INSTITUTIONAL DEVELOPMENT IN THE WATER SECTOR IN SAN LUIS POTOSI

BY

M.A. HARVEY

A project report submitted in partial fulfilment of the requirements for the award of the degree of Master of Science of Loughborough University of Technology

SEPTEMBER 1991

SUPERVISORS: L.G. Hutton B.Sc., Dip.Oc., C.Chem., MRSC, FGS, FIWEM

D.C. Sims C.Eng., MICE, FIWEM.

WEDC, Department of Civil Engineering

CERTIFICATE OF AUTHORSHIP

"I certify that:

all sources of information, including figures, are identified by references".

Signed: ....

M.A. HARVEY

SUMMARY

This project begins by considering the problems facing the water sector in the city of San Luis Potosi in Mexico. Problems of diminishing fresh groundwater reserves and unsafe methods of wastewater disposal.

It assesses the roles and effectiveness of the various organizations involved in management of the water sector, illustrates how future development may impact on these organizations and proposes a model for a single institution that would be better suited to meet the future needs of the city and its people.

The report proceeds to show how one section of the proposed institution can be strengthened and developed by means of a suitable self-implemented project. In this case a programme of reduction and control of unaccounted-for water carried out by the water supply section.

LIST OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

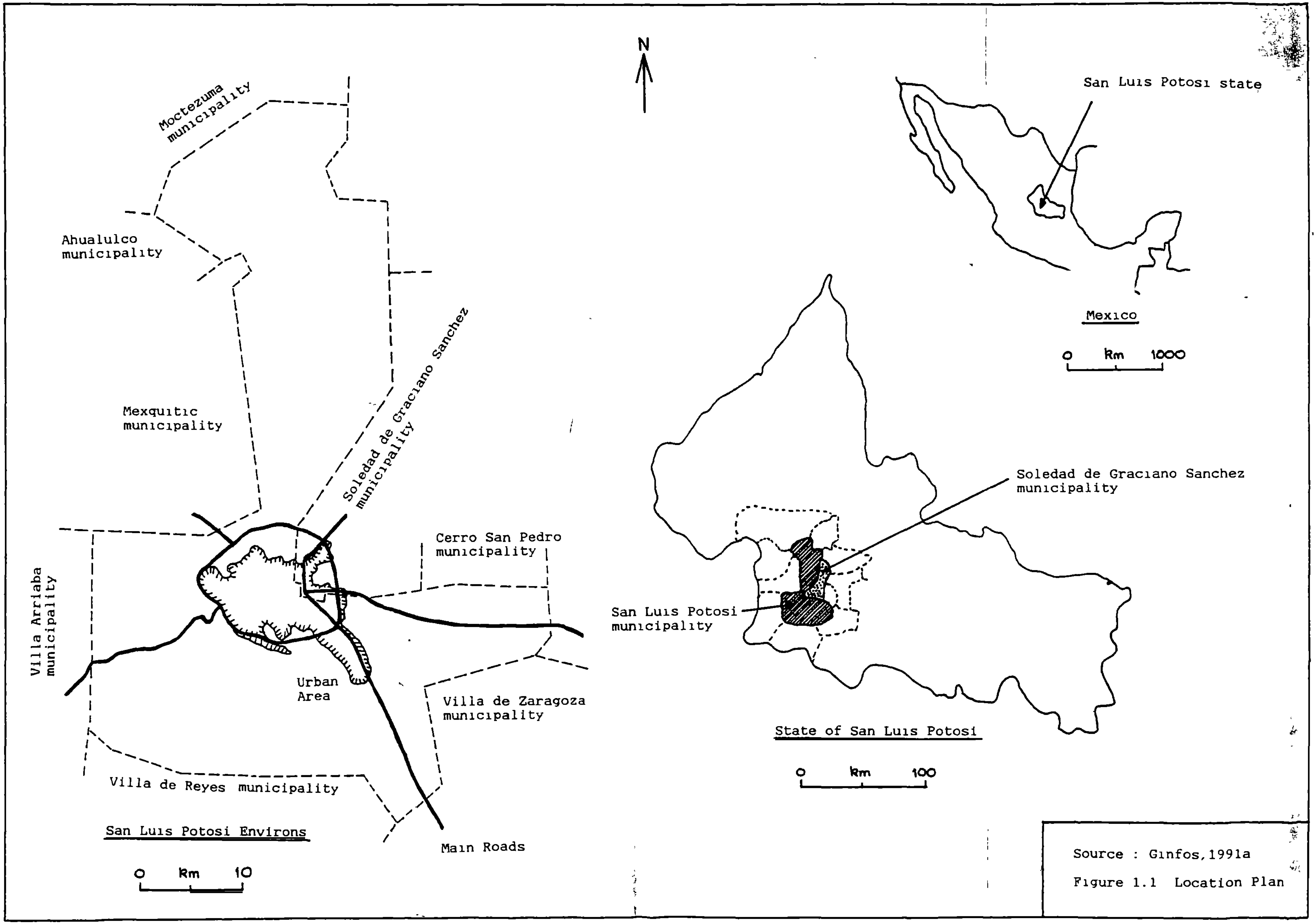
ABBREVIATIONS

Organizations:

CNA	Comision Nacional del Agua - National Water Commission
DAP	Direccion de Agua Potable - Drinking Water Department
DOP	Direccion de Obras Publicas - Public Works Department
JEAPA	Junta Estatal de Agua Potable y Alcantarillado - State Committee for Drinking Water and Sewerage
JM	Junta de Mejores - Local Water Committee
SAG	Secretaria de Agricultura y Ganaderia - Ministry of Agriculture and Livestock
SAHOP	Secretaria de Asentamientos Humanos y Obras Publicas - Ministry for Human Settlements and Public Works
SARH	Secretaria de Agricultura y Recursos Hidraulicos - Ministry of Agriculture and Water Resources
SEDUE	Secretaria de Desarrollo Urbano y Ecologia - Ministry of Urban and Ecological Development
SRH	Secretaria de Recursos Hidraulicos - Ministry of Water resources
SSA	Secretaria de Salubridad y Asistencia - Ministry of Health and Assistance
UASLP	Universidad Autonoma de San Luis Potosi - San Luis Potosi University

Other:

SLP	San Luis Potosi
SGS	Soledad de Graciano Sanchez
NRW	Non-Revenue Water
UFW	Unaccounted-for Water



Source : Ginfos, 1991a

Figure 1.1 Location Plan

CHAPTER ONE
INTRODUCTION

1.1 The City of San Luis Potosi

The city of San Luis Potosi is situated in the semi-arid north - central zone of Mexico. The city is the state capital and is at the centre of what was once a rich mining area, in recent decades it has developed into a services and industrial city.

The result of this development has seen the state rise from being among the bottom five in the country (*Trade and Travel Publications, 1988*), as far as per capita income is concerned to thirteenth out of the thirty-one Mexican states (*Noriega-Crespo, 1991*).

The city authority more correctly comprises the municipalities of San Luis Potosi and Soledad de Graciano Sanchez (formerly Soledad de Diez Gutierrez). Figure 1.1 shows the geography of the area.

Large industries attracted by the central location in Mexico and tax incentives have resulted in rapid industrialization and population growth. However, the physical infrastructure of the city is found to be somewhat underdeveloped and under increasing pressure. Relative poverty is also evident with 50% of households classified as having low or very low socio-economic level (*Ginfos, 1991a*).

The effect of this rapid growth on the water sector shows itself in two ways. Increasing water demand by industrial and domestic consumers means that the existing

fresh groundwater reserves are being mined and the continuing lack of adequate treatment and disposal of wastewaters is resulting in serious environmental and public health risks.

1.2 Problems Facing the Water Sector

1.2.1 Water Supply

The water supply of the city from its foundation in the late 16th century until the 19th century was obtained from the small intermittent rivers Santiago and Espanita and shallow wells in the unconfined aquifer. The surface water supply was strengthened in the 19th century by the construction of the San Jose dam and, later, El Peaje dam and an infiltration gallery near to the location of the more recent Canada de Lobos dam. The water being conveyed to the city by means of open channels, pipes and aqueducts.

By 1965 this existing system was becoming insufficient for the needs of the city and the first deep borehole was drilled to tap into the lower confined aquifer. Further boreholes were developed and in 1975 the lowering of the water levels in the boreholes was first registered. The situation has worsened as demands have increased and the University of San Luis Potosi conducted a study of the local aquifers and warned of the consequences of over-exploitation of this resource (*IMTA, 1987*).

At the present time the water supply to the city comprises 7% from surface sources and 93% from the deep aquifer. The estimated extraction rate of water from the

aquifer is 95 x 10^6 m^3/y with only 50 x 10^6 m^3/y being recharged (*Ginfos, 1991a*).

At this rate of mining of the aquifer it has been estimated that the source will be totally depleted by the year 2000 (*SEDUE, 1988a*).

The location of a future water source has not yet been confirmed although the potential of aquifers in the region has been investigated, as discussed later in Section 3.2. In fact it is not certain that the local groundwater resources are fully understood. Mention is made in Section 2.3.1 of the warm groundwater derived from some boreholes but it is not known if this constitutes a separate aquifer from the one tapped by other boreholes.

If the existing aquifer is to be depleted as predicted there is not much time in which to locate, plan and develop a new source.

1.2.2 Wastewater

The problem of wastewater management is also reaching a critical position in San Luis Potosi. It is estimated that 50 x 10^6 m^3/y of domestic and commercial wastewater and 8 x 10^6 m^3/y of industrial wastewater are currently being generated. (*SEDUE, 1988b*).

Only two wastewater treatment plants exist. The first was commissioned in 1989 and treats approximately 0.7 x 10^6 m^3/y of primarily domestic wastewater (*Ginfos, 1991a*) and uses the effluent to irrigate one of the city's parks. The second has recently been commissioned (June 1991) for

the same purpose in another park and will treat approximately the same amount of wastewater.

The remainder of the generated wastewater is discharged in a number of locations around the north and east sides of the urban area. The great proportion of it finds its way to two lagoons; Tanque Tenorio situated 9km to the east of the city centre and El Morro in Soledad de Graciano Sanchez situated 6km to the north-east of the city centre (See Figure 2.3).

Tanque Tenorio was originally designed as part of a flood control scheme but it has grown with time to be, reportedly, the largest lagoon of untreated wastewater in Latin America. Effluent from the lagoon is channelled in an unlined canal around to the north east of the city for re-use in irrigation of crops.

El Morro is in a residential/agricultural area and the wastewater here is also used for local irrigation. The consequences for the health of the people dealing directly with animals and crops and for the consumers of the produce of these areas are very serious.

The state of San Luis Potosi as a whole has a rate of enteric disease 70% above the national average and the city itself has the third highest rate of incidence in the state (*Ginfos, 1991a*).

In addition to the risks mentioned above the wastewater discharges have already made the unconfined shallow aquifer in the city unsafe to drink due to contamination. It is not understood whether such contamination will spread to the deep aquifer in the long

term - a problem that would compound the current one of mining of the water resource.

1.3 Future Growth of the City

The current extent of the two municipalities and plan for their future development is shown in Figure 1.2.

The current estimates of population are as follows:

Table 1.1 Population and Growth Rates

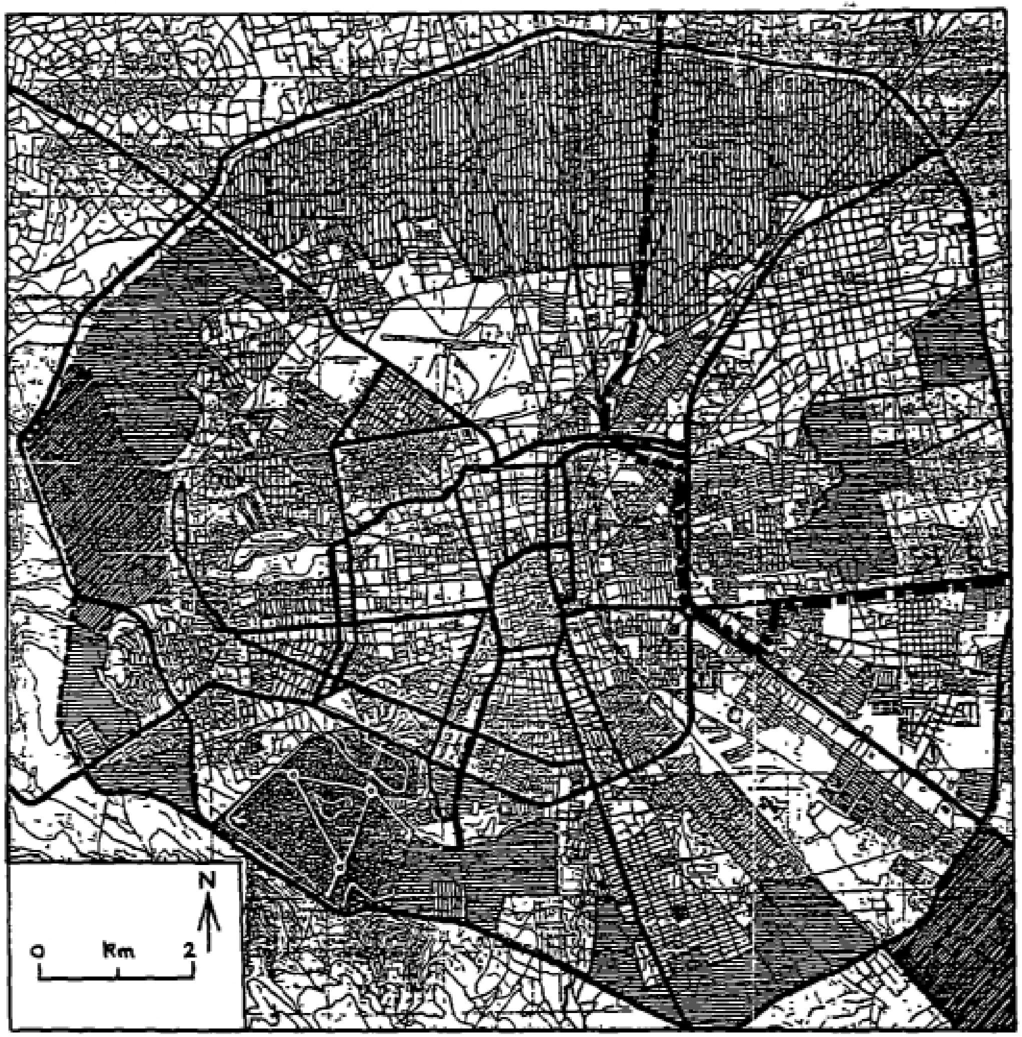
	CITY		**MUNICIPALITY**	
	Population	**Growth Rate**	**Population**	**Growth Rate**
San Luis Potosi	507399	3.67	546275	3.89
Soledad de Graciano Sanchez	126600	5.50	141790	5.50
TOTALS	633999		688065	

Notes: 1. Growth rates given in % per annum for 1991
2. Population figures are estimates for 1990

Source: Ginfos (1991a and b), data in these reports based on data from a census of 1980, Instituto Nacional de Estadistica Geografia e Informatica (INEGI)

Population projections are not required in detail for the purposes of this report they are presented only to show the future trend and degree of pressure that the water sector is under. Figure 1.3 shows the expected growth in population of the city, Appendix A contains the source data.

The future locations for residential and industrial development need to be identified if the water supply and sewerage infrastructure is to be adequately planned and incorporated into the existing systems.



Legend

Short-term growth

Medium and long-term growth

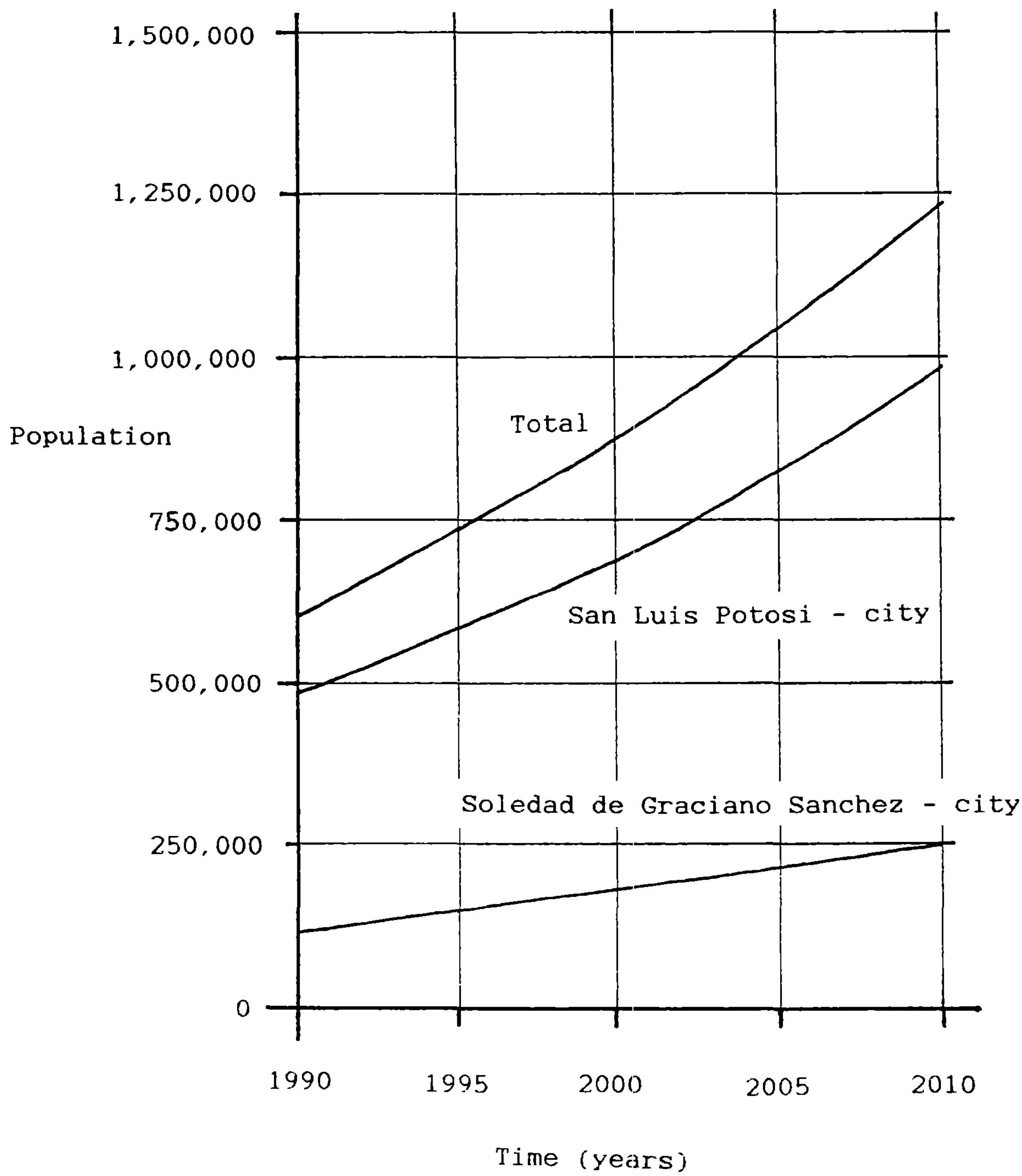
Industrial zones

Primary roads

San Luis Potosi/Soledad de Graciano Sanchez municipality boundary

Source . Ginfos, 1991a

Figure 1.2 Existing and Future Developments



Source : Ginfos, 1991a and b

Figure 1.3 Population Projections

The current pressing problem of imminent exhaustion of the existing water source means that efforts need to be made towards identifying other sources. This matter is discussed in more detail later with reference to the institutions involved but it is likely that large scale resource development will take place beyond the city's boundary. At the current time the location of a major source is only tentative therefore any strategy for water supply in the future must be flexible.

1.4 Aim of the Project

The aim of this project was developed during the first fortnight of the author's field trip. The initial stages of data collection, familiarisation with the city and interviewing of persons in different organizations allowed a picture to be built up of how the water sector in the city was managed.

Whilst concentrating efforts on the water supply systems in San Luis Potosi municipality, for which there was most information available, it was apparent that there was a need for a broader overview of the water sector. Interest expressed by persons in the National Water Commission and the Drinking Water Department led to the preparation of a plan - to review the existing institutional arrangements for water and wastewater management; formulate proposals for improvement of these arrangements; and identify a selective project that could utilize some of the available resources and accommodate current works programmes

to begin to address one of the main problems facing the city, that of shortage of water.

1.5 Data Collection and Field Study Organization

Whilst this report assesses the responsibilities and activities of the various organizations involved in the water sector and discusses the performance of the most significant ones a full institutional analysis following the WASH Guidelines (*Cullivan et al, 1986*) was not intended. Time and resources did not allow for this.

Data collection however was carried out by means of the four techniques recommended in the guidelines (*Cullivan et al, 1986*) during the author's field trip between 12 June and 29 July 1991.

A list of organizations visited and persons interviewed is contained in the Acknowledgements section at the rear of this report.

Where some items of information are not directly referenced they have been obtained from the interviews carried out with the above mentioned persons.

CHAPTER TWO
EXISTING INSTITUTIONS IN THE WATER SECTOR

2.1 The Institutions

A number of institutions are involved in various aspects of the water sector. Some of their functions and responsibilities are described in detail elsewhere (*SEDUE, 1988b*) but it is important to outline the roles of the key organizations here.

2.1.1 National Water Commission, CNA

The National Water Commission was created on 13 January 1989 out of SARH, its parent organization.

The Ministry of Water Resources, SRH, was originally created in 1947 and was wholly responsible for the development and conservation of the water resource with three main divisions for planning, construction and operation (*ECLA, 1979*). Hydro-electric schemes were outside its direct control but it was involved in that area.

In 1977 the SRH was merged with the Ministry of Agriculture and Livestock, SAG, to form the Ministry of Agriculture and Water Resources, SARH, to improve integrated water management by incorporating irrigation activities (*ECLA, 1979*) and to increase food production (*Garduno, 1985*).

By retaining responsibility for agriculture with SARH the CNA was created in 1989 to be solely responsible for management and administration of water that, according to the Mexican constitution, belongs originally to the Nation (*Garduno, 1985*). The CNA therefore, has a similar role to that of the original SRH.

For the purposes of this study the following points are significant:

a) The CNA grants permission to utilize the nation's surface water sources that cross state boundaries and all underground sources. For example the CNA is responsible for the dam El Potosino but not El Peaje and San Jose.

b) It conducts large scale studies and projects.

c) It has responsibility for billing industries and the water supply operating organizations (the municipalities).

d) It is implementing a nationwide water supply and sanitation programme. In former years 90% of funds was directed towards water supply, in 1990 the sanitation sector was beginning to receive a greater share with only 83% of funds directed to water supply.

e) In 1989 it started the Programa Nacional del Control de Perdida y Uso Eficiente del Agua (National Programme for the Control of Wastage and Efficient Use of Water).

f) A current trend is for the CNA to give concessions to private industry to treat wastewater and sell it for non drinking-water purposes.

g) All water users contribute some proportion of their charges to the CNA.

h) The CNA has offices at Federal, State and Regional level.

2.1.2 Ministry of Agriculture and Water Resources SARH

This organization still exists after the creation of the CNA but now is solely concerned with the agricultural industry. However it does still have an interest in water use for irrigation.

2.1.3 Ministry of Urban and Ecological Development, SEDUE

SEDUE has two operating arms, SEDUE Federal and SEDUE Estatal (State). Thus in San Luis Potosi there are two offices - the State SEDUE office and the state office of Federal SEDUE!

The State SEDUE responsibilities were defined in 1988 when Federal SEDUE decentralized some of its activities.

As far as the water sector is concerned the following comments apply:

a) State SEDUE sets standards for industrial discharges to sewerage systems.

b) Federal SEDUE sets standards for industrial discharges to bodies of water.

c) State SEDUE is required to have CNA approval and Federal SEDUE approval for any projects it wishes to implement.

d) State SEDUE assists the State Committee for Drinking Water and Sewerage, JEAPA, with sewerage and sanitation projects.

2.1.4 Municipalities

The municipalities are legally required to provide the population with a drinking water supply of acceptable quality and quantity. They discharge this responsibility by means of the Drinking Water Department, DAP, which is also responsible for planning, budgeting and implementing sewerage works. The execution of sewerage projects is carried out by the Public Works Department, DOP.

In addition:

a) The DAP is required to obtain the CNA's approval for new boreholes and any new project.

b) The DAP is responsible for operating the water supply system and initiating new works.

c) Municipalities with few resources in rural areas rely upon the JEAPA for their drinking water supplies and sanitation requirements.

2.1.5 Ministry of Health and Assistance, SSA

This organization is responsible for setting the drinking water standard (based on the WHO guidelines) and, on an irregular basis, monitoring drinking water quality.

2.1.6 Local Water Committee, JM

These are locally organized community based (urban) committees whose main interest is that of water supply. They check their area for signs of leakage from the distribution system and occasionally raise funds for localised water supply and sanitation projects.

2.1.7 Ejidos

In addition, in rural areas, Ejidos (land owned communally by the Indigenas, the descendants of Mexico's pre-Hispanic people) usually have their own borehole and have to operate it and repair it themselves, they are obliged to inform the State Government and the SSA of any pollution and they are responsible for making plans and applications for new boreholes.

2.1.8 Engineering Faculty at UASLP

The Facultad de Ingenieria conducts studies and carries out projects in various disciplines.

2.1.9 Institutional Relationships and Current Reforms

An activity and responsibility matrix (*Franceys, 1990; and WHO, 1986*) is presented in Figure 2.1 to clarify and expand upon the above information.

The boundaries between the responsibilities, involvements and interests in the various activities of the different institutions are not clearly defined. The system is heavily politicized but the most significant point at the moment is that from September 1991 the municipalities will have to pay a tax to the CNA related to the quality and quantity of wastewater discharges and that if the municipality wishes to recover this cost it must have an independent organization in place for the operation of wastewater collection, treatment and disposal. In addition the municipalities, from September 1991, will be able to charge a realistic tariff for water supply without reference to State Congress again provided an independent operating organization is in place by then. (Until now State Congress has set the water tariffs and has traditionally set low tariffs for electoral expediency). The less wealthy municipalities in rural areas will be able to apply for credits and loans at low interest rates.

2.2 Performance of the Institutions

As stated in Section 1.5 a full Institutional Assessment is beyond the scope of this report but the initial step of Assessing Output Measures (*Cullivan et al,*

ACTIVITY / RESPONSIBILITY	Evaluation of water resources		Wastewater collection		Wastewater treatment		Effluent disposal and re-use		Surface water drainage
	GW	SW	I	D	I	D	I	D	
CNA	■	■ 1	□	□	□	□	□	□	□
SEDUE(Federal)	□	□	■ 2				■ 2	■ 2	
SEDUE(state)	□	□	■ 2		■		■ 2	■ 2	
DAP	▨	■ 1							
DOP			■	■					■
SARH	▨	▨					▨	▨	
JEAPA	□	□	▨	▨					
SSA									
JM									
Ejidos	□	□							
UASLP	▨	▨			▨	▨			
Private enterprise	□	□			□	□	□	□	

Notes

1. Surface waters crossing state ł
   controlled by CNA, others by mu

2. Discharge to sewers/bodies-of-
   responsibility of state/federa

3. Responsibility/involvement dep

Activity and Responsibility Matrix
for the Institutions of the Water Sector

1986) is presented here.

The main institutions under consideration in the water sector are those of water supply and sanitation for the two municipalities covering the urban area.

Most of the output measures presented in Tables 2.1 and 2.2 were obtained directly (*Ginfos, 1991a and b*) and some were calculated from information found in those sources. Ginfos, however, only presents the information without comment but it is felt that these performance indicators require clarification and comment. It should be noted that the performance indicators are not used as a matter of course by the institutions under consideration here.

2.2.1 Comments on Performance Indicators

Indicator - Water Supply (Table 2.1)	Comment
A1 to A6	It has been reported (*Noriega-Crespo, 1991*) that the population figures under-estimate the true totals.
A9 to A10	Some industries are responsible for their own boreholes and some have both their own boreholes and are served by the municipal supply.
B1	Currently only 49 of the 70 boreholes under the SLP water department's control are fitted with flow meters, none in SGS are fitted with meters, therefore production figures should be treated with caution.

Table 2.1 Performance Indicators for Water Supply

Indicator	SLP	SGS
A. Service Coverage		
Urban population	489419	118681
No. households	119000	n/a
1. No. registered consumers	105365 (89%)	22284 (94%)
2. Metered consumers	76948 (65%)	0 (0%)
3. Unmetered consumers	28417 (24%)	22284 (94%)
Other quoted data		
4. Population with house connections	83.6%	n/a
5. Population with public taps	13.4%	n/a
6. Population using tankers	3.0%	n/a
Commercial consumers		
7. Metered	2527 (90%)	0 (0%)
8. Unmetered	284 (10%)	40 (100%)
Industrial consumers		
9. Metered	204 (70%)	0 (0%)
10. Unmetered	88 (30%)	17 (100%)
Other consumers		
11. Metered	105 (85%)	n/a
12. Unmetered	18 (15%)	n/a
13. Per capita consumption of water	177 l/c.d	111 l/c.d
B System Efficiency		
Production: borehole capacity	1934 l/s	n/a
1. borehole production	1725 l/s (89%)	402 l/s
Surface water treatment capacity	350 l/s	-
2. production	117 l/s (33%)	-
3. Storage as proportion of daily use	3750 m^3 (2.4%)	8822 m^3 (25.4%)
4. Leakage	32% or 675 l/s or 66 l/c.d	39-54%
5. Daily pressure variation	0-25m	n/a
6. Leaks repaired	1200 /y	n/a

...... **Table 2.1 continued**

Table 2.1 continued/..

C Finance		
1. Service affordability	<3%	<3%
	of minimum legal wage	
2. Billing efficiency volume billed/volume produced	60%	n/a
3. Collection Efficiency Bills collected/bills issued	64%	n/a
Bills more than 30 days outstanding/bills payable	40%	n/a
4. Cost of connection/fee charged		
½" supply	335%	n/a
¾" supply	451%	n/a
5. Total income	$M 10,928 /y	$M 405 /y
income from bills	$M 5,641 /y	n/a
6. Total expenditure	$M 12,723 /y	$M 1,623 /y
7. Operating cost	$ 219 /m³ (US$ 0.07 /m³)	$ 128 /m³ (US$ 0.05/m³)
8. Energy costs/total cost	62%	78%
salary costs/total cost	20%	11%
D Management		
1. Connections/employee	310	500
Population/employee	1400	2900
2. Illegal connections	n/a	2000
3. Customer relations	9500 complaints/y	n/a

Notes:

Figures are for 1990
n/a information not available

Source: Ginfos (1991a and b)

B3	Storage consists of small balancing tanks, only two service reservoirs exist as such and both are small for the size of the system.
B4, B6	Only passive leakage detection is carried out, no precise figures are available, nor are they defined as UFW or NRW.
B5	The pressure variation from 0m appears to indicate interruptions to the supply and a performance indicator for this should be adopted, e.g. no water available at the first water tap in the property for greater than 12 hours (*OFWAT, 1990*).
C1	Full details of the tariff structure are contained in Appendix B, a typical household would pay approximately US$ 0.18/m^3, and the tariff is a water-conserving one with consumers paying a higher charge for high consumption.
C5, C6	Limited financial information is available but it is evident that the water departments are subsidised by approximately 50%.
C7	The operating costs are less than US$0.1/$m^3$ which is low compared with figures available on a worldwide basis (*Franceys, 1990*).
C8	The high proportion of energy costs illustrates the reliance on pumping from deep boreholes and how sensitive operating costs are to the cost of electricity.

Table 2.2 Performance Indicators for Sanitation

Indicator	SLP	SGS
A Service Coverage		
1. Population served	80%	85%
B System Efficiency		
1. Domestic	49.9×10^6 m^3/y 1582 l/s	1200 l/s used for
2. Industrial	8.1×10^6 m^3/y 257 l/s	irrigation (untreated)
3. Total	1839 l/s	
4. Treatment		
Parque Tangamanga I	21 l/s	-
Parque Tangamanga II	40 l/s	-
5. Blockages repaired	n/a	n/a
6. Wastewater/water supplied	82% in both municipalities	
C Finance		
1. No tariffs charged	n/a	n/a
D Management		
1. Population/employee	"50,000"	n/a

Notes:
Figures are for 1990
n/a information not available

Source: Ginfos (1991a and b)

D1 The service coverage per employee appears to compare favourably with figures from the UK (*OFWAT, 1990*). However the comparison is not straightforward. Typical UK water company figures are 1200 to 2500 people served/employee which shows the SLP and SGS figures to be reasonable. A better comparison though is the number of connections/employee, 660 to

970 in the UK, showing that the SLP and SGS departments could attempt to reduce their staffing levels over time. This comparison of indicators reveals the possibility of misinterpretation between figures from different countries because of the different household occupancy rate and therefore number of people/connection (4.1 in SLP (*Ginfos, 1991a*), 2.5 in UK (*OFWAT, 1990*)).

D3 The number of complaints dealt with per year requires more detailed analysis if it is to reveal the effectiveness of the customer relations section. Levels of service for such a parameter in the UK (*OFWAT, 1990*) use banded response time for meaningful responses to both billing queries and customer's written complaints (e.g. response within 2 working days, 3-5 days, 6-10 days, 11-20 days, 21 or more days). This is quite detailed and also requires classification between queries and complaints.

<u>Indicator</u> - Sanitation (Table 2.2) **<u>Comment</u>**

A1 It is felt by some that the figures for service coverage of sewerage are optimistic. There are few other indicators that offer much insight into the organizations. Performance in sanitation is perhaps by its nature more difficult to quantify and is more subjective.

The proportion of wastewater that is currently treated (less than 5%) does not allow for much comparison of quality of effluents and the most revealing indicator is the severe understaffing shown by indicator D1. Were there an indicator of flooding incidents (*OFWAT, 1990*) the author feels that there would have been almost 100% of the population affected during the summer's rains!

The use of performance indicators in this case is an analysis at one point in time and the process should be repeated in subsequent years to show trends (*Shearer, 1988*). As they stand however they suggest that a full Institutional Assessment may be warranted, this is discussed more fully in Section 2.6.

2.3 Assets of the Institutions

A thorough inventory of the systems of water supply and sanitation in the two municipalities comprising the city authority is covered in detail by Ginfos (*1991a and b*).

Only brief descriptions of the systems are given here, with reference to Figures 2.2 and 2.3, but they present the situation that the authorities have inherited and have to manage.

2.3.1 Water Supply

The water supply of the two municipalities is derived from the surface water source of the Rio Santiago

and some 90 boreholes. The surface water source reaches the city via two dams to the west and an open channel and pipeline leading to the treatment plant at Los Filtros. From here water is pumped into the distribution system. The groundwater source reaches the distribution system via borehole pumps and, in most cases, small balancing tanks and low lift pumps. One area, known as the thermal zone, uses 10 boreholes to pump water to a "service reservoir" and then repumps with 5 low lift pumps to a second service reservoir and thence via a 24" main into the distribution system.

Most of the boreholes are considered to command their own "pressure zone" however in reality all of these zones are open to their adjacent zones through open valves and there is no thorough understanding of how the system operates. There are a few elevated tanks in the city, most of which are no longer in operation.

The distribution system comprises pipelines of 2" to 24" diameter with the majority being of 6" diameter. Pipe materials used are asbestos-cement, PVC and galvanized iron. Many of the older pipes in the older central part of the city are made of iron and are apparently the cause of most of the leaks from the system and the PVC pipes are susceptible to bursts probably due to the pressures imposed on them by direct pumping into the system.

Water treatment is only carried out on surface waters (i.e. 7% of the city's supply) and consists of plain sedimentation and rapid sand filtration. The water obtained from boreholes has a high fluoride content and dental fluorosis occurs in the population.

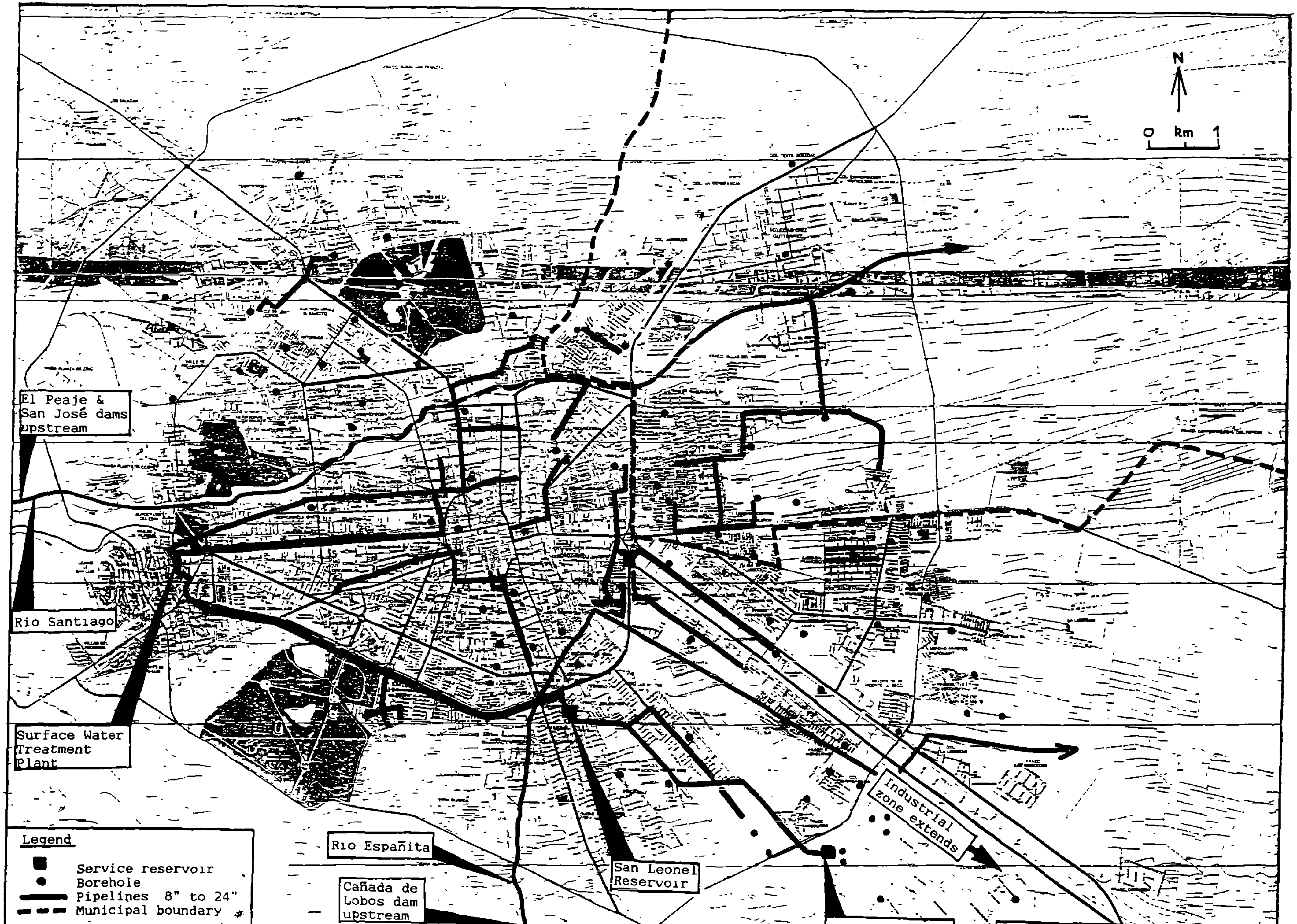


Figure 2.2 Water Supply System

Some of the boreholes produce water at a temperature of around 38°C which has implications for design of pipelines and selection of pipe material (*IWES, 1984*). It should also be noted that the area does suffer from frosts for 15 to 20 days per year on average (*Ginfos, 1991a*) and this should also be taken into account in pipeline design.

The municipality of Soledad de Graciano Sanchez is nominally separate from that of San Luis Potosi as far as water supply is concerned but its system functions along similar lines, using boreholes and pumping into apparently distinct distribution zones.

It has been suggested that there is one man in each of the water supply departments who has been working with the distribution system for many years and that only he understands how the respective systems function!

2.3.2 Sanitation

The sewerage system in the municipalities is nominally combined. There are a number of main collector sewers in the city but since the topography is very flat there are no distinct drainage basins. There are some sections functioning as separate systems and some areas of the industrial zone are provided with pumping stations. These have operational problems when it rains. Only some main roads have drainage of any significance.

The wastewaters discharge into the two surface water-courses, Rio Santiago and Rio Espanita, the latter was previously a tributary of the Rio Santiago but was diverted

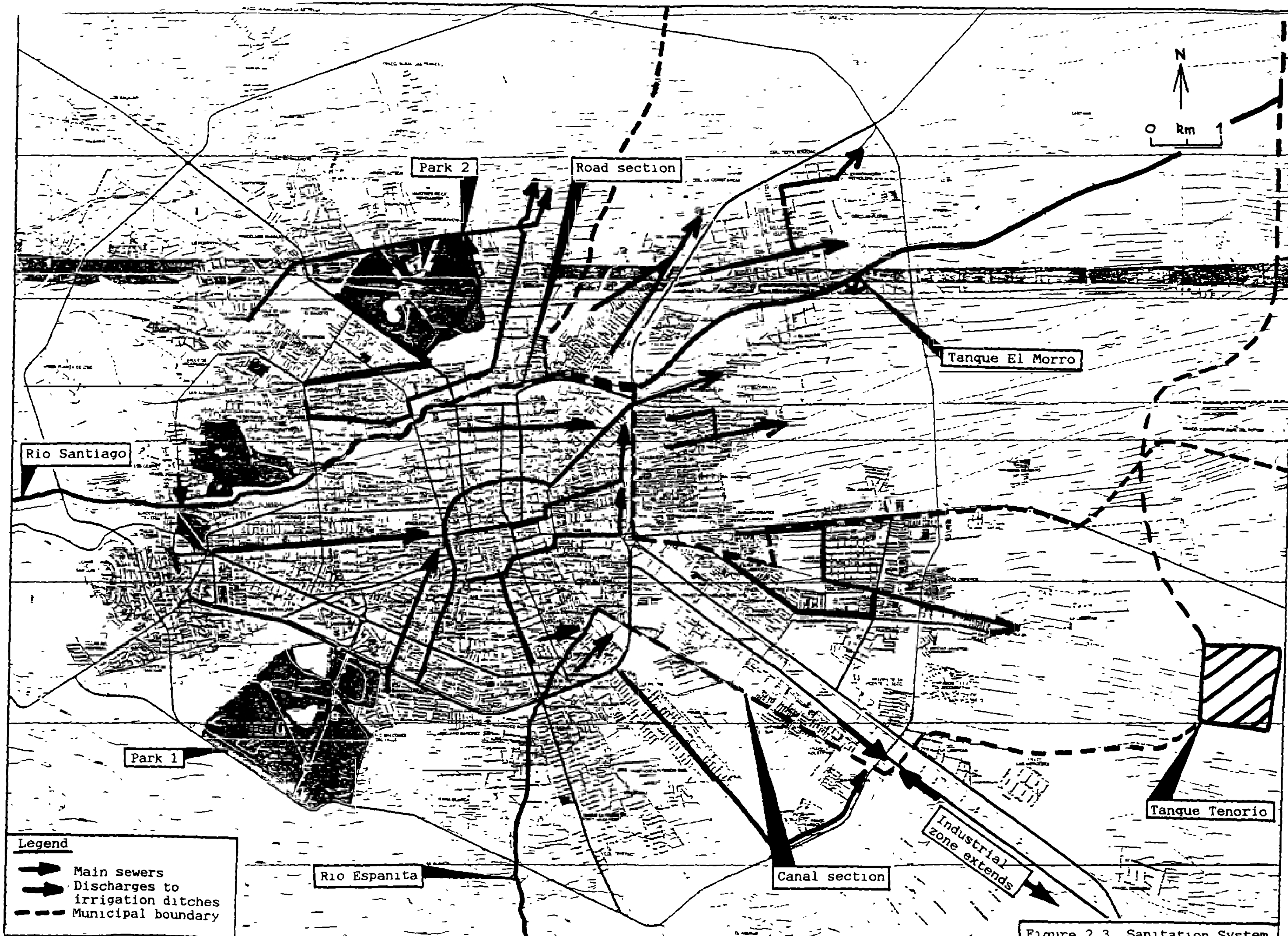


Figure 2.3 Sanitation System

by means of a man-made channel to flow south-eastwards through the industrial zone.

Subsequently the wastewater flowing in the Rio Santiago (approximately 18 x 10^6 m^3/y) (*Ginfos, 1991a*) is used in Soledad de Graciano Sanchez for crop irrigation, without receiving any treatment. Wastewater flowing in the Rio Espanita is discharged into Tanque Tenorio, again without treatment. (approximately 40 x 10^6 m^3/y). (*Ginfos, 1991a*).

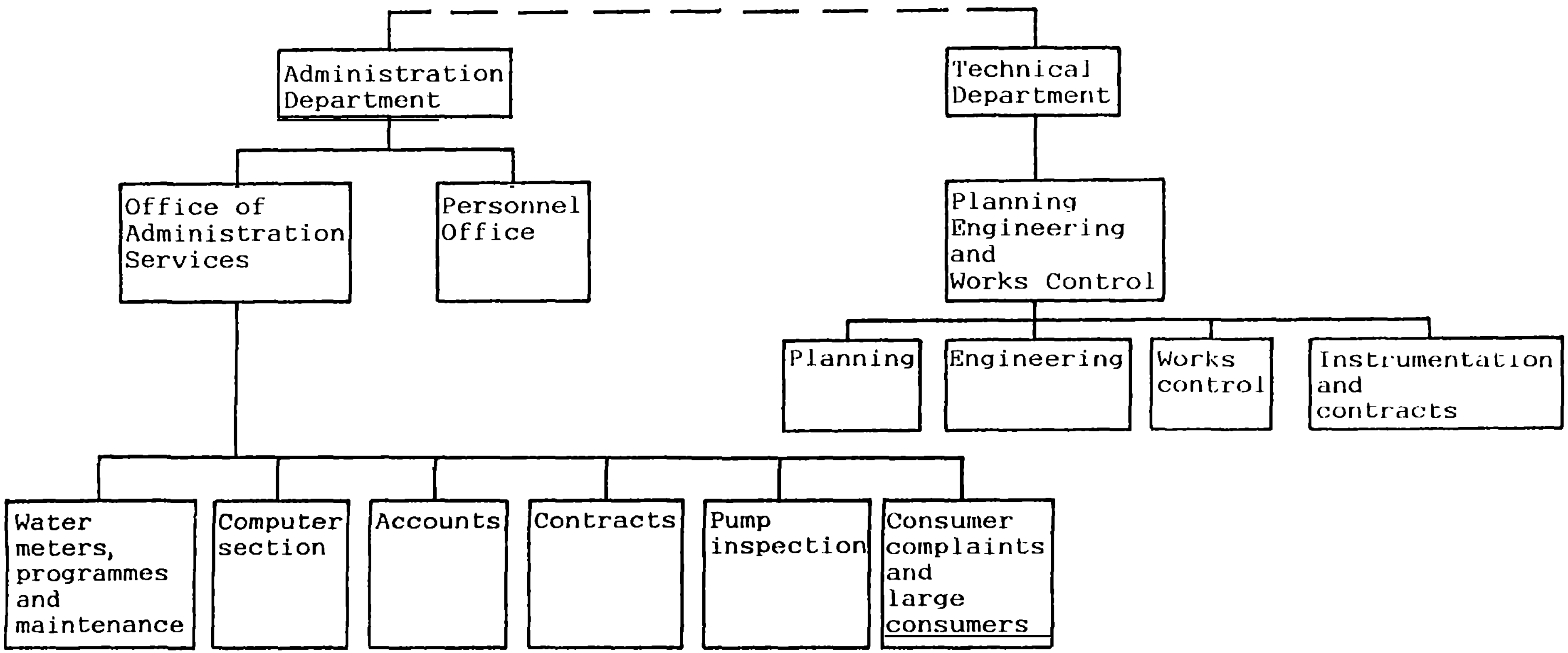
The only wastewater treatment of any sort is carried out on small flows by two package plants at each of the two main public parks.

There are few plans of the sewerage system existing and the information presented here is based upon plans from the Ministry for Human Settlements and Public Works, SAHOP (now disbanded and replaced by SEDUE) and from an undated plan from the Public Works Department, DOP.

2.4 Organizational Structure of the Institutions

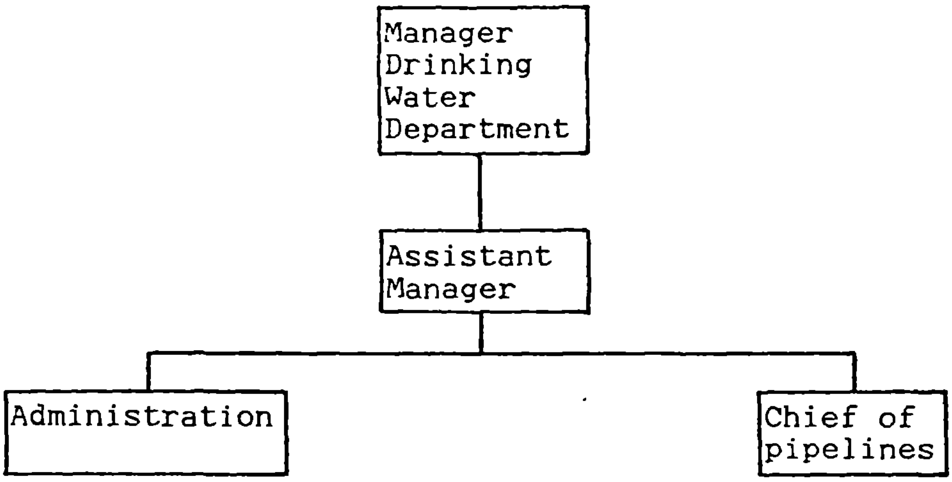
The organization charts of the water supply institutions are shown in Figures 2.4 and 2.5, more details of the structures are contained in Appendix C but since there are some incorrect details to be found in these the organizational structures are not as clearly defined as they could be.

The organizational structures can be described as Line Organizations, authority is centred around one or two key posts. (*Oldcorn, 1989*).



Source : Cinfos, 1991a

Figure 2.4 Water Department Organization Chart San Luis Potosi



Source : Ginfos, 1991b

Figure 2.5 Water Department Organization Chart
Soledad de Graciano Sanchez

One of the biggest problems facing the institutions is the nature of the changes that occur with state government elections every 6 years and municipal government elections every 3 years.

A proportion of the employees are trade union members but the remainder are known as "trusted" employees. These are expected to leave the organization together with the senior managers at any change of party in government.

This system only allows an organizational structure to have been created and developed into a functioning body over a short period of time. It is evident from the poor statistical base of the institutions and the lack of depth of knowledge regarding the distribution systems that this leaves the organizations without the necessary resources to operate their systems effectively. It is understood that with the personnel changeovers a certain amount of the crucial information is also removed as if it was the personal property of the departing personnel.

As a result there are few updated drawings and no drawing registers available in any of the institutions.

The water departments concentrate on the operation of the numerous boreholes serving the city. Up to now, as additional water was required another borehole would be drilled. By necessity there is fairly good information available about the boreholes, pumps and motors. However it is once the water enters the distribution system that the dearth of information is apparent.

Other inefficient practices occur; Figure 2.4 shows that consumer metering and complaints are the responsibility

of the administration section and, seemingly, the technical section has no direct input. However that section does need to know where and what the system demands are and where problems are occurring. Indeed, at the present time the technical and administrative sections are housed in separate buildings.

Records of leaks and bursts from the public being encouraged to contact the authorities for example, are only recorded as a statistic and not presented on plans to assist in determining weak areas in the distribution system.

The situation within the organizations and the position regarding other institutions outlined at the end of Section 2.1 means that at times either more than one organization is looking at the same problem or, more often the case, organizations neglect to address a problem because they leave the responsibility to others.

2.5 Current Programme of Works

The various institutions involved in the water sector have the following works in hand:

a) The DAP (SLP) are currently installing flowmeters on the delivery pipelines of all their boreholes, 45 were installed in 1990 and 27 should be completed in 1991.

b) The DAP (SLP) are currently creating pressure monitoring points at various locations in the distribution system, 100 were prepared in 1990 and 100 more should be completed in 1991. They will be

able to receive an under-pressure pitot meter and three such meters are being purchased.

c) The DAP (SGS) are currently rehabilitating their boreholes and have one third completed, this includes installation of equipment intended to improve the efficiency of the pumping plant.

d) The DAP (SGS) have a budget to install 10,350 domestic water meters and 22 borehole delivery main flow meters over the next four years, with 33% to be achieved this year.

e) The DAP (SGS) intend to drill 5 more boreholes to meet increasing demands.

f) SEDUE (State) are implementing the construction of wastewater treatment plants in the form of waste stabilization ponds to treat incoming wastes to Tanque Tenorio and El Morro.

g) Both municipalities run maintenance programmes of their water distribution systems but do not run any active programmes of leak detection.

2.6 Institutional Assessment

The assessment of output measures in Section 2.2 provides the first step of an Institutional Assessment. Amongst other purposes (*Cullivan et al, 1986*) it provides data for decision making on whether to proceed with Institutional Assessment and determines areas of potential weakness for follow-up.

It is felt that the organizations of the water sector would benefit from Institutional Assessment and Institutional Development Programmes.

Although these have not been attempted here brief comments relating to the nine performance categories (*Cullivan et al, 1986*) would usefully summarize the strengths and weaknesses of the San Luis Potosi water department.

2.6.1 Organizational Autonomy

The comments at the end of Section 2.1 are relevant here. There is little control over the generation of revenue and, up to now, setting tariff levels. Although some studies and plans are conducted, long-term planning is less than adequate.

2.6.2 Leadership

Only the San Luis Potosi water department can be judged here. It has indicators of high performance and perhaps only suffers from the problem that, with the personnel being distributed around 70 boreholes, it is not too easy to carry out field visits.

2.6.3 Management and Administration

There are inadequacies in the management skills throughout the organizations. Information does not appear

to be disseminated effectively, for instance there are few up-to-date drawings and no register and the technical and administration sections are housed separately.

2.6.4 Commercial Orientation

The costs of operation are heavily subsidised by the municipal government and the service function is not thought of as a business. But the billing is computerised and quite efficient.

2.6.5 Consumer Orientation

Although the level of complaints from the public is high the relationship with the public is quite good. The National Water Commission has a high profile and the public are encouraged to participate in leak detection, wastage reduction and health matters. This reflects on the local water department. The psychological importance that water has for users is significant in Mexico (*Garduno, 1985*).

2.6.6 Technical Capability

The technical resources of the organizations are generally quite good and attempts are underway to build on them (see Section 2.5). It is the lack of long term planning and inheritance of inadequate systems that cause the most problems.

Increasing use of computers is likely to occur in the future and plans exist in the long term for computer modelling of the distribution system. Some of the personnel are certainly familiar with computers but there may need to be provision made for training in their use and involvement with the computer section of the Civil Engineering Department at the University to design suitable courses should be considered.

2.6.7 Developing and Maintaining Staff

An element of the staffing methods is mentioned in Section 2.4 and this leaves the organization weak in this category.

2.6.8 Organizational Culture

The author learnt of the history of water supply to the city from more than one source in the department and this was told with pride and interest. It is felt that this is a good indicator of performance.

2.6.9 Interaction with Key External Institutions

This area is discussed in Section 2.1 in more detail. This area of activity is fairly well attended to but probably suffers from there being too many institutions attempting to manage the sector.

From the comments above it is felt that the most serious areas of need for improvement are those of Management and Administration and Commercial Orientation. Organizational Autonomy is shortly to be improved under new legislation and the subject is discussed in more detail in Chapter 3.

CHAPTER THREE
PROPOSALS FOR ORGANIZATION OF THE WATER SECTOR

3.1 Limitations of the Existing Institutions

Some of the problems facing the institutions of the water sector are outlined in Section 1.2 and some of the ways in which they are addressing these problems are mentioned in Section 2.5. However to summarize the situation the water sector institutions are in a position of simply maintaining their current levels of service with little time to objectively view their problems or to plan for the future.

The future holds greater problems for them in that their existing water source is being mined and the wastewaters are creating an increasing environmental and health hazard.

They have to work from a base which is lacking in resources in a number of areas; physical systems of water distribution and wastewater collection that have grown in a disjointed fashion; inadequate, non-existent or disappeared records; unclear areas of authority and responsibility for different activities; insufficient human resources to operate the systems effectively nor determine strategies to serve future developments; and consistent lack of financial resources to provide sufficient funds to pay for improvements and extensions to the systems.

The problems faced by the water sector in San Luis Potosi are not untypical of many towns and cities in Mexico. Mexico city itself was identified as facing severe water shortages some time ago and its critical time is yet to come despite intensive measures to combat the problem (*Durazo and Farvolden, 1989; and Hunt, 1990*). Ciudad Juarez on the border with the United States of America has been the subject of research to find solutions to its problems of over-exploitation of aquifers and disposal of wastewaters (*Lloyd and Marston, 1985*). Both Guadalajara and Monterrey face problems of water shortage, (*SEDUE, 1988b*).

At a national level the CNA has been created to find solutions to the problems facing these cities and is now addressing many of the deficiencies in national and regional water management in Mexico that have been reported elsewhere (*Guarduno, 1985*). San Luis Potosi, in the long term, will need to develop other sources of water to meet future needs. In that case large scale projects may be a solution (*Garduno, 1985*).

In their current state the water sector institutions at local level are ill prepared to operate such systems but it is surely important that they develop towards such a capability. If they do not do so they will be reliant upon the national body to provide solutions and resources and they will remain dependent rather than become autonomous.

With the imminent requirements to separate the operating authorities from the municipalities now is a suitable time to plan an appropriate institution capable of serving the city in the long term.

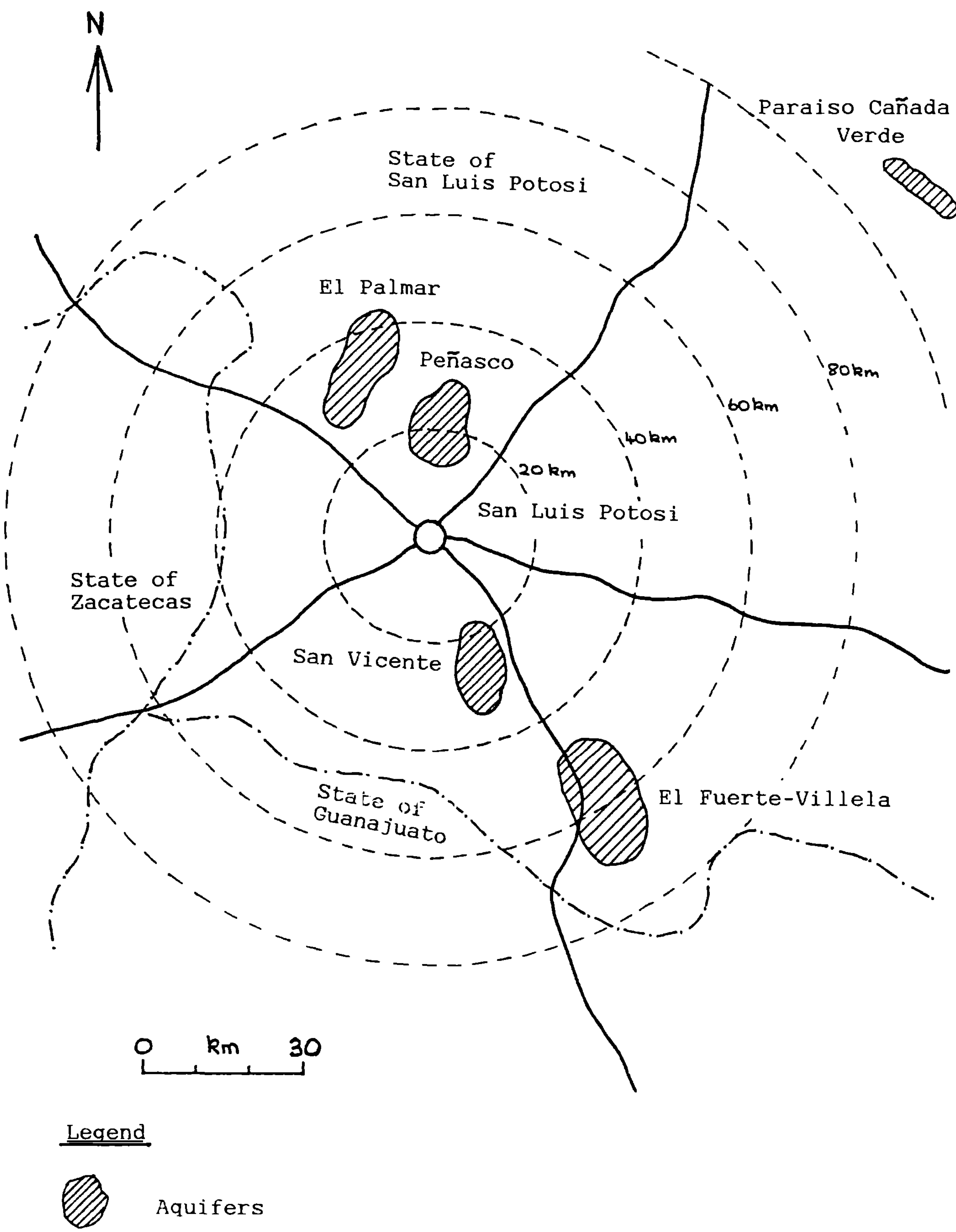
3.2 Future Developments Affecting the Institutions

Likely areas of future developements in the urban area are shown in Figure 1.2, these may not be certain but it illustrates the need for water sector planning to be flexible.

It can be seen from the plan that the municipalities will merge even more into a single urban area (if they are not so at the moment). In fact there are suggestions for the formation of a "greater conurbation" which will include parts of 5 municipalities - San Luis Potosi, Soledad de Graciano Sanchez, Mexquitic, Cerro San Pedro and Villa de Zaragoza (*Noriega-Crespo, 1991*).

A future water source is unlikely to exist in the immediate surroundings and it is not yet known from where a supply will come. Figure 3.1 shows the locations of possible aquifers that could be developed, the choice will determine how best to manage the water distribution system at the moment and how to develop it to take advantage of any new source.

At the moment the distribution system is based upon the surface water source supplying from the west, the "thermal zone" boreholes in the south and other boreholes throughout the urban area. The main pipelines of the distribution system of size 10" and above cover a significant proportion of the city but not in any clearly definable way, i.e. they do not constitute a logical branched or looped system.



Source : Ginfos, 1991a

Figure 3.1 Possible Future Water Sources

Figure 3.2 and 3.3 show the skeleton of the system described above, other important features and possible strategic plans incorporating a new water source.

The main points to be noted are as follows:

a) A new service reservoir should be constructed at the same elevation as the existing treated water tanks at the treatment plant in order to command the city from the same hydraulic level. It is unlikely that there is available land in this area so a location may need to be found to the south or west of the city.

b) If the new transmission route approaches from the same side of the city as the new reservoir can be located, then the main can deliver directly to that reservoir.

c) If the new route approaches from the opposite side to the reservoir then the main can serve a transmission/distribution function with the load centre between the source and the storage. This arrangement will usually be the most economical (*Steel and McGhee, 1985*).

d) Tentative routing of a transmission main needs to be considered at an early stage to allow its construction to be a part of future developments.

e) Infilling of the apparent gaps in the system to build towards a looped, branched or ring-main system should be planned so that construction can be achieved as the future developments are completed.

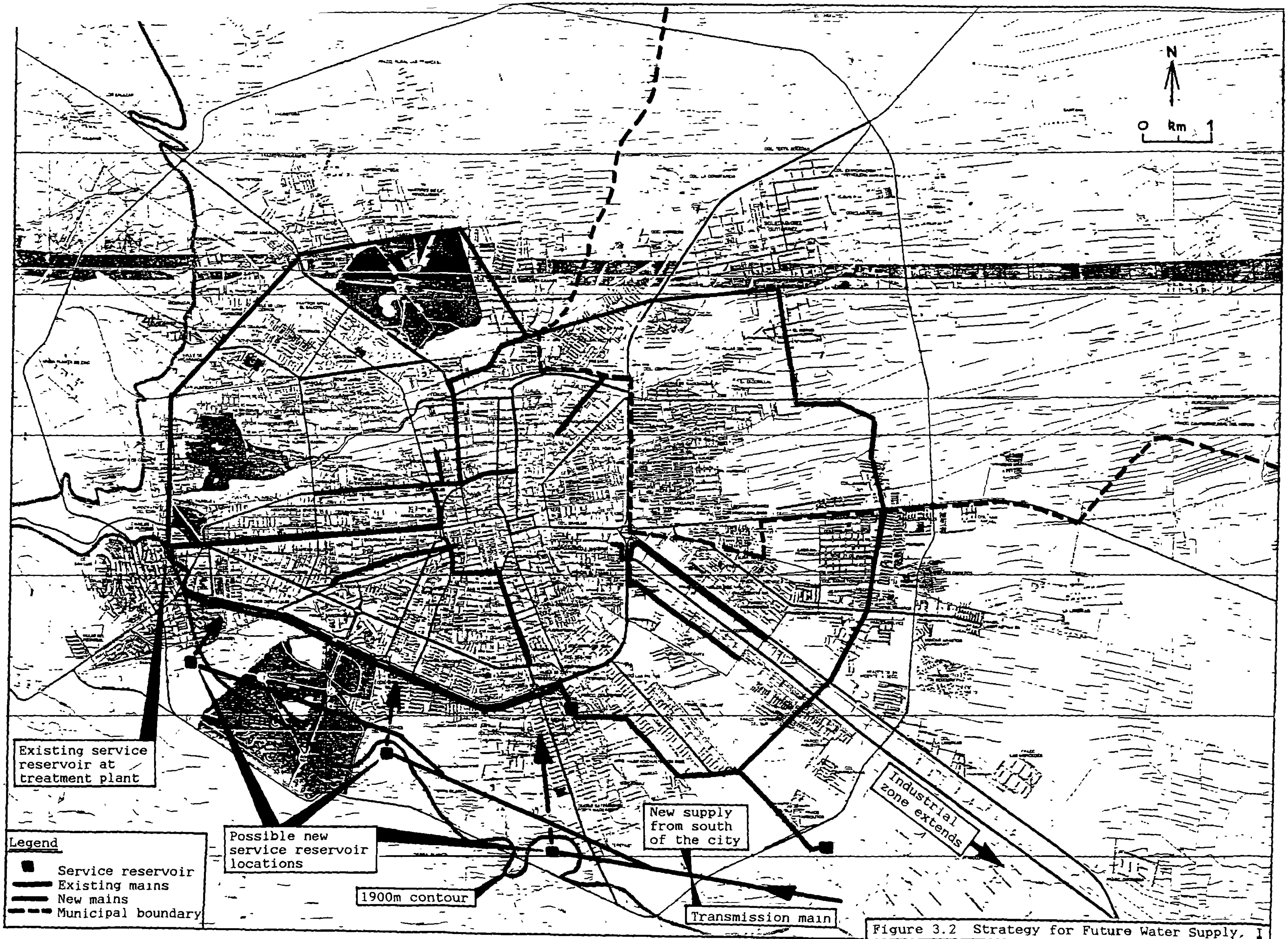


Figure 3.2 Strategy for Future Water Supply

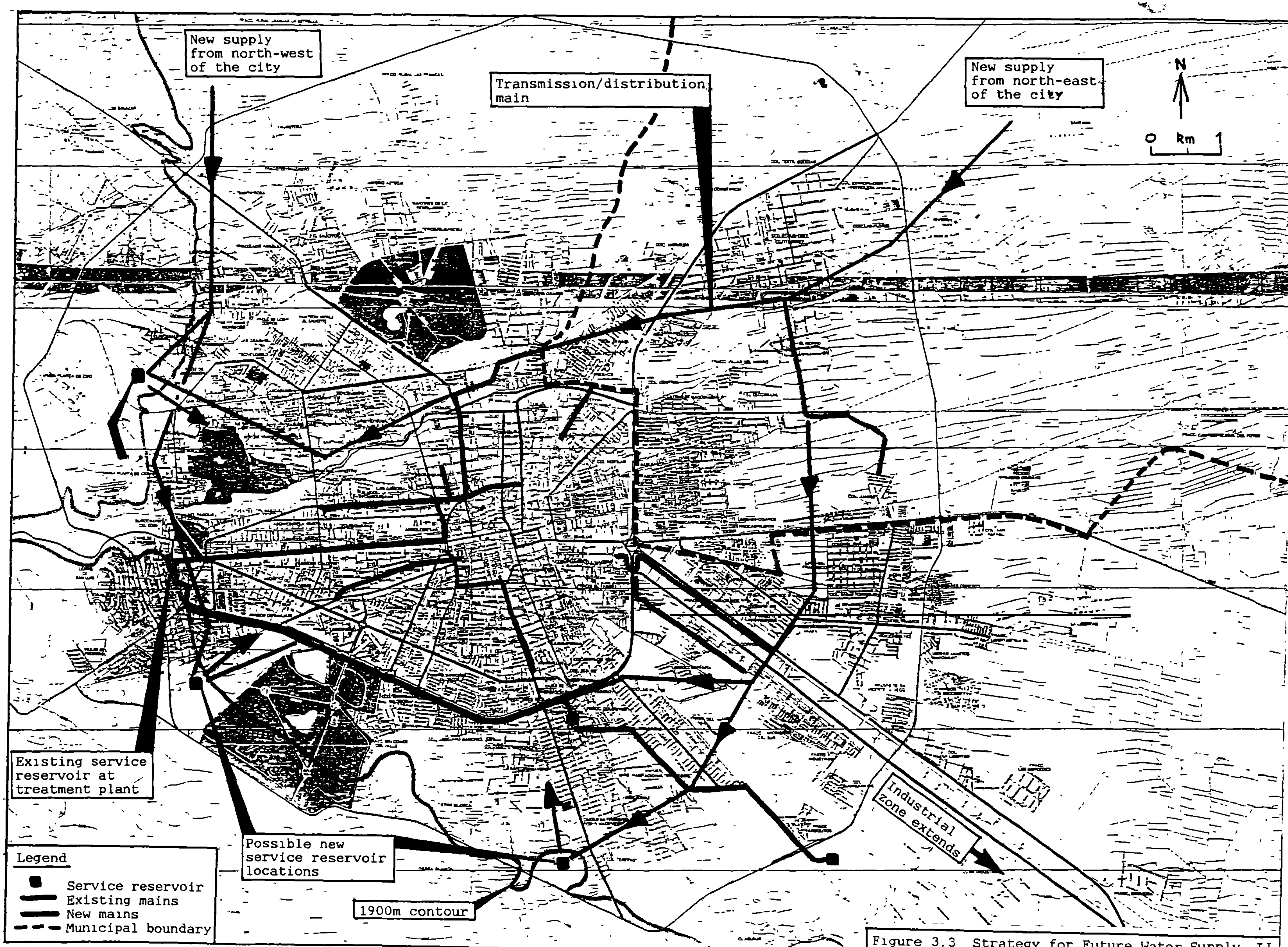


Figure 3.3 Strategy for Future Water Supply, II

Planning by national or regional bodies may well be able to provide solutions to the locating of a new source but it is important that the local authority has the capacity to plan its own requirements.

Similar considerations need to be given to the discharge of wastewaters. As increasing quantities of domestic wastewaters drain into the existing disposal system it will need to have adequate capacity to pass them and suitably sized treatment works to treat them to acceptable standards.

The management of wastewaters cannot be seen in isolation from that of stormwater. Despite the low rainfall in the region (average 359mm/y) (*Ginfos, 1991a*) the intensity of rainstorms can be high - on 11 June 1991 the average yearly rainfall fell in a 24 hour period.

So with increasing urban development, and therefore, impermeable areas, greater emphasis needs to be placed on the provision of storm water drainage.

Currently the main drainage routes of the Rio Santiago and Rio Espanita are inadequate at times of intense rainfall. The Rio Santiago has been substantially paved through the urban area to create a main road but this soon reverts to a river during heavy storms. This occurred during the author's field trip and is illustrated in Figure 3.4. After some of the heaviest rains for many years El Peaje, San Jose and Canada De Lobos dams were full and spilling water. Further downstream the "Rio Santiago" road was flooded and impassable to traffic and the Rio Espanita was flowing full, the latter was then discharging into the

Figure 3.4 Road Section of the Rio Santiago in Flood

Tanque Tenorio which was full and overtopping its surrounding bunds. The irrigation ditches fed from the Tanque Tenorio join the canalised Rio Santiago farther downstream and there is nowhere for the water to go! Normally this would be to the city's advantage if it was able to treat and re-use its wastewaters; at times of heavy rains it has the potential to be a disaster.

It should also be noted that the lack of drainage for stormwaters has other implications. Since the water distribution system has a pressure range from 25m to 0m (see Table 2.1) there are times when the mains will be susceptible to infiltration from shallow groundwaters. It is known that the shallow aquifer is contaminated and, as can be seen in Figure 3.4, surface waters during times of flood will undoubtedly contain solid waste and probably faecal matter. The water entering the distribution system from boreholes is currently untreated and not disinfected. This situation creates a serious public health hazard and concerns more than one of the existing organizations.

The majority of future growth will occur on the outskirts of the city, see Figure 1.2. Not all the wastewater and stormwater from these areas can be allowed to drain towards the existing system. It will not be able to cope.

It is essential therefore that knowledge of the spare capacity and functioning of the existing drainage system be determined and strategic plans be developed along the lines of perhaps interceptor sewers or separate drainage areas.

It is not known how extensive flow records are for the main drainage routes of the city, but the two rivers are both regulated by dams so there should be some information available to aid such planning.

Current design practice in the Public Works Department for surface water drainage of new developments uses a rainfall intensity of 25 mm/h in the Rational Method for calculation of peak run-off (*BSI, 1985*). It is felt that this figure should be reviewed. Standard practice in Britain uses 50 mm/h for small developments (*BSI, 1985*) and the rainfall intensity in Mexico was observed to be as high as in Britain.

Therefore, with the urban areas merging to become a single city but with the wastewaters currently draining across and discharging into different municipalities it is felt that the future developments affecting the city require some changes to the organization of the water sector, to improve both water supply and sanitation.

3.3 A Single Authority for San Luis Potosi

The analysis of the existing institutions of the water sector, the future pressures that will be put on their currently stretched resources and the expected changes to the structure of the local water departments have led to the proposal that - **the organizations required for the management of the water supply and sanitation services in the two municipalities from September of this year (1991) be merged to create a single institution.**

The merits of this proposal are as follows:

a) It is apparent that although two municipalities exist there is only one urban area. This merging of boundaries will increase with further urban development and it is inefficient to have separate organizations duplicating certain functions to achieve the same end.

b) Currently there is one source of water supply the deep aquifer. Any future supply is more than likely to be derived from outside the boundary of the city, both municipalities therefore face the same problem of shortage and will probably find they have to share the same long term solution. Two organizations merely create unnecessary administrative delay.

c) The wastewaters generated by domestic and industrial water use in the separate municipalities already impact upon each area. The problem of wastewater cannot be dealt with in isolation A large proportion of the effluent from San Luis Potosi is discharged in the municipality of Soledad de Graciano Sanchez, only one body can effectively manage this problem if one area is not to benefit to the detriment of the other.

d) The organizations directly involved in the operation of the water supply and sanitation in the municipalities are at different stages of development; they each have their strengths and weaknesses; they each have similar programmes of

works at the present time; there is potential that the water sector would benefit from their merger.

e) Both municipalities have responsibilities for certain functions in urban and rural areas, for two organizations to maintain the support structure for this is clearly an inefficient use of resources.

Arguments against such a proposal must be considered.

a) The legal framework would be necessary to create a single body, it is considered that the CNA have the authority to implement such a change.

b) The smaller municipality may resent a merger with its larger, economically and politically stronger, neighbour; however suitable negotiations should be able to prepare all agencies for the change.

c) The different service levels in the municipalities would need to be taken into account in designing a suitable tariff structure with possible needs for cross-subsidising.

d) The change itself would probably be considered a quite radical move by all parties concerned and they may not be prepared for this much change. However change is about to come anyway. It would be better to take the right step now than to take halfway measures.

e) Finally the current members of, and those outside of, the trade unions would need to be considered. The system needs to be less politicized than at

present so that the records and information about the services are seen as much a part of the infrastructure as the physical facilities.

An organizational structure for a single institution to manage the water supply and sanitation services in San Luis Potosi, Soledad de Graciano Sanchez and the surrounding rural areas is presented in Figure 3.5.

The organization would obtain the majority of its personnel from the existing bodies responsible for the present separate disciplines, i.e. two water departments, two sewerage departments and the JEAPA.

An external body, probably the CNA, would best be promoted to advise and assist in the establishment of the organization. It would have to involve itself in an audit of the available personnel to assess the strengths and weaknesses of the organization and appoint new managing engineers in key positions within the organization.

The amalgamation of currently separate organizations is bound to cause difficulties and some conflicts of interest. Promotion of enthusiastic and efficient persons from within the present structures should encourage an atmosphere of motivation. It could serve the institution best if the important post of General Manager was filled from outside of the current organizations.

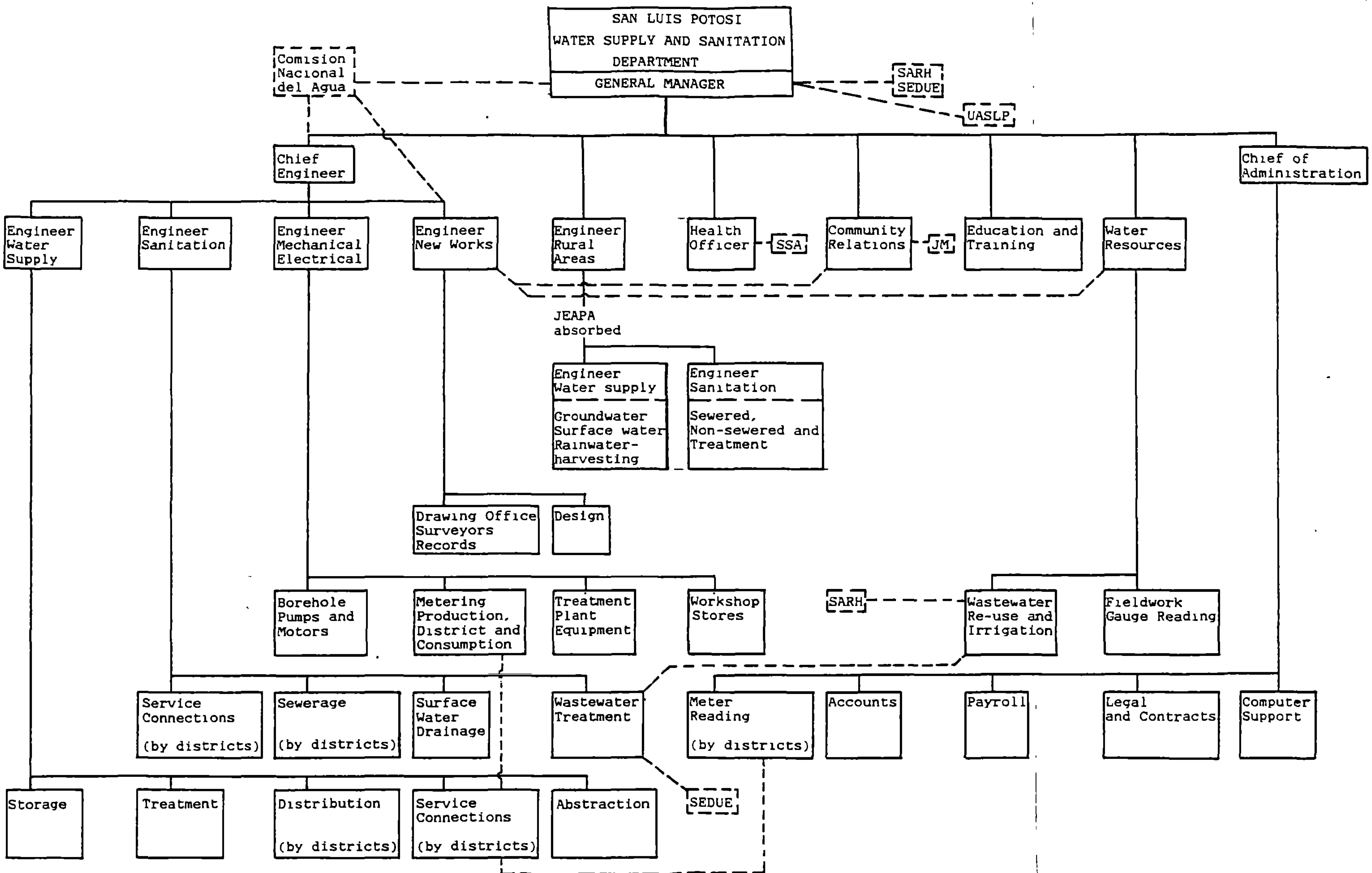


Figure 3.5 Organizational Structure of a Single Institution

The organization structure in Figure 3.5 shows the water distribution system, sewerage system and service connections managed by district. Initially an important division should be along the existing municipal boundary - this would allow the existing organization to continue to function as now but under the umbrella of a new general manager. Some degree of competitiveness could be introduced at this stage by the use of performance targets to encourage efficient practices and procedures.

The size of the organization may need reducing in the long term as it aims for improved efficiency. The current size of the San Luis Potosi water department is about 1400 consumers/employee and 310 connections/employee (*Ginfos, 1991a*) which compares to 1700-2500 and 660-970 respectively for some English water companies (*OFWAT, 1991*).

At the time of implementation of a new organization and revised tariffs (and in the case of sanitation services, newly imposed tariffs) it would be difficult to determine the efficient size. Determining staffing levels and tariff structures might wisely be set as priority tasks. This should also include a fair tariff structure for treated wastewater re-used for agricultural purposes. Also the current programme of works as outlined in Section 2.5 would have to be reviewed with respect to new requirements and initiatives.

The changeover to a single organization would be a stressful and difficult time, there would be many problems and initially it would probably appear that more problems were being created than solved. However in the long term a

single autonomous body running the water sector must be preferred if San Luis Potosi is going to be able to survive the imminent problems of water supply shortage and unsanitary wastewater disposal.

CHAPTER FOUR
A PROGRAMME FOR INSTITUTIONAL DEVELOPMENT

4.1 Components of an Institutional Development Programme

The imminent re-organization of the water supply and sanitation departments to create independent bodies able to set realistic tariffs provides an opportunity for a more radical change - the creation of a single institution to manage the water sector in San Luis Potosi, as described in Section 3.3.

The process of assessing output measures in Section 2.2 indicates that a full Institutional Assessment may be warranted. This judgement combined with the proposed amalgamation of the water sector organizations leads to the second key recommendation of this report, that the new institution with a long-term future should be developed and strengthened by means of a suitable, self-implemented project (*Franceys, 1990*).

Although experience (*Edwards, 1988*) suggests that effective institutional development projects are not common, three important factors relating to the external environment are conducive to potential success:

a) Local Government is supporting current reforms, and the CNA would support the changes as they have been considering the need for a single institution.

b) The consumers are demanding better services, population growth demands expansion, and the

"problem of water" appears as the first item of the current television campaign of one of the candidates for governor.

c) Economic factors will dictate that unless improved water services and wastewater disposal methods are introduced the local economy may suffer.

Whilst a full Institutional Development Programme can be considered for the proposed single organization it is felt that a productive exercise is to concentrate on one section of the organization for which a reasonable amount of information is available.

The drinking water department of San Luis Potosi municipality is the largest of the four organizations and would contribute the greatest numbers to the proposed organization. It has certain programmes of work at the moment that could be incorporated into a development programme, or form the basis of one, and lessons learned during implementation would extend readily to include the system in the neighbouring municipality.

Therefore it is proposed to identify a project that can be implemented by the Water Supply Section.

The institutional development programme should consider the five project goal areas suggested by Edwards (*1988*), namely:

a) Management development.

b) Systems and procedures development.

c) Commodities.

d) Training systems development and skill training.

e) Structural and organizational adjustment.

Of these, the proposed change to a single organization accounts for point (e) satisfactorily, although this should not be an end in itself and structural changes should be made cautiously.

It is felt that the other four points can be addressed effectively by a project based upon a programme of reduction and control of unaccounted-for water.

Such a programme requires "a continual repetition of a series of simple, logical processes and tasks to obtain increasingly accurate detailed data that facilitates ever more efficient detection of deficiencies" (*Jeffcoate and Saravanapavan, 1987*).

Project goal (b) above will be met by the carrying out of steps such as checking basic data, surveying actual consumption, mapping and/or re-mapping, checking un-metered consumption and reviewing meter-reading procedures. The systems and procedures developed will be more effective if prepared by the staff themselves rather than imposed from outside.

Project goal (c) will be met by testing and maintaining the existing equipment and facilities, installing new or repaired equipment as required, and introducing new apparatus as an essential component of the programme such as portable flow meters with recording charts, listening sticks, micro-computers and vehicles.

Project goal (d) will be met by the systematic introduction of new methods and skills on a district by district basis, starting with a pilot area. The learning process will also spread to and from the staff of the two municipalities as each will have their own particular areas of strength.

Project goal (a) will be met in a number of ways. The development of new systems and procedures should provide management with information to allow it to function more effectively. The use of performance indicators and targets should be introduced at an appropriate level of detail and breadth of view. Some management training will be necessary and the important aspect of incentives will need to be considered. However, it is felt that there is currently a key leader in each of the water departments who is committed to improving efficiency and introducing new ideas to improve the service provided to the consumer. It is in these key leaders that the willingness to change can be identified (*Edwards, 1988*) and through them, the institution developed.

In addition to providing the elements of an institutional development programme the reduction and control of unaccounted-for water will go some way towards relieving the urgency with which a new source of supply needs to be won. Whilst a reduction in wastage cannot be thought of as an alternative "source" it may postpone the date when a new supply will need to come on stream.

Leak reduction efforts have also been found to be a quick and cost-effective solution to a city's drinking-water

shortages (*AWWA, 1987*) and can reveal other distribution problems that would otherwise go unnoticed.

It is not expected that sophisticated hydraulic analyses will be carried out, but large amounts of data will be collected and will need to be processed and stored. Such data bases provide the foundations for future computer applications such as Network Analysis and it would be wise to involve the Engineering Faculty at the University at an early stage.

It is understood that there is not a specific computer program, such as the UK's WATNET, that is being used for teaching of network analysis. It is suggested therefore that the water department and the UASLP obtain computer programs for both water distribution networks and sewer hydraulics, for example those promoted by the World Bank (*UNDP, 1987; See Appendix D*). It would be possible to begin to devise suitable training programmes to provide a source of skilled graduates for the time when the organization is able to start constructing computer models of its systems.

4.2 A Programme of Reduction and Control of Unaccounted-for Water

It is proposed above that the elements of an institutional development programme can be found in a project for the water supply section of the single institution based on a programme of UFW reduction and control.

It is recommended that the working guidelines of the World Bank be followed (*Jeffcoate and Saravanapavan, 1987*), the report is available in Spanish (See Appendix D).

The programme itself cannot be started here but initial observations, suggestions and examples are presented to show how the programme could readily be implemented in San Luis Potosi.

4.2.1 Estimate of UFW

The first step is to compare total water production and consumption. The departments' estimates for leakage are 32% for San Luis Potosi and 39-54% for Soledad de Graciano Sanchez (*Ginfos, 1991a and b*).

At the present time neither supply is fully metered for production and only San Luis Potosi has near full coverage of consumer meters, so only estimates can be made. Table 4.1 presents a calculation of UFW from the basic data available in the source, it can be seen that the results differ slightly from the quoted leakage rates.

The amount of UFW is presented in various forms, and a fuller explanation of the appropriateness of these is given elsewhere (*Jeffcoate and Saravanapavan, 1987*). Percentage of water produced is the common form used worldwide, in Europe litres per property per hour is becoming popular and thought to be more meaningful and cubic metres per property per billing period (in this case, every 2 months) is suggested as an interesting approach.

Table 4.1 Estimates of Unaccounted-for Water

		SLP	SGS
Total water produced:			
surface water sources		117 l/s	-
boreholes		1725 l/s	402 l/s
		1842 l/s	402 l/s
Total water consumed:			
domestic		902 l/s	155 l/s
commercial		147 l/s	-
industrial, general		74 l/s	-
industrial, specific		58 l/s	-
other		8 l/s	-
		1189 l/s	155 l/s
UFW		35%	61%
	≡	653 l/s	247 l/s
	≡	20 l/prop.h	37 l/prop.h
	≡	28 m^3/prop.bim	54 m^3/prop.bim

Source: Ginfos, 1991a and b

Basic data checks such as the above showing UFW levels above 25% indicate that a preliminary investigation for UFW is justified (*Jeffcoate and Saravanapavan, 1987*).

4.2.2 Production Meters

The second step is to check the reliability of production figures. Flow meters have been installed at 45 of the 70 boreholes in San Luis Potosi and it is planned

that all 20 boreholes in Soledad de Graciano Sanchez will be so equipped in the near future. This will provide the department with useful information, however some points should be noted.

Some of the installations do not comply with normally accepted criteria for straight sections of pipework upstream and downstream of the meter (*IWES, 1984; and Jeffcoate and Pond, 1989*), and this may lead to inaccurate readings, compare Figures 4.1 and 4.2.

Also the pipework layouts at some of the borehole locations do not allow for either removal of the flowmeter without shutting off the pump or discharging to waste through the flowmeter to check its accuracy. Reference to two World Bank publications is recommended (*Jeffcoate and Pond, 1989; and Jeffcoate and Saravanapavan, 1987*), and installations not yet started in San Luis Potosi and Soledad de Graciano Sanchez should consider such design points as necessary.

A good example of an installation is shown in Figure 4.1. This installation, Borehole No.27 at Fray Diego de la Magdalena, includes a branch to receive a water level meter, an air-valve, a pressure gauge, non-return valve, sampling tap and flow meter. However it could usefully have a by-pass or diversion-to-waste facility for checking the flow meter.

Borehole No.15 at Vallejo, Figure 4.2, however is not so good with a complicated pipework layout and no appurtenances other than the flow meter.

Meter reading is carried out by a man stationed at each well who records the volume supplied in each 24-hour period, on a monthly form, which is processed by computer on a monthly basis. Currently the only possible means of determining daily flow variations is by specific observation and this is not done. Only one meter has the capability of a graphic record of flow against time.

It is felt that at present the reading of production meters is carried out satisfactorily and is not susceptible to malpractice.

4.2.3 Design of Districts

Division of the supply area into districts is the next important step.

The distribution systems are ostensibly managed in pressure zones related to a borehole or group of boreholes, however the zones have indistinct boundaries and there is said to be much transfer of water from one zone to its neighbour. The status of any isolating valves is not fully known and there is limited detailed mapping available.

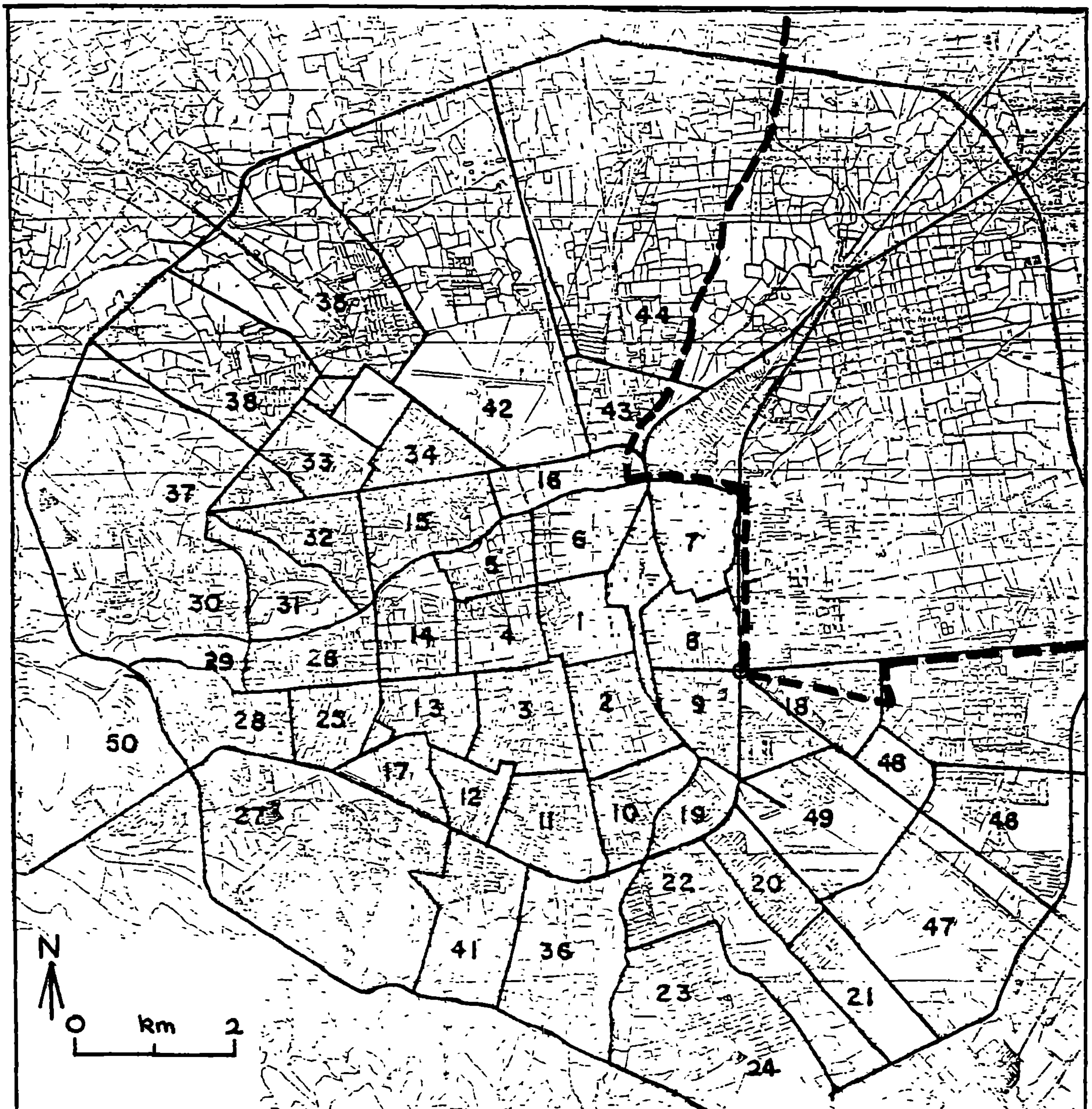
Figure 4.1
Production Meter
Installation -
Borehole No.27

Figure 4.2 Production Meter Installation - Borehole No 15

Districts should be defined based on information concerning pressure levels, age of pipes, pipe material, quality of construction and the frequency and nature of known breaks (*AWWA, 1987*). The essential point though is that each district must be able to be isolated, with flow entering only through meters, either permanently or temporarily.

Initially it is suggested that a pilot district should be identified. The area of the city that is likely to contain the most leaks is the old centre containing the oldest pipes. This is also likely to be one of the more difficult areas to investigate because of the scarcity of records from times long past, the busy nature of the central area in terms of traffic and noise and the likelihood of difficulty in locating underground facilities in an area that has seen many developments over the years. For these reasons it would be wise to select an 'easy' area for the pilot district for training and practising purposes.

The systems lend themselves to being divided into districts because of the distribution of boreholes across the city, a recommended initial size is 5000 to 10,000 properties (*Jeffcoate and Saravanapavan, 1987*) which would mean the two municipalities having between 15 and 30 such districts. The consumer registration system is shown in Figure 4.3 with the number of each region appearing on the consumer's bill, as shown in Figure 4.4. There are fifty or so such regions so a district should encompass 2 or 3 consumer regions.



Note
Regions 39,40 and 45
do not appear

Source : Ginfos,1991a

Figure 4.3 Plan of Consumer Regions

REGION	CONTRATO	MEDIDOR	LECT. ANTERIOR	LECT. ACTUAL	CONSUMO M
3	9176-1	2220145	1923	1963	40

	FECHA LECT	MESES
	12/MAR91	02-03

NOMBRE

DIRECCION
MANUEL MURO 825

FECHA VENCIMIENTO
04/JUN91

MESES ANTERIORES	10-11	12-01
CONSUMO M	40	84
PROMEDIO M	59	30
SU SALDO ANTERIOR		
+ RECARGOS		
+ CONSUMO BIMESTRAL	9900	49400
I.M.		
+ OTROS CARGOS		
- ANTICIPOS Y PAGOS	9900	49400
= SU SALDO NUEVO		

SU SALDO ANTERIOR	
+ RECARGOS	
+ CONSUMO	19600
I.M.	
0 0 0	
OT. COB	
= SU SALDO NUEVO	19600

FAVOR PAGAR ANTES DEL DIA

BIM. ADEUD. 0

LECT. TOMAD.

DEPTO ADMINISTRATIVO DE AGUA POTABLE

USUARIO

H. AYUNTAMIENTO DE SAN LUIS POTOSI

305

H. AYUNTAMIENTO DE LA CAPITAL DE SAN LUIS POTOSI, S.L.P.

DEPARTAMENTO ADMINISTRATIVO DE AGUA POTABLE

DOMICILIO
PLAN DE SAN LUIS 203

CUENTA	MEDIDOR	MESES	REGION	FECHA VENC DIA MES AÑO
59257-7	XXXXXXX	02/03	2	25/JUN91

PAGUESE ANTES DE: 12/JUL/91

SR. USUARIO, CON ESTA FECHA LE ESTAMOS LIMITANDO SU SERVICIO DE AGUA POTABLE BASADOS EN LA LEY DE AGUAS Y EN EL CODIGO SANITARIO EN VIGOR POR TENER UN ADEUDO DE $ 959400.00

EN CASO DE QUE AL RECIBIR EL PRESENTE, ESTE CUBIERTO SU ADEUDO LE ROGAMOS DEJAR SIN EFECTO EL MISMO AL PRESENTAR DOCUMENTACION O PAGOS CORRESPONDIENTES SEGUN ARTICULO 50. BIMESTRES ADEUDADOS : 41

ATENTAMENTE DIRECCION ADMINISTRATIVA DEPARTAMENTO DE AGUA POTABLE
ESTA LIMITACION CAUSARA UN CARGO ADICIONAL DE $10000.00

NOTIFICADOR

2/7/91
FECHA ENTREGA AVISO

Figure 4.4 Water Supply Consumer Registration

The district should be selected bearing in mind the layout of the important mains, as shown in Figure 2.2, and also that it would be wise to choose a district served by boreholes with, relatively, long and reliable flow records. Moreover, the current programme of creation of monitoring points throughout the San Luis Potosi system should be examined to enable the district to be supplied solely through such a monitoring point.

Finally, the guidelines suggest that an attempt should be made to correlate consumption meter statistics with the district boundary.

Bearing the above points in mind a pilot district is proposed in Figure 4.5. The main features of the district are illustrated, but pipelines of less than 4" diameter are omitted for clarity.

The district is in the northern half of the city, covers consumer regions 15 and 32 and is served by three boreholes all fitted with flow meters.

Reasons for selecting this area as an example are as follows:

a) The part of the city north of Avenida Carranza (regions 1, 4, 14, 26 and north of these - see Figures 2.2, 4.3 and 4.5) is served primarily from boreholes whereas the southern part is served from the long distribution main between San Leonel reservoir and the treatment plant (Figure 2.2). It is felt that it would be easier to trace mains from the boreholes to be able to isolate the district.

b) The area is of comparatively recent construction.

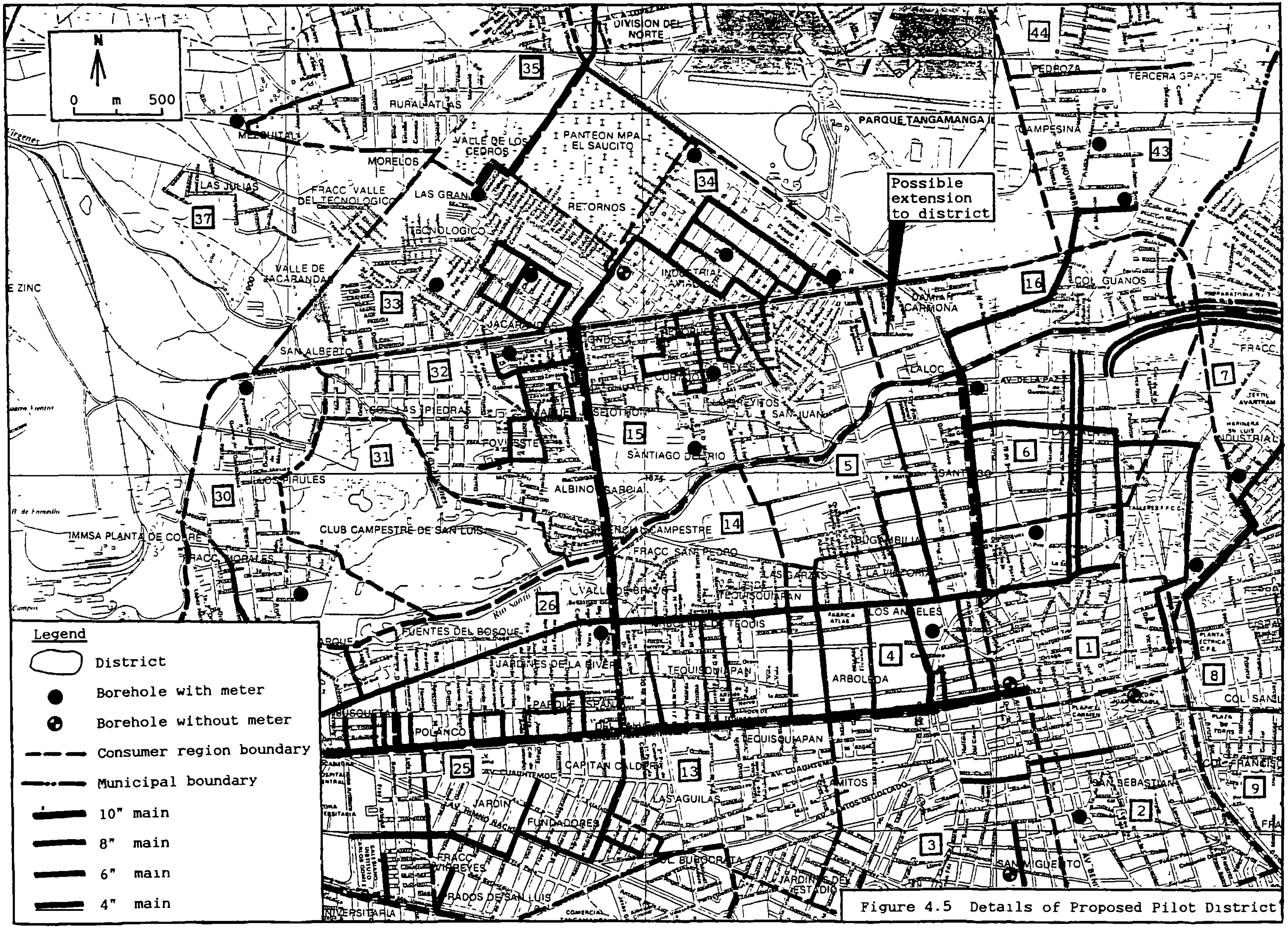


Figure 4.5 Details of Proposed Pilot District

c) It has clear physical boundaries - the Rio Santiago to the south and the railway line to the north. It is felt that any mains crossing these clear boundaries should be more readily detectable than they would be crossing busy city streets. Figure 4.5 indicates one 6" main entering the district from the south.

d) The three boreholes are fitted with meters and are reported to supply about 60 l/s which should provide adequate water for about 29,000 people or 7,000 households.

e) Some monitoring points have been prepared in the area but only with adequate mapping and knowledge of the boundaries of the district will it be known if these have been well sited. This would need review at an early stage.

f) Finally there is one area that could be included in the district at the west end of region 16, depending upon the nature of connections from the 10" main in that area. This is only presented as an example but shows that district boundaries may need correlation with consumer registers.

This selection is not restrictive and it might be considered prudent for initial investigations and a pilot district to be started in the industrial area where the consumers of large quantities of water can often provide substantial revenue to the water department. Although,

unfortunately at present there is a higher frequency of un-metered boreholes in this area.

4.2.4 Consumption Meters

A survey of domestic consumption and a sample study of accuracy of domestic meters is recommended in the guidelines to compare with quantities determined from meter reading to determine the UFW attributable to under-registration, non-metering, inaccurate metering and illegal connections.

It must also be borne in mind that experience in other countries has indicated that meter-reading procedures can be susceptible to malpractice and this may be a component of UFW.

The organization of the city into regions is shown in Figure 4.3 and a typical bill is shown in Figure 4.4.

The meter reading and billing procedure is carried out on a bimonthly basis with the fifty or so regions of the city dealt with in two halves. Half of the regions are billed for January plus February, March plus April, etc. while the remainder are billed for February plus March, April plus May, etc. The meter reading team consists of twelve men requiring that each man reads approximately 150 meters per day.

The accuracy of meter reading may benefit from a sample survey and experience gained in the San Luis Potosi municipality can be applied to the Soledad de Graciano

Sanchez municipality as it begins its programme of consumer metering.

Perhaps the most important first step however in the checking of consumption is to identify the high-use consumers in the district and this should be carried out at the same time as the checking of the production meters.

4.2.5 Mapping

An essential part of operating a water distribution system well is the keeping of good records (*Lackington, 1988*).

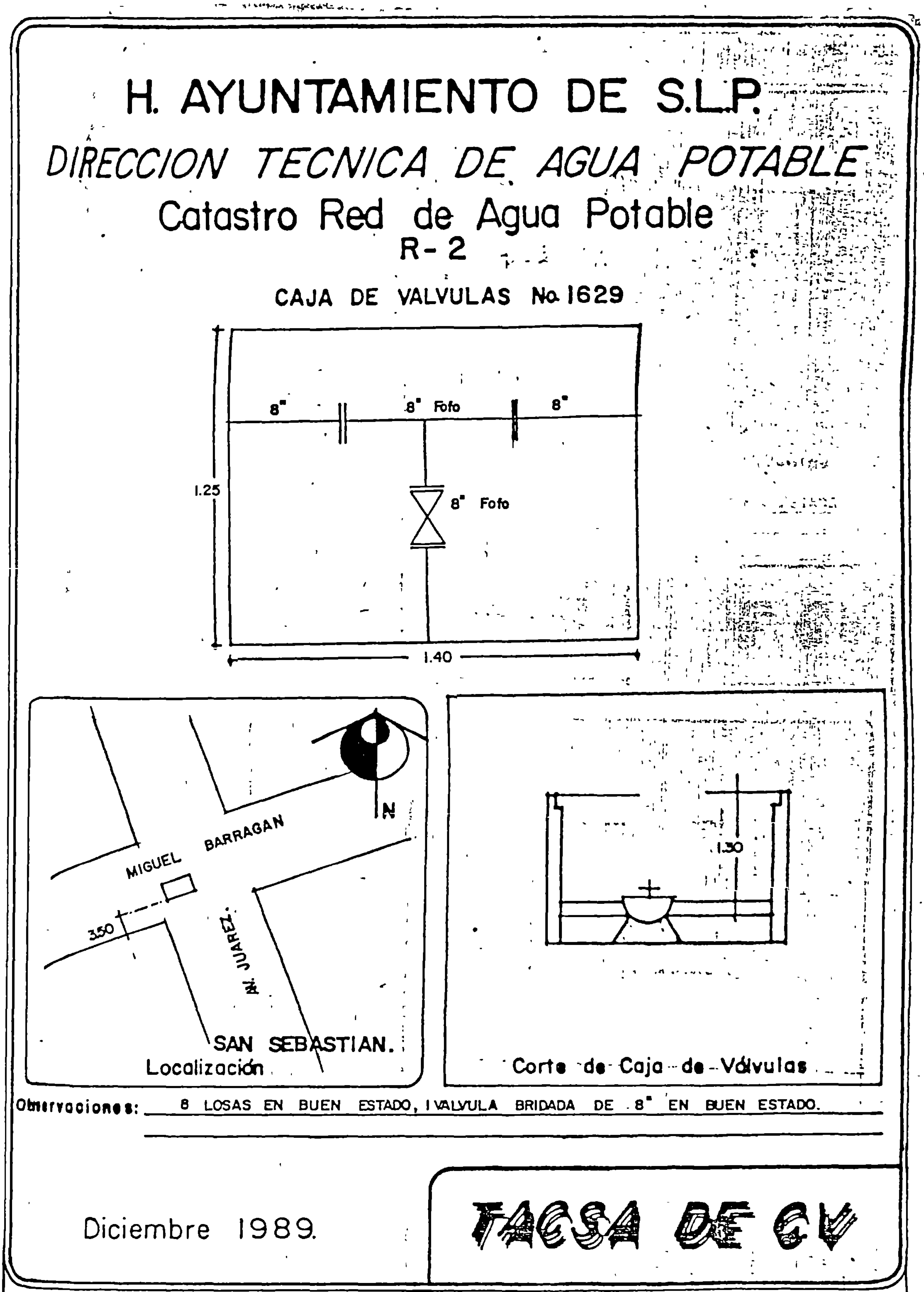
Although full detailed large scale mapping of the distribution system does not exist this does not prevent the UFW programme from starting. However accurate mapping will be required for UFW reduction and control to be effective in the long term.

What is available, for the San Luis Potosi municipality, is a register of valves in the city (*TACSA, 1989*). The records are contained in 4 volumes and consist of the following:

a) Inventory of borehole pumps and booster pumps, motors etc.

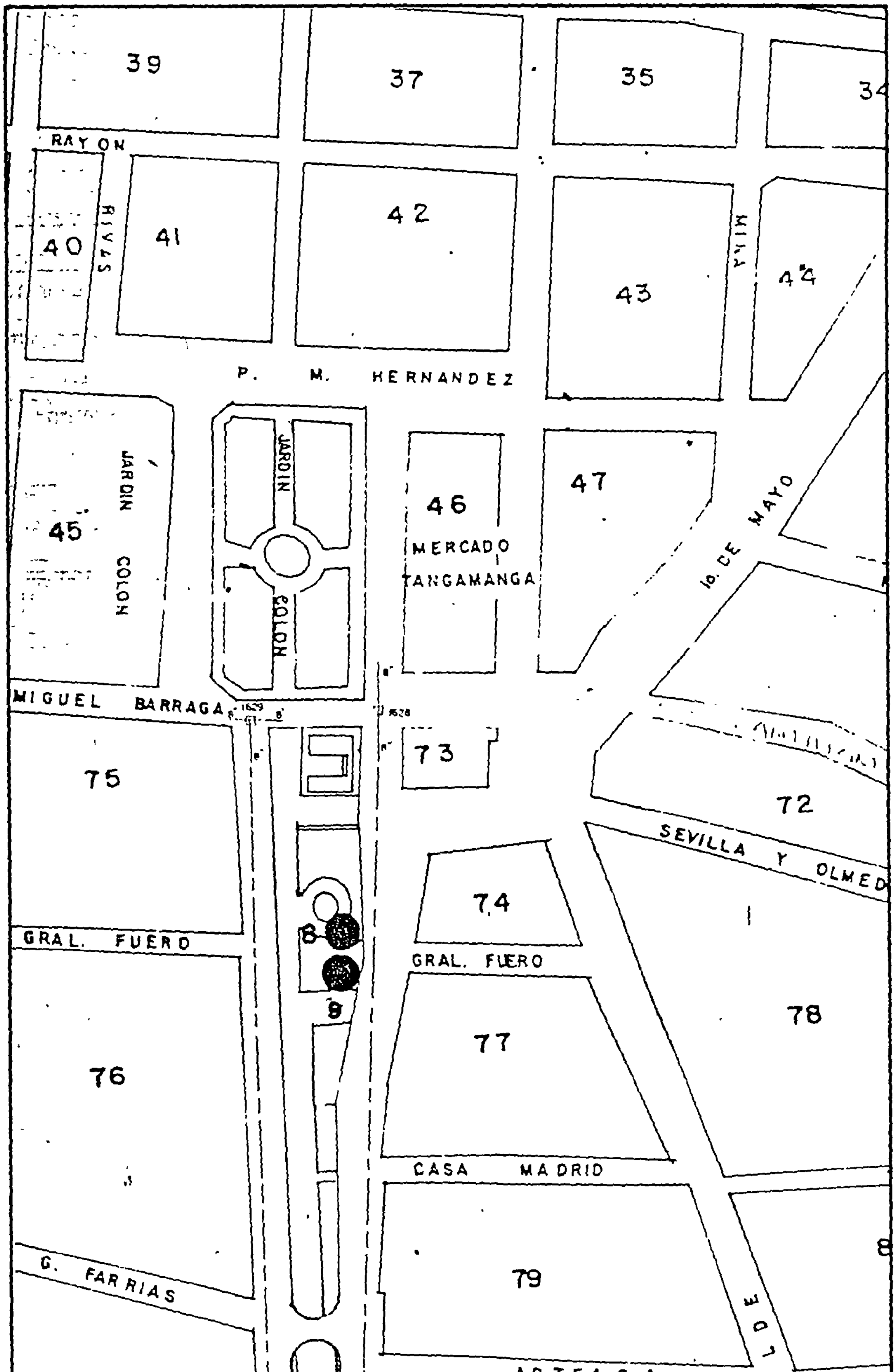
b) Inventory of 1639 No. valve boxes, each having a sheet as presented in Figure 4.6.

c) Plans of the distribution system at the following scales:



Source : TACSA, 1989

Figure 4.6 Typical Valve Record Sheet



Source : TACSA, 1989

Figure 4.7 Typical Detail From 1:2000 Plans

1 No. @ 1:20.000 - showing the city divided into 52 zones

2 No. @ 1:7,500 - showing the city in 2 parts

10 No. @ 1:5,000 - showing the city in 10 parts

42 No. @ 1:2,000 - these do not cover the entire city

The combination of the valve sheets and the plans provide the beginnings of a data base for the system but they are inadequate in a number of areas:

a) The 42 plans do not coincide with the 50 consumer regions that the city is divided into.

b) The 42 plans are only available as prints, not as transparencies which would be preferred.

c) The valves have been numbered sequentially from 1 to 1639, although each valve sheet has a region number e.g. R-2 on Figure 4.6, the plans only show the sequential valve number. It would have been preferable to number the valves sequentially within regions.

d) The plans and valve sheets have no information on levels. Although the city is relatively flat this information is necessary for any future network analysis.

e) The plans do not show sufficient details of pipelines. Figure 4.7 shows an area around one of the boreholes but there is little information about the system in an area that must contain other junctions and appurtenances.

f) There is no information recorded on the plans regarding the pipe material.

Adequate mapping of the urban area at a scale of 1:1000 on 226 No. sheets with levels is available at the Direccion General de Catastro (General Department of Land Registry). It is therefore recommended that any remapping be carried out using transparencies at this scale. With valves numbered sequentially within each district as defined in Section 4.2.3 above. As mapping of the Soledad de Graciano Sanchez area commences, the above mentioned deficiencies should be avoided.

4.2.6 Method of Leakage Control

There are different methods leakage control that can be adopted (*WAA, 1985*), the World Bank guidelines start with district metering. For the steps outlined in Sections 4.2.1 to 4.2.5 a team should be created from within the water supply section of the new organization and much of the work required will mesh with the routine tasks of the staff.

Additional efforts will be required however and many of these will take place in the field.

The first requirements will be for a review of the existing arrangement for leak detection and procedures for reporting and making repairs. (*Jeffcoate and Saravanapavan, 1987*). Only passive leak detection is carried out at present and it is not known how effective this is.

As in any project there will be a need for plant, labour and materials. It is not known what equipment is currently used or available, it is felt that stethoscopes

should be used initially for soundings as they are a cheap, robust and reliable instrument. (*WAA, 1985*).

The manpower required will depend upon the need for quick results. The guidelines (*Jeffcoate and Saravanapavan, 1987*) suggest a team of one inspector and one assistant can perform 100 soundings per day. For the pilot district of say 7,000 properties, 70 team-days would be required, say 3 teams occupied for about 5 weeks. The rate of sounding is similar to the rate of meter reading (see Section 4.2.4) and it is suggested that the sounding teams should cover the district with the meter readers which will help in location of service connections and finding stop-taps. It is also suggested that a policy of involving the borehole watchman in these teams be considered. By providing suitable incentives he can be encouraged to have greater responsibility for the immediate vicinity and become an important link in the consumer/department relationship.

Finally, material requirements must be assessed. There is little point in locating leaks to facilitate UFW control if they are not repaired. A stocktake of repair material should be undertaken at an early stage in the programme and deficiencies remedied as best as possible.

Suitable training in all areas will be required but initially the technical skills required are not too high and not beyond the scope of the current workforce. With suitable planning and managing, a pilot district should be able to provide positive results which will be replicable across the whole of the distribution systems.

4.2.7 Use of Computers

Although sophisticated network analysis is not expected at an early stage any data collation must be planned accordingly to ensure sufficient information is available.

Simple data bases will undoubtedly be required to maintain records and registers.

As far as network analysis is concerned the following information is required:

a) Pipes - material, age, condition, diameter, length, friction coefficient (the Hazen-Williams 'c' value or the effective roughness 'k_s' for the Colebrook-White formula depending upon the program to be used).

b) Nodes, i.e. junctions - ground elevations at the node and at the highest and lowest ground supplied from the node, demands at the node and supplies at the node.

c) Sources, i.e. reservoirs - top and bottom water levels, plan areas, elevation/storage characteristics and inlet float valve details.

d) Pumping stations - head, flow and power characteristics.

e) Other appurtenances - pressure reducing valves, non-return valves, pressure sustaining valves, break pressure tanks etc.

f) Demands - groups of consumers, individual consumers, diurnal variations and peaking factors.

Some of this information will be readily available or easily obtained, other may be more difficult to obtain. As suggested in Section 4.1 involvement of the University would be useful, for instance using the hydraulics laboratory to assess friction coefficients of pipes.

4.2.8 Programme Implementation

The use of a programme of reduction and control of unaccounted-for water has been proposed for the water supply section of the proposed single institution. Its aim is to assist in developing and strengthening the institution in key areas.

It would be possible to identify a similar project for the sanitation section, perhaps a sewer survey followed by an impermeable area survey leading to a Drainage Area Plan for the city. As in the UFW control project the building of an adequate data base of the existing system is perhaps the most vital task to be accomplished.

Neither of the ideas, UFW control or a sewer survey, require great technical ability nor extensive financial or material resources, merely the will to do it and managerial skill to see them through.

There is also the possibility of assistance being available through the current involvement of the British Overseas Development Administration (ODA). As mentioned in Section 2.5. SEDUE are currently implementing the construction of two wastewater treatment plants and the ODA have commissioned a firm of Consulting Engineers to provide

technical support in a number of areas. One aspect of this support will be in the area of control of wastage of water.

It is perhaps through this arrangement that the impetus for the programme can be found. The consultant should be able to provide training for an adequate number of local staff and likewise the institution should find a sufficient number of motivated employees.

The external nature of the consultant might also enable it to apply itself to the problem of lack of records and retention of local knowledge of key operations.

CHAPTER FIVE
CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Rapid industrialization and a fast growing population are placing greater burdens upon the water supply and wastewaster disposal systems of the urban areas of the San Luis Potosi and Soledad de Graciano Sanchez municipalities.

The deep aquifer that provides 93% of the water supply is being mined at current rates of extraction and insanitary methods of wastewater disposal are creating environmental and public health hazards.

There are several existing organizations connected with the water sector in the two adjacent municipalities but the boundaries between their responsibilities, involvements and interests are blurred. This is not conducive to managing the system effectively.

The key organizations themselves are lacking in performance in some areas and specifically their dearth of adequate records and limited detailed knowledge of the systems' characteristics inhibit effective operation.

The future developments likely to occur are not only going to place increasing pressure on the systems and the organizations but they are also going to produce a single urban area out of the two municipalities (if they have not done so already).

This observation combined with the knowledge that (i) there is one important water resource at present (ii) a future source of water is more than likely to be developed uniquely for the whole of the urban population and (iii) the environmental and public health hazards affect everybody, lead to the most important conclusion and recommendation that the existing organizations involved in providing water supply and sanitation services to the two municipalities be merged to form a single institution.

5.2 Recommendations

In addition to the main recommendation above proposing the creation of a single institution for the water sector in San Luis Potosi other specific recommendations arise from this report. These are summarised below.

An institutional development programme should be introduced, based on existing committed managers and the proposed restructuring, to improve the systems and procedures in use, the human resources available and the existing physical resources.

The institutional development programme proposed has been limited in this report to one area - a programme for the reduction and control of unaccounted-for water. Examples of how the existing facilities and resources can be used have been presented and recommendations specific to those items are contained in Chapter 4.

It is suggested however that the following main ideas be adopted by the water supply section:

a) Obtain a copy/copies of the World Bank Working Guidelines for Unaccounted-for Water, in Spanish. (*Jeffcoate and Saravanapavan, 1987*) (See Appendix D).

b) Obtain a copy/copies of the World Bank Working Guidelines for Large Water Meters (*Jeffcoate and Pond, 1989*) (See Appendix D).

c) Review domestic consumption rates, especially in the light of the CNA national campaign for the control of wastage and efficient use of water.

d) Introduce the concept of districts to the system and co-ordinate domestic meter records with them as necessary.

e) Improve mapping of the distribution system and generally strengthen the record keeping.

f) Obtain water distribution network analysis computer programs such as those promoted by the World Bank. (See Appendix D for details).

g) Introduce the concept of Performance Indicators in appropriate areas as a management aid.

h) Record on plans the location and details of leaks, bursts and repairs in the water distribution system.

This report has dealt primarily with the situation pertaining in the urban area of the two existing municipalities. It was recommended in Section 3.3 that the single institution absorb the rural water supply and sanitation body, the JEAPA. The existing municipal bodies are responsible for their own rural areas and it is

therefore recommended that the extent of the coverage of the proposed single institution be reviewed at state level with reference to the CNA.

The creation of a single body to manage all aspects of the water cycle in and around San Luis Potosi is recommended. Specific recommendations have been formulated to identify areas where the new institution can develop from the existing resource base.

It is hoped that with those ideas the seemingly great problem facing the city as regards its water supply and wastewater disposal can be overcome by means of effective management and sound engineering as San Luis Potosi celebrates its 400th anniversary in 1992.

5.3 Achievements of the Project

The true achievements of this project will only become apparent with time. It is the responsibility of the parties concerned to adopt in part or in full any of the main recommendations or other suggestions made in the report.

The views expressed are the author's personal ones and are made from the position of an external observer. This naturally has its benefits and its limitations. The author wishes to emphasise the acknowledgement of those organizations that opened their doors to him and accepted his questioning.

The field trip provided invaluable experience - visiting a formerly unknown area, conducting a study with

minimal back-up and attempting this within an unfamiliar culture and using a different language.

It is felt that the proposals for a single institution and the implementation of a programme for the reduction and control of unaccounted-for water respond to the interests expressed in the National Water Commission and the Drinking Water Departments. The author would be delighted to discover that the project has contributed to the future development of San Luis Potosi.

REFERENCES

American Water Works Association (1987);
Leaks in Water Distribution Systems; AWWA, Denver.

BSI (1985);
British Standard Code of Practice for Building Drainage BS 8301:1985 (Clause 8.8); BSI, London.

Cullivan D., Edwards D.B; McCaffery J; Rosenweig F. and Tippett B. (1986);
Guidelines for Institutional Assessment, Water and Wastewater Institutions, WASH Technical Report No. 37; USAID, Washington.

Durazo J. and Farvolden R.N. (1989);
The Groundwater Regime of the Valley of Mexico from Historic Evidence and Field Observations; J. Hydrology 112 (1989), 171-190.

ECLA (1979);
Water Management and Environment in Latin America, (Water Development, Supply and Management Vol.12); UN Economic Commission for Latin America, UNEP, Pergamon, Oxford.

Edwards D.B. (1988);
Managing Institutional Development Projects: Water and Sanitation Sector, WASH Technical Report No.49; USAID, Washington

Franceys R.W.A. (1990);
Community and Management, course notes; WEDC, Loughborough.

Garduno H. (1985);
Interregional Water Transfers in Mexico; from Golubev G.N. and Biswas A.K. (1985); Large Scale Water Transfers: Emerging Environmental and Social Experiences; UNEP; Tycooly Pub. Ltd., Oxford, UK.

Ginfos (1991a);
Estudio de Factibilidad Tecnico, Economico y Financiero del Sistema de Agua Potable y Alcantarillado en San Luis Potosi, S.L.P; Ginfos S.A. de C.V., Mexico D.F.

Ginfos (1991b);
Estudio de Factibilidad Tecnico, Economico y Financiero del Sistema de Agua Potable y Alcantarillado en Soledad de Graciano Sanchez,, S.L.P; Ginfos S.A. de C.V., Mexico D.F.

Gobierno del Estado de San Luis Potosi (1991);
Periodico Oficial del Estado; SLP.

Hunt S. (1990);
Quest for Water; IRDC Reports, October 1990, 8-9.

Instituto Mexicano de Tecnologia del Agua, (1987);
Estudio Geohidrologico del Valle de San Luis Potosi y Villa de Reyes; IMTA, SARH & UASLP.

IWES (1984);
Water Distribution Systems, Water Practice Manual No.4, Chapter 8; IWES, London.

Jeffcoate P. and Pond R. (1989);
Large Water Meters: Guidelines for Selection, Testing and Maintenance, Technical Paper No.111; World Bank, Washington.

Jeffcoate P. and Saravanapavan A. (1987);
The Reduction and Control of Unaccounted-for Water, Working Guidelines, Technical Paper No.72; World Bank, Washington.

Lackington D. (1988);
Solving Distribution Problems, Developing World Water, pp. 266-271; WEDC, LUT, Grosvenor Press International, Hong Kong.

Lloyd W.J and Marston R.A. (1985);
Municipal and Industrial Water Supply in Ciudad Juarez, Mexico; Water Resources Bulletin (AWWA) 21/5 (1985), pp841-849.

Noriega-Crespo P. (1991);
Personal communication.

OFWAT (1990);
The Water Industry of England and Wales, Levels of Service Information 1989/90; Office of Water Services, Birmingham.

Oldcorn R. (1989);
Management; MacMillan, Basingstoke.

SEDUE (1988a);
Problematica del Agua en San Luis Potosi; SEDUE Audiovisual, San Luis Potosi.

SEDUE (1988b);
Plan Maestro de Agua; SEDUE, San Luis Potosi.

Shearer D.M. (1988);
Performance Comparisons Between Water Authorities; J. IWEM 2, pp500-504.

Steel E.W. and McGhee T.J. (1985);
Water Supply and Sewerage, Fifth Edition, Chapter 6; McGraw-Hill, Singapore.

Tecnicos, Asesores y Constructores S.A. de C.V. (TACSA) (1989);
Estudio Dirigido a Complementar el Catastro Tecnico de la Red de Agua Potable de la Ciudad de San Luis Potosi; TACSA, Mexico.

Trade and Travel Publications Ltd (1988);
South American Handbook 1989, chapter 'Mexico'; Trade and Travel Publications Ltd, London.

UNDP (1987);
UNDP Interregional Project INT/81/047: Development and Implementation of Low-cost Sanitation Investment Projects; World Bank, Washington.

UNICEF (1989);
The State of the World's Children 1989; Oxford University Press, Oxford.

WAA (1985);
Leakage Control Policy and Practice; Water Authorities Association, London.

WHO (1986);
Institutional Development in Community Water Supply and Sanitation, CWS/86.9; World Health Organization, Geneva.

ACKNOWLEDGEMENTS

I would like to thank the following for their considerable help, support and friendliness during my field trip to San Luis Potosi.

Secretaria de Desarrollo Urbano y Ecologia

Arq. Pilar Noriega-Crespo

Direccion Tecnica de Agua Potable, San Luis Potosi

Ing. Ricardo Garza Blanc, Director Tecnico

Ing. Guillermo Escoto Mauricio

Arturo Salgador Orta

Direccion Administrativa de Agua Potable, San Luis Potosi

Lic. Gilberto Estrada Lara, Director Administrativo

Lic. Rodrigo de Artolozaga Noriega

Comision Nacional del Agua

Ing. Martin del Campo

Ing. Manuel Diaz Gonzalez

Ing. Margarita Romero

Ing. Myrna Tapia

Direccion de Obras Publicas, San Luis Potosi

Ing. Francisco de la Rosa Maldonado, Director de Obras Publicas

Departamento de Agua Potable, Soledad de Graciano Sanchez

Ing. Benito Romero

Universidad Autonoma de San Luis Potosi

Ing. David Atisha Castillo, Director, Facultad de Ingenieria

Laboratorio de Hidraulica:

Salvador Martinez Hernandez

Julio Rivera Juarez

Jorge Alberto Rodriguez Robledo

In addition the advice of David Sims, Len Hutton and Richard Franceys during the project period has been invaluable and I am grateful to Eileen Kearins for helping in the production of this report.

Finally I would like to acknowledge the assistance and support of the following without whom my year at WEDC would not have been possible:

Bob Reed, my personal tutor, for advising me to come to WEDC.

The Overseas Development Administration for the APOS award.

Sir William Halcrow and Partners Ltd for granting me leave of absence to undertake the M.Sc.

Stewart Cale, of Knight Piesold and Partners to whom I am grateful for the interest he has shown in my career.

APPENDICES

APPENDIX A

POPULATION PROJECTIONS

Recent growth rates for Mexico as a whole are 2.2% overall growth and 3.6% for urban growth (*UNICEF, 1989*).

The tables overleaf show that San Luis Potosi has a higher than average growth for Mexico.

Year	Population		Growth Rate (%/y)	
	City	Municipality	City	Municipality
1950	125,662	155,238	- -	- -
1960	159,980	193,670	2.44	2.24
1970	230,039	267,951	3.70	3.30
1980	362,371	406,630	4.65	4.26
1990	489,419	525,819	3.05	2.60
1991	507,399	546,275	3.67	3.89
1992	525,666	563,935	3.60	3.23
1993	544,591	582,167	3.60	3.23
1994	564,197	600,980	3.60	3.23
1995	584,509	620,417	3.60	3.23
1996	605,553	640,474	3.60	3.23
1997	627,353	661,180	3.60	3.23
1998	649,939	682,556	3.60	3.23
1999	673,338	704,622	3.60	3.23
2000	697,579	727,402	3.60	3.23
2001	722,693	750,918	3.60	3.23
2002	748,711	775,194	3.60	3.23
2003	775,666	800,256	3.60	3.23
2004	803,591	826,127	3.60	3.23
2005	832,522	852,835	3.60	3.23
2006	862,494	880,406	3.60	3.23
2007	893,545	908,869	3.60	3.23
2008	925,714	938,252	3.60	3.23
2009	959,041	968,585	3.60	3.23
2010	993,568	999,898	3.60	3.23

Source : Ginfos, 1991a

Table A.1 San Luis Potosi

Year	Growth Rate (%/y)	Population City
1990		120.000
1991	5.5	126.600
1992	5.3	133,310
1993	5.1	140,108
1994	4.9	146.974
1995	4.7	153,882
1996	4.5	160,806
1997	4.3	167.721
1998	4.1.	174.592
1999	3.9	181.407
2000	3.7	188.119
2001	3.5	194.703
2002	3.4	201,323
2003	3.3	207 967
2004	3.2	214.621
2005	3.1	221.275
2006	2.9	227,692
2007	2.8	234,062
2008	2.7	240,387
2009	2.6	246,632
2010	2.5	252,803

Source : Ginfos,1991b

Table A.2 Soledad de Graciano Sanchez

APPENDIX B

WATER SUPPLY TARIFF STRUCTURE

Service Affordability

The current (1991) tariff structure for the San Luis Potosi municipality water supply is shown on the following ge.

average consumption	=	177 l/c.d
average household	=	4.18 persons
2-monthly household consumption	=	177 x 4.18 x 60 ÷ 1000 = 44 m^3
2-monthly water bill	=	\$ 550 x 44 = \$ 24,200
minimum daily wage	=	\$ 9865 (*Noriega-Crespo, 1991*)

2-monthly household income, assuming 2 wage earners

= \$9865 x 2 x 5/7 x 60

= \$ 846,000

Service affordability	=	24200/846000 x 100
	=	2.9% of minimum wage

Variable Tariffs

1.–SERVICIO DOMESTICO:	Importe por M3 Bimestral
a).– 0 – 10	$ 350.00
b).– 10.01 – 20	$ 400.00
c).– 20.21 – 30	$ 450.00
d).– 30.01 – 40	$ 500.00
e).– 40.01 – 50	$ 550.00
f).– 50.01 – 100	$ 600.00
g).– 100.01 en adelante	$ 700.00
2.–SERVICIO COMERCIAL:	
a).– 0 – 10	$ 700.00
b).– 10.01 – 20	$ 750.00
c).– 20.01 – 30	$ 800.00
d).– 30.01 – 40	$ 850.00
e).– 40.01 – 50	$ 900.00
f).– 50.01 – 100	$ 950.00
g).– 100.01 – 250	$ 1,000.00
h).– 250.01 – 500	$ 1,100.00
i).– 500.01 – 1,000	$ 1,200.00
j).– 1,000.01 – 2,500	$ 1,300.00
k).– 2,500.01 – 5,000	$ 1,400.00
3.–SERVICIO INDUSTRIAL:	
a).– 0 – 25	$ 900.00
b).– 26 – 50	$ 1,050.00
c).– 51 – 100	$ 1,100.00
d).– 101 – 250	$ 1,200.00
e).– 251 – 500	$ 1,300.00
f).– 501 – 1,000	$ 1,400.00
g).– 1,001 – 2,500	$ 1,500.00
h).– 2,501 en adelane	$ 1,700.00
4.–SERVICIO INDUSTRIAL ESPECIAL:	
a).– 0 – 50	$ 1,000.00
b).– 51 – 100	$ 1,200.00
c).– 101 – 500	$ 1,400.00
d).– 501 – 1,000	$ 1,600.00
e).– 1,001 – 2,500	$ 1,800.00
f).– 2,501 en adelante	$ 2,000.00

Fixed Tariffs

SERVICIO DOMESTICO:	
a).–Primera (zona residencial)	$ 30,000.00
b).–Segunda	$ 12,000.00
c).–Tercera	$ 7,000.00
SERVICIO COMERCIAL:	
a).–Estanquillos y pequeños comercios	$ 20,000.00
b).–Comercios medianos	$ 80,000.00
c).–Grandes comercios	$ 100,000.00
SERVICIO INDUSTRIAL:	
a).–Pequeñas industrias	$ 40,000.00
b).–Medianas industrias	$ 80,000.00
c).–Grandes industrias	$ 260,000.00
-Servicio industrial especial	$ 350,000.00

Source : Gobierno del Estado de San Luis Potosi, 1991

Table B.1 Water Supply Tariff Structure

APPENDIX C
ORGANIZATION CHARTS OF EXISTING DEPARTMENTS

The three organization charts shown overleaf relate to the San Luis Potosi municipality drinking water department. It was not clear which one had precedence over the others.

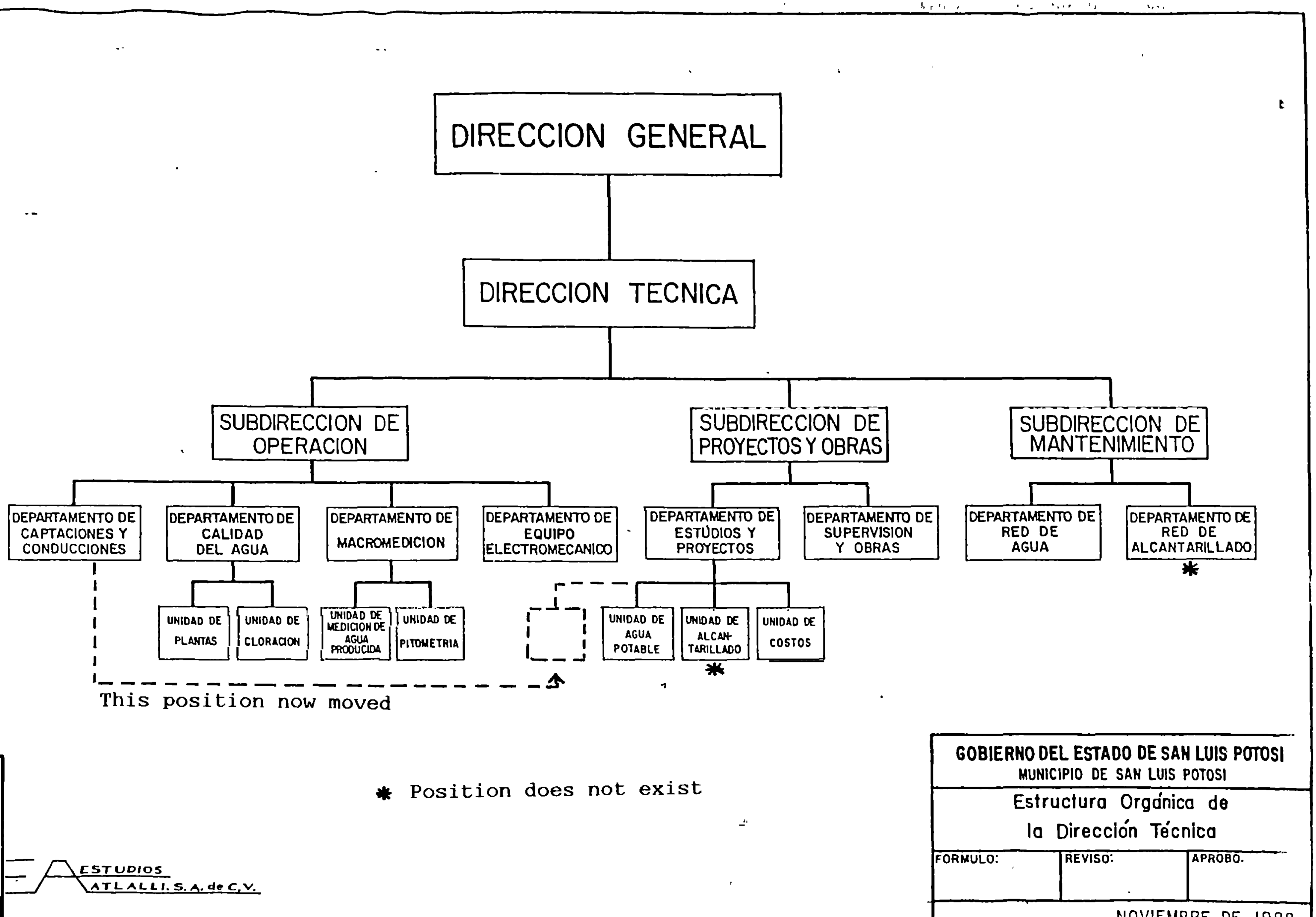
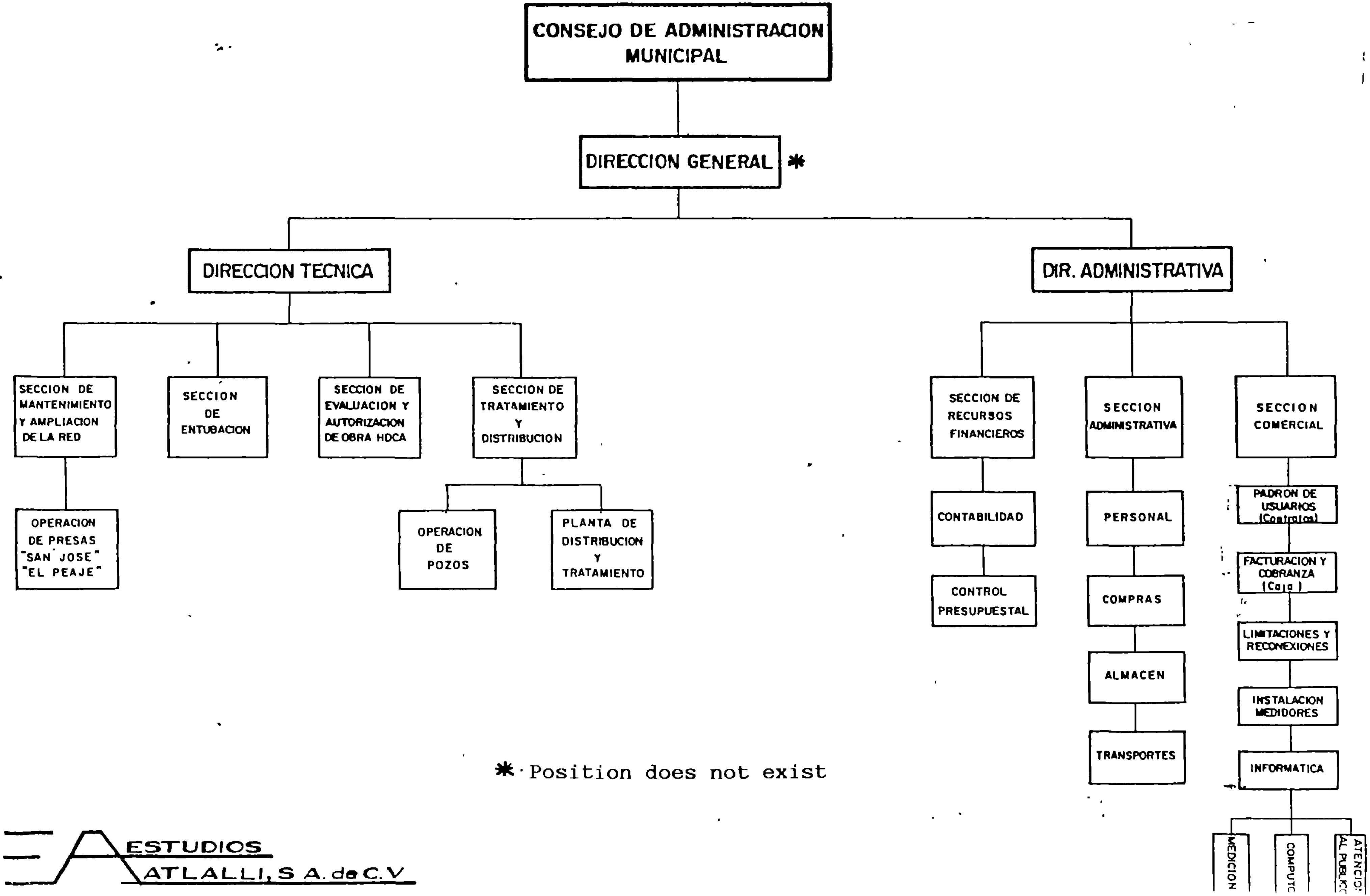

DIRECCION GENERAL
DIRECCION TECNICA
SUBDIRECCION DE OPERACION
SUBDIRECCION DE PROYECTOS Y OBRAS
SUBDIRECCION DE MANTENIMIENTO
DEPARTAMENTO DE CAPTACIONES Y CONDUCCIONES
DEPARTAMENTO DE CALIDAD DEL AGUA
DEPARTAMENTO DE MACROMEDICION
DEPARTAMENTO DE EQUIPO ELECTROMECANICO
DEPARTAMENTO DE ESTUDIOS Y PROYECTOS
DEPARTAMENTO DE SUPERVISION Y OBRAS
DEPARTAMENTO DE RED DE AGUA
DEPARTAMENTO DE RED DE ALCANTARILLADO
*
UNIDAD DE PLANTAS
UNIDAD DE CLORACION
UNIDAD DE MEDICION DE AGUA PRODUCIDA
UNIDAD DE PITOMETRIA
UNIDAD DE AGUA POTABLE
UNIDAD DE ALCANTARILLADO
*
UNIDAD DE COSTOS
This position now moved
* Position does not exist
ESTUDIOS ATLALLI, S.A. de C.V.
GOBIERNO DEL ESTADO DE SAN LUIS POTOSI
MUNICIPIO DE SAN LUIS POTOSI
Estructura Orgánica de la Dirección Técnica
FORMULO:
REVISO:
APROBO.
NOVIEMBRE DE 1989

Figure C.1

DIRECCION GENERAL DE AGUA POTABLE Y ALCANTARILLADO DE SAN LUIS POTOSI



* Position does not exist

Figure C.2

ESTUDIOS ATLALLI, S.A. de C.V.

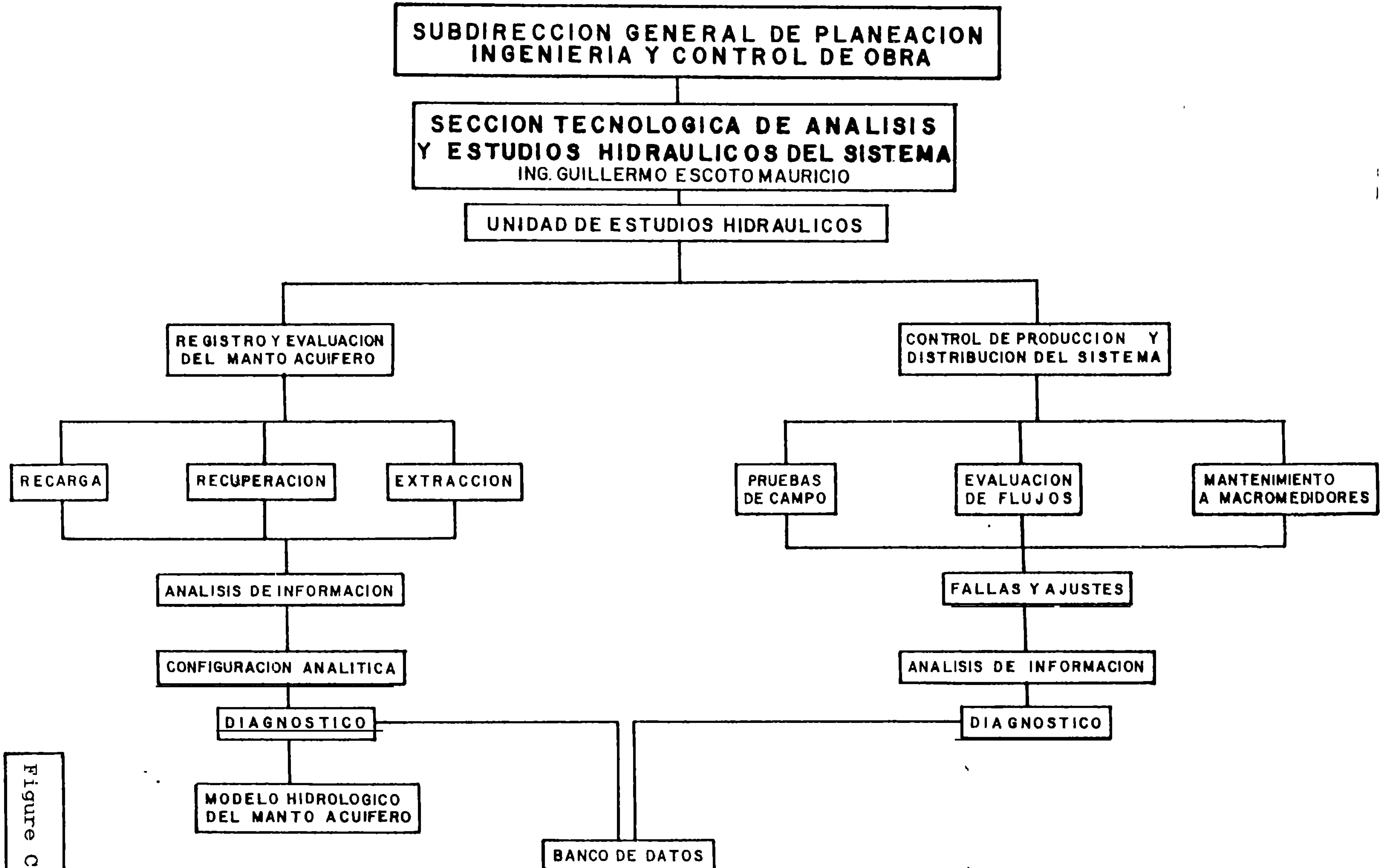

SUBDIRECCION GENERAL DE PLANEACION INGENIERIA Y CONTROL DE OBRA
SECCION TECNOLOGICA DE ANALISIS Y ESTUDIOS HIDRAULICOS DEL SISTEMA
ING. GUILLERMO ESCOTO MAURICIO
UNIDAD DE ESTUDIOS HIDRAULICOS
REGISTRO Y EVALUACION DEL MANTO ACUIFERO
CONTROL DE PRODUCCION Y DISTRIBUCION DEL SISTEMA
RECARGA
RECUPERACION
EXTRACCION
PRUEBAS DE CAMPO
EVALUACION DE FLUJOS
MANTENIMIENTO A MACROMEDIDORES
ANALISIS DE INFORMACION
FALLAS Y AJUSTES
CONFIGURACION ANALITICA
ANALISIS DE INFORMACION
DIAGNOSTICO
DIAGNOSTICO
MODELO HIDROLOGICO DEL MANTO ACUIFERO
BANCO DE DATOS

Figure C.3

APPENDIX D
ADDRESSES FOR OBTAINING MATERIAL

D.1 World Bank Publications:

INFOTEC
San Fernando No.37
Col. Toriello Guerre
Thalpan
Mexico D.F.

D.2 World Bank Computer Programs:

Carlo Rietveld
Sr. Engineer, Technology Advisory Group
Water and Urban Technologies and Assessment
Infrastructure Department
UNDP Interregional Project INT/81/047

at The World Bank
1818 H Street N.W.
Washington
D.C. 20433
U.S.A.

The programs are available free of charge, the following sheets give details of the 10 computer programs and system requirements.

D.3 Other Computer Programs:

In Britain the following programs are produced by the Water Research Centre:

WATNET - Water Network Analysis

WASSP - Wallingford Storm Sewer Package and the address for further information is

WRC Swindon,
PO Box 85,
Frankland Road,
Blagrove,
Swindon,
Wiltshire SN5 8YR
England

Technology Advisory Group

UNDP Interregional Project INT/81/047: Development and Implementation of Low-cost Sanitation Investment Projects

Executing Agency
THE WORLD BANK
1818 H Street N W.
Washington, D.C. 20433, U.S.A.

PROGRAM DESCRIPTIONS **FORM B**

Divider Number	Diskette Number	Description
		The microcomputer programs package contains programs on network design, financial screening and statistical analysis as well as supplementary programs
		Network Design Programs
1	1	BRANCH uses a linear programming algorithm and the Hazen-Williams flow equation for the optimal least-cost design of branched water distribution networks It handles up to 50 pipes, 51 nodes and 9 candidate pipe diameters, as well as multiple sources, existing pipes, and capacity expansion with parallel pipes. It calculates pipe diameters, hydraulic information, and costs The program is menu driven with direct on-screen entry and editing of data It is provided in compiled BASIC form to speed program execution time
2	1	LOOP uses Hardy-Cross analysis and the Hazen-Williams flow equation to simulate flows in looped water distribution networks It enables the engineer to quickly search among several alternative designs and easily find a very good or even optimal design It handles up to 500 pipes, 400 nodes as well as multiple sources with fixed flows or fixed hydraulic gradients, it does not handle booster pumping stations or pressure regulating valves It includes a cost-analysis subroutine The program is menu driven with direct on-screen entry and editing of data It is provided in compiled BASIC form to speed program execution time
3	1	SEWER uses heuristic programming and the Manning flow equation for the optimal design of gravity sanitary sewer systems It is suitable for the design of small bore sewers as well as large-diameter conventional sewers and handles up to 100 pipes and 101 nodes The user must select candidate pipe sizes for which the program calculates slopes, vertical alignments, hydraulic gradients, velocities and similar characteristics The program is menu driven and written in BASIC It is provided in compiled basic to speed program execution time
4	2	FLOW uses a variation of Newton-Raphson's method for solving a system of non-linear equations and either the Hazen-Williams or Manning flow equations (selected by the user) to simulate flows in looped water distribution networks The program is particularly appropriate for designing networks for large cities It handles up to 500 pipes and 500 nodes as well as multiple sources booster stations, and pressure regulating valves Data entry must be done through a separate text editor It is provided in compiled FORTRAN form to speed program execution time
		Financial Screening Program
5	3	SCREEN calculates the construction and equivalent annual costs of a proposed water system design. Based on community data supplied by the user, it produces several indicators of project affordability The program is menu driven and written in BASIC
		Statistical Analysis Program
6	1	REGRESS is a multiple linear regression program that estimates the best fit linear model for data provided by the user It handles data transformations and outputs, and calculates parameter estimates, correlation coefficients, t and F tests, scatter plots, prediction and confidence intervals, and residuals The program is menu driven and is written in BASIC It is provided in compiled basic to speed up execution time

UNDP Interregional Project INT/81/047: Development and Implementation of Low-cost Sanitation Investment Projects
Executing Agency:
THE WORLD BANK
1818 H Street N.W.
Washington, D.C. 20433, U.S.A.

PROGRAM DESCRIPTIONS (Cont'd)

Divider Number	Diskette Number	Description
		Supplementary Programs
7	3	HEADLOSS calculates the friction loss in a single pipeline using the Hazen-Williams flow equation It is particularly useful for quickly checking the capacity of an existing or proposed branched water distribution network to determine hydraulic feasibility It is menu driven and written in BASIC
8	3	MINTREE is a minimum spanning tree algorithm that is particularly useful for finding the shortest path connecting the nodes of a water distribution network It can be used to help identify the primary (branched) network of a looped water distribution network and can help to minimize cost. It does not, however, guarantee that the minimum spanning tree is necessarily the optimal layout of the primary network Data are entered by using DATA statements within the program.
9	3	LINPROG is a general linear programming algorithm that requires data input with DATA statements It automatically supplies slack, surplus and artificial variables It is suitable for engineering optimization problems that can be represented as linear programming models, that is, it can optimize a linear function that is subject to linear constraints It is written in BASIC
10	3	NELDER is a general nonlinear programming algorithm based on an algorithm developed by Nelder and Mead. It is suitable for optimization problems with unconstrained variables. It minimizes a nonlinear unconstrained function with several variables Data are entered by using DATA statements The program is written in BASIC

Technology Advisory Group

UNDP Interregional Project INT/81/047: Development and Implementation of Low-cost Sanitation Investment Projects

Executing Agency.
THE WORLD BANK
1818 H Street N.W.
Washington, D.C. 20433, U.S.A.

FORM C

PROGRAM SYSTEM REQUIREMENTS

Hardware

1 All programs are designed to run on the IBM Personal Computer (IBM/PC) and compatible microcomputers

2 The programs for "BRANCH", "LOOP," and "FLOW" require 256K Random Access Memory (RAM), while the other programs require only 128K RAM.

3. The microcomputer should be equipped with at least one floppy disk-drive, monochrome or color monitor, and parallel printer

4 Graphics capability is not required for any of the programs, although graphics are supported by the program "REGRESS"

Software:

1 The programs and data files are recorded on three 5-1/4 inch double-sided diskettes for PC-DOS version 1 0 and above.

2 The uncompiled programs in BASIC must be used with an IBM/PC or compatible version of BASIC

3 The FORTRAN program "FLOW" cannot be modified by the user without a FORTRAN compiler

4 The compiled programs "LOOP," "BRANCH" "SEWER," and "REGRESS" can be run directly from PC-DOS or MS-DOS BASIC is not necessary

NOTE

The programs currently available will not run on other types of micro-computers A user may wish to transfer the programs onto suitable diskettes for other microcomputers by entering the program listings of the uncompiled versions into the computer manually and making any necessary changes for its version of BASIC or FORTRAN