## L.1.2 Water Supply Management

### L.1.2.1 Future Water Use

Daily average water supply (excluding UFW) in Granada is estimated: about 19,000m$^3$/day by the year 2005; and about 22,300m$^3$/day in year 2010.

On the other hand, INAA has a plan to improve the efficiency rate from the present 57% to 75% by the year 2010. However, a reasonable figure for year 2000 and 2005 is estimated in 60% and 65%. In order to reach this 75% value by the year 2010, it is necessary to have in mind that a step by step solution should be implemented. Taking that into account, the 60% (year 2000) and 65% (year 2005) value is an intermediate value between the actual value of UFW and the one expected by the year 2010.

This process implies that INAA should have an adequate control, administration, and planning of the system; and should also have systematic investment in micro-measuring.

Referring to these figures, particulars of future water use are calculated based on the INAA's planning figures (e.g., coefficient of daily peak, coefficient of hourly peak, etc.) as shown in Table L-13.

Table L-13: Future Water Use

| | | 1995 | 2000 | 2005 | 2010 | Remarks |
|---|---|---|---|---|---|---|
| a. | Daily consumption demand (m$^3$/day) | 9,464 | 16,016 | 18,933 | 22,290 | |
| b. | Efficiency rate (%) | 57 | 60 | 65 | 75 | INAA's Pre F/S |
| c. | Daily average flow (m$^3$/day) | 13,534 | 26,693 | 29,127 | 29,720 | a./b. |
| d. | Coefficient of daily peak | NA | 1.5 | 1.5 | 1.5 | INAA's Pre F/S |
| e. | Daily peak consumption flow (m$^3$/day) | NA | 24,024 | 28,400 | 33,435 | a. x d. |
| f. | Daily peak flow (m$^3$/day) | NA | 34,701 | 38,593 | 40,865 | e.+(c.-a.) |
| g. | Coefficient of hourly peak | NA | 2.5 | 2.5 | 2.5 | INAA's Pre F/S |
| h. | Hourly peak consumption flow (l/sec) | NA | 463 | 548 | 645 | a. x g. |
| i. | Hourly peak flow (l/sec) | NA | 587 | 666 | 731 | h.+(c.-a.) |

Note : NA: not available

### L.1.2.2 Selection of an Optimum Technical System

**a. Water Resources**

6 wells serving for present water supply in Granada have, in total, maximum pumping capacity of 292.4 l/sec (25,263 m$^3$/day). Meanwhile, present average pumping amount ranges 159.2 litter/sec (13,755 m$^3$/day), which corresponds about 55% of the pumping capacity and satisfies present daily average consumption of 13,534 m$^3$/day.

Potable water supply sources could be classified into: underground water (deep water, shallow water); surface water; riverbed water; etc. in general. Present potable water source in Granada comes exclusively from deep wells. Since the underground water is comparatively in good quality and it only requires chlorination for potable use, which is much more economical than what requires conventional water purification facilities.

Furthermore, in view of the topography and geology there, it is highly possible that available underground water near the city is abundant.

Meanwhile, INAA's pre-F/S plans that water supply sources in Granada by the year 2010 should only be deep wells. In view of economical advantages, and topographic and geological conditions therein, it should be judged that the plan with deep wells are optimum and recommendable. Therefore the Study, in formulating the M/P, follows the INAA's plan of water sources relying on the underground water.

It is planned in the INAA's pre-F/S that 7 numbers of new deep well (pumping capacity: 75 litter/sec/well) should be installed by the year 2005 to satisfy the demand in the year 2010 as shown in Table L-14. The Study follows this concept in formulating the M/P.

It is envisaged that some of INAA's wells might be in danger of contamination with leachate from La Joya, since those wells are located at the groundwater downstream of La Joya site. Therefore, new wells should be located where the contamination impact of La Joya is not expected: i.e.; they should be located in groundwater upstream (west, southwest, south) from La Joya.

### Table L-14: Existing and Future Wells Capacity and Installation Plan

Unit : litter/sec.

| Year | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|
| Quinta Ena I | 47.3 | 47.3 | reserve | reserve |
| Quinta Ena II | 38.5 | 38.5 | abandon | - |
| Quinta Ena III | 36.2 | 36.2 | reserve | abandon |
| Quinta Ena IV | 43.4 | 43.4 | reserve | abandon |
| El Escudo I | 78.2 | 78.2 | reserve | abandon |
| El Escudo II | 48.8 | 48.8 | reserve | abandon |
| El Escudo IV | - | 75.0 | 75.0 | 75.0 |
| Future 1 | - | 75.0 | 75.0 | 75.0 |
| Future 2 | - | - | 75.0 | 75.0 |
| Future 3 | - | - | 75.0 | 75.0 |
| Future 4 | - | - | 75.0 | 75.0 |
| Future 5 | - | - | 75.0 | 75.0 |
| Future 6 | - | - | 75.0 | 75.0 |
| Total | 292.4 | 442.4 | 525.0 | 525.0 |
| Daily average flow | 131.3 | 308.9 | 337.1 | 345.6 |
| Daily average flow/Total | 44.9 % | 69.8 % | 64.2% | 65.8% |
| Daily Peak flow | - | 401.6 | 446.7 | 473.0 |
| Daily Peak flow/Total | - | 90.8 % | 85.1% | 90.1% |

Source : INAA's pre-F/S

**b. Water Purification System**

Present potable water source comes exclusively from deep wells. Since the underground water is comparatively of good quality and it only requires chlorination for potable use. And taking into account future water sources will rely on underground water, water purification systems (other than chlorination) is not required.

**c. Transmission and Distribution System**

Present transmission system employs direct transmission from the wells to the distribution network. In certain area, storage tanks are connected to the distribution network. Although this type of transmission and distribution system has problems of unstable and/or insufficient pressure and shortage of water supply quantity in some areas in the distribution network, it has an advantage in expanding distribution network with lesser costs.

On the other hand, INAA's Pre-Feasibility Study will abide by the concept of direct conduction to the reservoirs; and from the reservoirs to the network system.

The Study, in conformity with INAA's plan, will adopt this system in its formulating M/P; Table L-15 shows INAA's future improvement plan on transmission and distribution system.

Table L-15: Construction Plan of Transmission and Distribution System

| | | 2005 | 2010 |
|---|---|---|---|
| Transmission Line | Length (km) | 2.5 | 3.7 |
| | Diameter (mm) | 350 to 700 | 450 |
| Distribution Net | Length (km) | 17.69 | - |
| | Diameter (mm) | 100 to 450 | - |
| Small Diameter Connection | | for 20,000 new consumers | for 64,436 new consumers |

**d. Storage System**

Current storage capacity of the water supply system in Granada is 8,356 $m^3$. INAA's pre-F/S plans to install storage tanks:

- to satisfy the storage demands of the year 2010, by the year 2005; and
- to satisfy the storage demands of the year 2020, by the year 2010.

The outline of the storage system plan is shown in the Table L-16.

Table L-16: Construction Plan of Storage System by INAA's Pre F/S

| | | 1995 | 2000 | 2005 | 2010 | 2020 |
|---|---|---|---|---|---|---|
| Daily average flow ($m^3$/day) | | 13,534 | 26,693 | 29,127 | 29,720 | 43,891 |
| Daily peak flow ($m^3$/day) | | - | 34,701 | 38,593 | 40,865 | 49,377 |
| Detention time (hr) | For average flow | 14.8 | 7.5 | 13.7 | 20.7 | 14.0 |
| | For peak flow | - | 5.8 | 10.3 | 15.0 | 12.4 |
| Construction plan | | - | - | 8,250 | 9,000 | - |
| Total volume ($m^3$) | | 8,356 | 8,356 | 16,606 | 25,606 | 25,606 |

Storage capacity is determined, in general, as the quantity of 6 hours to 12 hours of daily peak supply plus a quantity for emergency use (in case of fire). Whereas, INAA determines the minimum storage capacity to be 6 hours of daily average supply plus 72m$^3$ as the emergency provision. Table L-16 shows that the INAA's pre-F/S recommends a more than sufficient storage capacity not only for the daily average supply but for the daily peak supply in 2010 in its plan.

Therefore, the Study's M/P reviews the proposal in INAA's pre-F/S and consequently proposes the following construction plan for the storage system in Granada, based on that the Study's proposal assures the storage capacity of about 10 hours of daily average supply; Table L-17 shows the outline of the Study's proposal for the storage system construction.

Table L-17: Proposed Storage System Construction Plan

| | | 1996 | 2000 | 2005 | 2010 | 2020 |
|---|---|---|---|---|---|---|
| Daily average flow ($m^3$/day) | | 11,534 | 26,693 | 29,127 | 29,720 | 43,891 |
| Daily peak flow ($m^3$/day) | | - | 34,701 | 38,593 | 40,865 | 49,377 |
| Detention time (hr) | For average flow | 7.5 | 14.8 | 13.7 | 13.4 | 14.0 |
| | For peak flow | 5.8 | - | 10.3 | 9.8 | 12.4 |
| Construction plan | | - | - | 8,250 | - | 9,000 |
| Total volume ($m^3$) | | 8,356 | 8,356 | 16,606 | 16,606 | 25,606 |

### L.1.2.3 Institutional Requirements

If the National Assembly ratifies Decree No. 27-95, 31-95, and 32-95, INAA will have to share its responsibilities with ENACAL and several changes will be needed. Even INAA maintains all its present attributions, institutional changes might not be required, because INAA is well structured in what it is concerned with water supply to the municipality. In addition, the industrial characteristic of this type of service recommends that it should be operated at a larger extension than the municipality segments because of economic reasons.

Where there exists water supply network, following should be specific and different from the household, commercial, or industrial uses:

- the costs;
- administrative procedures to contract; and
- the technical requirements to be connected to INAA's network.

Meanwhile, the municipality, representing the citizens and protecting their interests, should maintain close ties with INAA, such as to make sure that the water supply service expansion plans (which is already examined with a feasibility study) be fulfilled as scheduled.

Now and in future, a public education program regarding water management (e.g., to save water, to protect the sources, etc.) should be considered by all related institutions and be substantiated.

### L.1.2.4 The Water Supply Management Master Plan

The summary of M/P for DWWM, which is the outcome of the review up till previous section, is shown in Table 2.-6 and project implementation plan is shown in Table 2.-7. Furthermore, the implementation plan till the target year 2010 consists of three phases. Task for each phase is as follows:

- First phase (1998 - 2000) --- Preparation for priority projects implementation;
- Second phase (2001 - 2005) ---Implementing priority projects; and
- Third phase--- (2006 - 2010) ---Implementing M/P projects

## Table L-18: Outline of Water Supply System Master Plan

| Item | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|
| **FORECAST ON KEY INDICATORS** | | | | |
| Service projected area | 14.3 km² | 14.3 km² | 14.3 km² | 14.3 km² |
| Service projected population | 71,783 | 97,078 | 114,760 | 135,106 |
| Water supply coverage area | 8.4 km² | 8.4 km² | 9.3 km² | 9.3 km² |
| Supplied population | 64,411 | 82,516 | 97,546 | 114,255 |
| Coverage rate (to population) | 89.7 % | 85% | 85 % | 85 % |
| Number of connection | 11,352 | 14,202 | 18,199 | 21,425 |
| Water production amount | 6,107,590 m³/y | 9,742,945m³/y | 10,631,355 m³/y | 10,847,800 m³/y |
| Water production ratio | 259.8 l/person/d | 324l/person/d | 299 l/person/d | 260 l/person/day |
| Efficiency rate | 57 % | 60 % | 65 % | 75 % |
| Water consumption amount | 3,454,251 m³/y | 5,845,840 m³/y | 6,910,545 m³/y | 8,135,850 m³/y |
| - Domestic use | 85.7 % | 82 % | 82 % | 82 % |
| - Commercial use | 3.6 % | 13.6 % | 13.6 % | 13.6 % |
| - Industry use | 1.2 % | 1.7 % | 1.7 % | 1.7 % |
| - Others | 9.6 % | 2.7 % | 2.7 % | 2.7 % |
| Water consumption ratio(l/p/d) | 147 | 194(160) | 194(160) | 194(160) |
| **PARTICULARS OF THE PLAN** | | | | |
| **1. Water source** | | | | |
| Type of water source | Groundwater | Groundwater | Groundwater | Groundwater |
| Number of wells | 6 | 8 | 6 | 6 |
| Data on wells | | | | |
| - Total pump capacity | 292.4 liter/sec | 292.4 liter/sec | 525 liter/sec | 525 liter/sec |
| - Total production amount | 6,107,590 m³/y | 9,742,945m³/y | 10,631,355 m³/y | 10,847,800 m³/y |
| **2. Disinfection** | | | | |
| System | Line injection | Line injection | Line injection | Line injection |
| Method | Chlorination | Chlorination | Chlorination | Chlorination |
| **3. Water transmission and distribution facilities** | | | | |
| Method | Mainly direct connection | Mainly direct connection | Mainly direct connection | Mainly direct connection |
| Distribution reservoir | | | | |
| Number of reservoir | 4 | 4 | 5 | 5 |
| Total volume of reservoir | 8,356 m³ | 8,356 m³ | 16,660 m³ | 16,660 m³ |
| Total length of network | 98 km | 98 km | 118 km | 122 km |
| **4. Facilities' operation and maintenance** | | | | |
| Responsible authority | INNA Region IV Granada branch office | INNA Region IV Granada branch office | INNA Region IV Granada branch office | INNA Region IV Granada branch office |
| Type of operation | Direct | Direct | Direct | Direct |
| Number of persons | 48(inc. sewage) | | | |
| **5. Finances** | | | | |
| INAA annual budget (1,000 C$/year, inc. sewage) | 302,605 | 364,859 | 414,897 | 475,532 |
| Regional bureau budget (1,000 C$/year, inc. sewage) | 9,026 | 10,883 | 12,375 | 14,184 |
| Water charges | | 100% of real operation cost | 100 % of real operation cost | 100 % of real operation cost |
| - For household | 49.8 C$/month house | 49.8 C$/month house | 49.8 C$/month house | 49.8 C$/month house |
| - For other than household | 5.47 C$/ m³ | 5.47 C$/ m³ | 5.47 C$/ m³ | 5.47 C$/ m³ |
| Collection method | Direct collection | Direct collection | Direct collection | Direct collection |
| Collection rate | 96 % | 96 % | 96 % | 96 % |
| Revenue of water charge (1,000 C$/year) | 8,952 | 13,673 | 16,164 | 18,972 |

Table L-19: Phased Implementation Plan

| | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Planning and basic design | ■ | ■ | | | | | | | | | | | |
| Detail Design | | ■ | ■ | | | | | | | | | | |
| Construction of 2 new wells | | | ■ | | | | | | | | | | |
| Construction of 5 new wells | | | | ■ | ■ | ■ | ■ | ■ | | | | | |
| Construction transmission line | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Construction distribution net | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Construction of new reservoir | | | | | | | ■ | | | | | | |

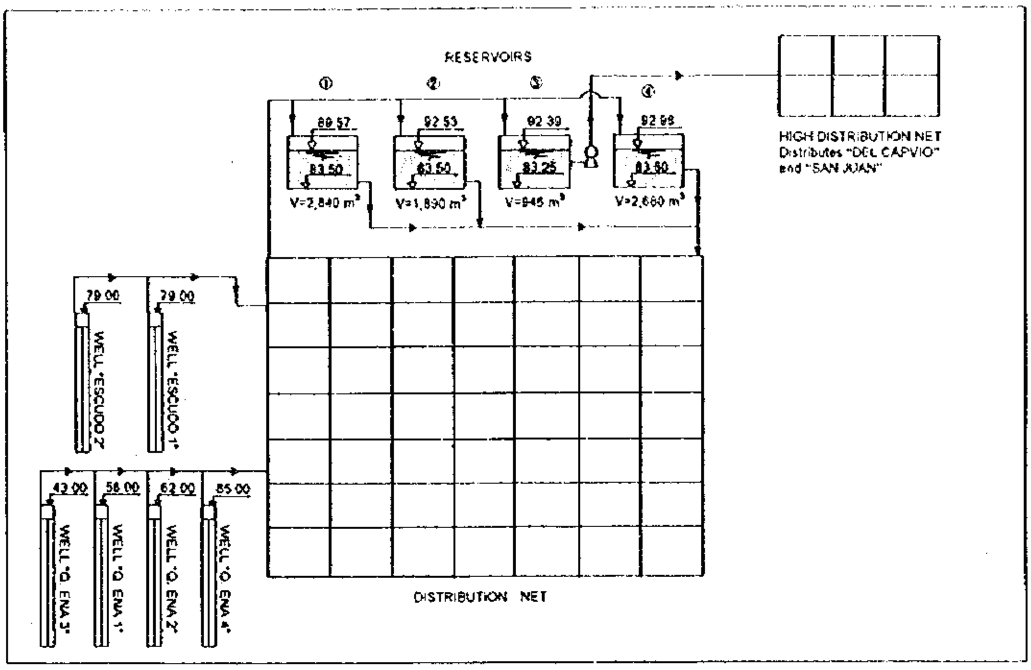
### L.1.2.5 Conceptual Design and Cost Estimation

#### a. Conceptual Design

Although water supply M/P of this plan basically follows existing INAA's plan, there are some major changes in this plan from the existing INAA's plan as follows:

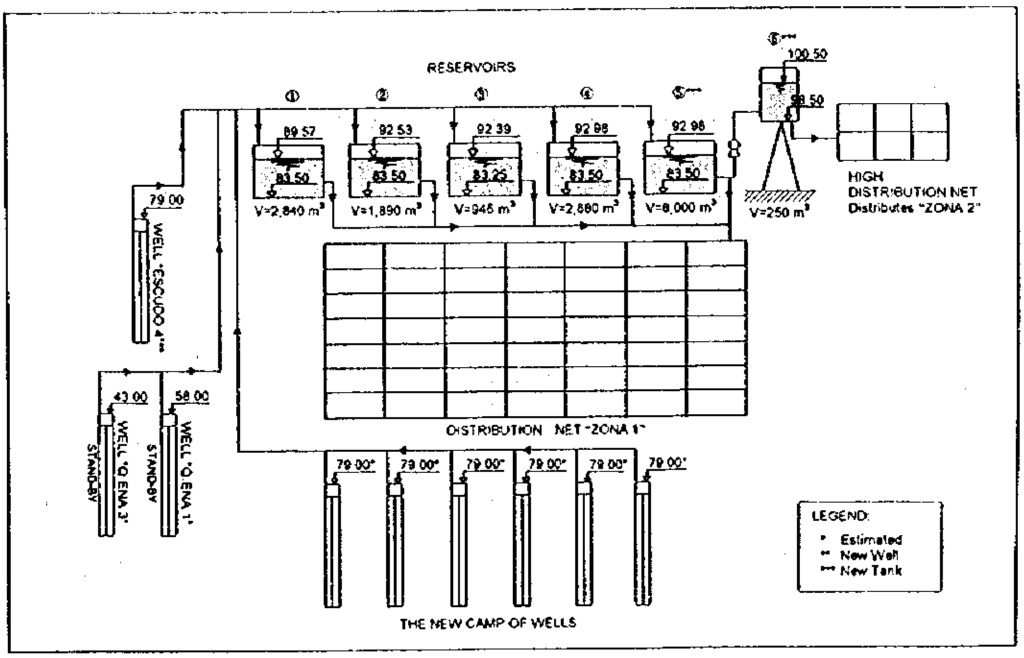
- Adjusted served population in the water supply M/P with the served population estimated in the F/S of sewer system which INAA has implemented with IDB funds;
- As a result of the above, the projected amount of water supply has changed;
- In accordance with the changes in the projected amount of water supply, timing for constructing reservoirs was reexamined.

As this has already been stated in earlier chapters, the statement regarding this is omitted here. Present water transmission and distribution network is shown in Figure L-6 and future water transmission and distribution network is shown in Figure 2.-2.




GRANADA
Present Water Supply and Transmission System

Figure L-6: Present Water Transmission and Distribution Network




GRANADA
Future Water Supply (2010) and Transmission System

Figure L-7: Future Water Transmission and Distribution Network

### b. Cost Estimation

The cost required to implement M/P is calculated in terms of the present (1997) value, price level, referring to the cost estimate (the price in 1994) of INAA's pre-F/S regarding water supply system. The cost estimation for the M/P is shown in Table L-20 and Table L-21.

Table L-20: Construction Cost

Unit : 1,000 C$

| | | Direct Cost | Over head (25%) | Total Construction Cost | Design and Supervision (10%) | Total Project Cost |
|---|---|---|---|---|---|---|
| Water Sources (wells) | Civil work | 8,752 | 2,188 | 10,940 | 1,093 | 12,033 |
| | Pipe work | 0 | 0 | 0 | 0 | 0 |
| | Equipment | 7,284 | 1,821 | 9,105 | 912 | 10,017 |
| | Total | 16,036 | 4,009 | 20,045 | 2,005 | 22,050 |
| Reservoir | Civil work | 4,547 | 1,137 | 5,684 | 568 | 6,252 |
| | Pipe work | 0 | 0 | 0 | 0 | 0 |
| | Equipment | 0 | 0 | 0 | 0 | 0 |
| | Total | 4,547 | 1,137 | 5,684 | 568 | 6,252 |
| Transmission | Civil work | 0 | 0 | 0 | 0 | 0 |
| | Pipe work | 12,267 | 3,067 | 15,334 | 1,533 | 16,867 |
| | Equipment | 0 | 0 | 0 | 0 | 0 |
| | Total | 12,267 | 3,067 | 15,334 | 1,533 | 16,867 |
| Distribution | Civil work | 0 | 0 | 0 | 0 | 0 |
| | Pipe work | 25,349 | 6,338 | 31,687 | 3,169 | 34,856 |
| | Equipment | 0 | 0 | 0 | 0 | 0 |
| | Total | 25,349 | 6,338 | 31,687 | 3,169 | 34,856 |
| Pump Station | Civil work | 149 | 38 | 187 | 19 | 206 |
| | Pipe work | 0 | 0 | 0 | 0 | 0 |
| | Equipment | 1,689 | 423 | 2,112 | 211 | 2,323 |
| | Total | 1,838 | 461 | 2,299 | 230 | 2,529 |
| Total | | 60,037 | 15,012 | 75,049 | 7,505 | 82,554 |

Table L-21: Operation and Maintenance Cost in 2010

| Item | Operation and Maintenance Cost (1,000 C$/year) |
|---|---|
| Utilities | 876 |
| Personnel Cost | 1,752 |
| Others | 1,752 |
| Total | 4,380 |

### L.1.3 DWW Management

Unit cost per person for a DWW treatment project decreases in proportion to the population served by a project increase. This is so called scale merit of project (scale of economy).

In general, sewage treatment projects (i.e. off-site system) are planned and implemented based on this theory. On the other hand in the practical side, since substantially longer time is needed to be spent in the improvement of the sewer systems, effect of investment hardly appears in case where the sanitation improvement is challenged only with sewer improvement.

In view of pros and cons of off-site system, the Study, in reviewing existing plans of off-site system, proposes plans which recommend area-wise improvement (i.e., area subject to off-site system improvement and area subject to other means should be identified and respective improvement plans are examined and proposed).

Outline of M/P on DWWM is listed in the table below.

Table L-22: Outline of Master plan on DWWM

| | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|
| **FORECAST ON KEY INDICATORS** | | | | |
| Service projected area | 14.3 km$^2$ | 14.3 km$^2$ | 14.3 km$^2$ | 14.3 km$^2$ |
| Service projected population/ Coverage ratio | 71,783/ 100% | 97,078/100% | 114,760/100% | 135,106/100% |
| Sewer system (off-site) | 15,706/ 21.9% | 21,260/ 21.9% | 44,125/38.5% | 74,266/55 % |
| On-site system | 1,122/1.6% | 1,553/1.6% | 11,555/10.1% | 23,110/17.1 % |
| Soak system (sumidero) | 26,917/ 37.5% | 36,356/ 37.5% | 27,817/24.2% | 16,979/12.5% |
| Latrine system | 20,188/28.1% | 27,298/28.1% | 24,991/21.8% | 20,851/15 % |
| No-system | 7,850/10.9% | 10,611/10.9% | 6,272/5.5 % | 0/ 0% |

Sewer (i.e., off-site treatment) coverage rate in Granada is presently about 20% of the urban population, where INAA's plan has the target of covering 55% of total urban population (i.e., 65% of the population served with the water supply) in the year 2010.

Therefore the Study's M/P on DWWM herewith will deploy planning respectively for:

- sewer projected areas in 2010 (as INAA projected); and
- no-sewer areas in 2010.

Furthermore, "no-sewer areas" in 2010 will comprise:

- the areas where the water supply is provided (about 30% of the urban population); and
- the areas where the water supply is not provided (about 15% of the urban population).

In this context, the M/P deploys planning for:

- the management of nightsoil and DWW for "with water without sewer" areas; and
- the management of nightsoil for "without water" areas.

In practice, since it is estimated that DWWM in "sewer area" will be achieved through the INAA's sewer development plan, the M/P will basically follow the INAA's plan for the "sewer area", and it will be reviewed if necessary. On the other hand, the M/P will independently deploy planning for the DWWM in "no-sewer" areas.

### L.1.3.1 Definition of Area by Method of Treatment/Disposal

#### a. Definition of Area

The service projected area is defined as the estimated urban area in the year 2010, which comprises: the water supply areas; and the no water supply areas. Furthermore, the water supply areas should consist of 2 areas: the areas where off-site treatment/disposal system (i.e. sewer) is rationally suited; and the area where on-site treatment/disposal system is rationally suited.

In practice, off-site system areas in year 2010 will comprise:

- present sewer coverage areas; and
- the areas where the future sewer extensions planned by INAA will be smoothly substantiated by the year 2010.

On the other hand, on-site system areas in the 2010 will comprise:

- the areas where the future sewer system by INAA will not be provided by the year 2010;
- the areas where the future sewer system by INAA will not be provided even after the year 2010; and
- the areas where the future sewer system by INAA by 2010 is planned but its provision will not be easily extended due to topographical constraints, etc..

Meanwhile, the area subject to nightsoil only treatment/disposal system (i.e., latrine system) is the area which is within the service projected areas but where the water is not supplied in 2010.

Outcome of reviews on the existing plan of on-site system (i.e., INAA's existing sewer system plan) is summarized in Figure L-8 below.

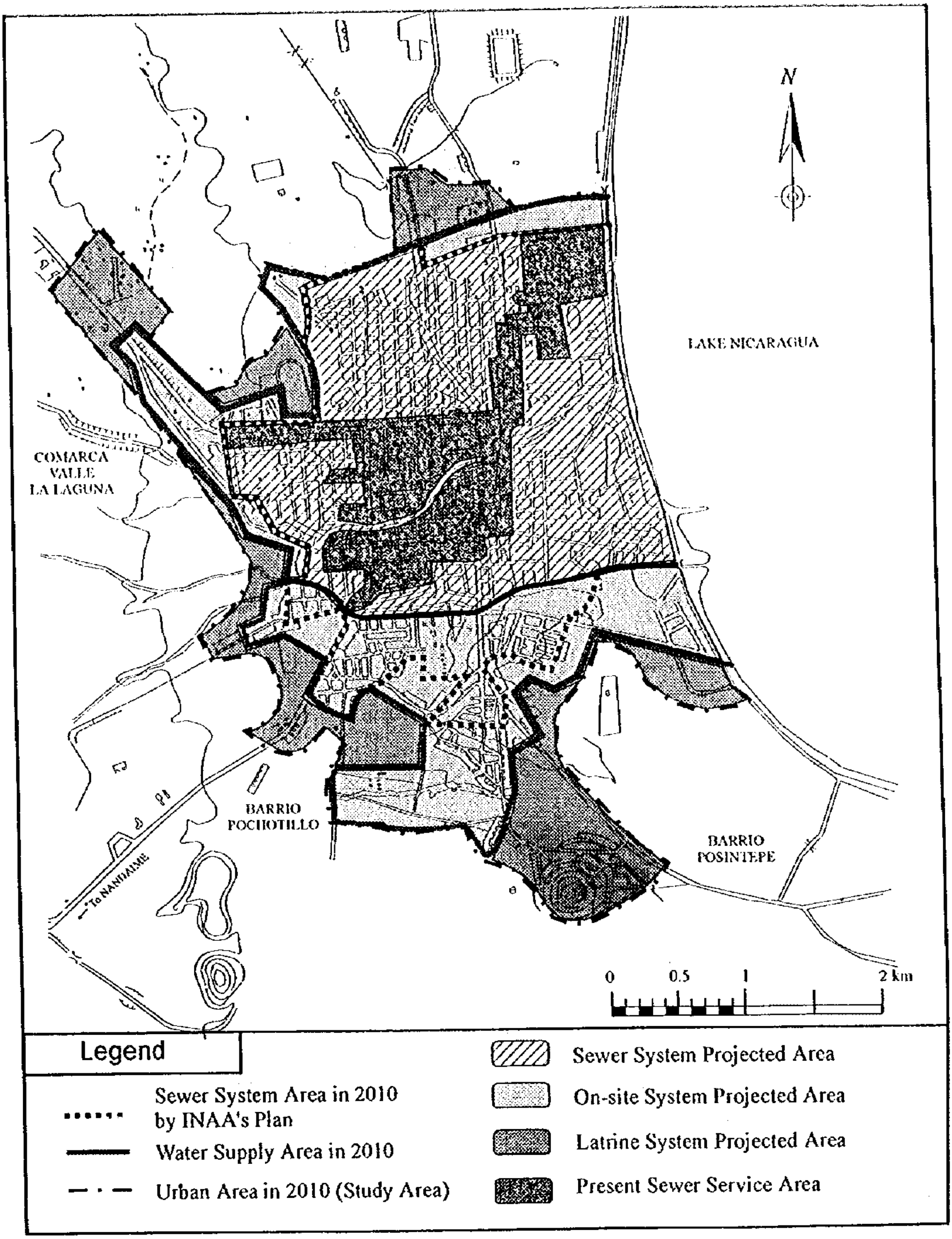



Figure L-8: Service Projected Area

### b. Sewer Service Area

The existing INAA's plan assumes that the sewer projected area for the year 2010 and 2020 be the same as shown in Figure L-8 and served population in that area become increased from 2010 to 2020. However in practice, it should be true that the served population increases in proportion to the expansion of sewer lines provision.

Therefore, the Study assumes that the sewer service area will expand gradually in the course of time passage. In principle, it is assumed that sewer service area will expand from the area where the sewer mains are already installed to southward gradually. The Study's assumption of sewer service expansion in 2005 and 2010 is outlined in Figure L-9.

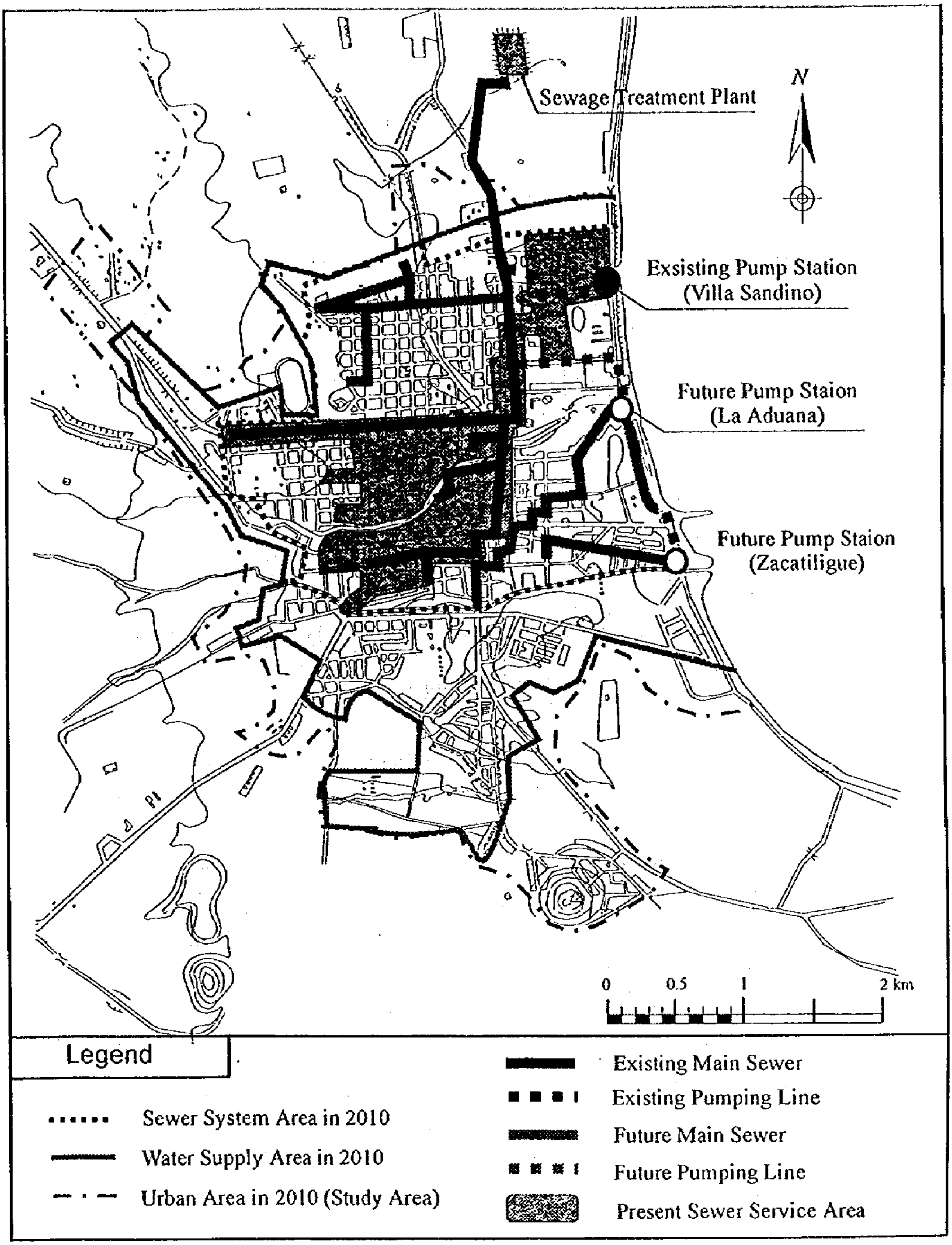



Figure L-9: Reviewed Sewer System Area Map

**c. Non-sewer System Area**

**c.1 Water Supply Area**

Considerable amount of DWW might be generated in the areas where the water is supplied. Therefore, an on-site system to treat and dispose both nightsoil and DWW will be proposed.

**c.2 Non Water Supply Area**

Amount of DWW generated might be substantially small in the areas where there is no water supply. Therefore, an on-site system to treat and dispose nightsoil only will be proposed.

**d. Step-wise Improvement Plan**

Actual practices for improving USE with regard to DWW comprise:

- DWWM by off-site sewer system;
- DWWM by on-site system or collective on-site system; and
- Nightsoil management by latrine system in no-water supply areas.

The stepwise improvement plan should promote the USE improvement by combination of the above practices (i.e., an appropriate practice be applied based on respective situation) and in consideration of step by step development in time frame.

In practice, M/P on DWWM by sewer system basically follows the INAA's plan. As for the situation in the areas other than covered by INAA sewer, the more populated area might have suffered more with USE deterioration.

The following are proposed in view of the situations in non-sewer areas:

- Improvement through on-site system should be carried out "area-wise" in order starting from an area with higher population density and then an area with lower density; and
- As population density in no water supply areas is very low, ranking indicator for such areas might not be clearly defined. However, judging from that the areas adjacent to on-site system areas might become more populated in future (than other no water area), "area-wise" improvement with latrine system will be started from the area adjacent to on-site system areas.

Table L-23 shows area and population density of respective areas.

## Table L-23: Population and Population Density of Projected Area

| | | 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) |
| Sewer System Area | | 559 | 53,525 | 96 | 59,652 | 107 | 66,698 | 119 | 74,266 | 133 |
| On-site System Area | C1 | 33 | 4,997 | 153 | 5,466 | 167 | 5,979 | 183 | 6,658 | 204 |
| | C2 | 31 | 3,992 | 130 | 4,608 | 150 | 5,319 | 173 | 6,251 | 204 |
| | C3 | 67 | 7,789 | 117 | 8,471 | 127 | 9,213 | 138 | 10,201 | 153 |
| | C7 | 60 | 868 | 14 | 1,899 | 31 | 4,147 | 69 | 9,224 | 153 |
| | F1, G | 176 | NA | NA | 3,172 | 18 | 4,958 | 28 | 7,655 | 43 |
| | Total | 367 | NA | NA | 23,616 | 64 | 29,616 | 81 | 39,989 | 109 |
| Latrine System Area | | 504 | NA | NA | 13,810 | 27 | 18,446 | 37 | 20,851 | 41 |

Note : NA : not available

The on-site domestic wastewater treatment system will cover areas where topographic problems would significantly impede the domestic wastewater treatment by an off-site treatment system even after 2010. In practice, areas C1, C2, C3, C7, F1 and G could be scoped as areas subject to the on-site system development. The conditions observed in these areas are as follows:

- 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.
- In contrast, the population density of C7 in 1995 was only 14 persons/ha. There is no data indicating the population of F1 and G in 1995; only future population estimates are available.
- 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. Such a plan is not possible for C7 as it has no streets, and F1 and G where only a few exist.

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

Accordingly, C1, C2 and C3 are subject to the M/P of on-site domestic wastewater treatment system. M/P assumes construction of on-site treatment facility by 2010 for these areas.

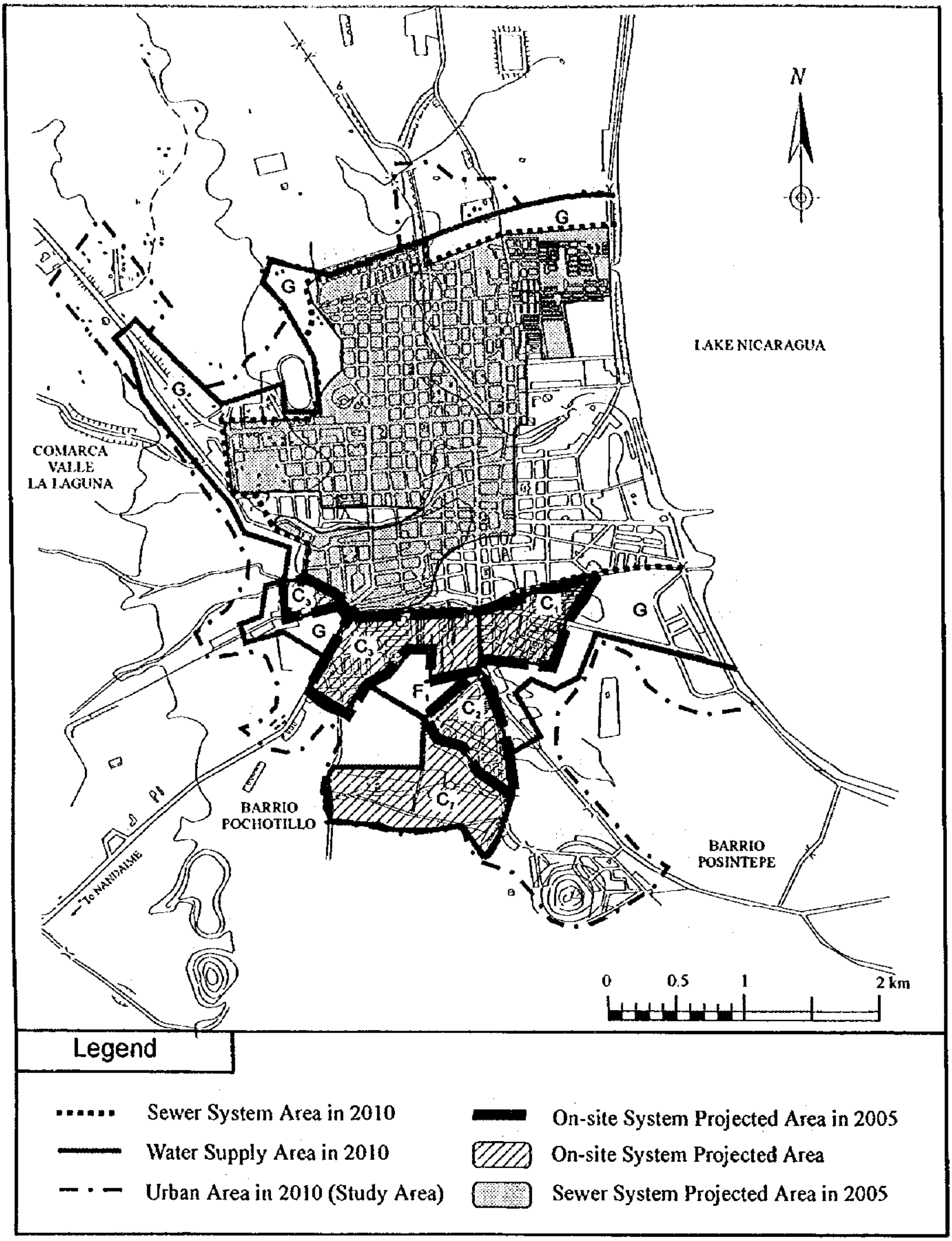



Figure L-10: On-site System Projected Area

## L.1.3.2 Future DWW Amount and Quality

### a. Sewer System

### a.1 Forecast of Future Sewage Amount

INAA estimates the sewer served population in 2010 to be 74,266. However, sewer served population in intermediate years are not estimated by INAA. Hence, the Study estimates the sewer served population and sewage amount in intermediate years as shown in Table L-24 based on the premise that: the present sewer coverage rate remains the same till the year 2000 where priority projects are only prepared by the time; the coverage rate then will approach the targeted rate of 2010 from the year 2000 to 2010 gradually.

Table L-24: Forecast of Future Sewage Amount

| Year | Urban Population | Sewer Served Population | Sewage Amount (daily average flow, $m^3$/day) |
|---|---|---|---|
| 1995 | 71,783 | 15,706 | 2,592 |
| 2000 | 97,078 | 21,260 | 3,402 |
| 2005 | 114,760 | 44,125 | 7,060 |
| 2010 | 135,106 | 74,266 | 11,883 |

### a.2 Forecast of Future Sewage Quality

### a.2.1 Pollution Loading Ratio (PLR)

Sewage quality and quantity are characterized with "pollution loading ratio (PLR)" and "sewage discharge ratio".

WPLS in the Phase I of the Study resulted pollution loading of: BOD 52.5g/person/day; COD 94.7g/person/day; and SS 90.4g/person/day. WPLS resulted average "water consumption ratio" being 202litter/person/day. INAA sets up "sewage discharge ratio" to be 80% of the "water consumption ratio". It derives "sewage discharge ratio", 162 litter/person/day, which almost equals to INAA's planning figure on "sewage discharge ratio" (i.e., 160 litter/person/day).

Table L-25 shows: the sewage quality calculated based on the above data; and the influent quality measured by INAA.

Table L-25: Comparison of Sewage Quality

| | | BOD | COD | SS |
|---|---|---|---|---|
| By Results of WPLS | PLR (g/person./day) | 52.5 | 94.7 | 90.4 |
| | Concentration (mg/l) | 324 | 585 | 558 |
| INAA measured (mg/l) | | 440 | 500 | 260 |

Table L-26 shows PLR calculated from the INAA measurement on sewage quality, sewage treated amount in 1995 (2,592 $m^3$/day) and the sewer served population (15,706 persons). It also shows some examples of PLR on BOD and SS in other countries as references.

Table L-26: Comparison of Water Pollution Loading Ratio

| | | BOD | COD | SS |
|---|---|---|---|---|
| Based on INAA's Data | Concentration (mg/l) | 440 | 500 | 260 |
| | PLR (g/person/day) | 72.6 | 82.5 | 42.9 |
| Examples in other Countries | Kampala, Uganda | 63 | - | - |
| | San Paulo, Brazil | 44 | - | - |
| | India | 35 | - | - |
| | USA | 76 to 100 | - | 46 to 91 |
| | Japan | 64 to 84 | - | 13 to 56 |
| | WHO (recommendation) | 45 | - | - |

In comparison with the BOD data, the PLR of BOD in Granada based on INAA measurement (72.6g/person/day) is extremely high. This could be attributable to the measurement frequency. In other words, the error might be attributable to the calculation that analysis results once in a few months are applied as the annual representing figure on BOD. Therefore, the M/P sets up the PLR design indicators as shown in the table below based on the WPLS results. It is estimated that the PLR design indicators set up remain constant to the future in the same value.

Table L-27: Pollution Loading Ratio for M/P

| | BOD | COD | SS |
|---|---|---|---|
| Results of WPLS (g/person/day) | 52.5 | 94.7 | 90.4 |
| PLR Design Indicators (g/person/day) | 53 | 95 | 91 |

Meanwhile, INAA designates the design indicator on "sewage discharge ratio" as 160litter/person/day. In this connection, the M/P also employs this value. Sewage quality (i.e., concentration) calculated from this value (sewage discharge ratio) and the PLR design indicators set up as shown in Table L-27 and their round figures as the "sewage quality design indicators" are listed in Table L-28.

Table L-28: Future Sewage Quality

| | BOD | COD | SS |
|---|---|---|---|
| PLR Design Indicators (g/person/day) | 53 | 95 | 91 |
| Concentration (mg/l) | 331 | 594 | 568 |
| Sewage Quality Design Indicators (mg/l) | 340 | 600 | 570 |

**b. On-site System**

Since sewage quality to be dealt with on-site system is deemed same as what was dealt with in the sewer system, the same design indicators (on "pollution loading ratio" and "sewage quality") for sewer system are employed as those for on-site system. Influent amount shall be calculated on a wastewater discharge ratio 100(liter/person/day), referring to the result of the pilot projects. The table below shows forecast of on-site system treatment amount.

Table L-29: Forecast of On-site System Treatment Amount

| Year | Urban Population | On-site System Population | On-site System Treatment Amount (daily average flow, $m^3$/day) |
|---|---|---|---|
| 1995 | 71,783 | 1,122 | 112 |
| 2000 | 97,078 | 1,553 | 155 |
| 2005 | 114,760 | 11,555 | 1,156 |
| 2010 | 135,106 | 23,110 | 2,311 |

### L.1.3.3 Selection of an Optimum Technical System

In this section, technical systems of DWWM is examined to select an optimum technical system which will be proposed in the M/P.

**a. Criteria for Selection**

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

1) Systems and technologies to be adopted should be as simple as possible so that operation and maintenance would be easy and inexpensive;
2) The foreign currency requirements for the purchase, operation and maintenance of systems should be minimized. The use of locally available materials and services should be maximized;
3) The use of labor intensive rather than capital intensive techniques should be used where technically feasible and economically viable; and
4) Technical system proposals have to be consistent with the institutional requirements should be maxim to ensure their efficiency.

**b. Examination of an Optimum Technical System**

**b.1 Sewer (Off-site) System**

**b.1.1 Collection System**

Collection systems for DWW comprise: the system to collect only sewage ("separate sewer system (SSS)"); and the system to collect both DWW and rainwater ("combined sewer system (CSS)").

SSS has the merit to employ smaller dimensions in sewers (than that for CSS), but has the demerit of requiring another sewer system for draining stormwater. Therefore, total cost of installing SSS will be higher than that of CSS. However, since the rainwater intrusion is much smaller and consequently, sewage flow is constant even when it is raining in the case of SSS (than the case of CSS), SSS is preferable in view of sewage treatment.

CSS collects DWW and rainwater together when it is raining, therefore a large peak is created in the flow entering the sewage treatment plant. Treatment capacity of sewage treatment plant is in general designed for sewage flow when it is not raining. Therefore, peak flows of rainwater and sewage water mixture over the design flow are directly discharged into public watercourses without treatment. It causes to the pollution of public watercourses.

The present DWW collection system in Granada employs SSS which is preferable for preventing the public watercourses contamination, and at the same time the INAA's plan on future sewer expansion in Granada proposes SSS. Therefore the M/P abides by SSS for DWW collection system in Granada.

#### b.1.2 Treatment System

Treatment systems for DWW comprise: the system to treat the wastewater employing acceleration of microbiology functions (activated sludge style system); and the system to treat the wastewater employing algae and microbiology functions (facultative lagoon style treatment).

The activated sludge style treatment has the merit of capacity to treat a large quantity of the DWW to a significantly improved quality requiring a small land area for the facility. On the other hand, costs of its construction, operation and maintenance are extremely large compared with the facultative lagoon style treatment.

The facultative lagoon style treatment has the merit of much smaller costs in its facility construction, operation and maintenance compared with the activated sludge style, although it requires larger land for lagoons. Consequently it has a much more applicability for the developing countries.

The present DWW treatment system in Granada is facultative lagoon style and INAA's plan on future sewage treatment in Granada proposes aerated lagoon treatment through aerators installation in the present facultative lagoon. Therefore, in view of efficient and effective utilization of existing systems and plans, the M/P abides by the INAA's plan on future treatment system.

### b.2 Non-sewer (On-site) System

Domestic wastewater mainly consists of nightsoil and DWW. Treatment of DWW is categorized mainly into three: nightsoil exclusive treatment; DWW exclusive treatment; and nightsoil/DWW composite treatment. Table L-30 summarizes on-site systems and the components of respective on-site system.

The on-site systems comprise: "individual on-site system" and "collective on-site system". The individual on-site system has a treatment at the generation points (i.e., in a premises) and the collective on-site system has its collective treatment/disposal system outside of the plural generation points (i.e., in a separate location).

The M/P examines the intrinsic situation of the areas subject to on-site system and proposes appropriate system(s) for the situation.

## Table L-30: On-site System Components

| Type of wastewater | Name of System | Toilet System | Collection System | Typical Treatment and/or Disposal | |
|---|---|---|---|---|---|
| | | | | Method | Mechanism |
| Night soil | On-site Disposal System | - Latrine<br>- VIP latrine<br>- Pour-flush toilet | Non | Soak pit | Soak to ground |
| | On-site Storage with Off-site Treatment System | - Vault toilet | - Special cart<br>- Special Vehicle | Throw into sewer system | Combine sewerage treatment |
| | | | | Digestion and gas recovery with tricking filter | An-aerobic decomposition and aerobic decomposition |
| | | | | Digestion and gas recovery with activated sludge method | Aerobic decomposition and aerobic decomposition |
| | On-site Treatment System | - Pour flush toilet<br>- Cistern-flush toilet | Non | Septic tank | An-aerobic decomposition |
| | | | | Simple jokaso | An-aerobic and/or aerobic decomposition |
| Night soil + Sullage | On-site Disposal System | - Cistern-flush toilet<br>- Pour-flush toilet | Non | Soak pit | Soak to ground |
| | On-site Treatment System | - Pour flush toilet<br>- Cistern-flush toilet | Non | Septic tank | An-aerobic decomposition |
| | | | | Combined jokaso | An-aerobic and aerobic decomposition |
| | On-site Collective System | - Pour flush toilet<br>- Cistern-flush toilet | Pipe line | Septic tank | An-aerobic decomposition |
| | | | | Combined jokaso | An-aerobic and aerobic decomposition |
| Sullage | On-site Disposal System | - | Non | Soak pit | Soak to ground |
| | On-site Treatment System | - | Non | Septic tank | An-aerobic decomposition |
| | | | | Combined jokaso | An-aerobic and aerobic decomposition |
| | On-site Collective System | - | Pipe line | Septic tank | An-aerobic decomposition |
| | | | | Combined jokaso | An-aerobic and aerobic decomposition |

### b.2.1 Nightsoil Treatment and Disposal System

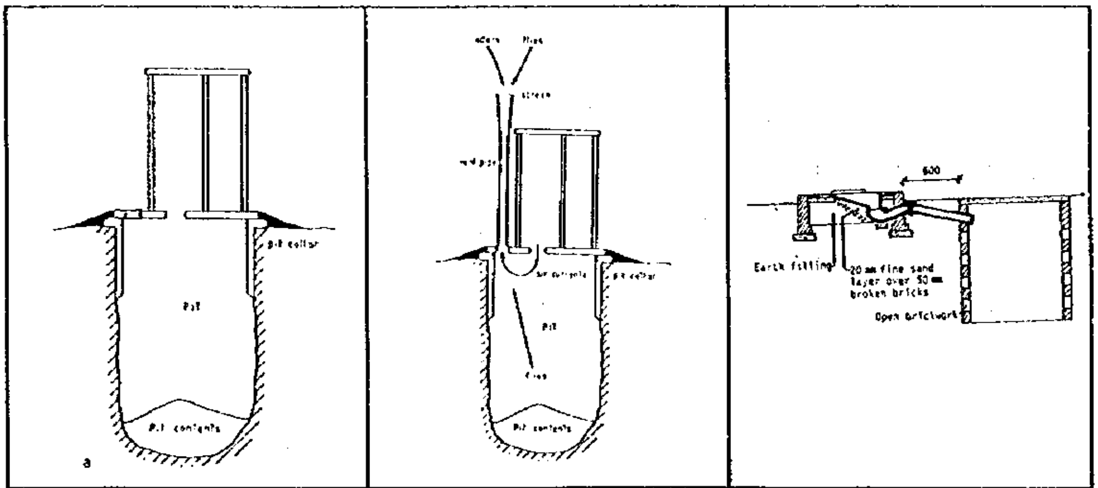
Nightsoil treatment/disposal systems, being closely related to "toilet systems", comprise the following three types.

**Type-1 On-site Disposal System**

Latrine (pit latrine), VIP(ventilated improved pit) latrine, Pour-flush toilet with pit are categorized into this type (i.e., Type-1: On-site Disposal System). Main advantageous features of this type are:

- the construction is easy;
- it has an effect on some diseases prevention (since the system prevents breeding of flies and mosquitoes); and
- the operation and maintenance costs are cheap.

On the other hand, the system has a disadvantage that it might probably contaminate the underground water if the groundwater table is comparatively high or the ground is relatively permeable, since nightsoil is infiltrated to the ground without disinfection.

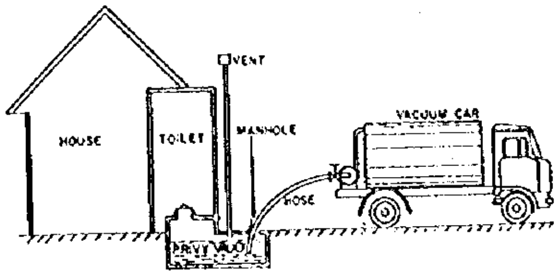


| Latrine (pit latrine) | VIP(ventilated improved pit) latrine | Pour-flush toilet with pit |
|---|---|---|

Figure L-11: Sample Figure of Toilet

**Type-2 On-site Storage with Off-site Treatment System**

Vault toilet, which was widely employed in the developing stages in Japan, is categorized into this type. (i.e., Type-2: On-site Storage with Off-site Treatment). It prevents the risks of underground water contamination, which is a disadvantage of Type-1. However, it additionally requires measures of transport/treatment/disposal of the stored nightsoil and comparatively higher cost of facility construction, operation and maintenance will accrue.

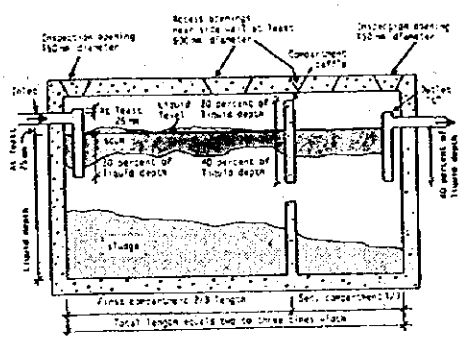


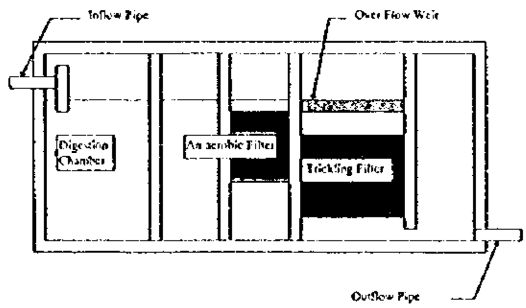

Vault toilet

Figure L-12: Sample Figure of Vault Toilet

**Type-3 On-site Treatment System**

Pour-flush toilet with septic tank or simple jokaso, Cistern-flush toilet with septic tank or simple jokaso are categorized into this type (i.e., Type-3: On-site Treatment System). Since this type is equipped with treatment function, it prevents risks of groundwater contamination and nuisance of periodical transport of stored nightsoil. On the other hand, costs of facility construction, maintenance and operation is the most expensive among the three types.






| Septic Tank | Simple Jokaso |
|---|---|

Figure L-13: Sample Figure of Septic Tank and Simple Jokaso

"Septic tank" system facilitates anaerobic digestion of nightsoil and DWW retained in a single or plural pits. It substantially achieves separation of solid contents, reduction of E.coli. However, the septic tank system lacks efficiency in removal of organic polluting substances.

"Jokaso" is the system that "septic tank" is followed by a secondary treatment (e.g., "trickling filter", "anaerobic filter" and "activated sludge system"). Hence, it removes organic polluting substances more than the septic tank only system. However, its total cost is considerably high and a comparatively high technology is required in its operation and maintenance activities.

**b.2.2 Combined with Nightsoil and Sullage Treatment and Disposal System**

Treatment/disposal systems for nightsoil and DWW composite, being closely related to "toilet systems", comprise the following three types.

**Type-1 On-site Disposal System**

"Pour-flush toilet with soak pit", "Cistern-flush toilet with soak pit" are categorized into this type (i.e., Type-1: On-site Disposal System). Main advantageous features of this type are:

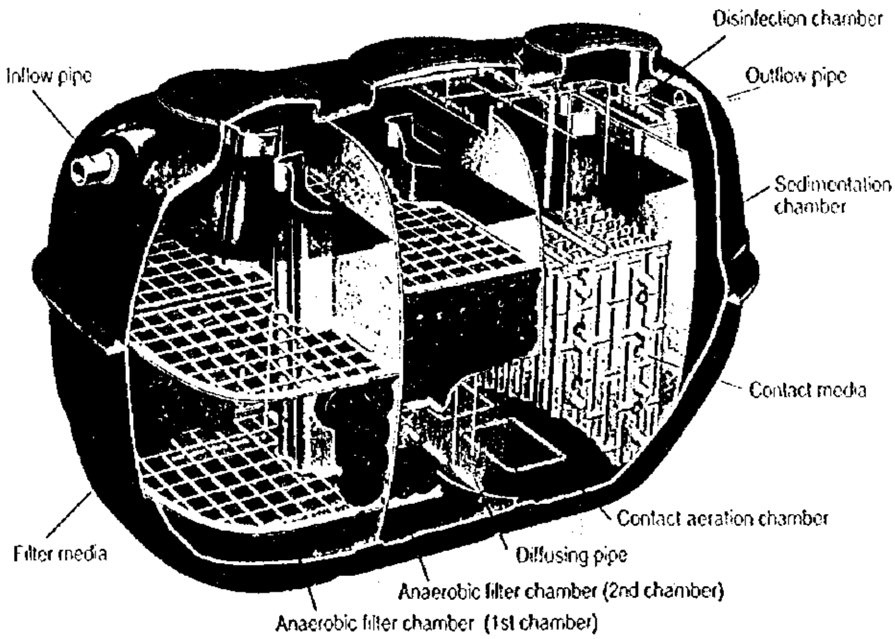
- the construction is relatively easy;
- it has an effect on some diseases prevention (since the system prevents breeding of flies and mosquitoes); and
- the operation and maintenance costs are cheap.

On the other hand, the system has a disadvantage that it might probably contaminate the underground water if the groundwater table is comparatively high or the ground is relatively permeable, since nightsoil and DWW are infiltrated to the ground without disinfection.

**Type-2 On-site Treatment System**

"Pour-flush toilet with septic tank or combined jokaso" and "Cistern-flush toilet with septic tank or combined jokaso" are categorized into this type (i.e., Type-2: On-site Treatment System). This type is to treat both nightsoil and DWW together in-situ, it prevents risks of groundwater contamination and nuisance of periodical transport of stored nightsoil. On the other hand, the facility construction, maintenance and operation requires considerably high costs. The system of "cistern-flush toilet with **combined** jokaso" is still widely used in Japan today where sewer system is not provided.

However, the initial construction cost for "cistern-flush toilet with **combined** jokaso" is considerably high, as well as that for "cistern-flush toilet with **simple** jokaso". Comparatively high technology is further required in its operation and maintenance activities.




Combined Jokaso

Figure L-14: Sample Figure of Combined Jokaso

**Type-3 On-site Collective System**

This type employs the same concepts with Type-2 in its treatment and disposal. Whereas the Type-2 is applied for individual households, the Type-3 is applied for plural households. The Type-3 could have a scale-merit compared to the Type-2. The collective system solution (e.g., cistern-flush toilet with **combined** jokaso **for plural households**) is still widely used in Japan today where sewer system is not provided.

### b.2.3 Sullage Treatment and Disposal System

Sullage (only) treatment/disposal systems also employ mostly the same technologies or practices as those for the treatment/disposal systems for nightsoil and DWW composite. The systems comprise the following three types. In case that existing systems of nightsoil treatment/disposal are working satisfactorily, the improvement of USE with "DWW treatment/disposal system" becomes effective.

**Type 1 On-site Disposal System**

The Type-1 basically takes measures of infiltrating DWW to the ground. Main advantageous features of this type are:

- it has an effect on some diseases prevention (since the system prevents breeding of flies and mosquitoes); and

- the operation and maintenance costs are cheap.

On the other hand, the system has a disadvantage that it might probably contaminate the underground water if the groundwater table is comparatively high or the ground is relatively permeable. However, groundwater contamination only by DWW infiltration might be less significant than nightsoil infiltration.

**Type 2 On-site Treatment System**

Main features of the Type-2 (DWW only on-site treatment) are mostly same as those of the Type-2 for "nightsoil/DWW composite". This system treats the DWW where it was generated. It prevents risks of groundwater contamination. On the other hand, the facility construction, maintenance and operation requires considerably high costs. Comparatively high technology is further required in its operation and maintenance activities.

**Type 3 On-site Collective System**

Type-3 also employs the same concepts of Type-2 in its treatment and disposal. Where the Type-2 is applied for individual households, the Type-3 is applied for plural households. The Type-3 could have a scale-merit compared to the Type-2.

### b.2.4 Selection of an Optimum Technical System

In view of the on-site system components described above, Table L-31 shows comparison of applicable technical systems to the M/P.

Team evaluates applicability of respective technical system for the M/P reminding the following 3 items:

- facility construction cost should be relatively low;
- operation and maintenance cost should be ranked in medium or low; and
- soil/groundwater contamination by the system should be none or very less.

Consequently, the systems listed below are concluded to be more applicable.

- "Pour-flush toilet with septic tank" of nightsoil exclusive treatment;
- "Pour-flush toilet with septic tank" of nightsoil/DWW composite treatment; and
- On-site system and on-site collective system of DWW exclusive treatment.

Meanwhile, the on-site collective system could have an advantage of scale merit compared to individual systems. Therefore, the Study recommends to optimize the application of the on-site collective system in Granada's USE improvement.

## Table L-31: Comparison of Applicable Technical System

| Type of wastewater | Name of System | Toilet and Disposal and/or Treatment System | Construction Cost | Operation Cost | Ease of Construction | Water Requirement | Possibility of Soil Contamination | Applicable for the project |
|---|---|---|---|---|---|---|---|---|
| Night soil | On-site Disposal System | Latrine with soak pit | Low | Very low | Very easy | Non | Yes | No |
| | | VIP latrine with soak pit | Low | Very low | Easy | Non | Yes | No |
| | | Pour-flush toilet with soak pit | Medium | Very low | Requires builder | Water near toilet | Yes | No |
| | On-site Storage with Off-site Treatment System | Vault toilet | Medium | High | Requires builder | Non | Non | No |
| | On-site Treatment System | Pour flush toilet with septic tank | Medium | Medium | Requires builder | Water near toilet | Non | Yes |
| | | Cistern-flush toilet with septic tank | High | Medium | Requires builder | Water pipe to house | Non | No |
| Night soil + Sullage | On-site Disposal System | Pour-flush toilet with soak pit | Medium | Low | Requires builder | Water near toilet | Yes | No |
| | | Cistern-flush toilet with soak pit | High | Low | Requires builder | Water pipe to house | Yes | No |
| | On-site Treatment System | Pour-flush toilet with septic tank | Medium | Medium | Requires builder | Water near toilet | Non | Yes |
| | | Cistern-flush toilet with septic tank | High | Medium | Requires builder | Water pipe to house | Non | No |
| | On-site Collective System | Pour-flush toilet with septic tank | Medium | Medium | Requires builder | Water near toilet | Non | Yes |
| | | Cistern-flush toilet with septic tank | High | Medium | Requires builder | Water pipe to house | Non | No |
| Sullage | On-site Disposal System | Soak pit | Low | Very low | Very easy | Non | Yes | No |
| | On-site Treatment System | Septic tank | Medium | Medium | Requires builder | - | Non | Yes |
| | On-site Collective System | Septic tank | Medium | Medium | Requires builder | - | Non | Yes |

#### b.3 Sludge Management

Treatment/disposal of sludge generated from sewage treatment varies depending upon the types of sewage sources and its treatment methods.

INAA has the plan of sewage treatment in Granada that the existing "lagoon style" treatment be continuously employed and the lagoons will be in future modified to "aerated lagoons" (i.e., aerators will be installed in the lagoon when in future it becomes necessary.). In general, sludge generated from "lagoon style" treatment is very small in quantity and therefore an independent management of on-site generated sludge can generally be neglected in planning.

Sludge generated from on-site treatment facilities is estimated to be about 0.35m$^3$/person/year. Table L-32 shows forecast of sludge generation amount from the on-site systems proposed in the Study for the years 2005 and 2010. The forecast of sludge generation from on-site facilities in 2010 be about 8,089m$^3$/year. Assuming that this amount is extracted from facilities in 240 working days, daily sludge generation in 2010 is estimated to be about 34m$^3$/day.

On the other hand, the lagoon sewage treated amount (or influent volume) in 2010 is estimated to be about 12,000m$^3$/day. If it is assumed that sludge generated from on-site facilities are discharged into the lagoons, it accounts for about 0.3% of the influent volume. Therefore, it could be considered that INAA's off-site system (i.e., the lagoon) has the capability to manage sludge generated from the on-site systems proposed in the Study. The M/P in this regard proposes sludge generated from on-site systems be disposed into the lagoon of off-site system.

Table L-32: Forecast of Sludge Generation Amount from On-site System

| | 2005 | 2010 |
|---|---|---|
| Served Population | 11,555 | 23,110 |
| Sludge Generation Amount (m$^3$/year) | 4,044 | 8,089 |

### c. Localization of Major Facilities

Major facilities of DWWM for the M/P comprise: sewage treatment plant and pump station in the off-site system; and on-site system facilities. Localization of those facilities are examined below.

#### c.1 Localization of Major Facilities for Sewer System

According to INAA's sewer development plan for Granada, a set of sewage treatment development (i.e., firstly introduction of aerators in the existing lagoons, secondly lagoon extension adjacent to existing lagoons) are planned to cope with the future sewage increase to be treated. Sewer system to collect sewage is also planned and constructed along with it. Meanwhile, total 3 pump stations are planned for the existing system expansion, one of the three (i.e., Villa Sandino pump station) is already operated today.

In this connection, localization of major facilities for sewer system in the M/P follows the INAA's plan. The localization of the facilities related are shown in Figure L-15.

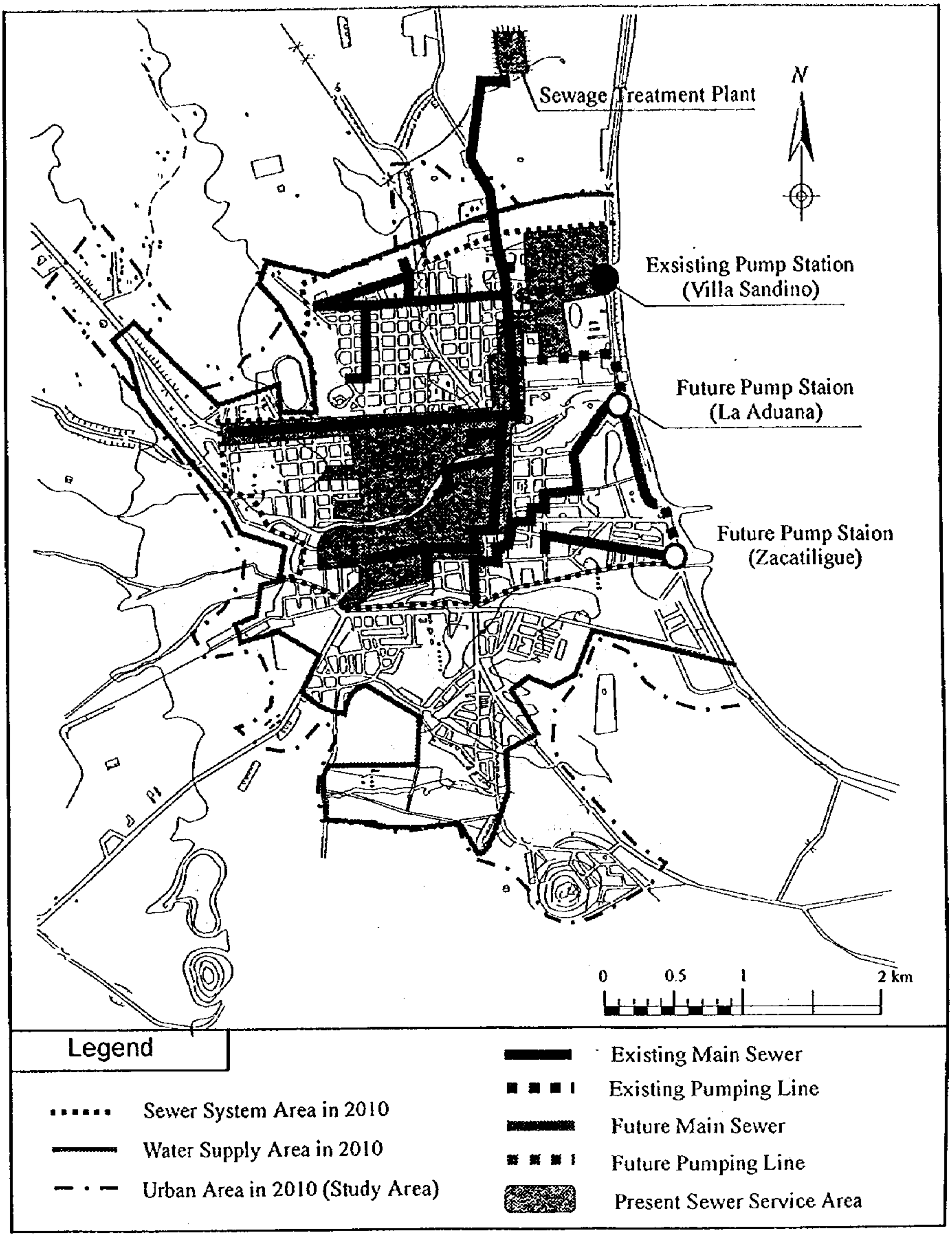



Figure L-15: Localization of Major Facilities for Sewer System

### c.2 Localization of Major Facilities for On-site System

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. Therefore, detailed locations to be proposed should be determined after a set of site investigation (e.g., topographic survey).

Key principles for the facilities localization are listed below and the concept of localization of on-site facilities are shown in Figure L-16.

- Sewer should be located away from vehicle roads and its overburden depth be about 60cm, in order to reduce the costs;
- 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 10 to 30, and the treatment facilities should be located in such a place that the above principles are satisfied.

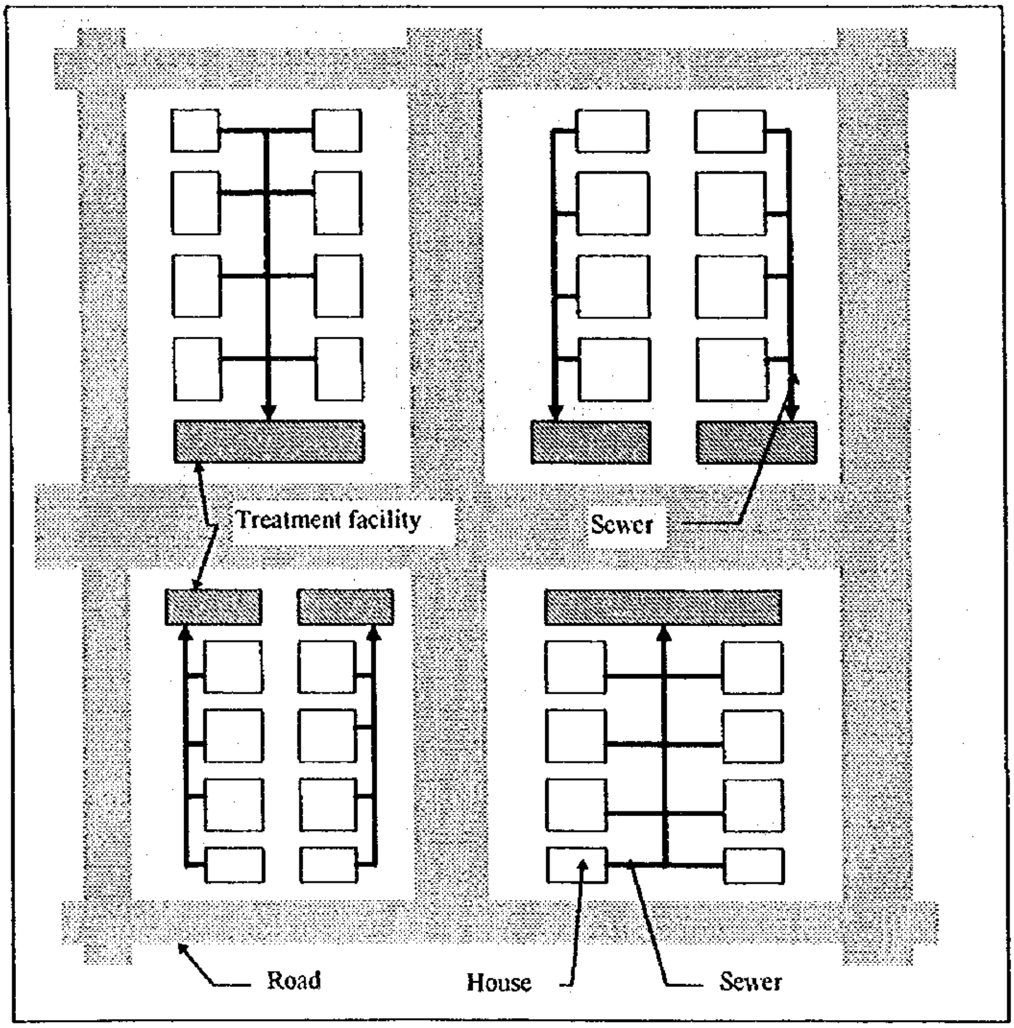



Figure L-16: Concept of On-site System

### L.1.3.4 Institutional Requirements

#### a. Connection to the Sewer

Where there exists sewer network, following should be specific and different from the household, commercial, or industrial uses:

- the costs;
- administrative procedures to contract; and
- the technical requirements to be connected to INAA's network.

A municipal Ordinance should enforce and orient the citizens, using the permits system in order to connect to the sewer network, during their houses are constructed, if it passes by in front of their houses.

INAA jointly with the municipality and MINSA should prepare a program to connect existing houses to the sewer at feasible costs for the householder.

#### b. Wastewater Management in Non-Sewer Area

#### b.1 Roles of INAA

Where there does not exist a sewage collector in the street, the citizen must provide an adequate treatment and disposal facility for his/her wastewater. Therefore, this facility should be built/installed according to INAA's technical instructions and INAA might recommend individual or collective systems for it, depending on which system is suited for respective situations. Municipal Ordinance might enforce the appropriate recommendation.

INAA should build and/or operate collective facilities. In any case, INAA should operate sludge collection service for the local treatment (both individual septic or soak systems and collective systems), and should provide inspection/maintenance services for the on-site facilities. The municipality and MINSA should plan and cooperate with INAA to get the most feasible local solutions for DWW originated in very poor communities where the sanitary and social conditions are determinants.

INAA should provide the citizens, through the municipality, of the requirements referred in the Annex N.

#### b.2 Domestic Wastewater Collective Treatment Systems (DWWCTS)

The municipality should establish, by Municipal Ordinance, the obligatory nature of citizens to make an appropriate disposal of their wastewater. For such purpose, viable alternatives and a reasonable assistance will be offered, before applying sanctions as they are established in the Ordinance.

In the micro-regions where sewer system would not be feasible, on-site treatment (preferably a collective system) should be adopted. However for the time being, it should be tolerated with the more primitive solutions of current practices, but with an appropriate sanitary control.

The municipality should coordinate a Special Program for Collective Treatment/Disposal of Domestic Wastewater (DWWCTS) to be developed together with INAA and MINSA, with initial funds granted for the investments since the beneficiaries agree to pay for the operation and maintenance of the correspondent facility. The investments and service payments could be reduced through the beneficiary citizens' burden sharing by participation, which should be stimulated by a community mobilization.

**c. Institutions other than INAA**

**c.1 Municipality**

The municipality should improve its organizational structure and personnel in order to:

- Provide norms and directives to the population with respect to the location, sanitary structures and civil procedures to live and work under satisfactory environmental and sanitary conditions;
- Provide services of their own competence, and coordinate and promote services of other entities;
- Emit and implement the Municipal Ordinance proposed in the Annex N, referring to the DWWM;
- Coordinate with MARENA and MCT, having INIFOM and MINSA as supporting institutions, in order to divide the competence on micro and macro drainage, as it is proposed in the Annex N. This is because the drainage system is closely related to damages done by wastewater which are not conducted by a pipe.

**c.2 MINSA**

MINSA should increase its capacity to mobilize communities and develop programs of sanitary education, observing not only to DWWCTS, but also to objectives and actions with intersectorial integration proposed (see tables in the Annex N).

### L.1.3.5 The DWWM Master Plan

The summary of M/P for DWWM, which is the outcome of the review up till previous section, is shown in Table L-33 and project implementation plan is shown in Table L-34. Furthermore, the implementation plan till the target year 2010 consists of three phases as shown in section 2.1.1. Task for each phase is as follows:

- First phase (1998 - 2000) --- Preparation for priority projects implementation;
- Second phase (2001 - 2005) ---Implementing priority projects; and
- Third phase--- (2006 - 2010) ---Implementing M/P projects

## Table L-33: Outline of DWWM Master Plan

| | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|
| **FORECAST ON KEY INDICATORS** | | | | |
| Service projected area | 14.3 km² | 14.3 km² | 14.3 km² | 14.3 km² |
| Service projected population/ Coverage ratio | 71,783/ 100% | 97,078/100% | 114,760/100% | 135,106/100% |
| Sewer system (off-site) | 15,706/ 21.9% | 21,260/ 21.9% | 44,125/38.5% | 74,266/55 % |
| On-site system | 1,122/1.6% | 1,553/1.6% | 11,555/10.1% | 23,110/17.1 % |
| Soak system (sumidero) | 26,917/ 37.5% | 36,356/ 37.5% | 27,817/24.2% | 16,897/12.5 % |
| Latrine system | 20,188/28.1% | 27,298/28.1% | 24,991/8% | 20,851/15 % |
| No-system | 7,850/10.9% | 10,611/10.9% | 6,272/5.5 % | 0/ 0% |
| **PARTICLARS OF THE MASTER PLAN** | | | | |
| **1. Sewer System Area** | | | | |
| Served area | 2.0km² | 2.0km² | 3.7km² | 5.6km² |
| Service population | 15,706 | 21,260 | 44,125 | 74,266 |
| Number of connection | 2,768 | 3,659 | 7,595 | 12,782 |
| Coverage ratio | 21.9 % | 21.9 % | 38.5 % | 55.0 % |
| Number of pump station | 1 | 1 | 1 | 3 |
| Sewage production per capita | 165.0 l/p/d | 160 l/p/d | 160 l/p/d | 160 l/p/d |
| **1.1 Sewage treatment plant** | | | | |
| Number of plant | 1 | 1 | 1 | 1 |
| Name of plant | Tepetate | Tepetate | Tepetate | Tepetate |
| Treatment method | Facultative lagoon | Facultative lagoon | Aerated lagoon | Aerated lagoon |
| Intake amount (mean value of the year) | 2,592 m³/day | 3,402m³/day | 7,060 m³/day | 11,883 m³/day |
| Intake water quality | BOD: 440 mg/l<br>COD: 500 mg/l<br>S S: 260 mg/l | BOD: 340 mg/l<br>COD: 600 mg/l<br>S S: 570 mg/l | BOD: 340 mg/l<br>COD: 600 mg/l<br>S S: 570 mg/l | BOD: 340 mg/l<br>COD: 600 mg/l<br>S S: 570 mg/l |
| Treated water quality | BOD: 440 mg/l<br>COD: 500 mg/l<br>S S: 260 mg/l | BOD: 90 mg/l<br>COD: 180 mg/l<br>S S: 80 mg/l | BOD: 90 mg/l<br>COD: 180 mg/l<br>S S: 80 mg/l | BOD: 90 mg/l<br>COD: 180 mg/l<br>S S: 80 mg/l |
| Discharge point | Infiltration | Infiltration | Infiltration | Infiltration |
| **1.2 Operation and maintenance** | | | | |
| Responsible authority | INNA Region IV Granada branch office | INNA Region IV Granada branch office | INNA Region IV Granada branch office | INNA Region IV Granada branch office |
| Number of persons | 48 (inc. water supply) | | | |
| **1.3 Finances** | | | | |
| INNA annual budget (C$ 1,000/year, inc. water) | 302,605 | 364,859 | 414,897 | 475,532 |
| Regional bureau budget (C$ 1,000/year, inc. water) | 9,026 | 10,883 | 12,375 | 14,184 |
| Sewage charge | | | | |
| - for household | C$16.7/month./house | C$16.7/month./house | C$16.7/month./house | C$16.7/month./house |
| - for other than household | C$ 1.7/m³ | C$ 1.7/m³ | C$ 1.7/m³ | C$ 1.7/m³ |
| Collection rate | 98 % | 98 % | 98 % | 98 % |
| Charge collection method | Direct collection | Direct collection | Direct collection | Direct collection |
| Revenue of sewage charge (C$ 1,000) | 799 | 1,069 | 2,558 | 4,500 |

| | 1995 | 2000 | 2005 | 2010 |
|---|---|---|---|---|
| **2. No-sewer System Area** | | | | |
| On-site system | | | | |
| Served population | 1,122 | 1,553 | 11,555 | 23,110 |
| Coverage ratio | 1.6 % | 1.6 % | 10.1 % | 17.1% |
| Soak system (sumidero) | | | | |
| Served population | 26,917 | 36,356 | 27,817 | 16,879 |
| Coverage ratio | 37.5 | 37.5 | 24.2 | 12.5 |
| Latrine system | | | | |
| Served population | 20,188 | 27,298 | 24,991 | 20,851 |
| Coverage ratio | 28.1 | 28.1 | 21.8 | 15 |
| No system | | | | |
| Served population | 7,850 | 10,611 | 6,272 | 0 |
| Coverage ratio | 10.9 | 10.9 | 5.5 | 0 |
| Facilities of On-site system | Septic tank | Septic tank and collective system | Septic tank and collective system | Septic tank and collective system |
| Responsible authority | INAA, MINSA, Municipality | INAA, MINSA, Municipality | INAA, MINSA, Municipality | INAA, MINSA, Municipality |
| Legislation | Non | To be established | To be established | To be established |

## Table L-34: Implementation Program of the Master Plan

| | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Off-site Sewer System | | | | | | | | | | | | | |
| Planning and basic design | ■ | ■ | | | | | | | | | | | |
| Detail Design | | ■ | ■ | | | | | | | | | | |
| Installation of Aerator to STP | | | ■ | | | | | | | | | | |
| Construction of Sewer Network | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Construction of Pump Station | | | | | | | ■ | | ■ | | | | |
| Construction of New STP | | | | | | | | ■ | | | | | |
| Installation of Aerator to New STP | | | | | | | | | | ■ | | | |
| On-site System | | | | | | | | | | | | | |
| Planning and basic design | ■ | ■ | | | | | | | | | | | |
| Detail Design | | | ■ | | | | | | | | | | |
| Construction of On-site System | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |

### L.1.3.6 Conceptual Design and Cost Estimation

#### a. Sewer (Off-site) System

Although the sewer (off-site) system proposed basically abides by INAA's F/S, the conceptual design and cost estimation reflect the outcome of reviews of target areas for sewer system as described in the Section L.1.3.1 above. In practice:

- The study reviews range of sewer provision planned in the existing INAA's plan: and
- As for the sewage treatment facilities, treatment capacity of existing sewage treatment facilities is examined and time for introduction and increase of aerators are defined.

Project costs were calculated referring to the project costs calculated in the existing INAA's plan.

#### a.1 Conceptual Design

#### a.1.1 Sewer Network

Sewer comprises of the following pipes (See Figure L-17). The outline of these main sewer is given in Table L-35.

- Main sewer which flows directly into sewage treatment site crossing the city from north to south;
- Main sewer which flow into La Aduana pumping site and the pumping line;
- Main sewer which flow into Zacatiligue pumping site and the pumping line; and
- Branch sewer which complements main sewer mentioned above.

Table L-35: Outline of Main Sewer

| Name of Sewer Network | Diameter (mm) | Length (m) |
|---|---|---|
| STP Intake line (CP-1) | 700 (PVC) | 1,350 |
| STP Intake line (CP-1) | 600 (PVC) | 400 |
| PS Intake (La Aduana, CP-3) | 600 (PVC) | 2,050 |
| PS Intake (La Aduana, CP-3) | 400 (PVC) | 400 |
| PS Intake (La Aduana, R-1) | 400 (PVC) | 800 |
| PS Outlet (La Aduana) | 500 (PVC) | 1,300 |
| PS Intake (Zacatiligue) | 200 (PVC) | 1,000 |
| PS Outlet (Zacatiligue) | 200 (PVC) | 650 |

Although total estimated areas that branch line needs to be provided is 559ha, only 200ha is covered so far. Therefore, pipe line needs to be provided to the rest of 359ha in the future.

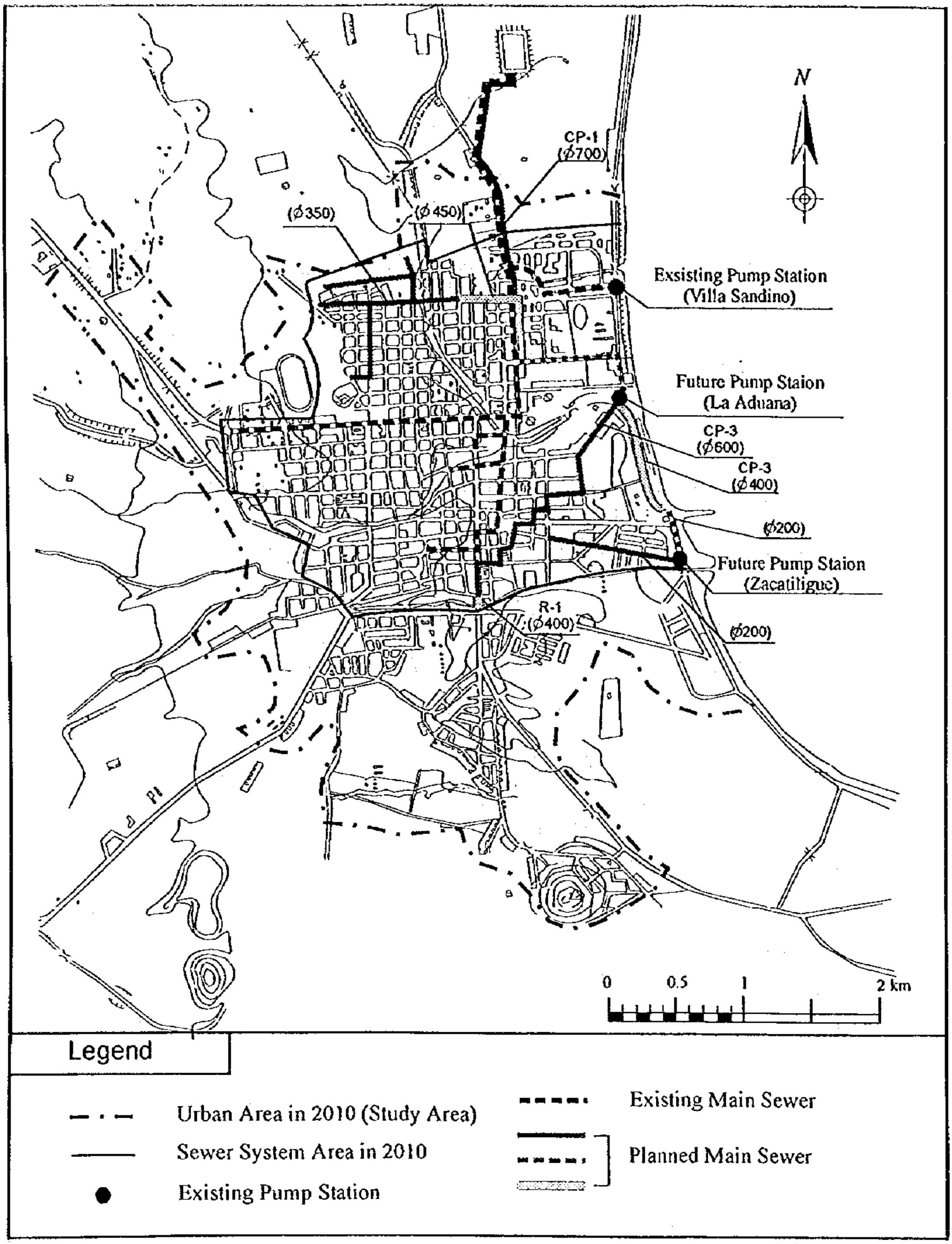



Figure L-17: Sewer Network

### a.1.2 Pump Station

Two new pumping stations should be established in the eastern part of the city where gravity flow in sewer is geographically impossible, in addition to the existing Villa Sandino pumping site. In total, three pumping sites need to be set up. The outline of pump stations is given below.

Table L-36: Outline of Pump Station

| Location | Villa Sandino | La Aduana | Zacatiligue |
|---|---|---|---|
| Construction Year | 1975 | Future | Future |
| Catchment Area (ha) | 45 | 131 | 56 |
| Pumping Capacity (l/sec) | 35 | 146 (year 2010) | 30 (year 2010) |
| Motive Power | NA | 50 HP x 2 | 10 HP x 2 |

### a.1.3 Sewage Treatment Plant

The forecast of future sewage treatment amount is shown in Table L-37 below. In INAA's F/S, the following three stages are planned to deal with the increasing amount of sewage inflow in consequence of the spread of the sewer system.

- First Stage --- Installing aerators in the present facultative lagoon;
- Second Stage --- Making additional facultative lagoon next to the present sewage treatment site; and
- Third Stage --- Installing aerators in the facultative lagoon additionally made at the Second Stage.

Treatment capacity of the sewage treatment plant based on this plan is given in Table L-38.

Table L-37: Forecast of Future Sewage Amount

| Year | Sewer Served Population | Sewage Amount ($m^3$/day) |
|---|---|---|
| 1995 | 15,706 | 2,592 |
| 1996 | 16,699 | 2,672 |
| 1997 | 17,738 | 2,838 |
| 1998 | 18,842 | 3,015 |
| 1999 | 20,014 | 3,202 |
| 2000 | 21,260 | 3,402 |
| 2001 | 25,306 | 4,049 |
| 2002 | 29,603 | 4,736 |
| 2003 | 34,163 | 5,466 |
| 2004 | 38,999 | 6,240 |
| 2005 | 44,125 | 7,060 |
| 2006 | 49,514 | 7,922 |
| 2007 | 55,212 | 8,834 |
| 2008 | 61,233 | 9,797 |
| 2009 | 67,593 | 10,815 |
| 2010 | 74,266 | 11,883 |

## Table L-38: Treatment Capacity by INAA's F/S

| | | | Existing Lagoon | | New Lagoon | |
|---|---|---|---|---|---|---|
| | | | Facultative | Aerated | Facultative | Aerated |
| Intake Water Quality | BOD (mg/l) | | 250 | 250 | 250 | 250 |
| | E-coli (NMP/100ml) | | $1.0^8$ | $1.0^8$ | $1.0^8$ | $1.0^8$ |
| Treated Water Quality | BOD (mg/l) | | 28.8 | 0.6 | 30 | 1.0 |
| | E-coli (NMP/100ml) | | $4.8x10^2$ | $1.0x10^4$ | $2.5x10^2$ | $9.6x10^3$ |
| Treatment Capacity ($m^3$/day) | | | 3,024 | 7,327 | 2,333 | 7,068 |
| Size of Lagoon | Primary | Size (m) | 258x 80 | | 206 x 76 | |
| | | Surface area($m^2$) | 20,640 | | 15,656 | |
| | | Volume ($m^3$) | 38,619 | | 29,644 | |
| | Secondly | Size (m) | 258x 80 | | 206 x 75.4 | |
| | | Surface area($m^2$) | 20,640 | | 15,532 | |
| | | Volume ($m^3$) | 39,939 | | 26,608 | |
| Aerator | | | - | 14 x 5.5kw | - | 11 x 5.5kw |

As years 1998 to 2000 are considered to be the preparation phase to implement prioritized project in the M/P, new facility will be constructed from the year 2001 onwards. Therefore, treatment capacity lacks approximately 200 $m^3$/day in 1999 and 400$m^3$/day in 2000. Present sewage treatment plant comprises of facultative pond as its first section and maturation pond as its second section which is divided into three by partition. Assuming the first partition of the second section (i. e. the maturation pond) functions as a facultative pond, the treatment capacity has increased up to approximately 3,450$m^3$/day as shown below.

| | | |
|---|---|---|
| Facultative pond surface area | : | 27,520 $m^2$ |
| Facultative pond volume | : | 51,932 $m^3$ |
| Maturation pond volume | : | 26,626 $m^3$ |

examination of facultative pond

$$\lambda s = 20T - 60 = 20 \times 27.3 - 60 = 486 \text{ (kg BOD/ha/day)}$$

$\lambda s$ : areal loading rate (kg BOD/ha/day)

$T$ : ambient temperature = 27.3 ($^oC$)

$$A = \frac{10 \times Li \times Q}{\lambda s} = \frac{10 \times 340 \times 3{,}450}{486} = 24{,}486 \, (m^2) < 27{,}520 \, m^2$$

$A$ : required surface area ($m^2$)

$Li$ : influent BOD concentration =340 (mg/l)

Q : influent flow rate ($m^3$/day)

examination of total fecal coliform removal

$$Be = \frac{Bi}{(1 + Kb \times t1)(1 + Kb \times t2)^n}$$

$$Be = \frac{100,000,000}{(1+9.257\times 15.0)(1+9.257\times 7.7)^1} = 9,893<10,000(NMP/100ml)$$

$$Kb = 2.6\times (1.19)^{(T-20)}$$

| | | |
|---|---|---|
| *Be* | : | effluent fecal coliform (NMP/100ml) |
| *Bi* | : | influent fecal coliform (NMP/100ml) |
| *t1* | : | detention time of facultative pond |
| *t2* | : | detention time of maturation pond |

Considering all the above, the followings are planned in the M/P:

- Improve treatment capacity to 7,300m$^3$/day by installing aerators in the existing facultative pond in 2000;
- Making a new lagoon in 2005 and improve total treatment capacity to 9,600m$^3$/day; and
- Installing aerators in the facultative pond of new lagoon in 2006 and improve treatment capacity to 14,300m$^3$/day.

The result of the simulation is shown in Table L-39 and Figure L-18.

Table L-39: Construction and Installation Plan of Sewage Treatment Plant

| Year | Sewer Served Population | Sewage Amount (m$^3$/day) | Treatment Capacity (m$^3$/day) | | | | |
|---|---|---|---|---|---|---|---|
| | | | Existing Lagoon | | New Lagoon | | Total |
| 1995 | 15,706 | 2,592 | 3,450 | Facultative | - | - | 3,450 |
| 1996 | 16,699 | 2,672 | 3,450 | Facultative | - | - | 3,450 |
| 1997 | 17,738 | 2,838 | 3,450 | Facultative | - | - | 3,450 |
| 1998 | 18,842 | 3,015 | 3,450 | Facultative | - | - | 3,450 |
| 1999 | 20,014 | 3,202 | 3,450 | Facultative | - | - | 3,450 |
| 2000 | 21,260 | 3,402 | 7,300 | Aerated | - | - | 7,300 |
| 2001 | 25,306 | 4,049 | 7,300 | Aerated | - | - | 7,300 |
| 2002 | 29,603 | 4,736 | 7,300 | Aerated | - | - | 7,300 |
| 2003 | 34,163 | 5,466 | 7,300 | Aerated | - | - | 7,300 |
| 2004 | 38,999 | 6,240 | 7,300 | Aerated | - | - | 7,300 |
| 2005 | 44,125 | 7,060 | 7,300 | Aerated | - | - | 7,300 |
| 2006 | 49,514 | 7,922 | 7,300 | Aerated | 2,300 | Facultative | 9,600 |
| 2007 | 55,212 | 8,834 | 7,300 | Aerated | 2,300 | Facultative | 9,600 |
| 2008 | 61,233 | 9,797 | 7,300 | Aerated | 7,000 | Aerated | 14,300 |
| 2009 | 67,593 | 10,815 | 7,300 | Aerated | 7,000 | Aerated | 14,300 |
| 2010 | 74,266 | 11,883 | 7,300 | Aerated | 7,000 | Aerated | 14,300 |

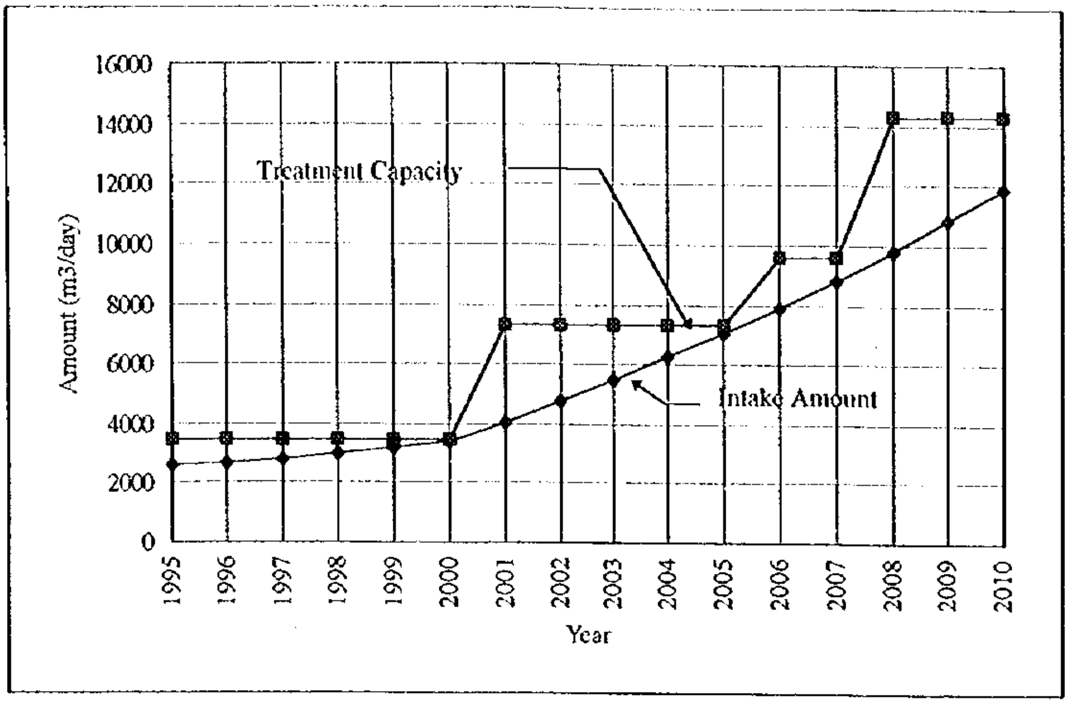



Figure L-18: Construction and Installation Plan of Sewage Treatment Plant

### a.2 Cost Estimation

Cost required to implement M/P is estimated referring to the information obtained from INAA Region IV and the cost estimation presented in the INAA's F/S for Granada's sewer improvement. The result of the cost estimation is shown in Table L-40.

Table L-40: Construction Cost of Off-site Sewer System

Unit : 1,000 C$

| | | Direct Cost | Over head (25%) | Total Construction Cost | Design and Supervision (10%) | Total Project Cost |
|---|---|---|---|---|---|---|
| Sewer Network | | 21,064 | 5,266 | 26,330 | 2,633 | 28,963 |
| Pump Station | Civil Work | 176 | 45 | 221 | 22 | 243 |
| | Equipment | 997 | 249 | 1,246 | 125 | 1,371 |
| | Total | 1,173 | 294 | 1,467 | 147 | 1,614 |
| STP | Civil Work | 6,103 | 1,526 | 7,629 | 763 | 8,392 |
| | Equipment | 1,526 | 382 | 1,908 | 191 | 2,099 |
| | Total | 7,629 | 1,908 | 9,537 | 954 | 10,491 |
| Total | | 29,866 | 7,468 | 37,334 | 3,734 | 41,068 |

Table L-41: Annual Operation and Maintenance Cost in 2010

| Item | Operation and Maintenance Cost (1,000 C$/year) |
|---|---|
| Utilities | 373 |
| Personnel Cost | 747 |
| Others | 747 |
| Total | 1,867 |

## b. Non-sewer (On-site) System

### b.1 Conceptual Design

As for on-site system to treat nightsoil and DWW, on-site collective system is proposed in the M/P as stated in section 2.3.3 above. In order to minimize the construction cost, the following points are taken into consideration for the plan.

- The maximum overburden depth of sewer should be about 60cm, in order to reduce the construction cost and to make the maintenance easy and the sewer should be located not to cross vehicle road;
- Gradient of sewer should follow the site gradient to enable a gravity flow;
- The system should be designed and constructed not to receive rainwater;
- Numbers of the households subject to an on-site system should be about 10 to30, and the treatment facilities should be located in such a place that the above principles are satisfied.

#### b.1.1 Sewer for on-site collective system

The lines should be arranged as stated above and the diameter of the lines is approximately 100mm to 150mm. PVC line should be adopted in view of easier workmanship and cheaper cost.

#### b.1.2 Sewage Treatment Facility

Wastewater subject to the on-site treatment is nightsoil and DWW same as off-site sewer system. Basic treatment flow consists of two stages: the primary treatment with septic tank (as practiced in the William Fonseca project); and filter trench for the secondary treatment . Moreover, more than two series of filter trenches need to be set up in order to facilitate self-recovery of the trench functions. When one filter trench is used for sometime and is filled up, the septic tank effluent should be switched to another filter trench for the treatment. The filled up filter trench should be left un-used for a half year to a year until the stone filter in the trench naturally becomes clean to recover the functions.

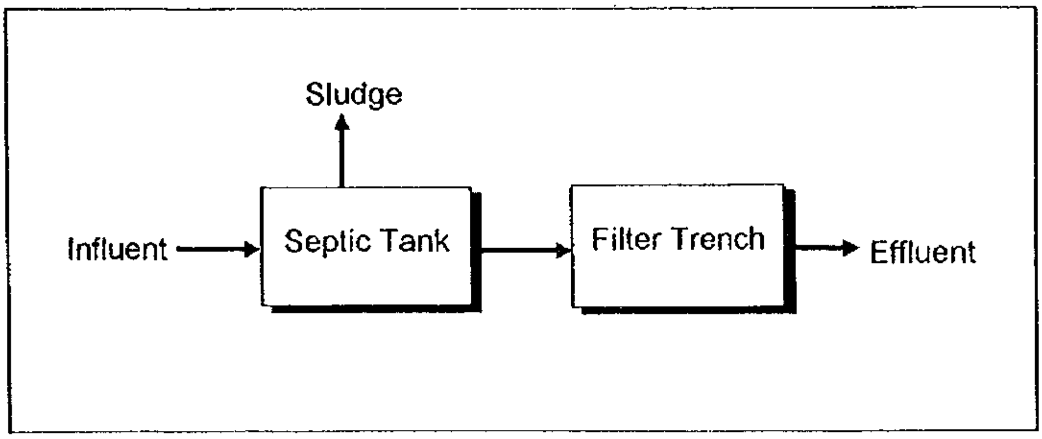



Figure L-19: Flow Sheet of On-site Treatment Facility b.2 Cost Estimation

The cost required to implement M/P is estimated basically referring to the results of Pilot Project (Adelita).

The result of this cost estimation is given in Table L-42.

Table L-42: Construction Cost of On-site Collective System

Unit : 1,000 C$

| | | Total Construction Cost | Design and Supervision (10%) | Total Project Cost |
|---|---|---|---|---|
| Sewer Network | | 7,013 | 701 | 7,714 |
| Treatment Facility | Civil Work | 21,988 | 2,199 | 24,187 |
| | Equipment | 0 | 0 | 0 |
| | Total | 21,988 | 2,199 | 24,187 |
| Total | | 29,001 | 2,900 | 31,901 |

Table L-43: Annual Operation and Maintenance Cost in 2010

| Item | Operation and Maintenance Cost (C$ 1,000 /year) |
|---|---|
| Personnel Cost | 232 |
| Others | 348 |
| Total | 580 |

## L.1.4 Industrial Wastewater Management

### L.1.4.1 Major Findings of the Industrial Waste Survey

Industrial waste generation amount in Granada is estimated 1,045,917 $m^3$/year. (see Table L-44)

Table L-44: Waste Generation Amount in Granada(1996)

| Wastewater (ton/year) | Solid Waste (ton/year) | Total (ton/year) |
|---|---|---|
| 1,044,910 | 1,007 | 1,045,917 |

Wastewater generation amount in Granada is estimated 1,045,000 $m^3$/year. Among other, industries in CIIU3523 (Soap, detergent, shampoos and likes) generate about 920,000 $m^3$/year in Granada.(see Figure L-20)

On the other hand, industrial wastewater from CIIU3231 industries (leather tanning) ranges about 55,000 $m^3$/year in Granada, which contains high concentration of organic compounds and hazardous compounds such as chromium. Therefore the pollution impacts to the environment would be thought serious. Immediate countermeasures for this industrial pollution should be raised in Granada.

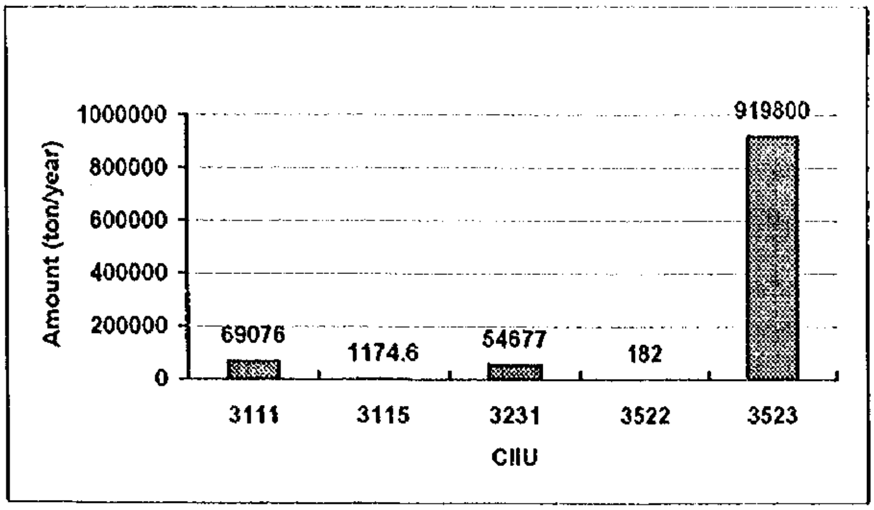



Figure L-20: Wastewater Generation Amount

Since the legislation is newly established, detailed regulations and technical instructions to complement it are not prepared at present. Therefore, current industrial wastewater are mostly discharged without treatment to the environment. Consequently it becomes one of major sources that deteriorate the USE.

### L.1.4.2 General Recommendations

#### a. Technical System

Since the industrial wastewater are generated and discharged as a result of industrial production activities, cost of its safe treatment/disposal should be born by the industries, based on the "polluter pays principle (PPP)".

On the other hand from technological management viewpoint, following will be listed as the key solutions for the problems:

- Reduction of wastewater generation amount and reduction of its generated pollution load by means of production processes (including raw/auxiliary materials) conversions;
- Wastewater treatment by industries themselves in their premises ; and
- Industrial wastewater treatment/disposal by third party (i.e., market mechanism of industrial wastewater treatment/disposal).

In this context, authorities' administrative measures and empowerment in conducting industrial wastewater management are awaited. Since actual application and enforcement of Decree 33-95 will be a key for this management, an integrated mechanism to bind both industries and authorities in facilitating the appropriate industrial wastewater management should be sought and established.

## b. Institutional System

### b.1. Roles of Organizations Concerned

MARENA is the competent authority for the management of industrial solid waste (ISW) and industrial wastewater (IWW) by the Law No. 217-96 and Decree 33-95. MARENA should establish the regulations related to ISW and IWW, as well as restrictions for its disposal and the operational limits of the municipality. It should also expedite easily understandable instructions to facilitate technical information to the IW generators, professionals, university students, and those interested in about IW and the IW management services that can be provided for industries in Nicaragua. On the other hand, MARENA should help and encourage supporting industries in finding accessible financial resources or grants to support their projects of IW treatment/disposal and/or "cleaner production".

The municipality, on the other hand, should not collect nor accept ISW in the municipal landfill, until the waste are certified as **"non-hazardous"**. and such certification should be provided by MARENA. MARENA should originate the instructions with which the municipality could guide industries located in the city area. Meanwhile, the competence to inspect and penalize the IW management belongs to MARENA and MINSA. INAA is also competent whenever they receive wastewater. The municipality can establish legal and technical norms restricted to the municipality which can not be more tolerant than the national norms (see Annex N).

The Annex N shows "Instructions and/or Regulations (as well as Tables with Strategies and Intersectorial Integration)" which is recommended for MARENA, and complementarily for MCT, MINSA and the municipality.

### b.2 Polluter Pays Principle (PPP) and Authorities' Management

The IW are qualitative and quantitative dependent of the type of industry, industrial process, of the raw materials, source of energy, and the management of the generator establishments, especially the training and discipline of the personnel, also the equipment maintenance and the working environment.

The IW is strictly industries' responsibility. Since the costs of IW management are included in the products price, the company that generates non hazardous IW and/or less IW, they could achieve lower production cost. In addition, the "environmentally friendly products" are commonly an important marketing element with respect to customers consciousness.

It is an universally accepted premise: **"The generator is responsible for the waste generated by him or her"**, i.e., he or she is responsible for the management of the waste and its effects on the environment and public health, with all the costs to be born therewith. These costs constitute an incentive to minimize waste, in other words, it encourages a "clean production" which is the objective of a competitive and environmentally-conscious industries.

In general, the largest part of ISW results from the industrial effluents, therefore, the management on ISW and IWW should consider all the IW in total.

The consulting and operational services related to IWM constitute an attractive economic activity, once the market has reached certain level. In this context, the public authorities could create the situation that makes such economic activity (ISWM by private sectors) viable, which solves the problems involved with industrial contamination and pollution when the regulations for the IW management is established and its requirements are enforced obviously in a stepwise manner in a feasible time frame. The municipal/national government should not invest more than necessary for the studies, cadastres, regulation, technical information, inspection, monitoring and sanction to the transgressor when it is related to IW.

## L.1.5 Storm Water Management

The tendency of damage in the inundation prone areas in each city was recognized by the questionnaire survey conducted in the first work in Nicaragua. The result indicated that the damage was a serious problem for the three cities.

It was inferred from the result of the questionnaire survey and the field reconnaissance that inundation causes would be classified into two major types and in detail for minor types as shown in the following table.

Table L-45: Inundation Prone Area Classification

| Principal Classification | Detailed Classification | Features |
|---|---|---|
| 1. Areas with drainage channels (mainly located in the urban area) | 1.1 These areas are located at downstream of larger catchment area | 1.1 Large amount of water flows into these areas from the hinterland catchment area. These areas usually experience considerable flood damage. |
| | 1.2 These areas are located in a smaller drainage basin, which mostly overlaps with the study area. | 1.2 Inundation occurs because the drainage channels in these areas are small or clogged with waste. The damage is comparatively small. |
| 2. Areas without drainage channels (mainly located in the urban fringe ) | 2.1 Flood plain (i.e., inside river banks) | 2.1 Flooding occurs when the water level of the river or stream rises due to heavy rain. |
| | 2.2 others | 2.2 These areas are located in lowlying areas and lack of road and roadside drains intensifies the damage. |

The result on inundation damage survey is limited only on the basis of interview and field reconnaissance, because there are no base data such as detailed topographical maps, river regime. And to obtain these data in this study is physically impossible as it requires considerable time and resources.

### L.1.5.1 Identification of Inundation Causation

The following table shows inundation causation in each areas and Figure L-21 shows the inundation prone areas in Granada City.

Table L-46: Inundation Causation

| No. | Name of Area | Classification | Damage | Causation |
|---|---|---|---|---|
| 1 | Villa Tepelate, Asentamiento Julián Quintana, Villa Sandino | 1.2 | Inundation of houses, occurrence of epidemic | 'Arroyo Pancasan' floods due to its small scale. |
| 2 | Reparto Bartolomé, Curva Chico Tripa | 1.2 | ditto | Stormwater coming from the northwestern steep area floods in this area at where the slope becomes gently. A drain in this area floods due to its small scale. |
| 3 | Barrio El Bolsón (next to the cemetery area) | 1.1 | ditto | 'Arroyo Zacatiligue' sometimes floods. And, there are no watercourses to let stormwater drain to Arroyo Zacatiligue. |
| 4 | Arellano Avenue | 1.2 | ditto | Stormwater gathers at the lowest part of 'Arellano Avenue'. |

The inundation prone areas are located at where capacities of rivers and watercourses become small and at where slopes become gently.

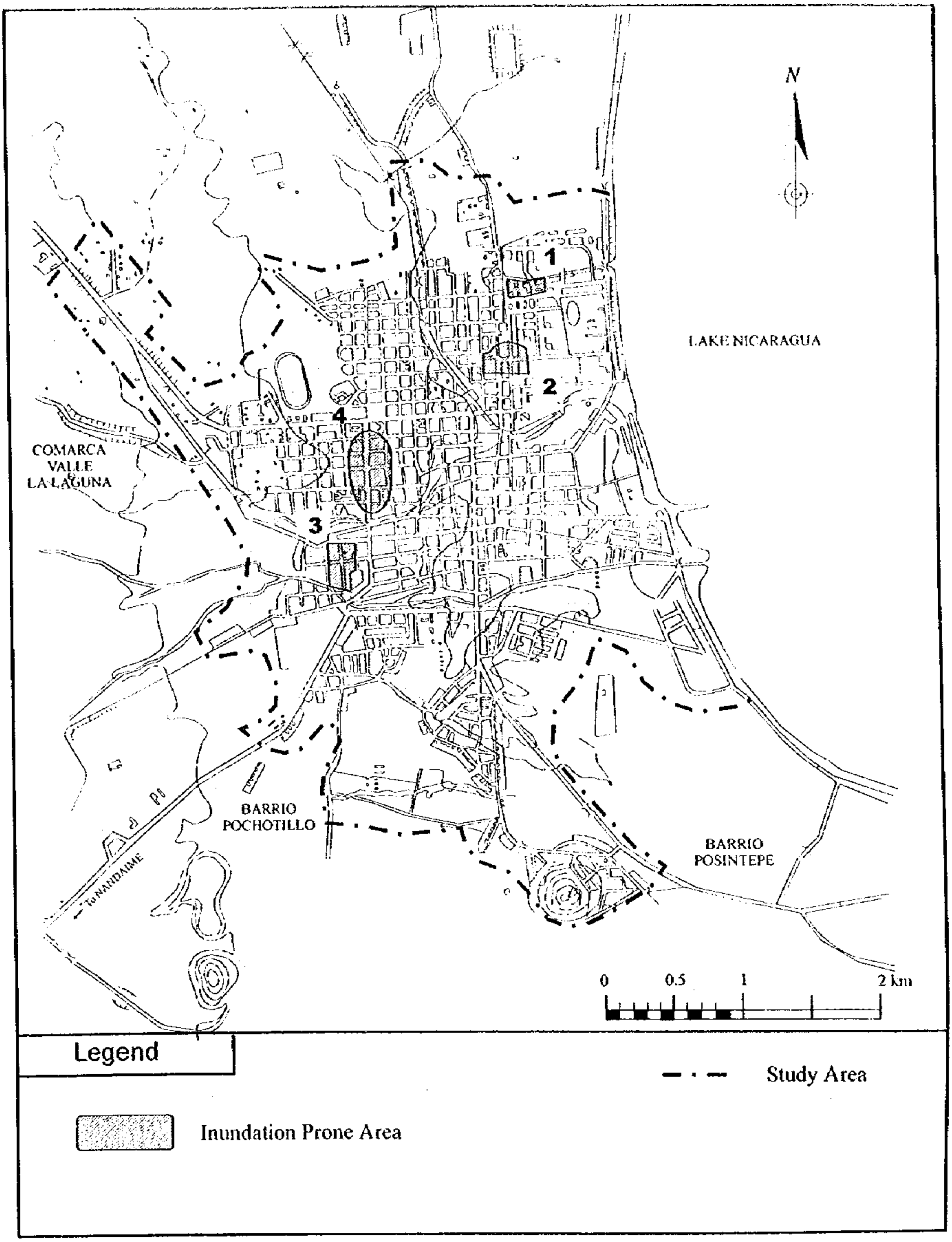



Figure L-21: Inundation Prone Areas in Granada