4.8.5 Analysis of the Environmental Impacts

a. Atmospheric pollution

A negative impact by atmospheric pollution will not be produced in the construction stage as well as the operation stage. 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 landfill gas removal facility will be installed, atmospheric pollution will be minimal due to that 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 furious odor spreading.

b. Dust increase

There will be no dust increase neither from the traffic of the waste collection vehicles, nor from the sanitary landfill operation proposed (e.g., disposal, compaction and soil coverage), since the access road (from the city to the SJV site) is going to 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. Furthermore, water tanker will be used for dust control, when sanitary landfill operation are carried out in the site.

c. Pollution risk for the subsoil and underground waters

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

d. Impacts provoked by the gaseous emission of CH_4 and CO_2

There will be no negative impact due to gaseous emissions in the zone, because the installation of 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 same, avoiding that CH_4 to accumulate in closed spaces.

Meanwhile, CO_2 being 1.5 times heavier than the air, will be ventilated 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.

e. 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 pathogenic microorganisms, workers will receive a supply of boots, gloves and masks, as well as cleanliness items, 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.

f. Proliferation of Vermin

In the sanitary landfill, daily soil coverage on waste will be carried out and therefore, proliferation of disease transmitting vermin could substantially be controlled and

avoided. Therefore, it is not expected that the sanitary landfill project produces impacts of vermin 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 vermin (e.g., roof rats *Rattus rattus* are attracted with poultry feeds, Zopilotes *Coragyps atratus* are attracted with residues from fowl meat processing). (see pictures in the Section 8.10 of Chapter 8 in the Data Book)

Therefore, it is important to confirm that the **present environmental quality of the poultry farm** is such that some vermin are attracted and proliferated with unsanitary situation of the same.

g. 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 combustion.

h. 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 breeding and no kind of flora and fauna in danger of extinction are found therein. Although vegetation of the project area will be removed at the construction period, since trees will be planted as the buffer zone, there will not be negative impacts of flora resources reduction. Likewise, there will not be negative impacts of fauna resources reduction.

With respect to the ecosystems in the forest and wetland area (i.e., Seasonal swamp with tall and medium size trees, and Wetlands with low-height vegetation), although the area makes up an ecosystem of abundant species, no kind of flora and fauna 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 buffer zone of fast growing trees will protect the ecosystem in the area. 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 case that the effluent should give negative impacts on the ecosystem, the impact will only be limited to a small pinpoint local area, considering the existing wide area of the wetland and its biodegradation capacity and toxicant removal/retention functions.

i. Noise impacts in the zone

The bordering areas to 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 planting, e.g., eucalyptus), the noise impact will be mitigated.

j. 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.). Because 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.

k. 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 ecological park. It will further give a favorable landscape which will be accessible by the citizen at that time.

l. Damages to archaeological and paleontologic sites of interest

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

m. Changes to the property costs

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 Mnicipality) and land owners will begin after the Environmental Permit (Permiso Ambiental) for the project is given 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 provide beneficial effects to the neighboring land uses and to the users of the access road.

4.8.6 Mitigation Measures

a. 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; and
- monitoring of important parameters.

Table 4-20 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 4-20: 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.

b. Evaluation of the Efficiency of each Mitigation Measure

b.1 Security of the Project Site

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

b.2 Good Sanitary Practices of Landfill Operation, Adequate Functioning of Facilities

b.2.1 Fencing of the Site

The fencing of the site will not permit the access of strangers, with which public health will be protected. Also, the light solid waste scattering out of the site will be avoided.

b.2.2 Construction of the Buffer Zone (Tree Planting)

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

b.2.3 Utilization of Compactor Trucks for Waste Collection

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

b.2.4 Inspection of the Incoming Waste

With the inspection of the waste, disposal of the hazardous, toxic, infectious or radioactive wastes will be restricted. With this, the 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.

b.2.5 Waste Compaction and Daily Soil Coverage

The waste will be extended and compressed in 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 reaching 3 m height. 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, with which public health is protected. The air pollution by bad odor will be avoided and scatter of the light solid waste at the bordering areas will be avoided.

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

b.2.6 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.

b.2.7 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.

b.2.8 Control of Waste Scatter

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.

b.2.9 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.

b.2.10 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.

b.2.11 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.

b.2.12 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.

b.2.13 Surface Water Drainage

The surface drainage system is designed to restrict the rainwater 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.

b.2.14 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.

b.2.15 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.

b.2.16 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.

b.3 Workers' safety

b.3.1 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.3.2 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.

b.4 Monitoring

b.4.1 Water Quality

By monitoring groundwater, 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, undergroundwater body and consequently all environmental settings including human health will be protected.

b.4.2 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.

c. 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.

d. 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).

e. 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.

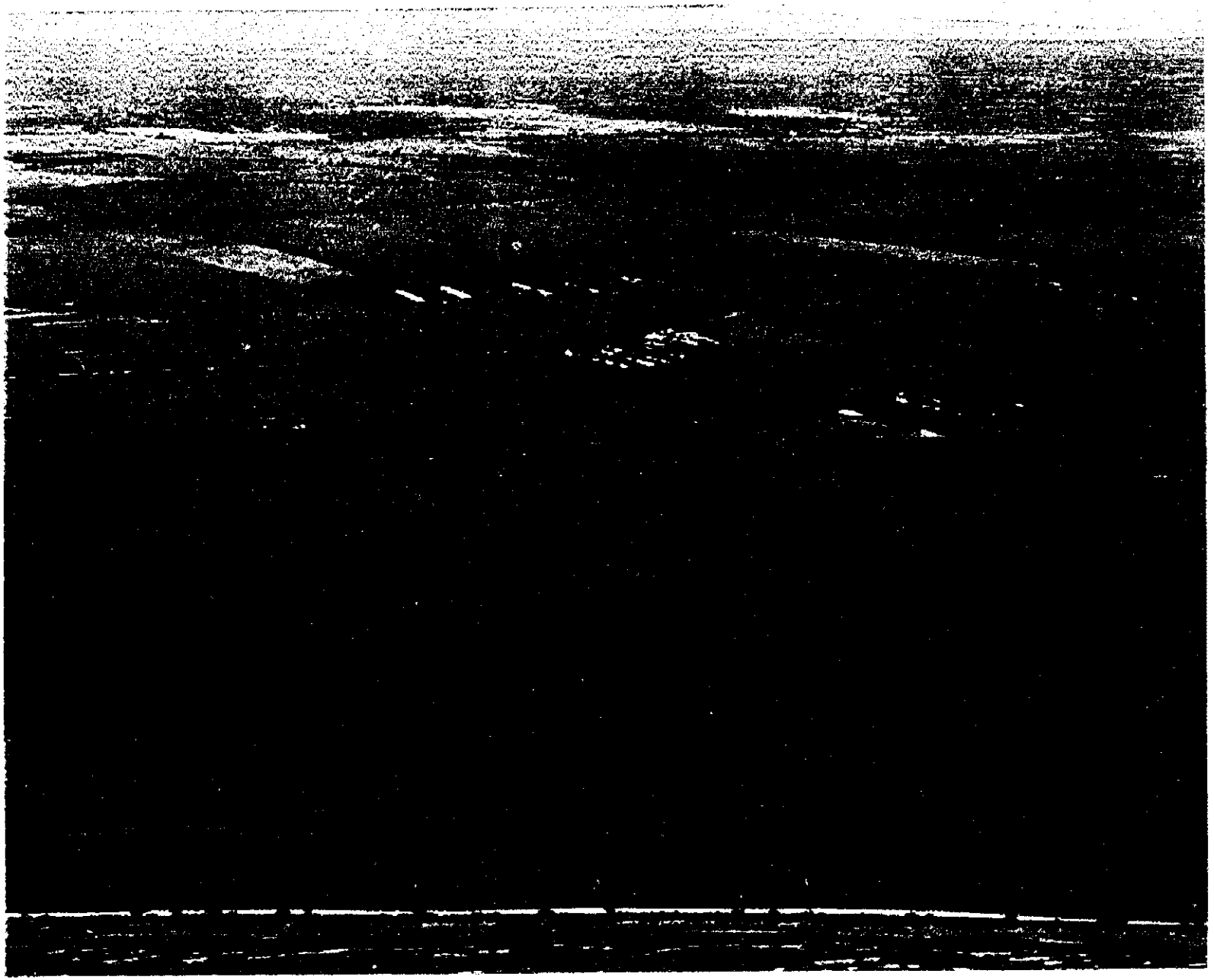


Figure 4-9: Present Landscape (1997)

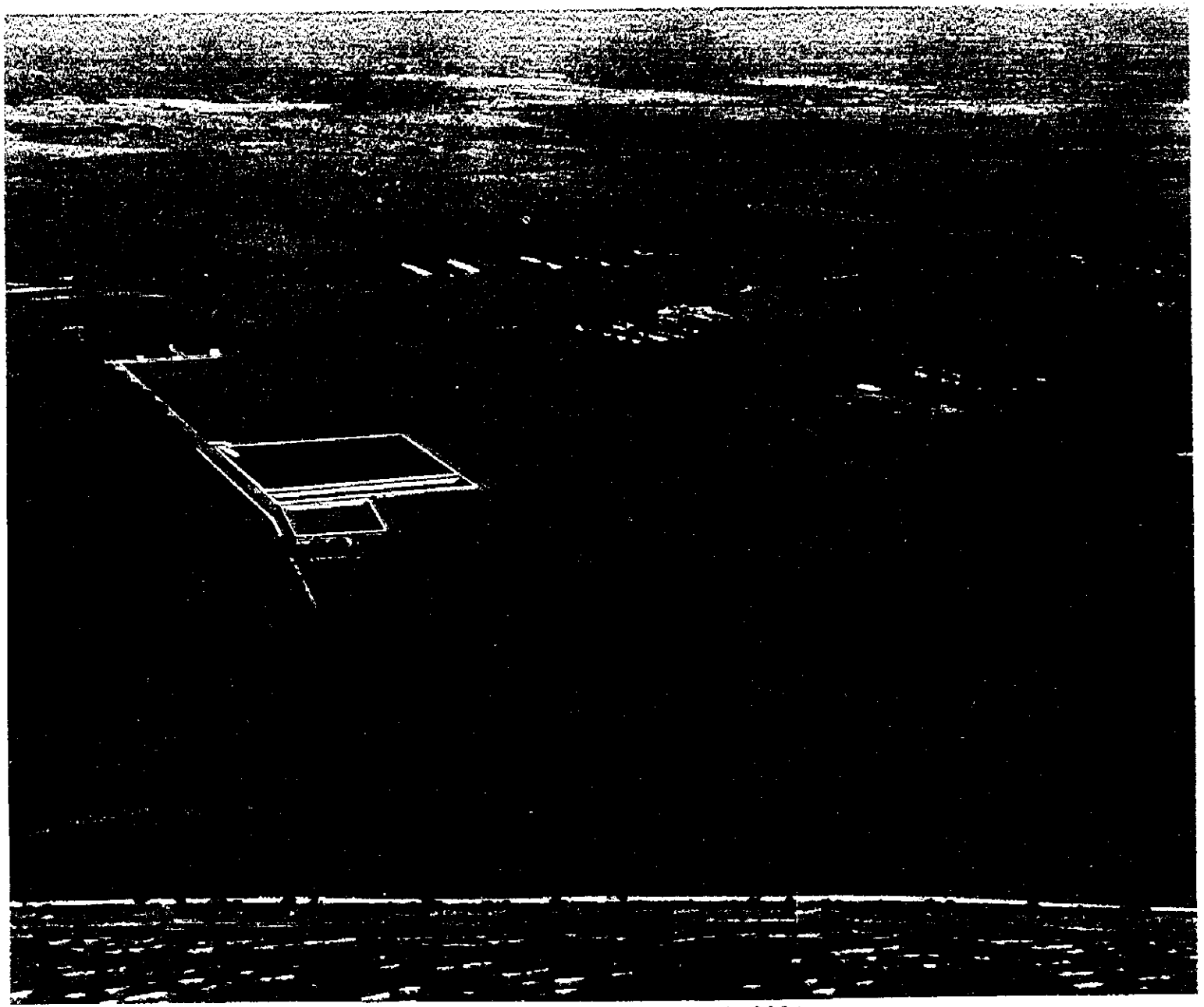


Figure 4-10: Landscape Expected in 2001

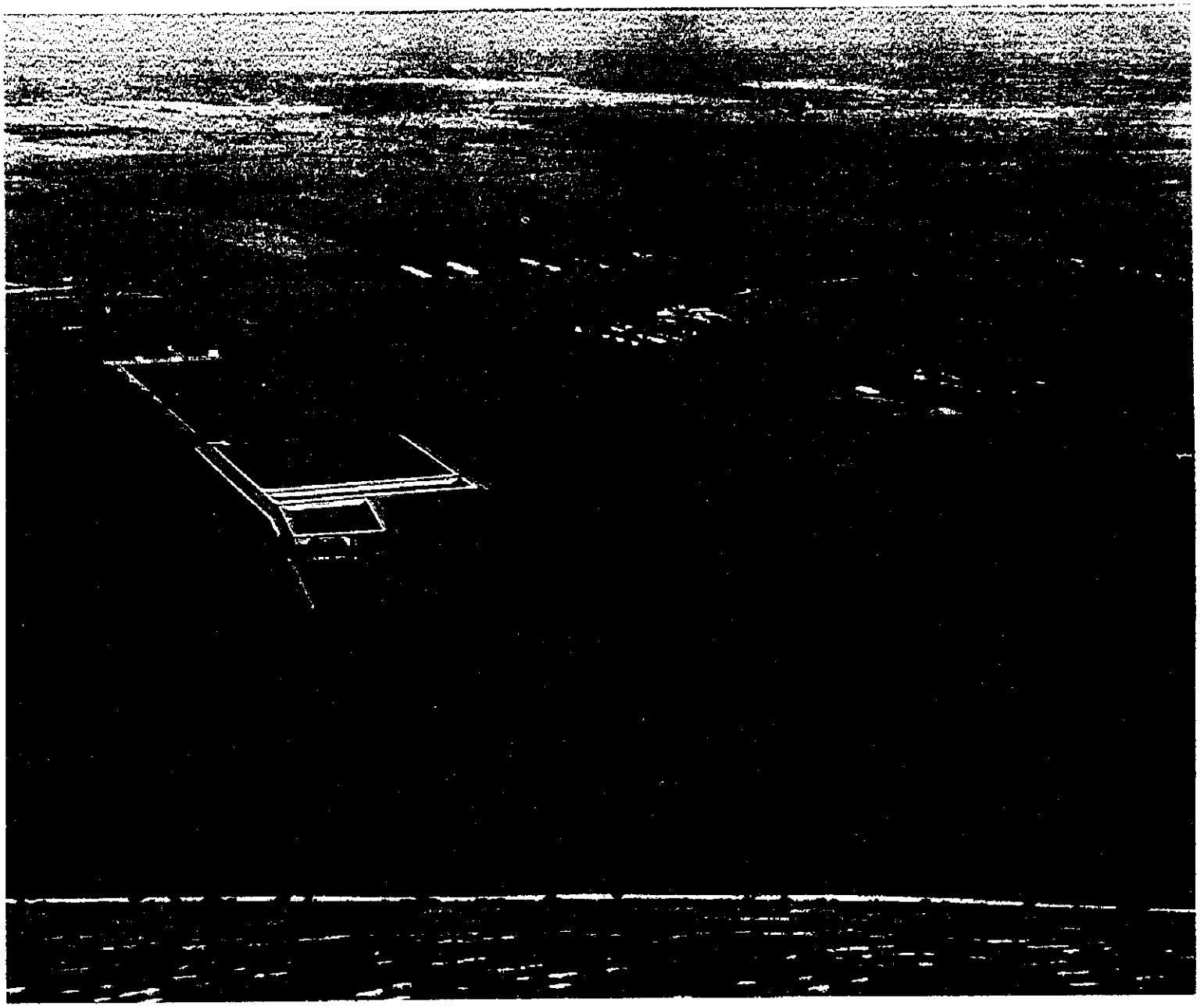


Figure 4-11: Landscape Expected in 2005

4.8.7 Environmental Management Program

a. 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.

a.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.

a.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 Data Book: Volume V)

a.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 4-21 lists parameters and the frequency to be surveyed.

Table 4-21: Monitoring parameters

Parameter	Groundwater	Leachate
Color	once per week	daily
pH	once per week	once per week
BOD	once per year	twice per year
COD	once per year	twice per year
SS	once per year	twice per year
Electric conductivity	once per week	once per week
NH_4-N	once per year	twice per year
Cl^-	once per year	twice per year
SO_4	once per year	twice per year
Fe	once per year	twice per year
E. coli.	once per year	twice per year

a.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.

b. 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.

c. 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.

d. 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.

e. 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.

f. 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.

4.8.8 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 emission 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.

4.9 Project Evaluation

Project evaluation for Municipal Solid Waste Management System Improvement Project was carried out from the technical, social, environmental, financial, and economical perspectives.

4.9.1 Technical Evaluation

The technical systems proposed in the priority projects are mainly constituted of two sub-systems, they are, a final disposal system and secondly, a collection and transportation system which is basically the same with present system. Therefore, technical evaluation was carried out from the viewpoint that whether or not proposed technical systems can be properly operated, managed, and maintained.

a. Collection and Transportation System

There is no problem in continuing "Curb Collection System" which has been carried out without any problems even in the urbanized areas in Granada Municipality now.

Regarding the point collection system which will be introduced in UFA, the biggest concern is whether or not cooperation from the residents can be obtained. In this regard, pilot projects confirmed that resident's cooperation can be obtained if waste collection bays are installed within 50 m from their houses, and discharge methods are fully explained to them. Therefore, the problems will be solved by fully giving consideration to the location of collection bays from the residents' houses and explaining discharge methods to residents.

The major concern in introducing compactor trucks as waste collection vehicles is the maintenance capability (especially, hydraulic systems). In the principal cities in Nicaragua such as Managua and Leon, majority of the collection vehicles are compactor trucks and the maintenance skills are already acquired in these cities. Therefore, if maintenance engineers for collection vehicles in Granada Municipality receive training in these cities, they can acquire necessary maintenance skills. Furthermore, mechanics of MDO who will have to be in charge of the compactor trucks' maintenance already deal with more complicated maintenance for hydraulic systems of a wheel loader and a motorgrader. Accordingly, there are no problems for them to acquire these skills.

Tipper trucks instead of compactor trucks are planned to be used for the removal works of illegally dumped waste and sedimented soil, which cause frequent breakdown of hydraulic systems.

Total six collection vehicles needs to be operated in 2001 and eight in 2005 so that only four vehicles shall be additionally operated. Therefore, they are capable of operating and maintaining this small number of additional vehicles.

As was mentioned above, the present mechanics of MDO workshop have certain technical ability to maintain the equipment. However, facility and repair equipment of the existing workshop is extremely poor. Thus, MDO's operation and maintenance system for refuse collection vehicles and landfill equipment shall be strengthened through improvement of the MDO facilities: such as operation yard pavement, lighting improvement, and also procurement of repair equipment and tools.

b. Street Sweeping

Street sweeping shall be basically carried out manually as it is now, no operational and maintenance problem arises.

c. Final Disposal

Final disposal method in Granada has improved through the La Joya pilot project by shifting from open dumping to first step of sanitary landfill, level 1: controlled tipping with casual soil covering. However, in SJV A New Municipal SW Disposal Site Development Project, level of disposal method is planned to enhance all at once to level 4: i.e., impermeable liner, leachate collection and treatment. This brings not only financial burden sharing but also technical problems. Therefore, technical key issues and its countermeasures were summarized in the table below.

Table 4-22: Key Issues and Solutions for Level 4 Landfill Implementation

Key Issues	Solutions
Availability of cover soil	Geological survey for the proposed site revealed that the surface layer of the site composed of either clay, silt or sand. It can be used as cover soil. Therefore, it can be procured in the site and there is no need to secure borrow pits.
Availability of clay material for the impermeable liner	Clay material of coefficient of permeability 10^{-7} (cm/sec) can be obtained at 20 km north east of the facility construction proposed site.
Construction of an impermeable liner	A foreign contractor with the experience of impermeable liner construction, (or a national contractor with relevant engineering skills) is indispensable for the construction.
Construction of leachate treatment facility	A foreign contractor with the experience of leachate treatment facilities construction, (or a national contractor with relevant engineering skills) is indispensable for the construction.
Operation of leachate treatment facility	A foreign expert with the experience of operating leachate treatment facility (or national with relevant experiences) is indispensable for the operation.
Operation of level 4 landfill	Foreign experts with the experience of operating level 4 landfill (or national experts with relevant experiences) are indispensable for the operation.

As stated above, for the construction operation and maintenance of the level 4 landfill, foreign assistance not only for the finance, but also for the technical aspects are

indispensable. However, Granada's experiences on the level 4 sanitary landfill (construction, operation and maintenance) will be a valuable technical asset not only for Granada but for many Nicaraguan cities which face with the problems of surface and groundwater pollution by municipal dumping sites.

b. Conclusion

Judging from all the technical aspects, it is anticipated that it will be difficult for Granada Municipality with the present technical level to deal with the construction, operation and maintenance of the level 4 sanitary landfill site. However, it is strongly expected that these level 4 technologies should become prevalent in Nicaragua in order to preserve USE and to avoid contamination of precious water resources. In this regard, foreign assistance on both financial and technical aspects should be sought to solve these problems.

Technical systems proposed, other than the level 4 landfill, are not complicated and are appropriate for the present technical level of Granada Municipality.

4.9.2 Social Evaluation

The Municipal SWM System Improvement Project will bring various benefits. The beneficiaries of the project, who are newly benefited with collection service namely improved USE, will reach approximately 54,000 persons. As a knock-on effect of improved waste collection, it will contribute less drain blockages caused by refuse clogging, which in turn will reduce flooding areas and frequency, and consequently increase road life and reduce road maintenance expenditures and pollution of surface and groundwater. The improved USE and aesthetic scenes in the city will introduce various positive impacts such as encouraging foreign and domestic investment, promoting tourist industry and raising property values in the city.

At present where waste collection service is insufficient, illegal dumping into the rivers nearby and the vacant land is frequently observed. In the UFA, mainly composed of residents on low income, and among others where refuse collection service is absent, illegal dumping is prominent. The questionnaire surveys in the pilot project confirmed that if regular and reliable refuse collection service is provided, illegal dumping will definitely decrease. This illustrates that by implementing this project, the USE of the low income areas will be considerably improved and accordingly, it will contribute to eliminate the social unfairness.

Technical systems proposed, except for the point collection system for UFA and level 4 landfill, have been widely accepted by Granada citizen thus far they are socially compatible. Regarding point collection system, pilot projects confirmed that cooperation from the residents can be obtained if public education is provided and publicity work is carried out. As for the introduction of sanitary landfill, the questionnaire surveys were conducted on the same group of people who were invited to see the La Joya disposal site before and after the experiment, in order to investigate the impact of the improvement project quantitatively. As a result, all appreciated that the disposal site was improved. Experiment on Sanitary Landfill Operation at La Joya Disposal Site was designed to improve the situation from open dumping to sanitary landfill level 1. Therefore, level 4 will greatly improve the environment of the surrounding areas than level 1. In conclusion, it can be judged that introduction of sanitary landfill will be welcome by citizen and socially acceptable.

4.9.3 Environmental Evaluation

Although the implementation of SJV A New Municipal Solid Waste Disposal Site Development Project brings various impacts to its environment, EIA concluded that the predicted positive impacts would outnumber the predicted negative impacts; all predicted negative impacts could be mitigated within the permissible limits by carrying out various mitigation countermeasures.

4.9.4 Financial Evaluation

(1) According to the POS, willingness to pay of the citizen in Granada City is C$ 8.54 per month per household. This Financial evaluation employs domestic waste collection fees with three categories: higher rate of C$ 15/month/household, average C$ 10/month/household and lower C$ 5/month/household, based on the present charges. Following this, beneficiaries also are stratified into three parts and namely each is estimated to count for 40%, 30% and 30% in total. Waste collection fee for other than households is, following Beneficiary Pay Principle, defined as C$ 362/ton

(2) If a loan is acquired to cover the entire project cost, the R/E would be less than 1 and the FIRR calculation indicates that the project would be financially unfeasible.

(3) If grant aid is to be acquired for 90% of the investment required in 2000, only Case B-1, where the forecast revenue is optimistic, was calculated to incur an FIRR (16.4%) that is higher than the cut-off rate (8.5%).

(4) If grant aid is to be acquired for the entire investment required in 2000, Case C-2 (where the forecast increase in municipal tax rates and SWM budget is most probable) was calculated to incur an FIRR (13%) higher than the cut-off rate. In this case, the profit and loss statement would be in the black and an internal reserve of C$11 million can be accumulated by 2005, enabling Granada Municipality to independently provide for the investments required after 2005.

4.9.5 Economic Evaluation

Economic evaluation is carried out using the Economic Internal Rate of Return (EIRR) as a basis. The EIRR was calculated using the total project cost, which is determined by revising irregularities in domestic market prices based on economic prices, and the overall project benefits, which took environmental benefits into account.

Of the cases in A, which proposes the acquisition of a loan to cover the entire project cost, the EIRR was calculated for A-2, which proposes the joint collection of refuse collection and water supply charges and a very appropriate tax revenue growth rate and SWM budget allocation.

The EIRR was calculated at 4.6% taking the present fee paid by the residents as a benefit. Although it is less than the cut-off rate, the project expenses will not incur deficits as the revenue would exceed the expenses. In case only the beneficiaries' willingness to pay is considered as a benefit, the EIRR was estimated at 2.8%.

The calculation, which took environmental benefits (e.g., improvements in public health and sanitation, increase in land prices and increased consumption due to developments in the tourist industry) into account in addition to the present fee paid, resulted in an EIRR

of 13.3%. Because it exceeds the cut-off rate, the implementation of the project is presumed to contribute to national economic development.

4.9.6 Total Evaluation

As a total evaluation, it was concluded that that the implementation of the Municipal SWM System Improvement Project was feasible in technical, social, environmental, financial, and economic aspects, as it was a condition for conservation of USE and public health of Granada Municipality, and for sustainable development of the Municipal activities.

CHAPTER 5

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

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

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

Thus, an area approximately 200 ha 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 the Model Community. Investigation including a topographical survey were carried out in order to examine the situation of the areas. Consequently, areas C1, C2, C3 were selected as Model Community areas, with the reasons described in the planning framework of F/S. The "Model Community Integrated USE Improvement Project" is detailed below.

5.1 Water Supply System Improvement Project

a. Water Supply System Improvement

As was described in the planning framework, the water supply system improvement project is not considered a priority project in this Study. However, the following costs 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. Rehabilitation works of shallow existing water pipe shall be carried out together with the domestic wastewater facility construction works. Therefore, the cost for improvement works is assumed in the contingency cost for domestic wastewater treatment facility construction.

b. Project Cost

Table 5-1 shows the project cost calculated based on the method stated above.

Table 5-1: Project Cost for Water Supply System Improvement in the Model District

	C1	C2	C3	Total
Facility Construction Cost (C$ 1,000)	1,289	1,786	1,864	4,939
Operation & Maintenance Cost (C$ 1,000)	124	172	179	475
Total	1,413	1,958	2,043	5,414

5.2 Refuse Collection Improvement Project

a. Conclusion Deduced from Pilot Projects

As was discribed 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 are willing to pay refuse collection fees, the amount they can afford to pay is extremely limited. WTP averages from C$3.3/month/household to C$3.9/month/household.
2. Therefore, cost for the collection service in the model community shall be kept to a minimum and it is necessary to examine the measures to minimize the financial burden by the residents.
3. The point collection system which reduces the refuse collection cost through residents cooperation is fully acceptable to them. However, waste collection bays have to be installed within 50m from housing.
4. A waste collection bay is sufficient if it is made of a concrete floor and notice boards 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;

Service 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.

5.3 On-Site Domestic Wastewater Treatment System Improvement Project

5.3.1 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. The 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 5-2: 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)
C_1	33	4,997	153	5,466	167	5,979	183	6,658	204
C_2	31	3,992	130	4,608	150	5,319	173	6,251	204
C_3	67	7,789	117	8,471	127	9,213	138	10,201	153
C_7	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, an 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 a few to several tens of households). Construction of the facility becomes possible only if consensus is reached per treatment block.

The items that require residents' agreement are;

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

Compared with off-site treatment systems, there are more items to be agreed on with residents in the community in the on-site treatment system. Facilities shall be constructed one after another starting with the community where residents have reached a concensus.

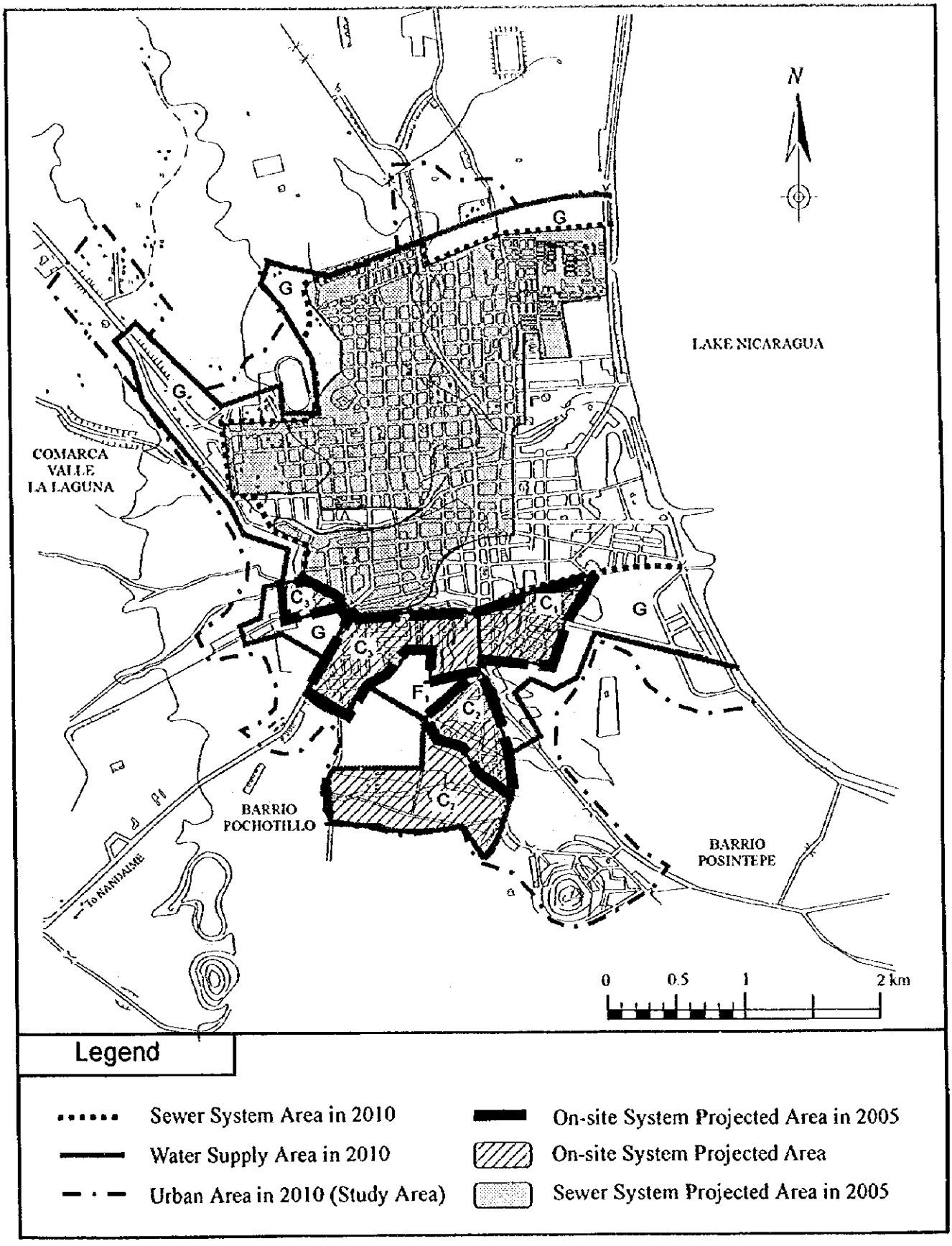


Figure 5-1 : On-site System Projected Area

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 5-2.

- 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.

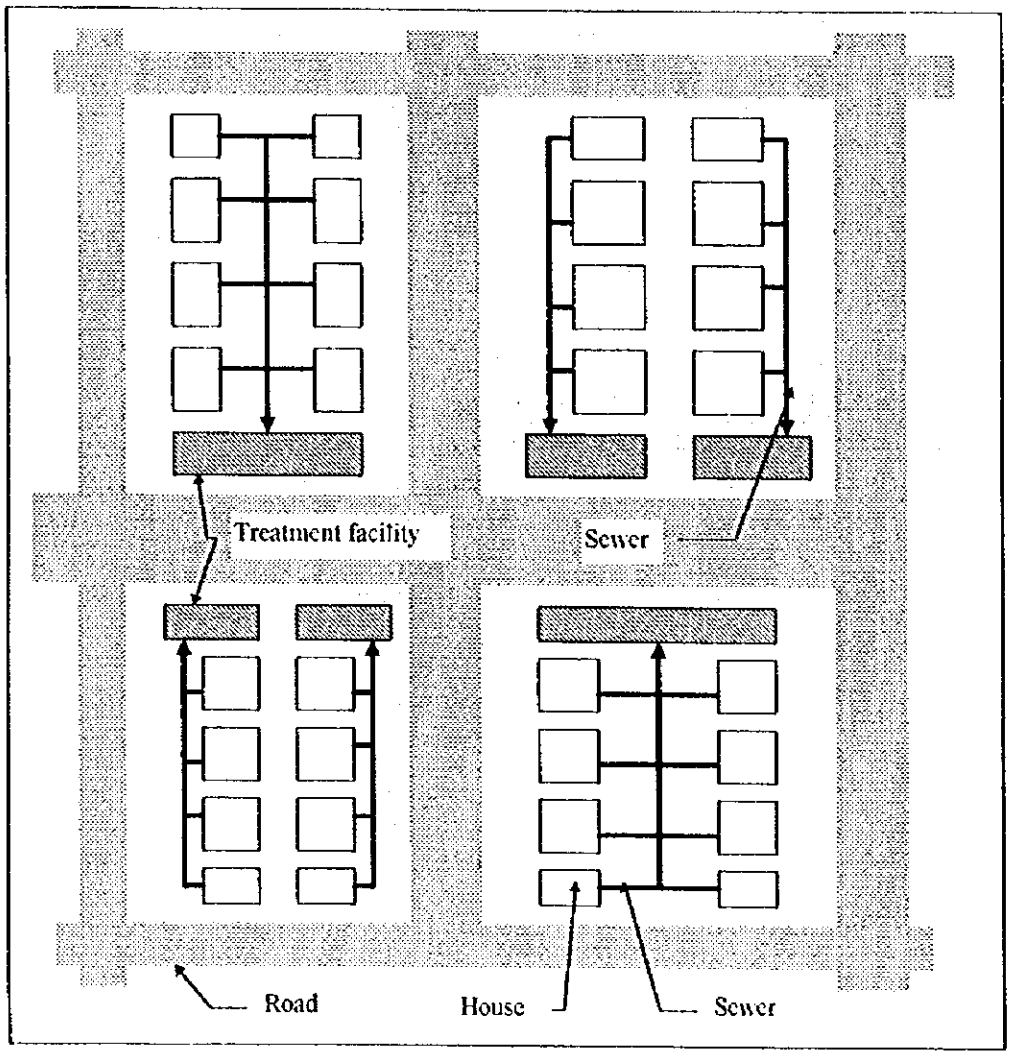


Figure 5-2: Concept of On-site System Localization

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 5-2 to Table 5-4. The on-site systems arrangement plan are shown in Figure 5-3 to Figure 5-5.

Table 5-3: 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 the establishment of community consensus and O&M system of a DWW treatment system, one block which is the smallest neighbors community is planned as one treatment community. If several blocks manage to create a treatment community, the unit construction cost (per household) of a treatment facility can be reduced though the cost of pipeline can not be reduced (See Annex R). Therefore, if the consensus among plural 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.

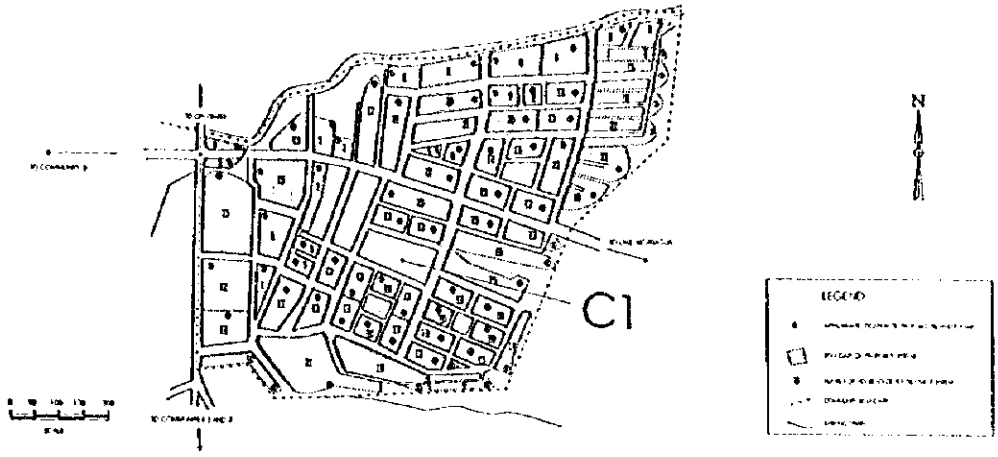


Figure 5-3 : On-site Systems Arrangement Plan (Zone C1)

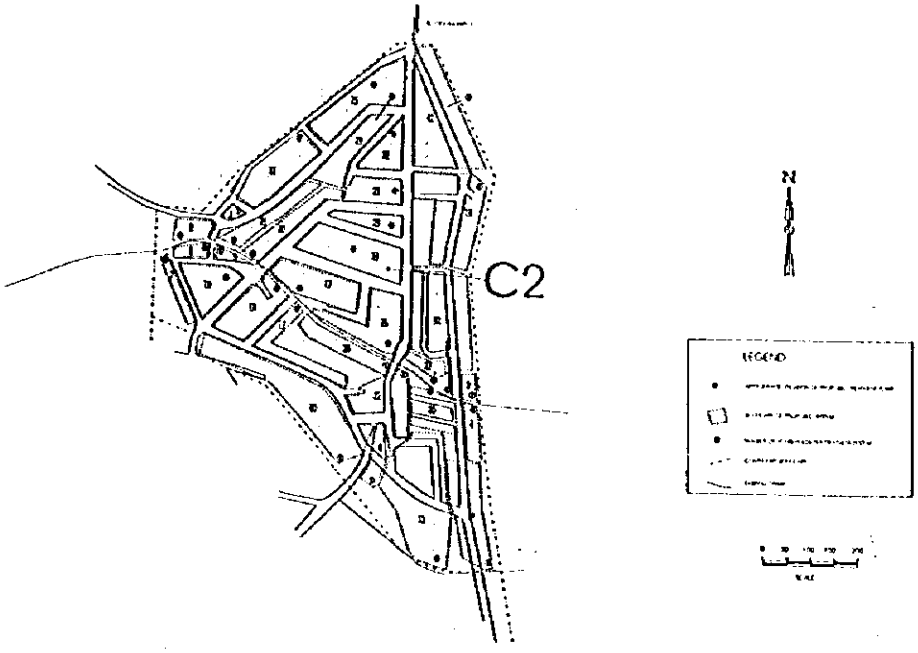


Figure 5-4 : On-site Systems Arrangement Plan (Zone C2)

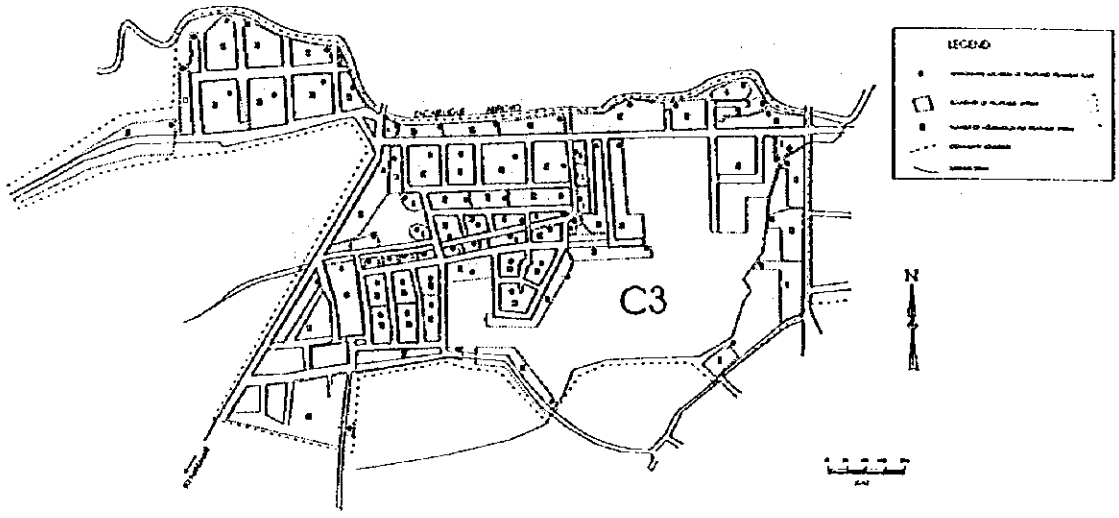


Figure 5-5 : On-site Systems Arrangement Plan (Zone C3)

Table 5-4: 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 the establishment of community consensus and O&M system of a DWW treatment system, one block which is the smallest neighbors community is planned as one treatment community. If several blocks manage to create a treatment community, the unit construction cost (per household) of a treatment facility can be reduced though the cost of pipeline can not be reduced (See Annex R). Therefore, if the consensus among plural 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.

Table 5-5 : 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				

c. Facility Planning

c.1 Pipeline

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

Table 5-6: 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 5-7 : 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 5-8 : Effluent Water Quality

pH	BOD	COD	Sedimentable Solid	Suspended Solid	E-coli. (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 5-9 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, 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 tanks. 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, the septic tank shall be adopted in this Plan. As was indicated in Table 5-10, BOD removal rate of septic tanks range 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 5-9 : 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.

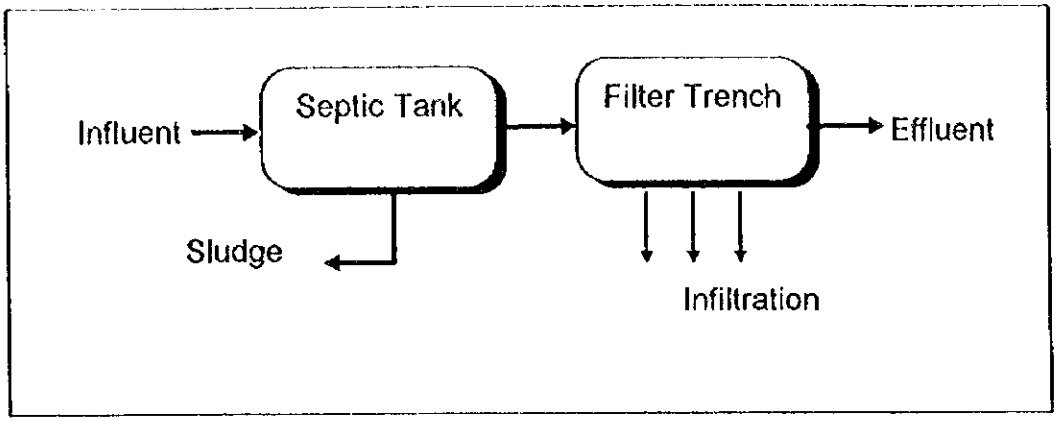


Figure 5-6 : Flow Sheet of the On-site Treatment Facility

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 5-10.

Table 5-10 : 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 5-2 and Table 5-6, and Table 5-11 summarizes the result of the main pipeline plan.

Table 5-11: 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.

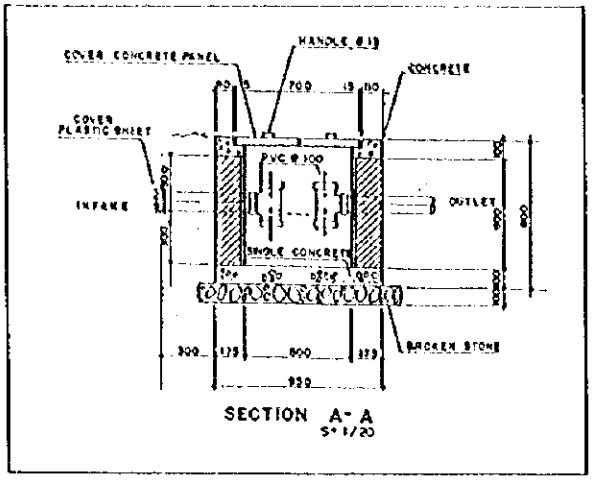


Figure 5-7 : Catch Pit

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 5-3 to Table 5-5. Table 5-12 shows the calculation result for septic tank capacity to deal with wastewater produced by respective population size (10 to 500 persons).

Table 5-12 : 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 form
- 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 biodegredation.

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.

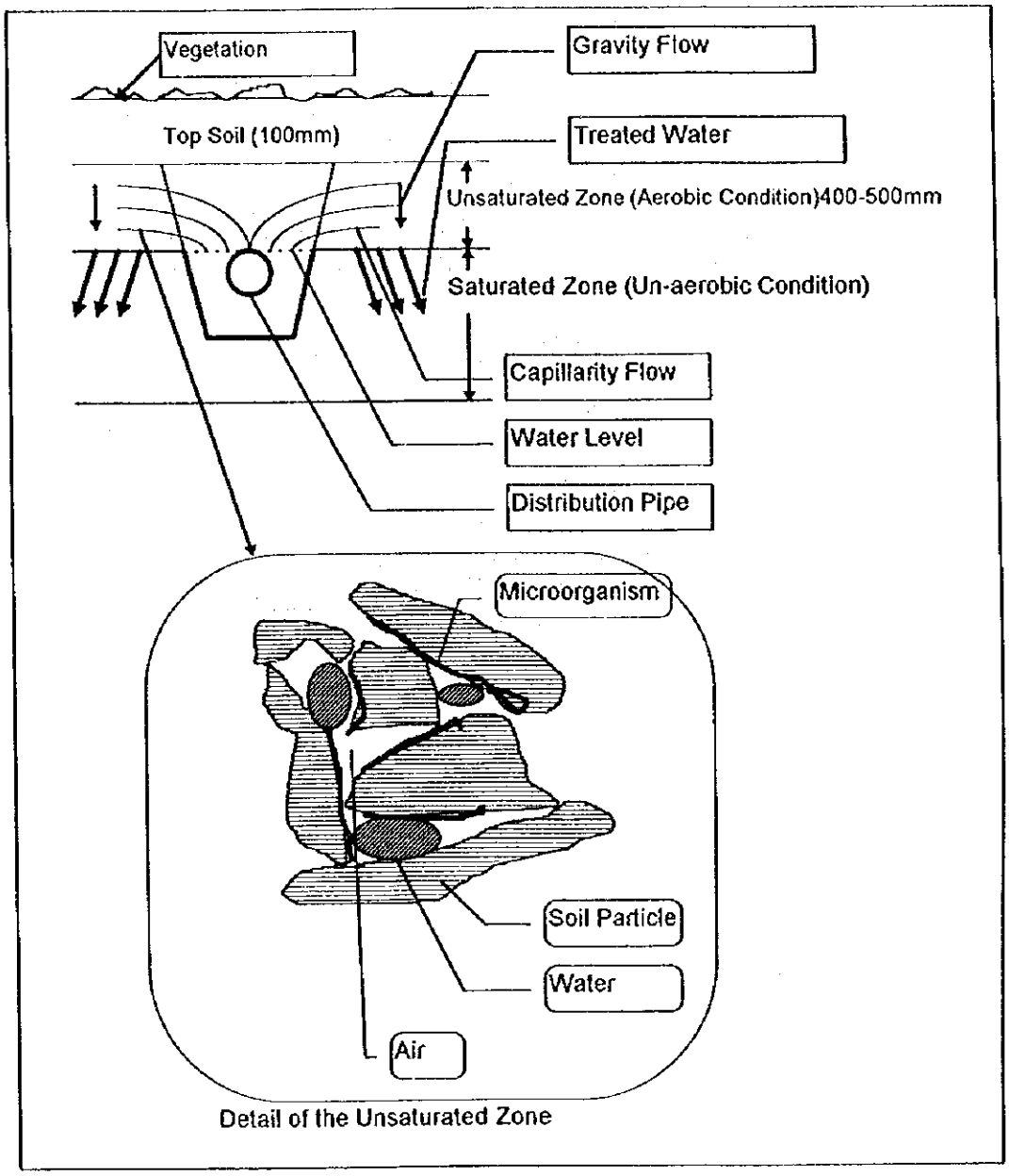


Figure 5-8: Treatment Mechanism of Filter Trench

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.

5.3.2 Improvement of the 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/Region IV 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 5-10 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) onto 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 5-11 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 onto model community integrated USE improvement project.
- assignment of an executive for the PECM, 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 DWW collection and treatment, 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 5-12 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 5-13 illustrates the functional scheme for MINSA/SILAIS (Granada).

5.3.3 Project Cost

Based on the preliminary design, calculation of the project cost for improving C1,C2, and C3 districts, 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 5-13: Construction Cost of the On-site System

Unit : C$ 1,000

	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 5-14 : Annual Operation and Maintenance Cost in 2010

Unit : C$ 1,000

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

Table 5-15 : Investment Schedule for F/S Projects

Unit : C$ 1,000

	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**

5.3.4 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 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 connecting 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	15,949	0	15,949
Total	21,062	0	21,062

a.2 Annual Expenditures

Unit: C$1,000

		1995	2000	2001 - 2005 (average)
Proposed System	Water Supply		37	437
	Wastewater Treatment (on-site)		16	601
Existing System + Proposed System	Water Supply	818	941	1,341
	Wastewater Treatment (on-site)		16	601

Note: Cost for proposed system (the year 3000) is a predicted interest portion for investment in the same year.

b. Cases for Financial Evaluation

For the 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 5-16: 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		
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 5-17: 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.

		1995	2000	2001-2005 (average)	2001-2005 (total)
New Projects	Water Supply		-320	-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 on DWW 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.

5.4 Stormwater Drainage Improvement Project

5.4.1 Technical System

a. Principles

At present, the majority of the roads in the model community are not paved and stormwater drainage facilities are in poor conditions. As a consequence, stormwater is flowing on the unpaved road surface when it rains. The surfaces of the roads are also eroded. Especially, the traffic of the vehicles becomes difficult in the rainy season, and the roads are not serving its original purpose. As a result, the following phenomena can be observed in the community:

- Access of waste collection vehicles to the area becomes difficult and waste collection can not be carried out as planned. This illegal dumping of waste into the rivers is frequently sees. As a result, USE in the area is deteriorated.
- DWW become stagnant, forming haphazard puddles on rods, especially on days when it isn't washed away by excessive rain. These puddles subsequently become breeding ground for mosquitoes. This in turn deteriorates the neighborhood USE.
- As a result of road erosion, the shallow water supply pipes become exposed. This often leads to the damage of the water supply pipes.

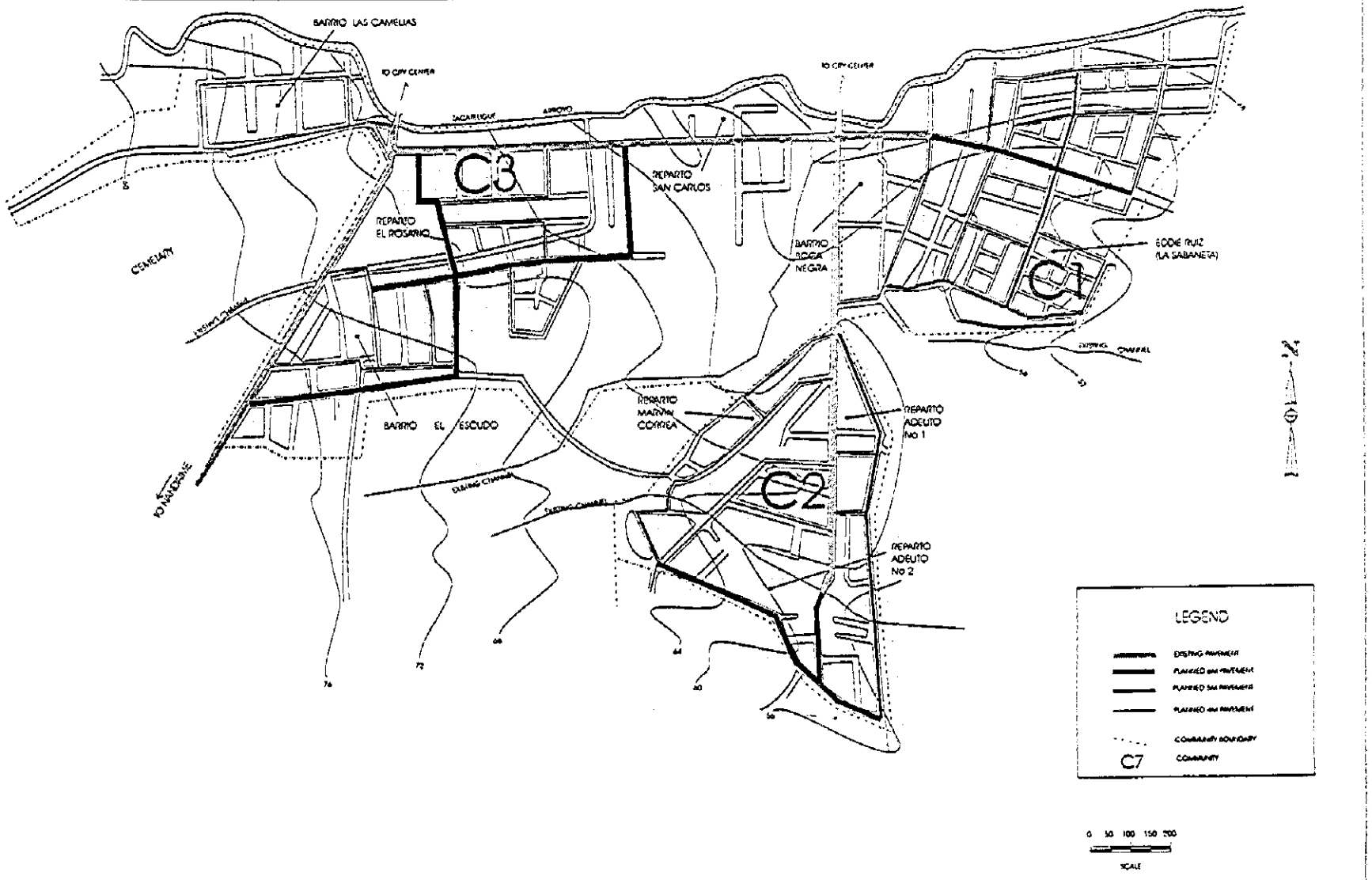
As a solution, the improvement of stormwater drainage facility together with road pavement are indispensable. As rainfall intensity in Granada is significantly high (e.g., 61.6 mm/hr for a half year return period), stormwater drains require a large dimension, and its construction cost becomes high if the drainage is designed exclusively for stormwater. Thus, the road surface shall be paved and utilized as stormwater drainage in order to reduce the improvement cost for stormwater drainage facilities in this Plan.

b. Road Network

Considering the high population density residing near the road, and traffic volume, etc., three types of road width, classified into class 1 (road width 6 m), class 2 (road width 5 m) and class 3 (road width 4 m), were considered and examined in the road improvement plan, which also serves as a drainage. The location of stormwater outfalls from the road are determined with topographical conditions. The outline of the road networks are shown in Table 5-18 and Figure 5-9.

Table 5-18: Outline of the Road Networks

	Unit	C1	C2	C3	Total
Class 1 (6m width)	m	470	195	0	665
Class 2 (5m width)	m	315	885	1,800	3,000
Class 3 (4m width)	m	3,170	2,680	3,220	9,070
Total length	m	3,955	3,760	5,020	12,735
Discharge point of drainage	(Nos.)	6	8	7	21



PROPOSED STREET PAVING OF THE MODEL COMMUNITY INTEGRATED U.S.E. IMPROVEMENT AREA

Figure 5-9 : Road Layout Plan

c. 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:

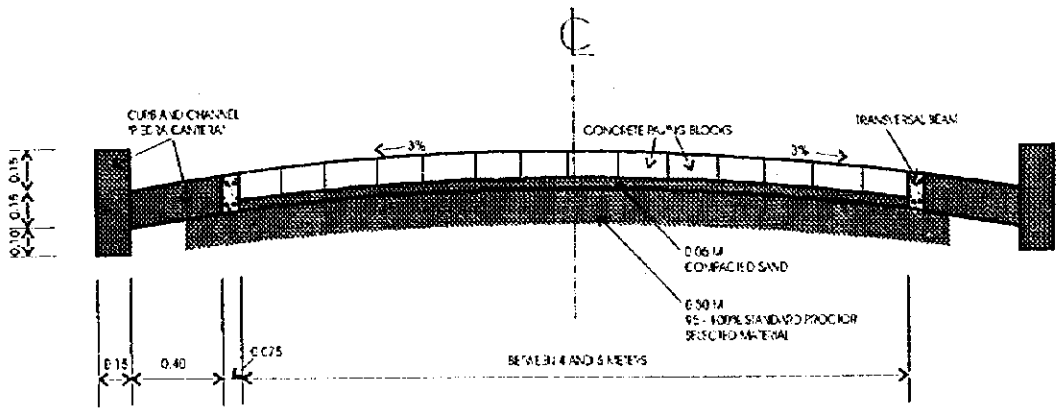
- Low cost solution
- General vehicle access
- Safe and effective drainage
- MSW collection

d. Preliminary Design

d.1 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.

Three typical sections (traveled way width of 4, 5, and 6 meters) are 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

d.2 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.

d.2.1 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. The following table shows ARIs adopted in mainly residential areas of Managua, Japan and the area in Granada.

Table 5-19 : Comparison of Average Recurrence Interval (ARI)

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

For the calculation of peak flow rate (Qm³/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. The runoff coefficient used in Managua (C=0.35) is adopted for this plan.

Q(peak flow rate)=(1/360) C I A

d.3 Road Drainage Capacity

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:

$$\mathbf{Q(road\ drainage\ capacity) = (1/n)\ A_D R^{2/3} S^{1/2}}$$

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[1]. A value of 0.019 is assumed for the Manning roughness coefficient for the road paved with concrete blocks.

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 5-20: 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

[1] Vd <0.4m²/s, Possible Major/Minor Design Standards, The Institution of Engineers, Australia, Revised Ed. 1987. "Australian Rainfall and Runoff", Volume 1.

As can be seen in the table above the drainage of the three selected areas, ARI of 1 in 2 year, the capacity of the road section is sufficient. The road layout plan is shown in Figure 5-9.

5.4.2 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.

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.

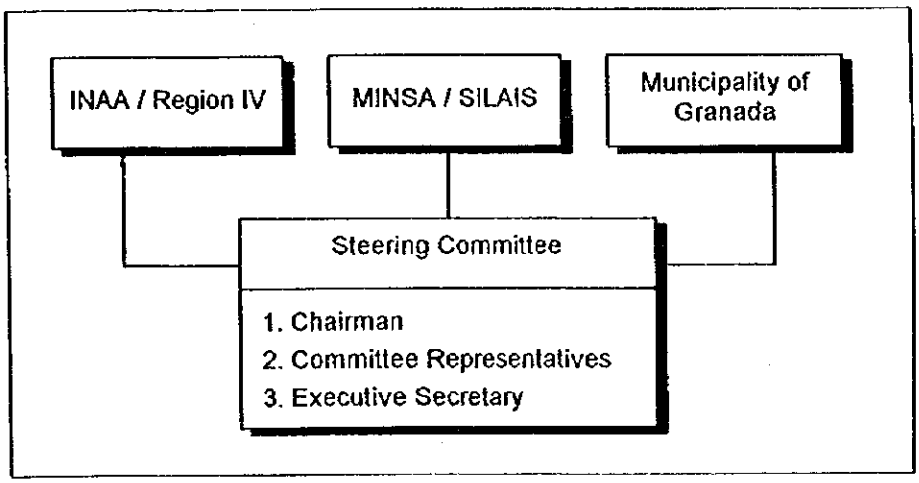


Figure 5-10: Structure of the Steering Committee

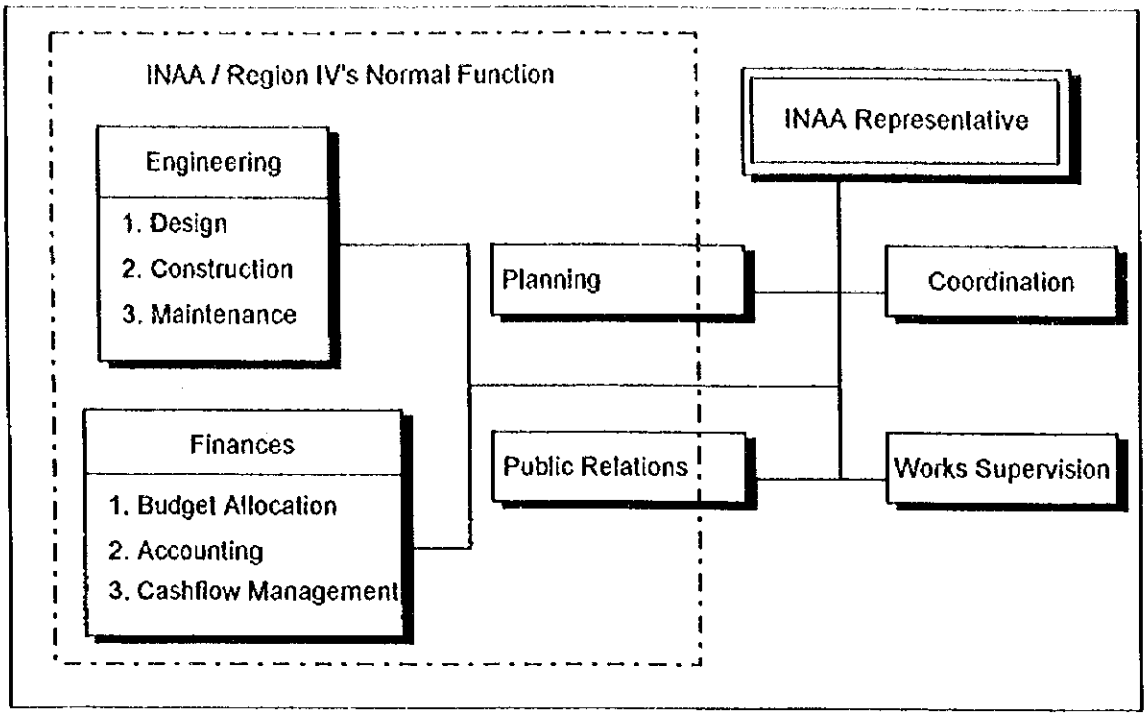


Figure 5-11: Functional Scheme for INAA / Region IV and INAA's Steering Committee Representative

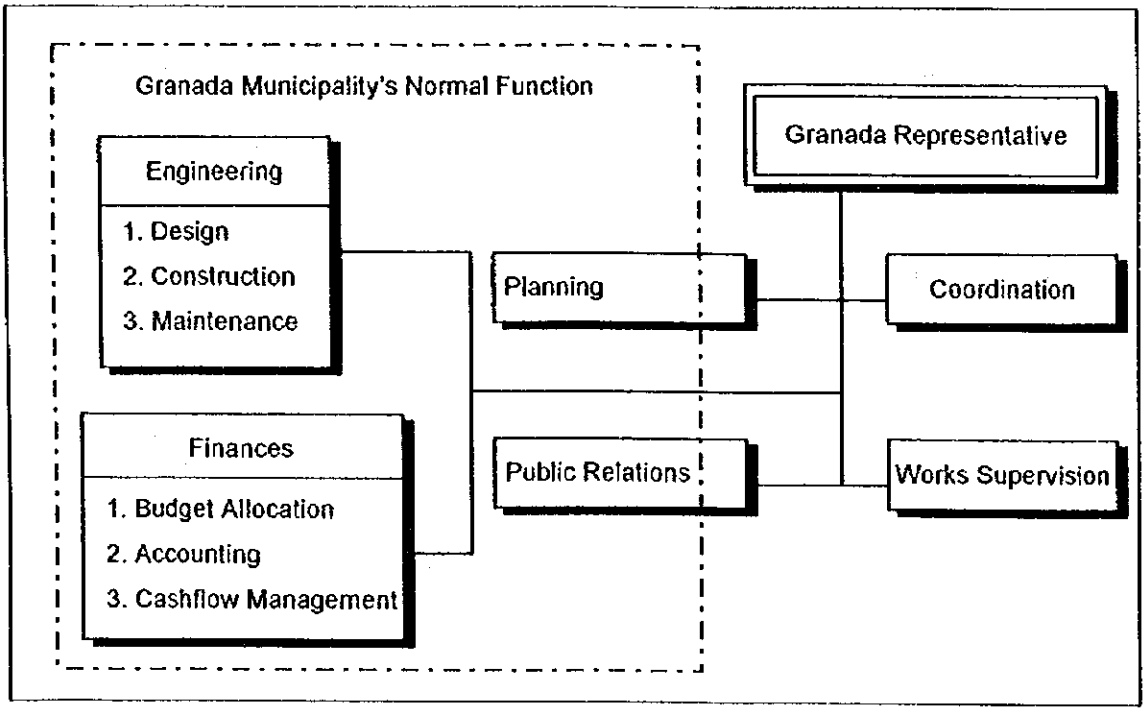


Figure 5-12: Functional Scheme for Granada Municipality and Granada's Steering Committee Representative

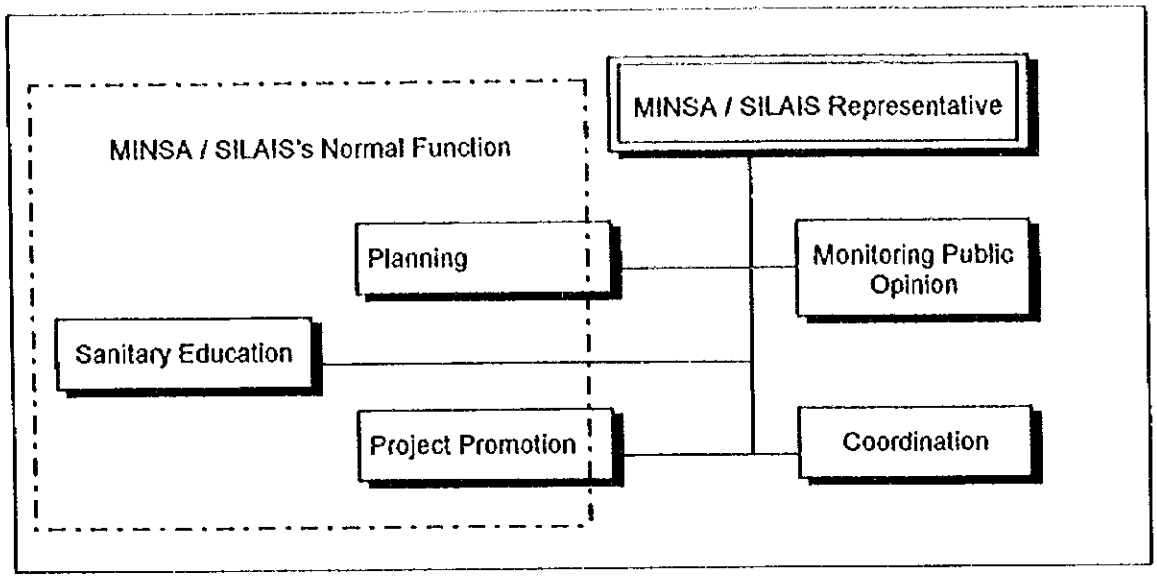


Figure 5-13: Functional Scheme for MINSA and SILAIS's Representative

5.4.3 Project Cost

Based on the preliminary design, calculation of the project cost for improving C1,C2, and C3 districts, referring to the construction cost of the pilot projects are summarized in Table 5-21. Operation and maintenance cost of the facility in 2010 is shown in Table 5-22. Moreover, Table 5-23 shows investment schedule for F/S projects till 2005.

Table 5-21: 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 5-22 : 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 5-23 : Investment Schedule of F/S Projects

Unit : C$ 1,000

	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

5.4.4 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	Rain water drains will be improved along with the installation of the on-site 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 investment costs for the project
- Source of Revenue: Budget to be allocated from vehicle tax revenues for the stormwater drainage 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 Rain Water Drainage Improvement Project

Revenues from vehicle tax are the assumed source of financing for the stormwater drainage 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 drainage 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 drainage. 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 drainage improvement (30% per annum)
Case b	Assuming a moderate increase in vehicle tax rate (12.9% per annum) and budget allocation for stormwater drainage improvement (20% per annum)
Case c	Very pessimistic assumptions regarding increase in vehicle tax rate (12.1% per annum) and budget allocation for stormwater drainage 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, the 4 cases for increase ($3 \times 3 \times 4 = 36$). The results are shown in the table below.

		Case	FIRR (%)	R/E
Leon (for total investment cost)	Optimistic Assumption	A-a	2.9	1.4674
	Moderate Assumption	A-b	n.a.	0.9452
	Pessimistic Assumption	A-c	n.a.	0.4430
Grant aid for investments in 2000 only	Optimistic Assumption	B-a	5.1	1.6597
	Moderate Assumption	B-b	1.1	1.1425
	Pessimistic Assumption	B-c	n.a.	0.6403
Grant aid for 2000-2001	Optimistic Assumption	C-a	8.8	1.8519
	Moderate Assumption	C-b	3.5	1.3398
	Pessimistic Assumption	C-c	n.a	0.8377
Grant aid for 2000-2002	Optimistic Assumption	D-a	18.9	2.0441
	Moderate Assumption	D-b	8.3	1.5371
	Pessimistic Assumption	D-c	0.5	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 drainage 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 5-24: Cash Flow of the Rain Water Drainage 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 5-25: Profit and Loss Statement of the Rain Water Drainage 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

5.5 Project Evaluation

The project evaluation of Model Community Integrated USE Improvement Project, was carried out from technical, social, environmental, financial, and economic aspects.

5.5.1 Technical Evaluation

Technical systems proposed in the Model Community Integrated USE Improvement Project comprises the following four subs-systems; namely, (1) water supply system improvement to deal with the increasing population, (2) refuse collection improvement by point collection system, (3) on-site domestic wastewater treatment system improvement, (4) stormwater drainage improvement. Therefore, technical evaluation was carried out from the perspectives whether or not the proposed technical systems can be properly operated, maintained, and managed.

a.1 Water Supply System

No technical problems can be predicted as the technical systems proposed are the same as that of INAA's current systems. Moreover, as INAA, currently providing water to 64,400 people (as of 1995), will be in charge of the construction, operation, maintenance, and management of this improvement, there will be no problems in dealing with approximately 2,000 increased population.

a.2 Refuse Collection Improvement

The greatest concern in newly introducing "point collection system" in the model communities is whether cooperation from the residents can be fully obtained or not. In this regard, pilot project confirmed that residents' cooperation can be obtained. As was stated in the technical evaluation in Municipal Solid Waste Management System Improvement Project section, no problems can be envisaged with regard to other technical issues (e.g., refuse collection vehicles, and the final disposal site) of this improvement.

a.3 On-Site Domestic Waste Water Treatment System Improvement

Since On-Site Domestic Waste Water Treatment System was experimentally introduced in this Study considering the characteristics of the model communities, there are numbers of unknown factors. Therefore, technical evaluation of the system hinges on the results of the experimental operation of Adelita II on-site domestic wastewater treatment system, which was built for a pilot project and started its operation at the end of August, 1997. The actual as-built capacity of the facility cannot be judged at the moment, as it generally takes about a half year to let the microbes increase and provide stable bio-degradation mechanisms in the treatment facilities. Therefore, continuous observation is required to see treatment effect of the facilities.

However, the technology used in this on-site domestic wastewater treatment system has already widely disseminated in Granada Municipality, except for filter trench. Therefore, there are no problems in the application of this technology, except for filter trench, which needs to be judged from the operation results. Moreover, as INAA, presently undertaking sewerage service for about 15,700 people (as of 1995), will be in charge of the construction, operation, maintenance, and management, with residents' cooperation, there will be no problems in dealing with approximately 12,000 increased population.

a.4 Rain Water Drainage Improvement

Rain water drainage improvement shall basically focus on the improvement of roads which also serve as stormwater drains, and of drainage outfalls. Roads which also serve

as stormwater drains will be paved with concrete blocks, which is common practice in UFA in Granada Municipality. Moreover, outfalls shall be improved with the riprap drains using mortar and stones and installing gabions as a flow dissipator, which are common practices in Nicaragua. Therefore, there will be no problems in its construction, operation and maintenance, and management of this improvement.

5.5.2 Social Evaluation

The model Community Integrated USE Improvement Project aims to improve overall USE in the UFA, where population density is high and impact of poor USE infrastructure on people is very serious. Therefore, the implementation of the project will bring about various benefits. As a direct impact of this F/S project, the number of people who will benefit reaches 1,966 for water supply system improvement project, 6,200 for refuse collection improvement, 11,555 for both on-site domestic wastewater treatment system established, and stormwater drainage improvement. As a knock-on effect, it will contribute to less drain blockages caused by refuse clogging as well as flooding, which in turn will increase road life and reduce surface water pollution by domestic wastewater. The improved sanitary condition and landscape will generate various significant positive impacts such as encouraging both domestic and foreign investment, promoting tourist industry and increasing land prices.

UFA is an area where socially vulnerable poor people live and the basic infrastructure of the city is in an extremely poor condition compared with other parts of the city. Improvement of USE in these areas has been a long standing issue not only in Nicaragua, but also in other developing countries. Leaving USE of UFA in Nicaragua without improving it symbolizes the social unfairness of the developing countries and leads to the social instability. The implementation of this plan is very important as it with contribute to eliminate social inequity and contribute to the social stability.

Moreover, judging from the questionnaire surveys carried out before and after the projects in the model communities, almost all residents in the area are hoping for the improvement of USE in the model community even though they have to share some burden. Public participation is the precondition to this Plan, from the planning phase to implementation, and operation and maintenance phase. The positive indication from the residents towards the implementation of this Plan illustrates that this Plan is socially appropriate.

Judging from the facts above, the Model Community Integrated USE Improvement Project is fully acceptable in view of social aspects.

5.5.3 Environmental Evaluation

Although the implementation of Model Community Integrated USE Improvement Project brings various impacts to its surroundings, it became clear that the predicted positive impacts stated below would outnumber the predicted negative impacts (e.g., slight offensive odor from domestic wastewater treatment facility);

- By offering safe and clean drinking water, public health in the model
- The community will be enhanced.
- By providing refuse collection service, illegal dumping will be eliminated.
- Sanitary environment in the model community will improve.

- Purification of rivers and Lake Nicaragua will be promoted.
- Pollution on the road surface and the drainage channels by discharge of untreated domestic wastewater will be prevented.
- Damage caused by inundation in the model community will be prevented, road pavement improves traffic conditions, and reduces the dust and noise level.

5.5.4 Financial Evaluation

a. Assessment of Projects with INAA as Main Executing Bodies

1. Based on the total revenue and expenditures of the water supply and sewage services in INAA Region IV (the sewer projected area which is profitable was also included in the calculation of revenues), the water supply system improvement and on-site domestic wastewater system improvement projects in the model communities, mainly with INAA as the main executing bodies, were considered to be unfeasible unless a part of the expenses for the domestic wastewater project is covered by grant aid.

2. The conduct of the on-site domestic wastewater treatment system improvement project would no be financially feasible with FIRR 0/8% on its own even if grant aid is secured to cover the entire investment in 2000-2003. Although, with this case, balance of payment for 2001-2005 will be surplus.

3. To make new projects in model communities financially feasible and profitable, the revenues of the existing water supply system should be included in the calculation.

4. The on-site domestic wastewater treatment system improvement and water supply system improvement projects in the model communities are financially feasible with FIRR 12.4% being excess over cost of opportunity if fees are collected from the users of these facilities, and if a part (investment for three years from 2000-2003) of the on-site domestic wastewater treatment system improvement project expenses is covered by grant aid.

5. For the sustainable conduct of the on-site domestic wastewater treatment system improvement project in the model communities, at least domestic and external grant aid to cover the investment for 2000-2002 should be acquired.

b. Assessment of Projects with Granada Municipality as the Main Executing Organ

Granada Municipality is the main executing organ for refuse collection improvement and stormwater drainage improvement projects; the former has already been assessed through the Municipal Solid Waste Management System Improvement Project.

The investment cost and O&M expenses in the model communities were calculated and shown below, based on the ratio of increase in the number of beneficiaries in the model communities to the increase in the number of beneficiaries in the entire municipality.

Unit: C$1,000

	Investment Cost	O&M Expenses	
	Total Investment in 2000~2005	Average in 2001~2005	Total in 2001~2005
Collection Service	1,875	208	1,038

The low service charge of C$5/household/month was set as the refuse collection fee for the model community, which is the center of service operations.

With the above conditions, the revenue of the collection service in the model communities was calculated as shown below.

	2001~2005 (average)	2001~2005 (total)
Revenue	195	977
Cost	445	2,226
O&M costs only	(208)	(1,038)
Loss	-250	-1,249

1. Although the revenue and expenditures put the finances in the red, more than 90% of the O&M costs can be covered.
2. The calculation of the FIRR was not possible as the R/E is less than 1. Accordingly, this would not be financially feasible.

The stormwater drainage improvement project would be sustainable if: (1) grant aid is secured to cover the investment for 3 years, from 2000 until 2002, (2) 70% of the vehicle taxes can be collected, and (3) 20% of the collected amount is appropriated for the stormwater drainage improvement project. However, further discussions should be carried out to determine the possibility of using the bulk of the revenue from vehicle taxes for the stormwater drainage improvement project. In any case, having Granada Municipality shoulder the entire cost would be extremely unfeasible. Therefore, the project should be implemented using internal and external grant aid.

c. Residents' Ability to Pay

The following conditions were used to determine whether the service charge established is appropriate in view of the residents' ability to pay:

- For a water rate estimation, C$ 49.8/month/household, - the average water bill of the total population in Granada City -, is applied. Since data on an average water bill in the model area is not available, although which could be smaller than the estimated value. WTP of residents who have not received this service in the three cities (Leon, Chinandega and Granada)is C$ 14.9/household/month.
- Domestic wastewater treatment fee i estimated on C$ 16.7/month/household that is the average rate of the total population in Granada City, when WTP of residents who have not received this service in the three cities (Leon, Chinandega and Granada).
- Waste collection fee is C$ 5/household/month since the type of collection is Point Collection, whereas. WTP is C$ 3.3/household/month in the pilot project area.

- Assuming that the average household income in the model communities is 70% (C$890/household/month) of the average household income in Granada Municipality.
- Assuming that the average household income is going to increase along with the GRDP per capita (assuming that the average household income in 2005 will be C$940/household/month). GRDP increases 5.4% per year, however, population growth ration is high of 4.8% and, therefore, per capita GRDP growth ratio is only 0.8% per year.

The results of the analysis show that the service charge established would be too much to handle, as it would amount to 7.6% of the household income in 2001 to 2005. However, burden of water service charge will be relieved where water consumption is less, and this will automatically reduce the service charge of DWW treatment. Water consumption ratio in the model area is lower than the average of the city. It mat be assumed that the average service charge in the area will be lower than the value used in the calculation. Therefore, 7.6% of the household income will be a maximum pay that a household in the are is required to burden.

Table 5-26: Service Charges and their Percentage in Household Income

Unit: C$1,000

		1995	2005
Average Household Income (C$/month)		890	940
Water Supply	Fee (C$/month)	49.8	49.8
	Percentage in household income (%)	5.60	5.30
Wastewater Management (on-site)	Fee (C$/month)	0	16.7
	Percentage in household income (%)	0	1.78
Municipal SWM	Fee (C$/month)	0	5
	Percentage in household income (%)	0	0.53
Total	Fee (C$/month)	49.8	71.5
	Percentage in household income (%)	5.58	7.61

There is a need to conduct this project along with economic policies such as creation of jobs.

5.5.5 Economic Evaluation

The benefits considered for the economic evaluation were: (1) the willingness to pay of the households currently not receiving the service, based on the POS, (2) environmental improvement benefits (improvements in public health and sanitation, increase in land prices, increased consumption due to developments in the tourist industry), and (3)the fee currently paid by the residents. The EIRR and the ratio of the cost to the benefits (B/C) under a 0% discount rate were calculated for the following 3 cases:

Case 1: Considering the willingness to pay of the residents in the 3 cities surveyed (POS) as a benefit

Case 2: Considering the willingness to pay (as in case 1 above) and environmental improvement impacts (improvements in public health and sanitation, increase in land prices, increased consumption due to developments in the

tourist industry) as benefits. The environmental benefits were represented in terms of household benefits.

Case 3: Considering the fee currently paid by the residents as a benefit.

In contrast to the financial evaluation, the economic evaluation of the project was carried out only considering as benefits the willingness and ability to pay of the additional population in the periods 2000~2001, 2000~2002, 2000~2003, 2000~2004, and 2000~2005.

Table 5-27: Economic Evaluation Results

Projects	Case 1		Case 2		Case 3	
	EIRR(%)	B/C	EIRR(%)	B/C	EIRR(%)	B/C
Water Supply*	C$14.90/month		C$88.0/month		C$49.8/month	
	n.a	0.2484	4.2	1.4671	-1.9	0.8301
Domestic Wastewater Treatment (on-site)	C$8.32/month		C$29.0/month		C$16.7/month	
	n.a	0.2898	0.1	1.0100	-4.9	0.5816
Solid Waste Management	C$6.48/month		C$79.6/month		C$5.0/month	
	15.1	1.1434	490.8	25.0198	-8.1	0.8296
Rain Water Drainage Improvement	20% of Vehicle tax		30% of Vehicle tax		20% of Vehicle tax	
	-4.5	0.4697	4.1	1.6338	0.1	1.0069
Entire Model Community	-8.9	0.3363	3.9	1.8340	-2.8	0.7286

Note: * only the additional population

The EIRR for Case 1, which considers the willingness to pay of residents currently not receiving the service as a benefit, was difficult to calculate because the B/C was considerably low. The EIRR for Case 2, which considers the willingness to pay of the residents and the environmental improvement impacts as benefits, was calculated at 4.1%. Although this would put the finances in the black, it is lower than the cut-off rate. As for Case 3, which considers as a benefit the amount currently paid by the residents - the water supply fee and waste collection fee of C$5/household/month was based on this amount - the EIRR calculation for the model community showed negative results.

None of the EIRR calculated for the three cases exceeded the cut-off rate of 8.5%. However, the implementation of this project is considered to contribute to national economic development in view of the various favorable impacts it has on the environment, which, although were not measured during the study, are expected to help in the preservation of potable water sources, in particular the preservation of Lake Nicaragua, the favorable potable water source for Managua City in the future .

5.5.6 Total Evaluation

As a total evaluation, it was concluded that the implementation of the Model Community Integrated USE Improvement Project was feasible in technical, social, environmental, financial, and economic aspects, as it was a condition for conservation of USE and public health of Granada Municipality, and for sustainable development of the Municipal activities.