---|---|---|
| Influent water quality | 340 | 600 | 570 |

#### c.2.2 Effluent Water Quality

INAA's design value for effluent quality for wastewater treatment plant listed below shall be adopted for the design effluent quality of the on-site system in this Study.

Table R-8 : Effluent Water Quality

| pH | BOD | COD | Sedimentable Solid | Suspended Solid | E-col.(NMP/100ml) |
|---|---|---|---|---|---|
| 6.9 | 110 (mg/l) | 220 (mg/l) | 1.0 (mg/l) | 100 (mg/l) | 1E+04 |

### c.2.3 Treatment Method

#### c.2.3.1 Treatment Flow Sheet

BOD concentration level of influent in this Study is 340 (mg/l) and required effluent quality to be treated is 110 (mg/l). Therefore, BOD removal rate required for this facility is more than 68%.

Table R-9 shows various type of domestic wastewater treatment system and BOD and SS removal rate. All treatment systems except for septic tank and combined jokaso are applied for large scale off-site treatment facility. Accordingly, either septic tank or combined jokaso shall be adopted in this Plan. Although combined jokaso is a widely used system in Japan, no Nicaragua does not have experiences in adopting this system in the past. Furthermore, this system requires relatively high techniques for facility construction and operation and maintenance, electricity to operate facilities, and the cost for operation and maintenance is high. On the other hand, Nicaragua has experiences in facility construction, operation and maintenance of septic tank. As electricity is not necessary to operate the facility in this treatment system, the operation and maintenance cost automatically becomes low. Considering all the above, septic tank shall be adopted in this Plan. As was indicated in Table R-10, BOD removal rate of septic tank ranges from 55% to 70% and BOD concentration level of the septic tank effluent can be assumed to be from 153 (mg/l) to 102 (mg/l), there will be some cases that target BOD concentration level of the effluent (110 mg/l) can not be attained with septic tank treatment only. Therefore, in order to secure effluent quality of less than BOD 110 (mg/l), a filter trench shall be installed next to a septic tank.

Table R-9 : Domestic Waste Water Treatment Method

| Treatment method | Removal Ratio (%) | |
|---|---|---|
| | BOD | SS |
| Lagoon | 70 - 95 | - |
| Aerated lagoon | 70 - 95 | - |
| Activated sludge method | 90 - 95 | 80 - 90 |
| Trickling filter method | 80 - 95 | 80 - 90 |
| Combined jokaso | 90 - 95 | 90 - 95 |
| Septic tank | 55 - 70 | - |

In the pilot project, plastic sheet for collecting leachate was spread at the bottom of the filter trench in order to confirm the performance of filter trench treatment. The construction cost for spreading this plastic sheet will be three times as much compared with filter trench without it.

Therefore, when the model community improvement is carried out, bottom plastic sheet for leachate collection shall be eliminated from the filter trench and effluent shall be planned to infiltrate into the soil in order to reduce construction cost. However, effluent collection pipes shall be installed, assuming that some filter trenches will be installed where infiltration capacity is low.

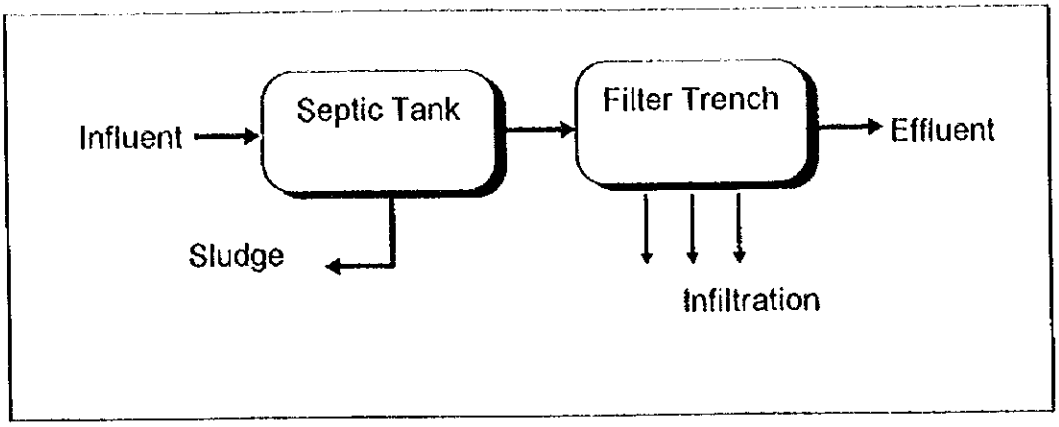



Figure R-6 : Flow Sheet of the On-site Treatment Facility

### c.2.3.2 Treated Water Quality

BOD removal rates in case the treatment system which combined septic tank and filter trench mentioned above are used are;

- BOD removal rate by septic tank is 55% to 70%
- BOD removal rate by filter trench is 50% to 70%

The design effluent quality calculated are shown in Table R-10.

Table R-10 : Intake and Treated Water Quality

| | Intake water | Septic tank effluent | Filter trench effluent |
|---|---|---|---|
| BOD removal ratio | - | 55 - 70 (%) | 50 - 70 (%) |
| BOD concentration | 340 (mg/l) | 153 - 102 (mg/l) | 77 - 51 (mg/l) |

## d. Preliminary Design

### d.1 Pipeline

### d.1.1 Main Sewer

Based on the plans indicated in Figure R-2 and Table R-6, and Table R-11 summarizes the result of the main pipeline plan.

Table R-11 : Outline of the Pipeline Plan

| | C1 | C2 | C3 |
|---|---|---|---|
| PVC 100 mm | 6,000 m | 5,800 m | 9,800 m |
| PVC 150 mm | 700 m | 700 m | 1,200 m |
| Total | 6,700 m | 6,500 m | 11,000 m |

### d.1.2 Catch Pit

The catchpit, which also serves as a separate sediment tank, shall be installed in order to prevent large solid materials from entering into the sewer pipes when wastewater from the respective households flows into the sewer pipes. PVC pipe of 75 mm, which is one size smaller than main sewer, shall be used for the pipes connecting from catch pit to sewer pipes in order to avoid clogging of main sewer pipes.

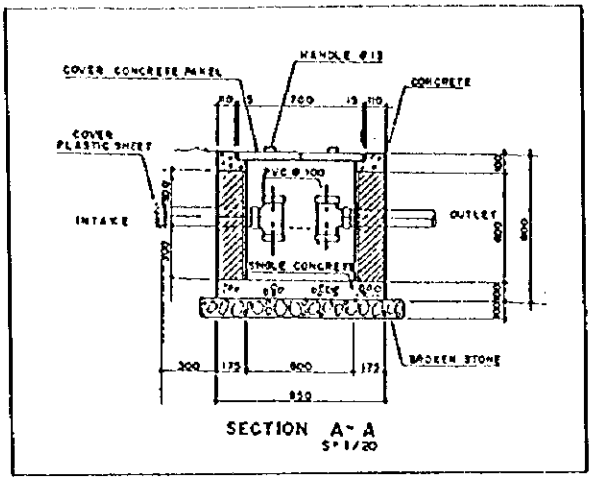



Figure R-7 : Catch Pit

## d.2 Treatment Facility

### d.2.1 Septic Tank

If detention time is set to be three days based on the result of the pilot projects, required treatment capacity of septic tank per person are;

100 (liter/person/day) ×3 days = 300 (liter/person)

On the other hand, the size of the population in the sub-district covered by an on-site treatment system will be 15 to 486 in 2010 as shown in Table R-3 to Table R-5. Table R-12 shows the calculation result for septic tank capacity to deal with wastewater produced by respective population size (10 to 500 persons).

Table R-12 : Required Volume of Septic Tank

| Sub-district population (persons) | Waste water amount ($m^3$/day) | Required volume of septic tank ($m^3$) |
|---|---|---|
| 10 | 1 | 3 |
| 20 | 2 | 6 |
| 30 | 3 | 9 |
| 40 | 4 | 12 |
| 50 | 5 | 15 |
| 60 | 6 | 18 |
| 70 | 7 | 21 |
| 80 | 8 | 24 |
| 90 | 9 | 27 |
| 100 | 10 | 30 |
| 120 | 12 | 36 |
| 140 | 14 | 42 |
| 160 | 16 | 48 |
| 180 | 18 | 54 |
| 200 | 20 | 60 |
| 250 | 25 | 75 |
| 300 | 30 | 90 |
| 350 | 35 | 105 |
| 400 | 40 | 120 |
| 450 | 45 | 135 |
| 500 | 50 | 150 |

### d.2.2 Filter Trench

Removal functions of filter trench for wastewater are as follows;

- keeping inside of the soil aerobic and let capillary flow formed.
- encourage aerobic bacteria increase in the soil
- letting wastewater contact the aerobic bacteria and remove contaminants (organic substance) from the wastewater through aerobic discomposition by the function of aerobic bacteria.

Treatment mechanism of filter trench is shown in Figure 5-8. This treatment system is applicable with wide range of soil from sand to clay material. Especially soil made of loam is considered to be most appropriate.

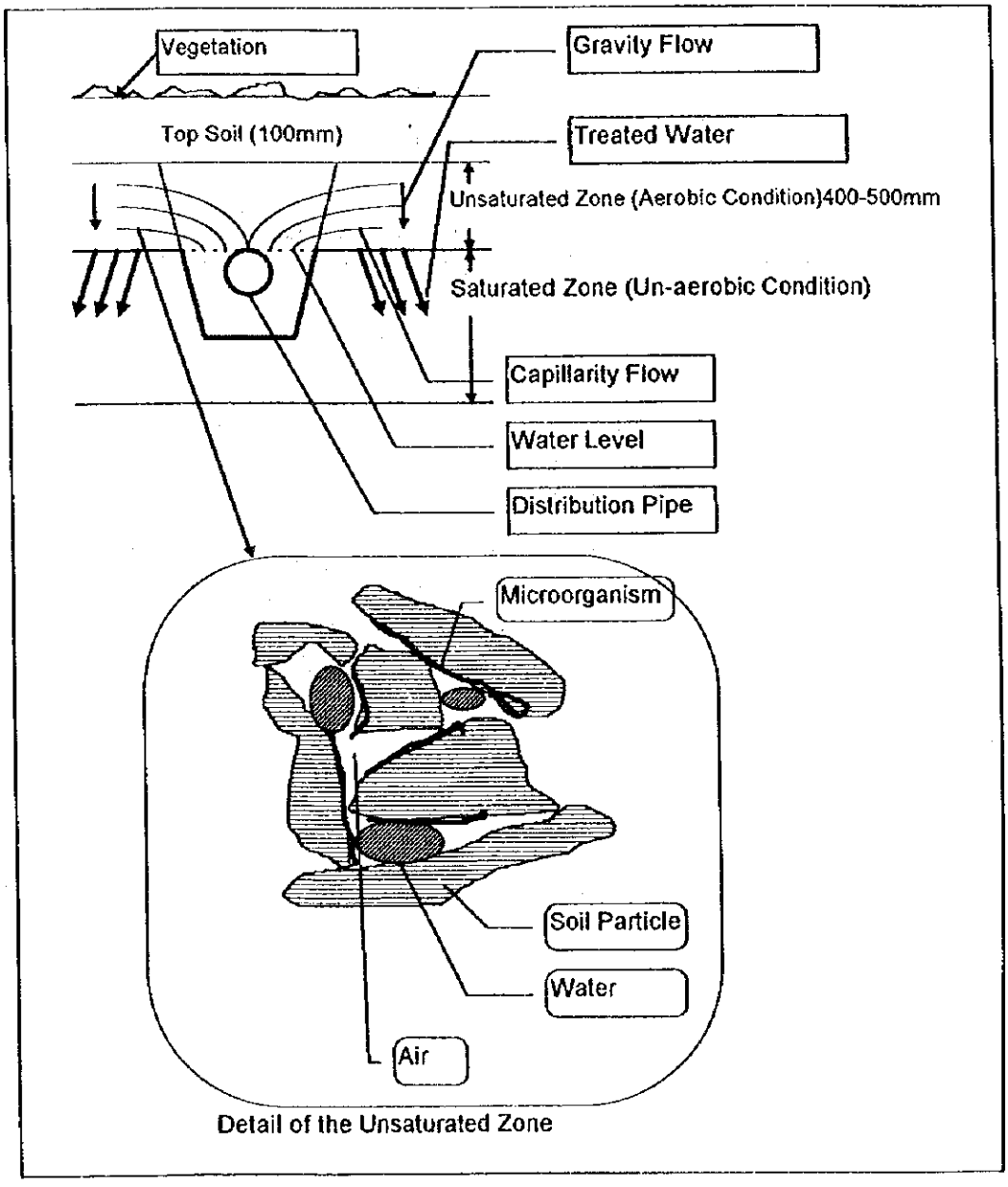



Figure R-8: Treatment Mechanism of Filter Trench

The design of the filter trench was made taking into account the volume of wastewater that can be treated daily per 1m filter trench. This plan adopts the value (200 ℓ/m/day of domestic wastewater containing approximately 150 to 90 mg/l of BOD) used in an experiment conducted in Japan.

The biological treatment of wastewater containing organic pollutants can be effectively carried out by setting the water temperature below 40° C. Taking weather conditions into account, the water temperature required to treat the previously mentioned filter trench load of 200ℓ/m/day in Japan ranges from 15° C to 20° C. Since the temperature in Nicaragua is higher, the possibility that the filter trench could accommodate a higher load can be considered.

## R.3.2 Institutional System

### a. Operational Authorities

The model community will require 176 systems for on-site DWW collection and treatment to accommodate the estimated population of 23,110 inhabitants by the year 2010, and will require an investment of US$ 3,320,000 and funds to cover operational costs of US$ 330,000 during this period.

As the local population cannot generate all the investment costs, external funds would be needed, However, the beneficiaries should pay the operational costs; the public must be motivated to do so. Institutional reform must be initiated in order to raise funds and manage external grants as well as motivate and encourage the communities to pay the operational costs.

The project would be called the "Special Program for Model Community Integrated USE Improvement Project" (PECM) and would be a joint venture among INAA, the municipality and MINSA/SILAIS. The three authorities should create a steering committee: each committee member will work in their special field, but aiming to reach a common goal. This means that INAA will be the executing body that will manage the on-site DWW treatment system, but the municipality and MINSA/SILAIS will be indispensable for realizing the PECM. The steering committee's president will be elected annually from the committees' members and an executive secretary should be employed.

The on-site DWW treatment system in a given area must be integrated with a special drainage system that is managed by the municipality. The steering committee must oversee the two systems as they both need technical and social integration as well as external funding.

The location of an on-site treatment system is dependent on the physical ground condition, housing design as well as acceptance by the community. Each community should be involved in the PECM as they will be paying for the services and maintaining the facilities. The joint task of the three authorities will be to motivate the community to become involved; this would be a necessary criteria prior to the installation of the system. The duties and responsibilities of the four key players are outlined below.

#### a.1 INAA/IV Region Office

Being the authority in charge of water supply and wastewater management, INAA will be responsible for the technical and economic aspects, the design, construction and

operation of the facility, as well as the training and supervision of an agreed temporary community labor force.

### a.2 The Community

Being the beneficiary of the PECM, the community will pay the sewage charges to INAA and occasionally provide labor during (e.g., connection to the catch pit) and/or after construction (e.g. cleaning of the treatment facility), aiming to reduce costs.

### a.3 MINSA/SILAIS

Being the authority in charge of public health and monitoring urban sanitation, MINSA/SILAIS will assist and guide the citizens regarding the proposed system and explain the necessity of their participation as beneficiaries. MINSA/SILAIS should aim to obtain the community's consent to install the facilities.

### a.4 Municipality

Being the political and administrative authority in charge of the model community as well as the representative of the citizens, the municipality must work toward the success of the PECM, mainly during the planning phase and in encouraging the community to participate.

The following steps would have to be followed by the four main parties involved, in order to realize the PECM:

- **Planning and land acquisition**

The municipality must submit a list of priority areas to INAA that require the installation of the system based on its urban development plans. Priority areas should then undergo a preliminary study in order to select communities that would be most eligible to have an on-site DWW treatment system. The next step would be to obtain the consent of the community to install the system in their neighborhood as well as their formal commitment to pay for the service, build and maintain their individual connection to the main sewer. The residents will be encouraged to provide labor, occasionally, in order to reduce costs: MINSA/SILAIS will play a crucial role during this phase. Following acquiescence and formal agreement by the community, INAA should secure finances for the system as well as the required land.

- **Institutional Improvements Construction**

INAA will be responsible for the construction of the systems, if possible, with the help of the community labor force.

- **Operation and maintenance**

INAA will be responsible for the maintenance of the systems, if possible, with the help of the community labor force.

### b.1 Steering Committee

The steering committee should comprise three representatives from the institutions involved, that is INAA/Region IV, MINSA/SILAIS and Granada Municipality. Granada Municipality should coordinate the various tasks that need to be executed under the PECM. The representatives should elect a chairman who will take the post for

a one year term. An executive secretary should attend to the administrative needs of the committee. Figure R-12 illustrates the proposed structure of the committee. The tasks and duties that the committee must perform are as follows:

1. to formulate directives for the PECM.
2. to conduct the planning and design of the projects proposed by the executive authorities, and evaluate their practical, technical and financial feasibility.
3. to approve the inclusion of systems that have been evaluated by the steering committee.
4. to request finances for the approved systems to the responsible national institution (or international organizations if the committee has the legal capability).
5. to ratify the technical reports on the PECM.
6. to ratify the accounts and financial reports.

### b.2 INAA

INAA's regional office should diversify and lead the DWW Treatment System Improvement Project, as the executive member of the steering committee. A task force will be set up within INAA(Granada) for the model community integrated USE improvement project. It should be able to raise funds, apportion finance for the DWW Treatment System Improvement Project and work with the municipality and MINSA/SILAIS during the planning phase. The task force will develop feasibility studies and the DWW Treatment System Improvement Project for the different priority areas; the central office in Managua, with its skilled personnel, will be in charge of technical and economic matters for the task force. As the DWW Treatment System Improvement Project is expanded to cover many areas, the task force should be enlarged gradually to provide supervision for the construction works and maintenance needs. INAA's representative in the steering committee will coordinate and monitor INAA activities related to the PECM; the project will be incorporated into INAA's general responsibility. The representative will also coordinate and work with the other institutions involved in planning and community relations. These activities will be developed according to the steering committee's directives in conjunction with the activities performed by the other two authorities involved. INAA's representative will supervise civil works and financial activities related to the PECM. Figure R-13 illustrates the functional scheme for INAA Region IV.

### b.3 The Municipality

The municipality requires the improvement of its structure and legal framework, and enhancement of its human resources, with emphasis on the following:

- Organize and set up a task force for the model community integrated USE improvement project.
- assignment of an executive for the PECM, a member of the task force who will be the municipality's representative in the steering committee and coordinator of its operations in the project, with the same duties as INAA's representative.

- revision of the Municipal Ordinance, supplying legal support on matters related to the DWW Treatment System Improvement Project, and to restrict urban development and construction without planning, as proposed in the M/P.

The responsibility of the municipality will also be similar to that of the INAA Managua central office in that engineering works i.e. design, construction and maintenance of the facilities will be undertaken by the New Constructions Section of the Bureau of Public Works and Services. Similarly, financial matters pertaining to the PECM will be the responsibility of the Accounting and Budget Control Sections of the Bureau of Administration and Finance. The municipal representative will work closely with the Public Relations Assistant and the Bureau of Municipal Planning and Projects regarding planning and community relations during the program.

Figure R-14 illustrates the functional scheme for Granada Municipality.

### b.4 MINSA

The role of the regional MINSA/SILAIS(Granada) in the project will be to motivate the public and provide sanitary and health education. The MINSA/SILAIS(Granada) representative in the steering committee should be selected from the task force member, and also be an expert and should act as a coordinator between MINSA/SILAIS and the other two authorities. Educational resources for public education regarding the PECM may be supplied by the central Sanitary Education Department of MINSA. Investments into the PECM will be offset by the reduction in the number of diseases, vermin and other damages to sanitation. Figure R-15 illustrates the functional scheme for MINSA/SILAIS (Granada).

## R.3.3 Cost Estimation

### a. Treatment Facility

The treatment facility constructed in the Adelita as the pilot project employed "bottom plastic sheet" (see Figure R-9), in order to verify the effect of the treatment. Therefore the Adelita pilot project required: whole excavation of the trench area up to the level of the bottom plastic sheet; plastic sheet laying; gravel laying; backfill work; compaction; and trench shape formation. It consequently lead to a considerable increase of construction cost in the pilot project.

On the other hand, since the pilot project verified the treatment effect of the filter trench, the on-site collective treatment system proposed in the M/P needs not employ the bottom plastic sheet for the treatment effect verification (see Figure R-10). Therefore, the construction cost will be significantly cheaper than the case of the Adelita pilot project.

Considering the results of pilot project and the above-mentioned cost reduction factor, cost estimation for the on-site collective treatment facility is carried out. In practice, construction cost of a treatment facility unit, respectively for 50, 100, 200 and 300 service population, is calculated and a correlation curve of "service population" and "construction cost" is produced.

$y = (105x^{-0.0938}) \times 1.4 \times 1.1$ (R=0.9618)

y: unit cost (U$/person), x: service population

Unit construction cost (per service population) of the on-site collective treatment facility is shown in Table R-13 below in relation to the scale of service population of one treatment system.(50 to 500 service population).

Table R-13: Unit Construction Cost of On-site Collective Treatment Facility

| Population | Unit Cost (U$/Person) |
|---|---|
| 50 | 112.0 |
| 100 | 105.0 |
| 150 | 101.1 |
| 200 | 98.4 |
| 250 | 96.3 |
| 300 | 94.7 |
| 350 | 93.3 |
| 400 | 92.2 |
| 450 | 91.2 |
| 500 | 90.3 |

As shown in the table above, unit construction cost decreases in relation to the increase of service population of a treatment facility. Total construction cost of facilities in the On-site DWW Treatment System Improvement Project is calculated based on this cost estimation formula.

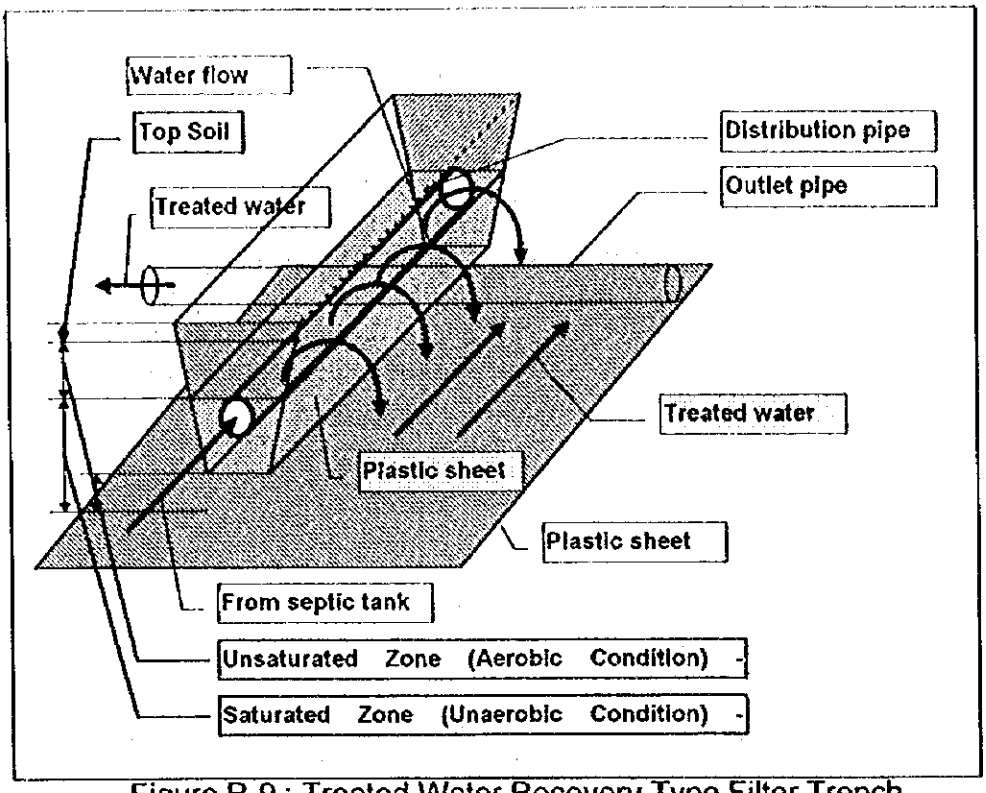



Figure R-9 : Treated Water Recovery Type Filter Trench

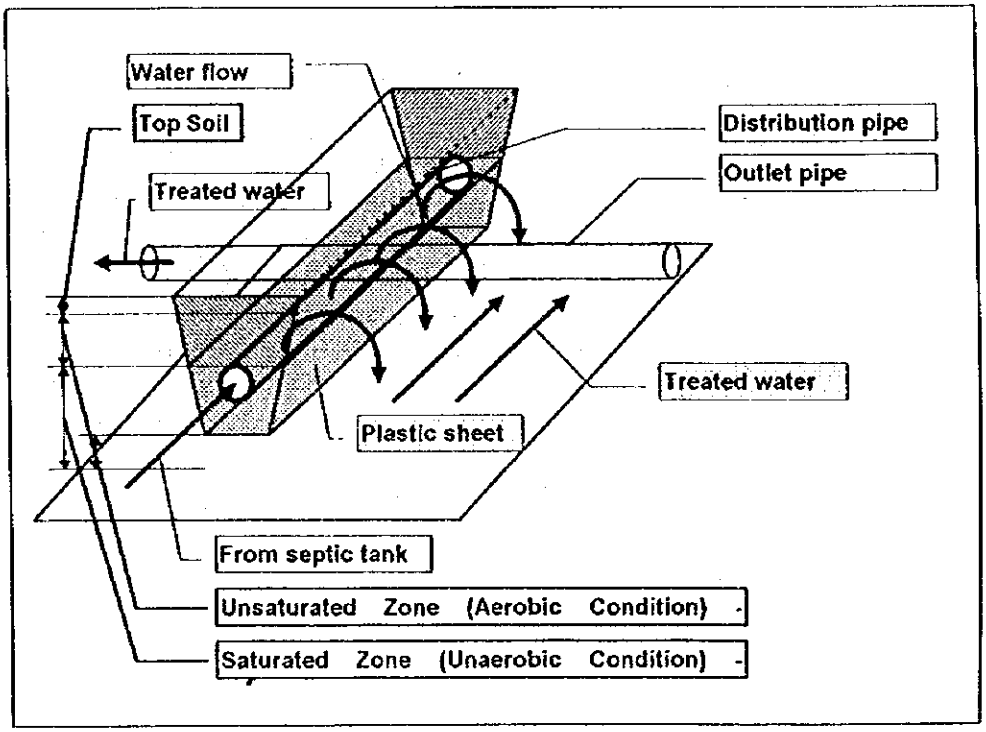



Figure R-10 : Treated Water Non-recovery Type Filter Trench

### b. Sewer

Unit construction cost of sewer system (per service population), unlike unit construction cost of treatment facility, does not decrease in relation to the increase of service population of a system. In general when sewer becomes longer where the surface gradient is gentle (although it depends on the ground surface gradient above sewer line), pipe buried depth becomes deeper and consequently unit construction cost of a sewer tends to be larger. And in such a case, level of inflow to the treatment facility becomes deeper and it leads to an increase of treatment facility construction cost. Therefore, in this project, on-site system lot divisions in this model communities are designed so that the sewer depth of the project will range at the same depth realized in the Adelita pilot project. Therefore, unit construction cost of sewer (including costs of catch pits and manholes construction) is set C$ 303.5/person based on the results of Adelita pilot project.

### c. Operation and Maintenance

Operation and maintenance (O & M) cost covers: personnel cost for patrol and inspection for those facilities; and cost of sludge suction vehicle.

It is estimated that an INAA personnel can patrol, inspect and maintain one system for one day once per month. Where their working days are estimated 22 days/month, one personnel will be in charge of 22 systems. Sludge of septic tank will be suctioned once per year and one sludge suction vehicle can serve 3 facilities per day. O & M cost, and the ratio of "facility construction cost" versus "O & M cost" in year 2010 are calculated. The ratio is used to estimate O & M cost in other years.

- Number of the systems in year 2010 — 176 systems
- Number of personnel: 176 systems ÷ 22 systems/person = 8 persons
- Sludge suction vehicle used: 176 systems ÷ 3 systems/day = 59 day/year
- Personnel cost: 8 persons × C$ 2,500/months × 12 months = C$ 240,000/year
- Vehicle cost: 59 days/year × US$ 600/day × C$ 9.6/US$ = C$ 339,840/year
- Total = C$ 579,840/year

Ratio of "O & M cost" over "construction cost":

C$ 579,840/year ÷ C$ (7,013,407+21,988,332)/year=2.0%

Therefore, it is assumed that O & M cost should be 2.0% (personnel cost 0.8%, other cost 1.2%) of the construction cost.

### d. Project Cost

Based on the preliminary design, calculation of the project cost for improving C1,C2, and C3 district, referring to the construction cost of the pilot projects are summarized in

Table 5-12. Operation and maintenance cost of the facility in 2010 is shown in Table 5-13. Moreover, Table 5-14 shows investment schedule for F/S projects till 2005.

Table R-14: Construction Cost of the On-site System

unit : 1,000 C$

| | C1 | C2 | C3 | Total |
|---|---|---|---|---|
| **Sewer** | | | | |
| Pipeline | 1,818 | 1,707 | 2,786 | 6,311 |
| Connection | 202 | 190 | 310 | 702 |
| Sub-total | 2,020 | 1,897 | 3,096 | 7,013 |
| Design and supervision (10%) | 202 | 190 | 310 | 702 |
| **Sewer total** | **2,222** | **2,087** | **3,406** | **7,715** |
| **Treatment facilities** | | | | |
| Treatment facilities | 6,663 | 5,740 | 9,586 | 21,989 |
| Design and supervision (10%) | 666 | 574 | 958 | 2,199 |
| **Treatment facilities total** | **7,329** | **6,314** | **10,544** | **24,187** |
| **Projects cost** | | | | |
| **Sewer total** | **2,222** | **2,087** | **3,406** | **7,715** |
| **Treatment facilities total** | **7,329** | **6,314** | **10,545** | **24,187** |
| **Projects cost total** | **9,551** | **8,401** | **13,951** | **31,902** |

Table R-15 : Annual Operation and Maintenance Cost in 2010

unit : 1,000 C$

| | C1 | C2 | C3 | Total |
|---|---|---|---|---|
| Personal | 70 | 61 | 101 | 232 |
| Others (sludge disposal, etc) | 104 | 92 | 152 | 348 |
| Total | 174 | 153 | 253 | 580 |

Table R-16 : Investment Schedule for F/S Projects

unit : 1,000 C$

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | Total |
|---|---|---|---|---|---|---|---|
| Served population | - | 2,311 | 4,622 | 6,933 | 9,244 | 11,555 | - |
| Number of systems | - | 17 | 17 | 18 | 18 | 18 | 88 |
| | | | | | | | |
| **Investment** | | | | | | | |
| Sewer | 771 | 771 | 771 | 772 | 772 | - | 3,857 |
| Treatment | 2,418 | 2,418 | 2,418 | 2,419 | 2,419 | - | 12,092 |
| **Investment total** | **3,189** | **3,189** | **3,189** | **3,191** | **3,191** | - | **15,949** |
| | | | | | | | |
| **O & M cost** | | | | | | | |
| Personal | - | 23 | 46 | 70 | 93 | 116 | 348 |
| Others | - | 35 | 70 | 104 | 139 | 174 | 522 |
| **O & M total** | - | **58** | **116** | **174** | **232** | **290** | **870** |

## R.3.4 Financial Analysis of INAA

### a. Conditions for Financial Evaluation

The conditions used for financial evaluation are shown in the table below.

| | |
|---|---|
| Project Life | 31 years, from 2000 until 2031 |
| Executing Organ | INAA |
| Investment Plan | Improvement of on-site domestic wastewater treatment system and water supply system to accommodate increase in population. |
| Residents Roles | Every household that receives the service should bear the cost of internal pipe connection(to the catch pit) . The facilities will be constructed on (1) public land within the area, or (2) private land donated by a resident/residents. Therefore, all costs for internal pipe connections and land acquisition is excluded from the project cost. |
| Residual Value | The residual value of the water supply and domestic wastewater treatment systems in the year 2031 was considered. |
| Cut-off Rate | A cut-off rate of 8.5%, which is also equivalent to the prime rate of the Central Bank of Nicaragua in 1997, was assumed. The cost to be covered by the grant was excluded from the project cost items subject to the financial analysis. |

The model community is entirely covered by the water supply services. On-site domestic wastewater treatment system installation is also planned for the area. However, water supply improvements should also be carried out to cope with the increase in population.

Along with the installation of the domestic wastewater treatment system (on-site), the investment required from 2000 to 2004 to improve the water supply system in order to cope with the increase in population, and the O&M costs for 2001 to 2005 were calculated and shown below.

#### a.1 Investment Cost

unit: C$1,000

| | New Investment | Renewal Costs | Total |
|---|---|---|---|
| Water Supply System | 5,113 | 0 | 5,113 |
| Domestic Wastewater Treatment System | 15,951 | 0 | 15,951 |
| Total | 21,064 | 0 | 21,064 |

### a.2 Annual Expenditures

unit: C$1,000

| | | 1995 | 2001 - 2005 (average) |
|---|---|---|---|
| Proposed System | Water Supply | | 598 |
| | Wastewater Treatment (on-site) | | 177 |
| Existing System + Proposed System | Water Supply | 1,158 | 1,350 |
| | Wastewater Treatment (on-site) | | 177 |

### b. Cases for Financial Evaluation

For financial evaluation, various cases were established to determine the appropriate financial source for the domestic wastewater treatment system.

- Financial Source: Financial source for investment costs for the project
- Source of Revenue: Service charge

### b.1 Financial Source

The following six (6) cases were considered to determine the most feasible financial source.

| | |
|---|---|
| Case A | Proposes the use of a loan to cover the entire investment cost |
| Case B-1 | Proposes the use of grant aid to cover only the investment costs for the installation of a domestic wastewater treatment system in 2000. |
| Case B-2 | Proposes the use of grant aid to cover the investment costs for the installation of a domestic wastewater treatment system in 2000-2001. |
| Case B-3 | Proposes the use of grant aid to cover the investment costs for the installation of a domestic wastewater treatment system in 2000-2002. |
| Case B-4 | Proposes the use of grant aid to cover the investment costs for the installation of a domestic wastewater treatment system in 2000-2003. |
| Case B-5 | Proposes the use of grant aid to cover the investment costs for the installation of a domestic wastewater treatment system in 2000-2004. |

For the improvement of the water supply system, the acquisition of a loan to cover the required investment cost was planned.

### b.2 Source of Revenue

Households will be charged C$16.7/household/month (the average amount households in Granada Municipality paid for sewerage services in 1996) for the use of the on-site domestic wastewater treatment system, the same amount charged for the monthly use of the sewers (off-site domestic wastewater treatment system). The collection rate for the on-site domestic wastewater treatment system is assumed to be equal to the present collection rate of 96%.

For water supply, the monthly fee was set at C$49.8/household/month, the average amount households in Granada Municipality are capable of paying in 1996. The fee

collected from the current users of the water supply system in model communities will be also included in the calculation of revenues (96% collection rate).

### c. FIRR

The FIRR was calculated for the 6 cases considered to determine the appropriate financial source. The results are shown below.

| Investment Cost | Case | FIRR (%) | R/E |
|---|---|---|---|
| By a loan (total investment cost) | A | 3.9 | 1.2398 |
| Grant aid for investment costs in 2000 only | B-1 | 5.7 | 1.2955 |
| Grant aid for investment costs in 2000-2001 | B-2 | 8.2 | 1.3511 |
| Grant aid for investment costs in 2000-2002 | B-3 | 12.4 | 1.4068 |
| Grant aid for investment costs in 2000-2003 | B-4 | 20.0 | 1.4624 |
| Grant aid for entire costs for domestic wastewater treatment system construction | B-5 | 32.7 | 1.5181 |

Note: *The above plan includes the O&M expenses for the existing water supply system.

### d. Cash Flow

If a grant aid is used to cover the investment costs from 2000-2002 for the installation of the domestic wastewater treatment system, the FIRR would be 12.4%, higher than the cut-off rate of 8.5%. The cash flow and profit and loss are shown in the following tables.

Table R-17: Cash Flow of the Water Supply System Improvement & Domestic Wastewater Treatment System Installation Projects in the Model Community (Case B-3)

Unit: C$1,000

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | Total |
|---|---|---|---|---|---|---|---|
| a.1 Financing | | | | | | | |
| Grant | 3,189 | 3,189 | 3,189 | 0 | 0 | | 9,567 |
| Loan | 1,022 | 1,022 | 1,022 | 4,216 | 4,213 | | 11,495 |
| Sub-total | 4,211 | 4,211 | 4,211 | 4,216 | 4,213 | 0 | 21,062 |
| a.2 Revenue | | | | | | | |
| Fee | | | | | | | |
| Residents | | 1,946 | 2,062 | 2,177 | 2,293 | 2,408 | 10,886 |
| Sub-total | 0 | 1,946 | 2,062 | 2,177 | 2,293 | 2,408 | 10,886 |
| Cash-in | 4,211 | 6,157 | 6,273 | 6,393 | 6,506 | 2,408 | 31,948 |
| b.1 Investment | 4,211 | 4,211 | 4,211 | 4,216 | 4,213 | 0 | 21,062 |
| b.2 Expenditure | | | | | | | |
| Existing System | | 904 | 904 | 904 | 904 | 904 | 4,520 |
| Proposed System | | | | | | | |
| O/M Cost | | 82 | 164 | 246 | 328 | 410 | 1,230 |
| Interest | 37 | 112 | 188 | 279 | 386 | 477 | 1,479 |
| Fee-collection | | 68 | 72 | 76 | 80 | 84 | 380 |
| Sub-total | 37 | 1,166 | 1,328 | 1,505 | 1,698 | 1,875 | 7,609 |
| Cash-out | 4,248 | 5,377 | 5,539 | 5,721 | 5,911 | 1,875 | 28,671 |
| c. Reserves | -37 | 743 | 1,477 | 2,149 | 2,744 | 3,277 | 3,277 |

Table R-18: Profit & Loss Statement of the Water Supply System Improvement & Domestic Wastewater Treatment System Installation Projects in the Model Community (Case B-3)

Unit: C$ 1,000

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | Total 2000-2005 |
|---|---|---|---|---|---|---|---|
| a.1 Revenue | | 1,946 | 2,062 | 2,177 | 2,293 | 2,408 | 10,886 |
| b. Cost | | | | | | | |
| b.1 Expenditure | 37 | 1,166 | 1,328 | 1,505 | 1,698 | 1,875 | 7,609 |
| b.2 Depreciation | | 34 | 68 | 102 | 243 | 383 | 830 |
| Cost Total | 37 | 1,200 | 1,396 | 1,607 | 1,941 | 2,258 | 8,439 |
| c. Profit and Loss | -37 | 746 | 666 | 570 | 352 | 150 | 2,447 |

The tables show that the revenue from collection fees will be able to provide the O&M costs as well as the depreciation costs and interest rate not covered by the grant aid. An amount of C$ 3,600,000 can also be accumulated by 2005.

### e. Balance in Revenue & Expenditures

As in the area to be covered by the sewerage improvement project, the conduct of new projects are also considered infeasible in the model communities. Even with a 3 year grant aid for the installation of the domestic wastewater treatment system (on-site), the project finances from 2001 to 2005 are estimated to result in a deficit. However, the project finances for the entire model community may be in the black if the revenue from the fees collected for the use of the existing water supply system is added to the investment, that is given that a 3 year grant is secured.

Unit: C$ 1,000

| | | 1995 | 2000 | 2001-2005 (average) | 2001-2005 (total) |
|---|---|---|---|---|---|
| New Projects | Water Supply | | -38 | -320 | -1,602 |
| | Wastewater Treatment (on-site)* | | 0 | -34 | -169 |
| New Projects + Existing System | Water Supply | 825 | 890 | 607 | 3,035 |
| | Wastewater Treatment (on-site) | | 0 | -34 | -169 |
| | Total area | 825 | 890 | 573 | 2,866 |

Note: * the above balance in revenue and expenditures was assumed based on case B-3, which proposes the use of grant aid to cover the entire investment from 2000 to 2002.

### f. Balance in Revenue & Expenditures of INAA Region IV

The balance in the revenue and expenditures of INAA Region IV, with grant(s) for three years' investment in the domestic wastewater treatment system(on-site), was calculated and shown below.

| | 1995 | 2001-2005 (average) | 2001-2005 (total) |
|---|---|---|---|
| Water Supply System | 3,169 | 2,546 | 12,730 |
| Wastewater Treatment System | | | |
| off-site | 405 | -63 | -3,027 |
| on-site | | -68 | -339 |
| INAA Region IV Total | 1,318 | 1,034 | 5,169 |

The above table shows that to sustain the project, grant aid should be acquired to cover the investment costs required for the installation of the domestic wastewater treatment system in the 2000-2002 period.

## R.4 Improvement of Rain Water Drains

### a. Introduction

Fringe areas of Granada, mentioned in the "Model Communities Integrated USE Improvement Plan", are conspicuous because of the many cheaply built houses, unpaved roads, and the general unhygienic conditions. It is proposed that if a road network incorporating a stormwater drainage system can be constructed then many urban sanitation problems confronting the residents could be alleviated.

A regular refuse collection system could be established, removing unsightly and unhygienic solid waste. In addition to the collection vehicles, the road network would provide year round access all sorts of vehicles, buses could take people to and from school or work, cars and trucks could transport goods and services, thus stimulating development. If the implementation is coordinated with the other proposed projects of the F/S, improved drainage of the fringe area will also reduce possible breeding sites for mosquitoes and as well as lessening the incidence of waterborne diseases.

### b. Existing Conditions

Existing drainage of the site is favorable for the construction of a stormwater drainage system. The terrain is gently sloping and there exist many channels into which stormwater could be discharged. Granular porous volcanic soils predominate, providing a well drained, stable base for construction.

### R.4.1 Technical System

#### a. Preliminary Design

#### a.1 Design Approach

The preliminary design was undertaken to prove the project's technical feasibility and to provide sufficient data for the preliminary cost estimation.

Taking into consideration the existing conditions of the area under the "Model Communities Integrated USE Improvement Plan", certain priorities were set:

- Low cost solution
- General vehicle access

- Safe and effective drainage
- MSW collection

### a.1.1 Low cost solution

The standard of housing and incomes in the fringe areas are extremely low, even by Nicaraguan standards. Hence, construction of new facilities must be considered in this context.

For the design of any stormwater drainage system, the cost of damage resulting from a flood must be considered against the cost of the planned stormwater drainage system. This is the principle reason why the plan proposes roads as the stormwater drainage system. Furthermore, this fact influences the selection of the average recurrence interval (ARI), 1 in 2 years, although the ARI for residential areas in Managua is 1 in 5 years.

### a.1.2 Access for general vehicles

When deciding which roads should be paved first it was first necessary to determine which routes are the most important, i.e., carry the most traffic, buss routes, etc. Hence, the roads were ranked according to their importance. The pavement of the most important routes is wider than the lesser routes, and streets of the least significance are not paved at all.

### a.1.3 Safe and efficient drainage

Because it is planned to use the roads as drains, it is necessary to take into account possible problems. The soil of the area is porous and the construction of paved streets will result in increased runoff. Therefore, a velocity/depth restriction was included in the preliminary design and additional stormwater discharge points proposed. Further, this type of stormwater drainage is found in other parts of Granada and, therefore, be easily accepted by the residents.

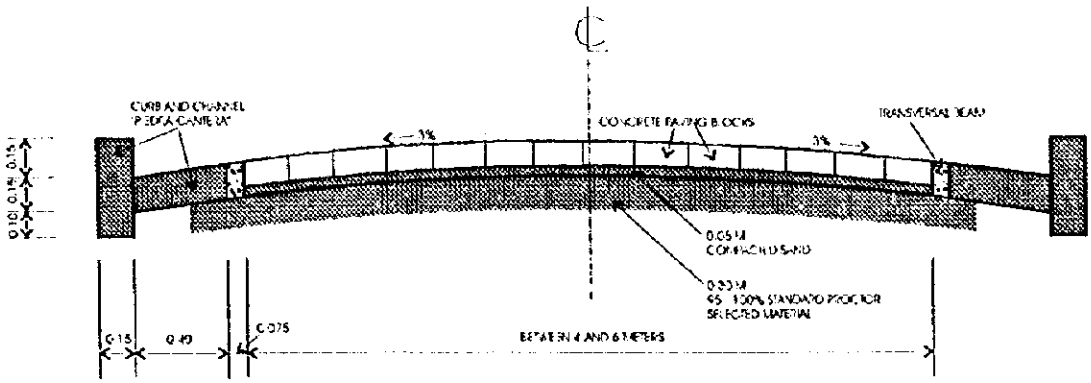
### a.1.4 MSW collection

One of the main functions of the paved road network is to provide MSW collection points in the fringe areas. So that residents will cooperate and regularly take their waste to the collection points it is necessary to have the collection points in convenient locations. The preliminary design assumed that the majority of residents should not have to walk further than one average size block to a collection point, hence, the paved streets were positioned to meet this condition.

### a.2 Road Pavement

The road pavement, concrete block pavement, is common in Nicaragua. It is inexpensive, simple to construct, long lasting, and maintenance is easy and inexpensive.

As mentioned above, the width of the roadway has been assumed taking into account expected usage. Three typical sections (traveled way width of 4, 5, and 6 meters) were used in the preliminary design. The 4-meter road is proposed for areas with the least traffic and 5 and 6-meter road for more important streets. The road also includes stone curb and channel as shown below. Other roads have been assumed to remain in their existing unsealed condition.




TYPICAL ROAD SECTION

NO SCALE

## a.3 Rain water Drainage Design Calculations

Preliminary stormwater drainage calculations are based on those that have been used in other urban stormwater drainage projects in Nicaragua.

The most important data for stormwater drainage design are described here, and apply only to those areas defined in the "Model Communities Integrated USE Improvement Plan".

### a.3.1 Rainfall Data

Rainfall data for the period 1969 to 1987 was collected at a meteorological station located in Granada and obtained from INETER (Nicaraguan Institute of Territorial Studies). Although the station ceased recording in 1988, the available data are comprehensive and sufficient to determine rainfall intensities. Data exist for the following storm durations: 5, 10, 15, 30 minutes and 1, 2, and 3 hours.

### a.3.2 Calculation of Rainfall Intensity

The rainfall intensity calculations were carried out in accordance to the "Managua Municipality Area Rain water Drainage Regulations (Regulamento de Drenaje Pluvial para el Area del Municipio de Managua)", 1981. INETER recommended the general formula shown below. This empirical equation gives results that are more accurate than those obtained by interpolation of graphs[1].

$$I = \frac{a}{(t+b)^n}$$

where,

I: rainfall intensity, mm/hr

t: duration of storm, hours

a, b, n: constants for Granada

[1] A.R. Rao, 1995, "Surface Water Hydrology", CRC Press, Florida.

Table R-19: Constants of Rainfall Intensity Formula

| ARI | a | b | n | I |
|---|---|---|---|---|
| 2 | 333.43 | 5 | 0.475 | 61.60 |
| 5 | 370.68 | 5 | 0.443 | 76.73 |
| 10 | 396.28 | 5 | 0.427 | 86.83 |
| 25 | 430.53 | 5 | 0.411 | 99.86 |
| 50 | 456.04 | 5 | 0.401 | 109.61 |
| 100 | 481.95 | 5 | 0.393 | 119.17 |

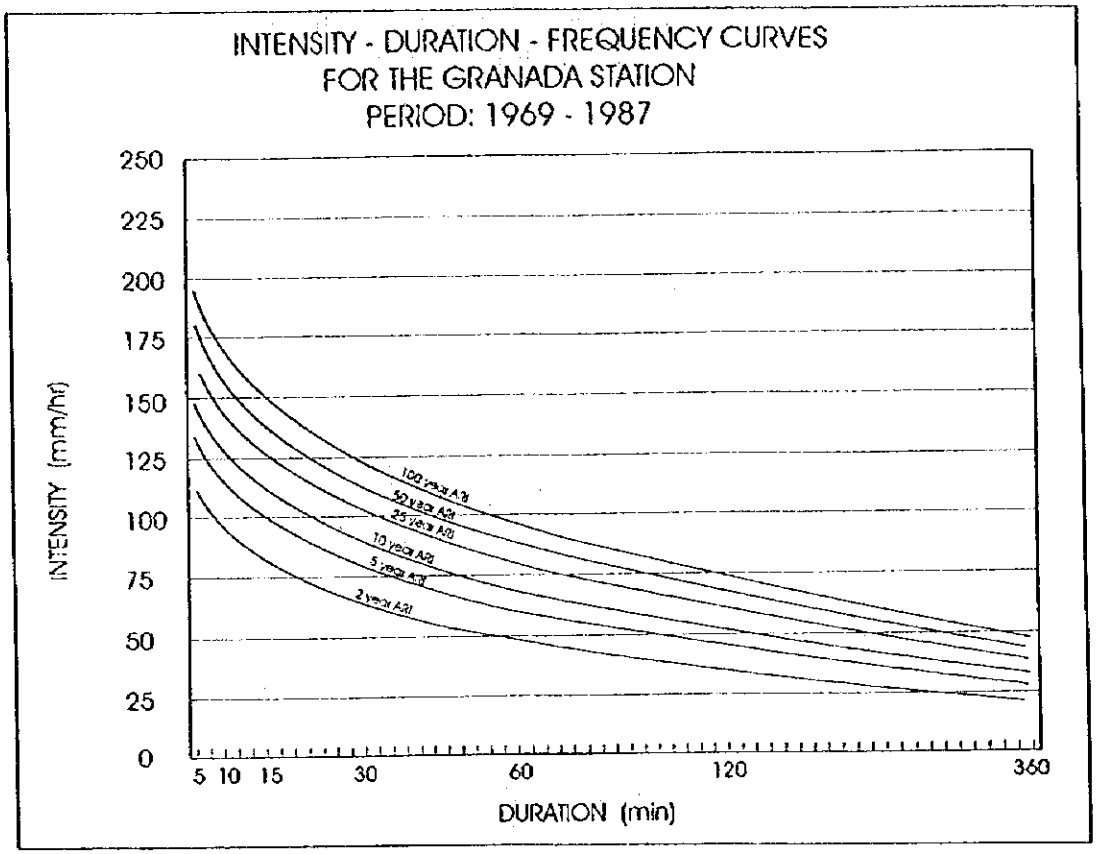



Figure R-11 : Intensity - Duration - Frequency Curves (Granada1969-1987)

### a.3.3 Selection of Design Values

1) Average recurrence interval (ARI)

Information obtained indicated that an ARI of 1 in 5 years is used for residential areas in Managua. However, taking into account the low value of the existing structures in the area under consideration it was decided that this value is too large. Therefore, a 1 in 2 year ARI was chosen considering the conditions of the area. Table R-20 shows ARIs adopted in mainly residential areas of Managua, Japan and the area in Granada.

Table R-20 : Comparison of Average Recurrence Interval (ARI)

| | This design (Granada) | Managua | Japan |
|---|---|---|---|
| Design scale | 1 in 2 years | 1 in 5 years | 5 - 10 years |

2) Storm duration

A storm duration of 30 minutes was selected. This was determined from the drainage characteristics of the catchment area.

### a.3.4 Calculation of Peak Flow Rate

1) Formula

For the calculation of peak flow rate ($Qm^3/s$), the Rational Method is adopted, as is the case in Managua. The Rational Method is suitable for the area because the total catchment area is rather small, less than 200 hectares. This area is further broken down into smaller areas for the analysis. In addition, there is very little surface storage.

2) Runoff coefficient

The runoff coefficient used in Managua is adopted for this plan. It is considered that a runoff coefficient of 0.35 is appropriate. The area consists of medium low density housing (zoning type U-3). Moreover, the soil type is more porous than that found in Managua, hence the value is likely to be on the conservative side.

3) Unit of design flood discharge

The unit of design flood discharge is calculated as follows.

$$Q = \left(\frac{1}{360}\right) CIA \quad \text{(Rational Method)}$$

where,

| | | |
|---|---|---|
| Q | :$m^3/s$ | peak flow rate of ARI of 2 years |
| C | :0.35 | runoff coefficient for ARI of 2 years |
| I | :61.6 mm/hr | average rainfall intensity for ARI of 2 years |
| A | :1 ha | area of catchment |

**Q= 0.060 m3/s/ha is used for the preliminary design**

### a.4 Drain Design

The road section acts as a drain (i.e., there are no subsurface drains). For the calculation of the flow capacity of the road, the Manning Formula for flow in open channels is used:

$$Q = \left(\frac{1}{n}\right) A_D R^{\frac{2}{3}} S^{\frac{1}{2}}$$

where,

| | | |
|---|---|---|
| Q | :$m^3/s$ | capacity flow rate of road |
| n | : | Manning roughness parameter |
| $A_D$ | :$m^2$ | cross sectional area of the drain |
| R | :m | hydraulic radius |
| S | :m/m | channel slope |

Because the stormwater flows on the surface of the road, a velocity depth restriction is recommended. Taking into account the conditions of the site a value of V.d < 0.5 $m^2/s$ is considered sufficient[2].

1) Manning Roughness Parameter

A value of 0.019 is assumed for the Manning roughness coefficient for the road paved with concrete blocks. This parameter was obtained from Managua City stormwater drainage standards for paving stone channels.

For simplicity, only the three most critical areas were investigated. These areas were chosen because of the large size of their catchments and the slope of the road.

Table R-21 : Road Drainage Capacity

| Selected Catchment Areas (ha) | Peak Flow $Q_{2year}$ = (1/360)CIA ($m^3/s$) | Slope (m/m) | Road Drainage Capacity Q (cap) = (1/n) $A_D$ $S^{1/2}$ $R^{2/3}$ | Velocity Depth Restriction V.d ($m^2/s$) |
|---|---|---|---|---|
| 9.0 | 0.539 | 0.005 | 0.72 | 0.13 |
| 10.2 | 0.611 | 0.02 | 1.49 | 0.15 |
| 4.2 | 0.252 | 0.04 | 2.10 | 0.06 |

**a.5 Result**

As can be seen in the table above the drainage of the three selected areas for an ARI of 1 in 2 year the capacity of the road section is sufficient.

## R.4.2 Institutional System

As proposed in the Master Plan, an investment of US$ 1,410,000 will be required to improve the micro-drainage system in the model community area to accommodate an estimated population of 23,110 inhabitants by the year 2010: US$ 141,000 will be spent per annum to extend the drains until the target year.

As the local population cannot generate all the investment cost, external funds would be needed. However, the beneficiaries should pay the maintenance costs; the public must be motivated to do so. Institutional reform must be initiated in order to raise funds and manage external grants as well as motivate and encourage the communities to sweep the streets outside their property.

The municipality should not levy charges or contributions to cover the maintenance costs, however, USE improvements will increase property values as well as enable SW collection vehicles to enter areas previously inaccessible. Therefore, the municipality should be able to recover maintenance costs from the increase in various indirect taxes generated by the improved micro-drainage system.

Because surface drains and on-site DWW treatment systems are interrelated, it would be pragmatic to integrate the two into the PECM: communities that are able to simultaneously implement these improvements will be given a higher priority.

[2] Vd <0.4$m^2/s$, Possible Major/Minor Design Standards, The Institution of Engineers, Australia, Revised Ed. 1987. "Australian Rainfall and Runoff", Volume 1.

The steering committee for the PECM will oversee the improvements in both the surface drains and the on-site DWW treatment systems: the municipality will be responsible for matters pertaining to the drainage system, the other two authorities will contribute to the integrated planning and encourage communities to agree with the improvements and their responsibility that comes with it.

The municipality must improve its organizational structure and legal support, especially its human resources, according to the M/P proposals.

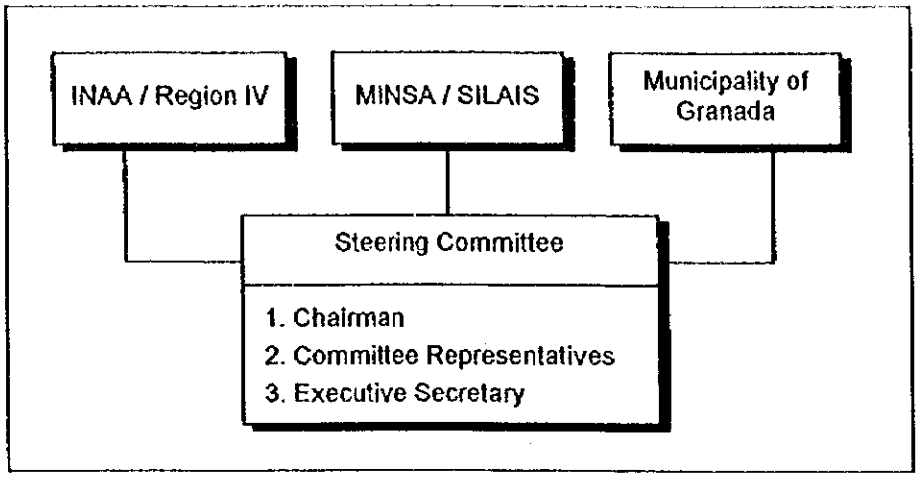



Figure R-12: Structure of the Steering Committee

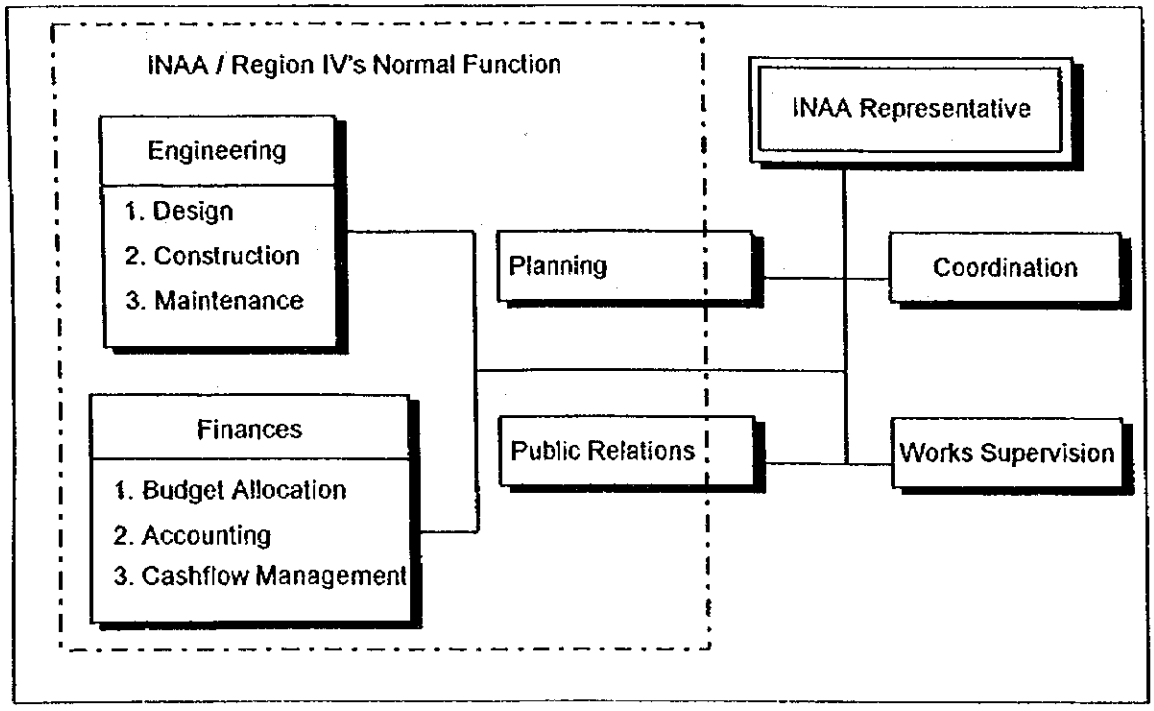



Figure R-13: Functional Scheme for INAA / Region IV and INAA's Steering Committee Representative

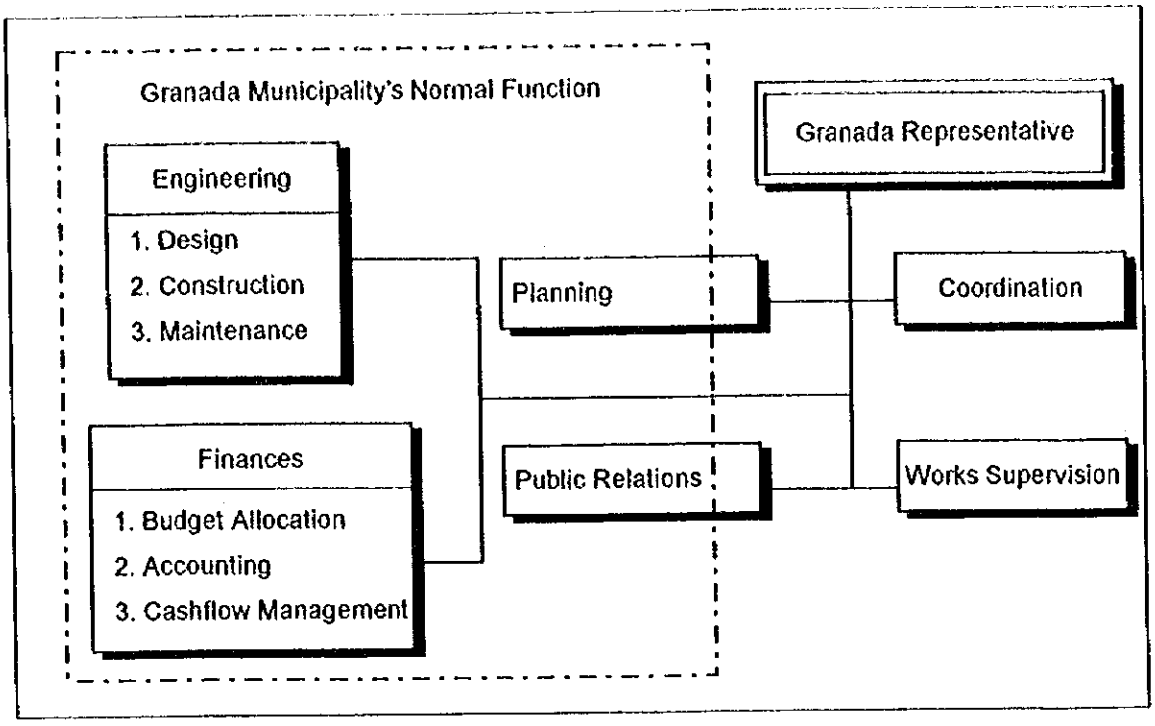



Figure R-14: Functional Scheme for Granada Municipality and Granada's Steering Committee Representative

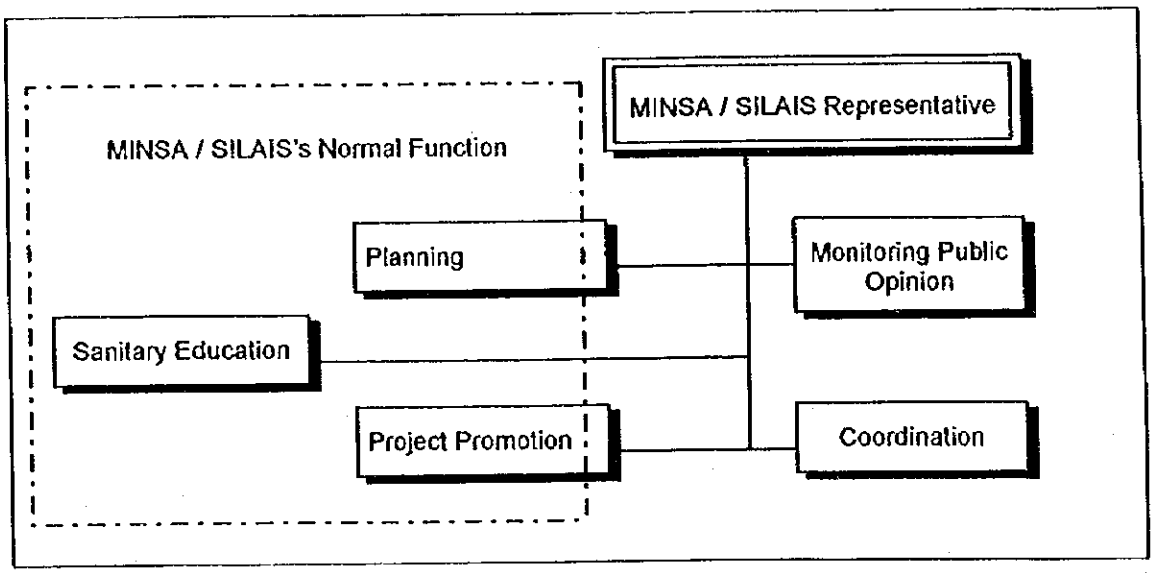



Figure R-15: Functional Scheme for MINSA and SILAIS's Representative

### R.4.3 Cost Estimation

Based on the preliminary design, calculation of the project cost for improving C1,C2, and C3 district, referring to the construction cost of the pilot projects are summarized in Table 5-4. Operation and maintenance cost of the facility in 2010 is shown in Table R-22. Moreover, Table 5-6 shows investment schedule for F/S projects till 2005.

Table R-22 : Investment Cost for Improvement of Rain Water Drains

Unit : C$ 1,000

| | C1 | C2 | C3 | Total |
|---|---|---|---|---|
| Road improvement work | 2,762 | 2,602 | 3,450 | 8,814 |
| Storm overflow facilities | 89 | 20 | 48 | 157 |
| Contingency | 285 | 262 | 350 | 897 |
| Total direct cost | 3,136 | 2,884 | 3,848 | 9,868 |
| Over head (25%) | 784 | 721 | 962 | 2,467 |
| Total construction cost | 3,920 | 3,605 | 4,810 | 12,335 |
| Design and supervision (10%) | 392 | 361 | 482 | 1,235 |
| Total | 4,312 | 3,966 | 5,292 | 13,570 |

Table R-23 : Annual Maintenance Cost in 2010

Unit : C$ 1,000

| | C1 | C2 | C3 | Total |
|---|---|---|---|---|
| Personal | 13 | 12 | 16 | 41 |
| Others | 9 | 8 | 10 | 27 |
| Total | 22 | 20 | 26 | 68 |

Table R-24 : Investment Schedule of F/S Projects

Unit : 1,000 C$

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | Total |
|---|---|---|---|---|---|---|---|
| Investment | 1,357 | 1,357 | 1,357 | 1,357 | 1,357 | - | 6,785 |
| Maintenance | - | 7 | 14 | 20 | 27 | 34 | 102 |
| Total | 1,357 | 1,364 | 1,371 | 1,377 | 1,384 | 34 | 6,887 |

## R.4.4 Financial Analysis of Granada Municipality

### a. Conditions of the Analysis

The conditions adopted for the financial analysis are shown in the table below.

| | |
|---|---|
| Project Life | 31 years, from 2000 until 2030 |
| Executing Organ | Granada Municipality. |
| Investment Plan | Stormwater drains will be improved along with the installation of the domestic wastewater treatment system. |
| Residual Value | The residual value of the roads and outfalls in 2031 was considered, assuming that they have a life span of 30 years. |
| Cut-off Rate | A cut-off rate of 8.5%, which is also equivalent to the prime rate of the Central Bank of Nicaragua in 1977, was assumed. The cost to be covered by the grant was excluded from the project cost items subject to the financial analysis. |

### b. Case Studies

Case studies were established for the financial analysis of the following two items:

- Financial Source: Financial source for a part of the project cost
- Source of Revenue: Budget to be allocated from vehicle tax revenues for the stormwater drains improvement project

#### b.1 Financial Source for a Part of the Project Cost

The following cases were established to determine the financial source for a part of the project cost:

| | |
|---|---|
| Case A | The entire project cost will be shouldered by Granada Municipality. |
| Case B | To acquire grant aid to cover only the investment for the roads and outfall works in 2000 |
| Case C | To acquire grant aid to cover the investment for the roads and outfall works in 2000 and 2001 |
| Case D | To acquire grant aid to cover the investment for the roads and outfall works in 2000 and 2002 |

#### b.2 Budget Allocated from Vehicle Tax Revenues for the Stormwater Drains Improvement Project

Revenues from vehicle tax are the assumed source of financing for the stormwater drains improvement project. Vehicle tax revenues were not the target source of finance for the road improvement project. But if an agreement is reached with the municipal committee regarding the use of these revenues, they shall be used to subsidize the expenses for the stormwater drains improvement project. Accordingly, the three cases below were assumed to estimate the vehicle tax growth rate and the percentage of the revenues to be allocated for the improvement of stormwater drains. The cases were classified into three scenarios, e.g. optimistic, moderate and pessimistic, and the assumed percentage of the revenues for allocation were 30%, 20% and 10%.

| | |
|---|---|
| Case A | Very optimistic assumptions regarding increase in vehicle tax rate (13.7% per annum) and budget allocation for stormwater drains improvement (30% per annum) |
| Case B | Assuming a moderate increase in vehicle tax rate (12.9% per annum) and budget allocation for stormwater drains improvement (20% per annum) |
| Case C | Very pessimistic assumptions regarding increase in vehicle tax rate (12.1% per annum) and budget allocation for stormwater drains improvement (10% per annum) |

### c. FIRR

The FIRR was calculated for a total of 12 cases resulting from the combination of the above 3 cases for vehicle tax rate increase, and the 4 cases for the financial source ($3 \times 4 = 12$). The results are shown in the table below.

| | Budget Allocation (%) | | Loan (for total investment cost) | Grant aid for investments in 2000 only | Grant aid for 2000, 2001 | Grant aid for 2000-2002 |
|---|---|---|---|---|---|---|
| Optimistic Assumption: 13.7% increase in vehicle tax rate per annum | 30 | FIRR | 2.9 | 5.1 | 8.8 | 18.9 |
| | | R/E | 1.4674 | 1.6597 | 1.8519 | 2.0441 |
| | 20 | FIRR | n.a | 1.4 | 3.9 | 8.9 |
| | | R/E | 0.9783 | 1.1705 | 1.3628 | 1.5550 |
| | 10 | FIRR | n.a | n.a | n.a | 1.1 |
| | | R/E | 0.4891 | 0.6814 | 0.8736 | 1.0659 |
| Moderate Assumption: 12.9% in vehicle tax rate per annum | 30 | FIRR | 2.6 | 4.6 | 8.2 | 17.3 |
| | | R/E | 1.4177 | 1.6151 | 1.8123 | 2.0097 |
| | 20 | FIRR | n.a | 1.1 | 3.5 | 8.3 |
| | | R/E | 0.9452 | 1.1425 | 1.3398 | 1.5371 |
| | 10 | FIRR | n.a | n.a | n.a | 1.0 |
| | | R/E | 0.4726 | 0.6699 | 0.8672 | 1.0646 |
| Pessimistic Assumption: 12.1% increase in vehicle tax rate per annum | 30 | FIRR | 2.0 | 4.0 | 7.3 | 15.5 |
| | | R/E | 1.3290 | 1.5263 | 1.7237 | 1.9210 |
| | 20 | FIRR | n.a | 0.7 | 2.9 | 7.4 |
| | | R/E | 0.8860 | 1.0833 | 1.2807 | 1.4780 |
| | 10 | FIRR | n.a | n.a | n.a | 0.5 |
| | | R/E | 0.4430 | 0.6403 | 0.8377 | 1.0350 |

The case considered to be most appropriate is the one which assumes a 12.9% increase in vehicle tax rate, a 20% increase in budget allocation, and the acquisition of grant aid to cover the investment from 2000 until 2002. The FIRR for this case was calculated at 8.3%, quite close to the cut-off rate of 8.5%. Accordingly, to implement the stormwater drains improvement project, grant aid should be acquired to cover the investment for a period of 3 years, from 2000 to 2002.

### d. Cash Flow and Profit & Loss

The cash flow and the statement of profit and loss for Case D-b are shown in the following tables. Case D-b proposes covering the investment for a three year period, from 2000 to 2002, by grant aid, assumes a 12.9% increase in vehicle tax rate and a 20% increase in budget allocation.

Table R-25: Cash Flow of the Stormwater Drains Improvement Project (Case D-b)

Unit : C$ 1,000

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | Total 2000-2005 |
|---|---|---|---|---|---|---|---|
| a.1 Financing | | | | | | | |
| Grant | 1,357 | 1,357 | 1,357 | 0 | 0 | 0 | 4,071 |
| Loan | 0 | 0 | 0 | 1,357 | 1,357 | 0 | 2,714 |
| Sub-total | 1,357 | 1,357 | 1,357 | 1,357 | 1,357 | 0 | 6,785 |
| a.2 Revenue | | | | | | | |
| Budget Allocation | 0 | 138 | 156 | 176 | 199 | 224 | 893 |
| Sub-total | 0 | 138 | 156 | 176 | 199 | 224 | 893 |
| Cash-in | 1,357 | 1,495 | 1,513 | 1,533 | 1,556 | 224 | 7,678 |
| b.1 Investment | 1,357 | 1,357 | 1,357 | 1,357 | 1,357 | 0 | 6,785 |
| b.2 Expenditure | | | | | | | |
| O/M Cost | 0 | 7 | 14 | 20 | 27 | 34 | 102 |
| Interest | 0 | 0 | 0 | 7 | 20 | 27 | 54 |
| Sub-total | 0 | 7 | 14 | 27 | 47 | 61 | 156 |
| Cash-out | 1,357 | 1,364 | 1,371 | 1,383 | 1,404 | 61 | 6,939 |
| c. Reserves | 0 | 132 | 274 | 424 | 576 | 739 | 739 |

Table R-26: Profit and Loss Statement of the Stormwater Drains Improvement Project

Unit : C$ 1,000

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | Total 2000-2005 |
|---|---|---|---|---|---|---|---|
| a.1 Revenue | 0 | 138 | 156 | 176 | 199 | 224 | 893 |
| b. Cost | | | | | | | |
| b.1. Expenditure | 0 | 7 | 14 | 27 | 47 | 61 | 156 |
| b.2 Depreciation | | 0 | 0 | 0 | 45 | 90 | 135 |
| Cost Total | 0 | 7 | 14 | 27 | 92 | 151 | 291 |
| c. Profit and Loss | 0 | 131 | 142 | 149 | 107 | 73 | 602 |