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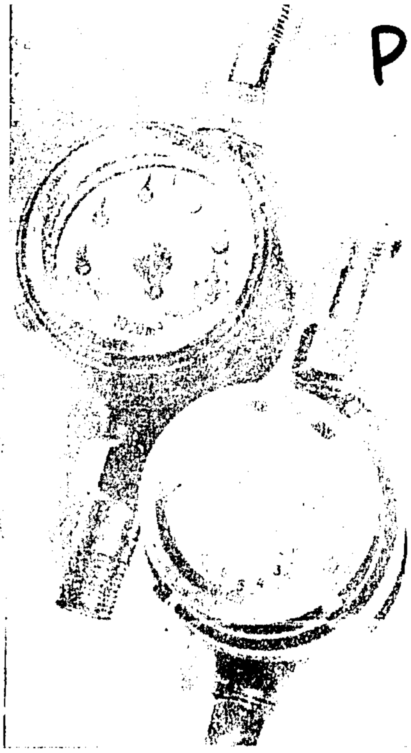

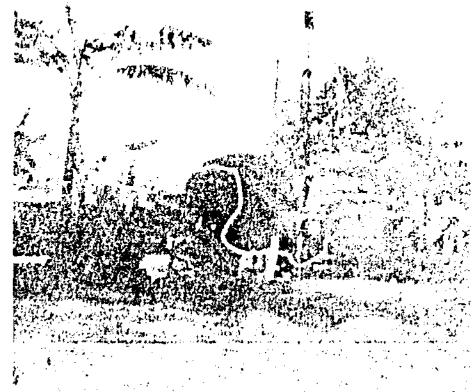

TEXT
VOLUME I

WATER

TUBIG

FINAL REPORT
FEASIBILITY STUDY

WATER SUPPLY

SILAY WATER DISTRICT

SEPTEMBER 1977

PREPARED JOINTLY:

LOCAL WATER UTILITIES ADMINISTRATION
PROJECT STAFF

CAMP DRESSER & McKEE INTERNATIONAL INC.
PROJECT CONSULTANTS

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11 November 1977

Mr. Carlos C. Leaño, Jr.
General Manager
Local Water Utilities Administration
7th Floor, NIA Building
EDSA, Quezon City

Subject: Final Report - Feasibility Study for Water Supply - Silay City Water District (SIL-WD)

Dear Mr. Leaño:

In accordance with the contract between Local Water Utilities Administration (LWUA) and Camp Dresser & McKee International Inc., dated 14 October 1974, and amended on 10 August 1976, we take pleasure in submitting this report.

This report is presented in two volumes: Volume I which contains the recommended plan and detailed analysis, and Volume II which contains the support information common to all urban areas covered in the contract.

Extensive improvements and additions to the present water supply system are needed to overcome current deficiencies and to meet future requirements. The recommended plan is the result of alternative studies and cost of optimization work. While the cost of the recommended long-range water system facilities is substantial, we consider it within the people's ability-to-pay.

The feasibility studies were done utilizing mostly the services of LWUA counterparts to fulfill the on-the-job training requirements of the LWUA/CDM contract. For the next phase, the LWUA counterparts will take the dominant role in the project studies.

We wish to extend our thanks to the LWUA Board, all the members of the LWUA staff, the SIL-WD staff and the officials of various agencies of the Government of the Philippines, who so generously assisted us during the course of our study.

Very truly yours,

CAMP DRESSER & McKEE INTERNATIONAL, INC.

LEONARDO V. GUTIERREZ, JR.
Project Manager

ANTONIO DE VERA
Counterpart Project Manager

FOREWORD

This feasibility study presents the recommended plan for the upgrading and expansion of the water supply system of the Silay City Water District (SIL-WD). This study was made by the Local Water Utilities Administration (LWUA), with the technical assistance of Camp Dresser and McKee International Inc. This study is the result of many months of work in the city of Silay in Negros Occidental Province, and is supported by extensive experience with other water districts in the Philippines during the First Ten Provincial Urban Areas Feasibility Studies.

This study was prepared in two volumes: Volume I, the main report, which contains the recommended plan and the methodology memoranda; and Volume II, which contains detailed background information relating to specific sections of Volume I. A complete understanding of the two volumes would require reading the previously published Water Supply Feasibility Studies Methodology Manual (Volumes I and II), a compilation of the handouts used in the six-month long training seminar conducted in 1975 by CDM during the First Ten-Area Feasibility Studies.

The recommended plan is a technically and economically feasible program for providing the SIL-WD adequate water supply up to the year 2000. The plan should not be viewed as a rigid plan; every attempt was made to develop a plan compatible with the needs and desires of the water district and of the people. However, during the final engineering design of the recommended facilities, changes could still be made. Design changes would be based on more recent field data, changing priorities of the water district and more economical methods of providing the recommended facilities. Any changes considered in the final design should help to further reduce the expected financial impact of the project.

While the main objective of the Second Ten Provincial Urban Areas Feasibility Studies was the preparation of feasibility reports, another important objective was the training of Filipino counterpart engineers in water supply project planning. The training program which included lectures and on-the-job training aimed to develop local planning capability for water supply projects. The Filipino engineers learned by actually doing the work, with the CDM consultants providing the necessary expertise and guidance.

The following have contributed significantly to the development of the Second Ten-Area Feasibility Studies:

James Arbuthnot, Chief Engineer
Eugene Rumph, Hydrogeologist
James DeYoung, Water Supply Engineer
Bruce Conklin, Systems Engineer
Peter West, Distribution Engineer

Antonio de Vera, Counterpart Project Manager
Wilfredo Cevillejo, Counterpart Chief Engineer
Paul N. del Rosario, Group Leader
Delia Castañeda, Economist
Jean Casten, Economist
Lourdes Gutierrez, Technical Writer
Rodulfo Guilleguiwan, SD-WD General Manager

The following project staff members have also contributed to the technical/non-technical work of the studies:

Ronaldo Barboño, Staff Engineer
Reynaldo Tabac, Staff Engineer
Miguel Buenavides, Junior Staff Engineer
Salvador Ner, Junior Staff Engineer
Mario Bermejo, Junior Staff Engineer
Rommel Liamco, Junior Staff Engineer
Meliton Avillanosa, Field Technician
Pedrito Camilet Jr., Field Technician
Cesar Matig-a, Chief Draftsman
Angel Angeles, Draftsman
Meredith Maraño, Secretary/Typist
Cesar Florendo, Printing Assistant
Diosdado Dursa, Printing Assistant

LIST OF ABBREVIATIONS

Organizations

ADB	Asian Development Bank
BAN-WD	Bangued Water District
LB-WD	Los Baños Water District
BAY-WD	Baybay Water District
BIS-WD	Bislig Water District
CAL-WD	Calamba Water District
CDM	Camp Dresser & McKee International Inc.
COT-WD	Cotabato City Water District
DCCD	Design Consultation Construction and Development Engineering Corporation
FER-WD	San Fernando Water District
GAP-WD	Gapan Water District
IBRD	International Bank for Reconstruction and Development
LWUA	Local Water Utilities Administration
MWSS	Metropolitan Waterworks and Sewerage System (formerly National Waterworks and Sewerage Authority or NWASA)
NEDA	National Economic Development Authority
NIA	National Irrigation Administration
NWRC	National Water Resources Council
OLO-WD	Olongapo City Water District
PAGASA	Philippine Atmospheric, Geophysical and Astronomical Services Administration
ROX-WD	Roxas City Water District
SIL-WD	Silay City Water District
URD-WD	Urdaneta Water District
USAID	United States Agency for International Development

Units

AC	asbestos cement
CCI	centrifugally cast iron
CI	cast iron
cm	centimeter
cum	cubic meter
cumd	cubic meter per day
cumd/ha	cubic meter per day per hectare
cum/hr/sqkm	cubic meter per hour per square kilometer
cumd/m	cubic meter per day per meter
cum/mo	cubic meter per month
cum/sqkm/yr	cubic meter per square kilometer per year
FEC	foreign exchange component
GI	galvanized iron
GS	galvanized steel

ha	hectare
HGL	hydraulic grade line
hr	hour
kg	kilogram
km	kilometer
lpcd	liter per capita per day
lpd	liter per day
lps	liter per second
lps/m	liter per second per meter
m	meter
m/ha	meter per hectare
mg/l	milligram per liter
min	minute
mm	millimeter
mm/yr	millimeter per year
mo	month
m/sec	meter per second
MSL	mean sea level
%	percent
₱	Philippine peso
pH	logarithm (base 10) of the reciprocal of the hydrogen ion concentration in water, moles per liter
PVC	polyvinyl chloride
RU	revenue unit
sqkm	square kilometer
sqmd	square meter per day
$	United States dollar
yr	year

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CHAPTER I SUMMARY AND RECOMMENDATIONS

A. SUMMARY OF STUDIES

Description

The Silay City Water District (SIL-WD) was formed on 16 March 1976 by virtue of Resolution No. 162 passed by the city council of Silay. Following its formation, the SIL-WD acquired the ownership and management of the entire water system from the city government.

Silay City is situated in the northwestern portion of Negros Occidental Province in the Western Visayas region. With an area of 18,510 hectares, Silay is divided into the poblacion and 8 barrios. The terrain in Silay service area is predominantly flat, with elevations ranging from 2 to 5 meters above mean sea level. The area is drained by several creeks and streams discharging westward into Guimaras Strait and northward into Malogo River.

The total population of Silay City in 1970 was 69,200, 66 percent of whom were classified as rural and 34 percent, urban. A major source of income is agriculture, with sugar cane as the main crop.

Existing Water System

The water system of SIL-WD was originally constructed in 1931-32, with 2 deepwells as sources. Three other deepwells were drilled in 1947, 1960 and 1965. At present, only three deepwells, located in the poblacion (pump stations no. 1, 2 and 4), are in use and had a measured total production of 3,420 cumd in January 1977. Treatment consists of injecting chlorine gas directly to the distribution mains of the three pump stations.

Storage facilities include a 380-cum elevated storage tank located near pump station no. 1 and a 190-cum storage tank located near pump station no. 4.

The present distribution system covers almost twice the area covered by the original 1931-32 system. The distribution pipes have a total length of 15.5 km of which 51 percent are galvanized steel and 49 percent, centrifugally cast iron. Pipes range in size from 62 to 150 mm.

Projections

The present service area of SIL-WD covers the poblacion and the barrios of Rizal and Mambulac. The service area through the year 2000 will extend to the barrios of Guinhalaran and Lantad.

The total population of the poblacion and the barrios of Rizal, Mambulac, Guinhalaran and Lantad in 1975 was 62,[illegible]24 and is projected to increase to 177,[illegible] by 2000, with average growth rates varying from [illegible] to 5.3 percent per year. During this same period, the population served by the SIL-WD is expected to increase from 5,900 to 103,160.

The per capita demand for water is expected to be 198 lpcd in 1980 with a total average daily usage of 3,090 cumd. The per capita demand is projected to decrease to 193 lpcd in 1990 due to improved water accountability and then increase to 199 lpcd in 2000. The total average daily water usage is estimated to be 10,590 cumd in 1990 and 20,530 cumd in 2000.

Water Resources

The potential sources of water supply for the SIL-WD are deepwells, induced infiltration wells along the Malogo River, and surface water from Imbang River. Because of the relatively small capacities of springs discovered, their great distance from Silay and the difficulty of collecting and amalgamating various sources, springs currently are not considered a practical alternative.

Silay Poblacion is located at the seaward edge of a flat gently sloping coastal plain that supports good wells for domestic, commercial, industrial and irrigation supply. This plain is an excellent widespread aquifer consisting of sands, gravels, silts and clays derived from volcanic ash beds and other volcanic rocks to the east. Recharge to the aquifer is mainly from direct infiltration of precipitation and infiltration from flowing streams in the higher land to the east. Well water can supply the SIL-WD requirements beyond the year 2000 but salinization of coastal wells may occur if well production becomes too great or too concentrated.

Imbang and Malogo Rivers originate in mountains east of Silay and pass at a point 2 km and 7 km, respectively, northeast of the poblacion. Both rivers have minimum flows large enough to meet the SIL-WD requirements of the year 2000. Use of surface water source for water supply would require extensive diversion, treatment and transmission facilities. Because of these factors, economic analysis indicates that surface water would be more costly than groundwater.

Another potential source for the SIL-WD is induced infiltration wells along the Malogo River. However, based on economic studies, water from infiltration wells would be more costly than water from local deepwells. These alternative sources, including springs, should be considered if coastal well water quality deteriorates.

Alternative Studies

Present worth studies on alternative sources of water for SIL-WD indicate that continued use of groundwater from deepwells is the most economical over the project planning period. Surface water from the Imbang River and water from induced infiltration wells along the Malogo River were found to be considerably more costly.

The requirements for the distribution system were analyzed with the aid of a computer and the resulting system is described in detail in Chapter IX. Based on the analysis of the pressure requirements of the system, a single pressure zone has been considered since majority of the service area is situated at almost the same elevation.

Economic analysis of the distribution storage requirements indicates that intermediate quantity of storage and additional capacity of wells to meet the peak flows are the most economical. The existing 190 cum storage would be abandoned because of its low overflow elevation while the existing 380 cum storage would be retained. An additional 1,200 cum storage would be needed to augment well capacities to meet the peak demands up to the year 2000.

B. RECOMMENDATIONS

General

A water supply system utilizing wells, constructed in and near the service area, as the source of supply is recommended for the SIL-WD. Construction of wells, distribution and administrative facilities will be carried out during an immediate improvement program and a long-term construction program divided into four phases. The main features of the recommended long-term project for SIL-WD are summarized in Table I-1 and shown in Figure IX-1 (appended).

Source

A total of 12 wells will supply maximum-day demands of 24,640 cumd to SIL-WD in the year 2000. The three existing sources, wells no. 1, 2 and 4, will be abandoned during Stage I. Chlorination will be the only treatment required, with facilities constructed in a program parallel to the well construction program.

Storage

Because the relatively low overflow elevation of the existing 190-cum storage tank is hydraulically incompatible with recommended facilities, this tank will be abandoned early in the construction program. An additional 1,200 cum of storage capacity, will be

TABLE I-1

SUMMARY OF PROPOSED WATER SUPPLY IMPROVEMENTS
SILAY CITY WATER DISTRICT

	Immediate Improvement Program	Construction Phase I-A	Construction Phase I-B	Construction Phase II-A	Construction Phase II-B
Construction Period	1978-79	1980-85	1986-90	1991-95	1996-2000
Total Project Cost (₱)	5,182,300	11,491,500	9,688,200	13,521,500	10,278,500
Foreign Exchange Component*(₱)	2,648,700	5,288,700	4,806,500	6,174,300	5,213,700
Source Development	Construct one well pump station complete with disinfection facilities	Add 2 wells complete; Abandon existing well no. 2	Abandon existing wells no. 1 and 4; add 4 wells complete	Add 3 wells complete	Add 2 wells complete
Distribution Facilities	100 mm-4.2 km 150 mm-2.2 km 200 mm-3.0 km 250 mm-0.2 km	100 mm-1.3 km 150 mm-2.9 km 200 mm-6.7 km 250 mm- .35 km	100 mm-1.4 km 150 mm-1.7 km 200 mm-4.2 km 250 mm-0.05 km	100 mm-1.0 km 150 mm- .3 km 200 mm-5.4 km 250 mm- .7 km	150 mm- .9 km 200 mm-3.5 km 250 mm- .9 km
Storage		Abandon 190-cum tank; construct 500-cum tank		Construct 200-cum and 500-cum tanks	
Internal Network	Leakage survey and repair	67.4 hectares	93.6 hectares	192.1 hectares	237.3 hectares
Service Connections	Meter existing 908 Repair/replace 318 Add 1,532	Repair/replace 318 Add 3,065	Add 3,065	Add 3,900	Add 3,900
Fire Hydrants		289 hectares	137 hectares	237 hectares	237 hectares
Miscellaneous	Administrative building, equipment and vehicle	Plumbing shop			

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* All foreign exchange figures used in this report were synthesized from data based on actual costs in U.S. dollars. To be consistent with previous studies, these foreign exchange costs were converted to R.P. pesos at a rate of US$1.0 = RP ₱7.0. To obtain correct current foreign exchange costs, multiply those presented in this report by the ratio of the current exchange rate and 7.0. The actual local component of costs (in pesos) is as presented herein.

provided for the SII-WD - a 500-cum tank in 1982 and a 200-and 500-cum tank in 1993 will be constructed to meet the distribution storage requirements to the year 2000.

Distribution Facilities

The distribution system will be reinforced and expanded by the installation of 28.2 km of pipeline with sizes from 100 to 250 mm, by 1990. An additional 12.5 km of pipelines will be constructed by the year 2000 to provide service to additional customers.

By 2000, approximately 929 hectares within SII-WD will receive internal network pipelines. Service connections will be installed in a program parallel to internal network construction. There will be approximately 8,570 and 16,370 service connections within the service area by 1990 and 2000, respectively.

Capital Cost Summary

The capital costs for each phase of construction, including the immediate improvement program, are summarized in Table I-2. A more detailed breakdown of costs for the immediate improvement program and Phase I-A is given in Table I-3 (July 1978 price levels).

Annual Operation and Maintenance Costs

Annual operation and maintenance costs are expenses incurred for personnel, power, chemicals, maintenance and miscellaneous expenses. Estimates of the annual operation and maintenance costs of the water district (based on July 1978 price levels) are given in Table I-4.

TABLE I-2

CAPITAL COST SUMMARY

Construction Phase	Construction Period	Construction Cost (P)	Project Cost (P) Local	Foreign*	Total
Immediate Improvement Program	1978-79	4,224,200	2,533,600	2,648,700	5,182,300
I-A	1980-85	9,436,800	6,202,800	5,288,700	11,491,500
I-B	1986-90	7,985,700	4,881,700	4,806,500	9,688,200
II-A	1991-95	11,162,300	7,347,200	6,174,300	13,521,500
II-B	1996-2000	8,638,300	5,064,800	5,213,700	10,278,500
		41,447,300	26,030,100	24,131,900	50,162,000

*U.S. $1.00 = P7.00

TABLE I-3

COST SUMMARY OF IMMEDIATE IMPROVEMENT
PROGRAM AND CONSTRUCTION STAGE I PHASE A

Item	Cost (₱) Local	Foreign*	Total
A. Immediate Improvement Program			
Source Facilities			
Pump Station and Chlorination Facilities	81,000	161,300	242,300
Distribution Facilities			
Leakage, Detection and Repair	25,000	96,000	121,000
Distribution Pipelines	824,800	771,800	1,596,600
Valves	32,200	44,200	76,400
Service Connections			
Installation, Conversion and Repair	670,500	1,009,900	1,680,400
Administrative and Miscellaneous			
Administrative Building and Equipment	381,000	43,000	424,000
Vehicle	30,000	30,000	60,000
Miscellaneous	6,500	17,000	23,500
Total Construction Cost	2,051,000	2,173,200	4,224,200
Contingencies	248,900	254,900	503,800
Engineering	118,700	220,600	339,300
Land	115,000		115,000
Total Project Cost	2,533,600	2,648,700	5,182,300
B. Stage I Phase A Construction			
Source Facilities			
2 wells complete with equipment and chlorination facilities	807,000	537,600	1,344,600

*US $1.00 = ₱7.00

TABLE I-3 (continued)

Item	Cost (₱) Local	Foreign	Total
Storage Facilities	1,046,500	261,600	1,308,100
Distribution Facilities			
Distribution Pipelines	1,206,300	1,234,900	2,441,200
Valves	25,200	37,900	63,100
Internal Network	393,000	282,700	675,700
Service Connections	1,176,000	1,575,700	2,751,700
Fire Hydrants	193,600	267,800	461,400
Plumbing Shop and Tools	365,000	26,000	391,000
Total Construction Cost	5,212,600	4,224,200	9,436,800
Contingencies	675,600	526,000	1,201,600
Engineering	290,000	538,500	828,500
Land	24,600		24,600
Total Project Cost	6,202,800	5,288,700	11,491,500

TABLE I-4

OPERATION AND MAINTENANCE COSTS

Year	Administration and Personnel	Power and Fuel	Chemicals	Maintenance	Miscellaneous	Total
1976	186,000	43,600	1,900	29,000	24,200	285,300
1980	253,000	128,500	14,100	67,900	35,400	498,900
1985	389,900	272,200	27,800	136,400	57,100	883,400
1990	513,400	416,000	41,500	205,300	91,900	1,268,100
1995	673,600	605,000	59,600	294,000	148,000	1,780,200
2000	757,600	794,100	77,800	370,900	238,400	2,238,800

Financial Feasibility

The financial feasibility analysis made for the study establishes a detailed set of guidelines that the water district management may use in making crucial decisions during the next few years. A plan has been developed to indicate the manner and time funds will be used to operate and maintain the system; implement the program; establish reserve funds; and retire indebtedness. Water rates have been developed on the basis that the system will be financially self-supporting. These rates appear to be within the ability-to-pay of the average SIL-WD householder.

The water rates by revenue unit in three-year increments are as follows:

	Rate/RU
1978-1980	₱0.80
1981-1983	1.20
1984-1986	1.50
1987-1991	1.70

It is recommended that the implementation of these rates follow a socialized pricing policy to make the financial burden on the consumers proportionate to their ability-to-pay. A sample socialized rate structure for 1978-1980 that would generate sufficient revenue is as follows:

Usage per Month	Cost (per cum)
first 16 cum	₱ 0.90
from 17 to 24 cum	1.95
greater than 24 cum	2.75

Borrowing requirements will include ₱6.437 million from 1978 to 1984 for the immediate improvement program; ₱14.[illegible]31 million from 1978 to 1985 for Phase I-A improvements; and ₱15.181 million from 1986 to 1991 for Phase I-B improvements.

Economic Feasibility

The recommended improvements to the SIL-WD water supply system will bring about numerous economic benefits to the study area. Economic feasibility studies show that the benefits will exceed the costs associated with the development and operation of the water system.

Two approaches were adopted to determine economic feasibility: the benefit-cost ratio and the internal economic rate of return (IERR). In both approaches, four benefits valued at 1978 prices were included and discounted at 12 percent. The benefits considered are increase in land values, health, reduction in fire damage and beneficial value of water. Analyses shows a benefit-cost ratio of 1.78:1 and an IERR of 80.5 percent.

CHAPTER II INTRODUCTION

A. FIRST TEN PROVINCIAL URBAN AREAS

The study contract signed by the Local Water Utilities Administration[1] (LWUA) and Camp Dresser & McKee International Inc. (CDM) on 14 October 1974 provided for the feasibility studies for the First Ten Provincial Urban Areas[2] (see Figure II-1). The feasibility studies are part of LWUA's effort to develop basic water supply plans for provincial urban areas of the Philippines.

During the first 10-area project, training seminars for LWUA engineers were conducted by the CDM staff. "The Methodology Manual for Water Supply Feasibility Studies" was also developed and printed. In addition to the 10 areas, prefeasibility studies were also made for 131 cities/municipalities.[3] As of August 1976, the feasibility studies were completed and submitted to LWUA.

The studies for five of the first 10 areas, Cebu, Zamboanga, Daet, Ozamis and Butuan - have been appraised by the Asian Development Bank (ADB). On the basis of the interim reports, the ADB extended a $16.8 million loan to LWUA in December 1975 to provide design engineering services to these 5 areas and to implement Phase I-A of the recommended long-term construction program (except Cebu whose share of the loan covered only engineering services). In August 1976, the United States Agency for International Development (USAID) signed a $10 million loan with LWUA to provide engineering services and funds for the implementation of the interim improvements of selected waterworks covered by the prefeasibility studies. In April 1977, the International Bank for Reconstruction and Development (IBRD) allocated $18.8 million towards the final design and initial phase implementation of the remaining five of the first 10 areas, namely: Lipa, Lucena, Tarlac, Cabanatuan and San Fernando (La Union).

B. SECOND TEN PROVINCIAL URBAN AREAS

On 10 August 1976, LWUA and CDM signed an amendment to the original study contract, extending the feasibility studies to include the Second Ten Provincial Urban Areas.[4] These areas are: Urdaneta, Gapan, Calamba, Bislig, Silay City, Bangued, Baybay, Roxas City,

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[1] A background on LWUA is given in Volume II, Appendix D.

[2] Refer to Appendix B for summary of first 10-Area feasibility studies.

[3] Refer to Appendix C for summary of prefeasibility studies on 131 cities/municipalities.

[4] Although the inclusion of the 10 areas is stipulated in the contract, feasibility studies for 12 areas have actually been made.

Cotabato City, San Fernando (Pampanga), Olongapo City and Los Baños (see Figure II-1). This report includes the technical, financial and economic studies for the improvement of the water supply system in Silay City.

The dollar component of the second 10-area feasibility studies has been financed from proceeds of a loan to the Government of the Republic of the Philippines from the United States of America through the USAID, Loan No. 492-T04001 dated 9 September 1976. The peso component of the studies, approximately 41 percent, has been funded by the Government of the Philippines.

The study contract for the second 10 areas includes the following tasks:[2]

1. Training of counterpart LWUA engineers through on-the-job assignments on various aspects of water supply feasibility studies;

2. Preparing water supply feasibility studies for 5 provincial urban areas, using the expatriate and local consultant personnel for conducting such studies;

3. Preparing water supply feasibility studies for additional 5 urban areas, with the LWUA engineers taking a dominant role in the conduct of such studies.

The studies began on 1 September 1976 for a period of 18 months. The project staff was composed of 6 US engineers and 26 Filipino personnel. The personnel of the respective water districts also assisted during the course of the studies.

C. HISTORICAL BACKGROUND OF SILAY CITY WATER DISTRICT

The water supply system of Silay City was constructed in 1931 by the Bureau of Public Works. In 1956, the city government turned over the system to the National Waterworks and Sewerage Authority (currently the Metropolitan Waterworks and Sewerage System) which was established to manage waterworks systems throughout the country. The system reverted to the city government in 1964.

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[2] Refer to Appendix A for complete Terms of Reference.

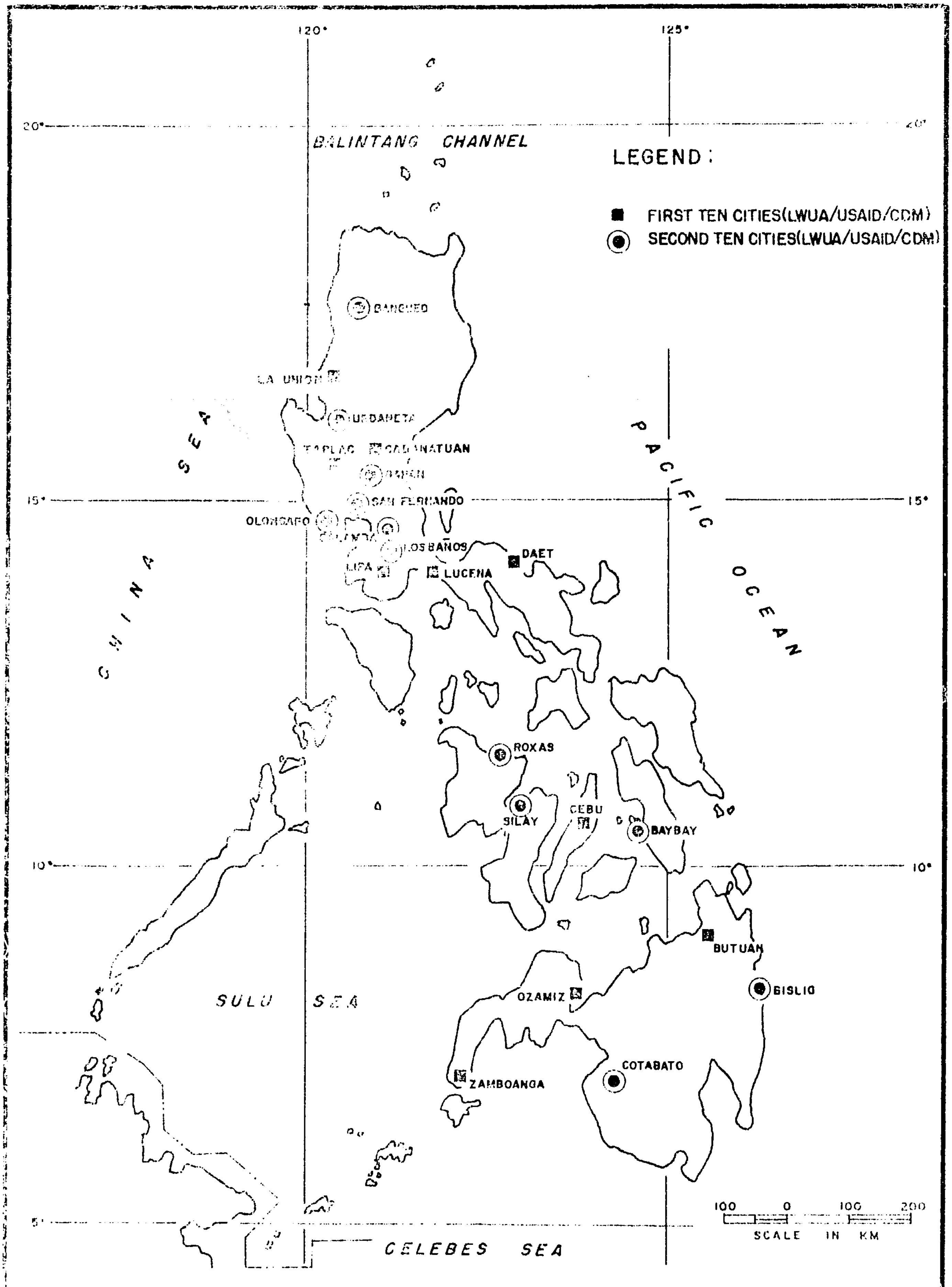

FIGURE II-1
LOCATION MAP
REPUBLIC OF THE PHILIPPINES

The SIL-WD was established on 16 March 1976 by Resolution No. 162 of the Sangguniang Panglunsod (city council) to include the entire city of Silay. Subsequently, the SIL-WD acquired the ownership and management of the public waterworks from the city government in accordance with Presidential Decree (PD) No. 198 (The Provincial Water Utilities Act of 1973).

The formation of SIL-WD was prompted by the need for adequate water supply and an upgraded waterworks system. Limited funding prevented substantial improvements to the system. Moreover, the local officials recognised the potential role of the water district in providing sufficient, safe and potable water supply.

The SIL-WD was thus established for the purposes of acquiring, installing, improving, maintaining and operating the water supply system, as well as the wastewater collection, treatment and disposal facilities. To perform these functions, the SIL-WD can obtain financial and technical assistance from LWUA. PD No. 198 provides that the water district shall operate eventually on a financially self-sufficient basis.

The SIL-WD is a quasi-public corporation and is politically independent from the local government. As constituted, the water district is subject to the provisions of PD No. 198 and the rules and regulations of LWUA. The SIL-WD can promulgate its own operating laws through its 5-member board of directors who are appointed by the city mayor. The district can only be dissolved through the act of this board.

On 12 August 1976, LWUA awarded the Conditional Certificate of Conformance to the SIL-WD after it had complied with the minimum requirements of LWUA's certification program. This certificate entitles the SIL-WD to rights and privileges authorised under PD No. 198.

CHAPTER III DESCRIPTION OF THE WATER DISTRICT[1]

A. PHYSICAL DESCRIPTION

Location

Silay City is located in the northwestern portion of the province of Negros Occidental[2] in the Western Visayas region. With an area of 18,510 hectares, Silay is divided into the poblacion[3] and 8 barrios.[4]

The present service area[5] of SIL-WD lies along the western coast of Silay and covers the poblacion, and the barrios of Rizal and Mambulac. The service area in the year 2000 will include the barrios of Guinhalaran and Lantad. (See Figures III-1 and VI-1.)

Physical Features

The terrain in Silay is predominantly flat and forms part of the western plains of Negros Occidental. Ground elevations in the service area vary from 2 to 5 meters above mean sea level.

Surface runoff originating from the hills and mountains, 20 km southeast of the poblacion, drains into several creeks and streams discharging westward into Guimaras Strait. Several creeks from the eastern mountains drain into Malogo River, northeast of Silay.

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[1] The SIL-WD covers all lands within the geographic boundaries of Silay City.

[2] Negros Occidental forms the northern and western parts of Negros island in the Western Visayas region. Its boundaries are the Visayan Sea on the north, Sulu Sea on the south, Negros Oriental on the southeast; Tañon Strait on the east and northeast; and Guimaras Strait on the west.

[3] Town proper

[4] The barrio is a political division of a city or municipality.

[5] The service area represents sections of the water district which are currently served or intended to be served by the water system.

Silay is classified under the type III climate, with short dry season but no pronounced maximum rain period. The climate is distinctly dry from February to April; wet season occurs during the rest of the year (see Figure III-2).

The average annual rainfall for the period 1960-65 was 2,591 mm. During the same years, temperature ranged from 25.7°C in January to 28.4°C in May, with the average at 27°C. The climatological data are listed in Table III-1.

TABLE III-1

CLIMATOLOGICAL DATA[6]
(1960-65)

	Rainfall (mm)	Temperature (°C)
January	126.4	25.7
February	106.5	25.9
March	91.3	27.1
April	62.7	27.4
May	172.7	28.4
June	264.7	27.7
July	270.8	27.1
August	273.6	27.2
September	249.7	27.1
October	311.3	27.2
November	381.1	27.0
December	280.5	26.6
Total	2,591.3	
Average		27.0

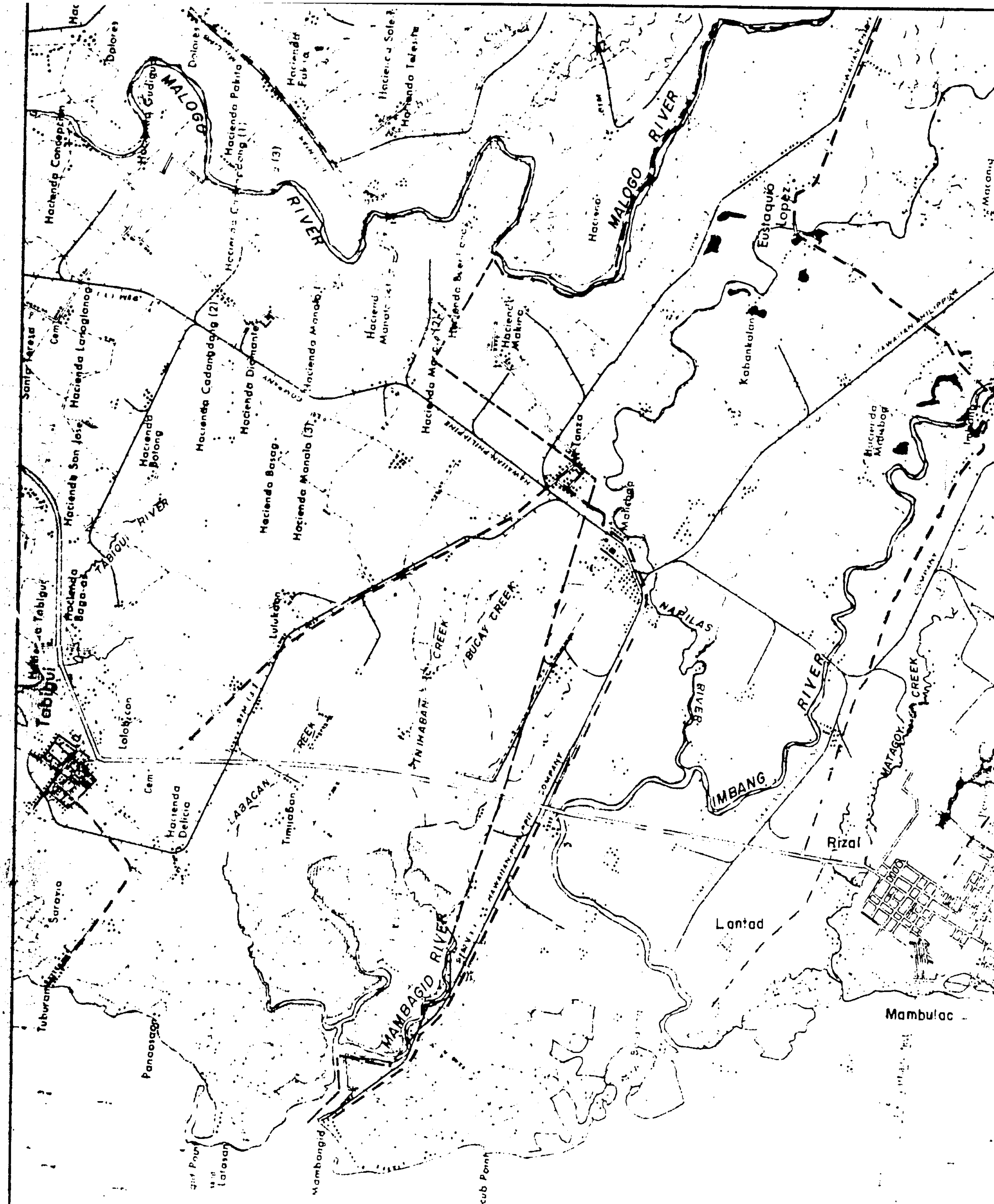
B. POPULATION

Silay's population in 1970 was 69,200, an increase of 14.7 percent over the 1960 total of 60,324. The 1970 population was composed of 10,915 households or an average of 6.3 members per household. The general characteristics of the population are listed in Table III-2.

C. LIVING CONDITIONS

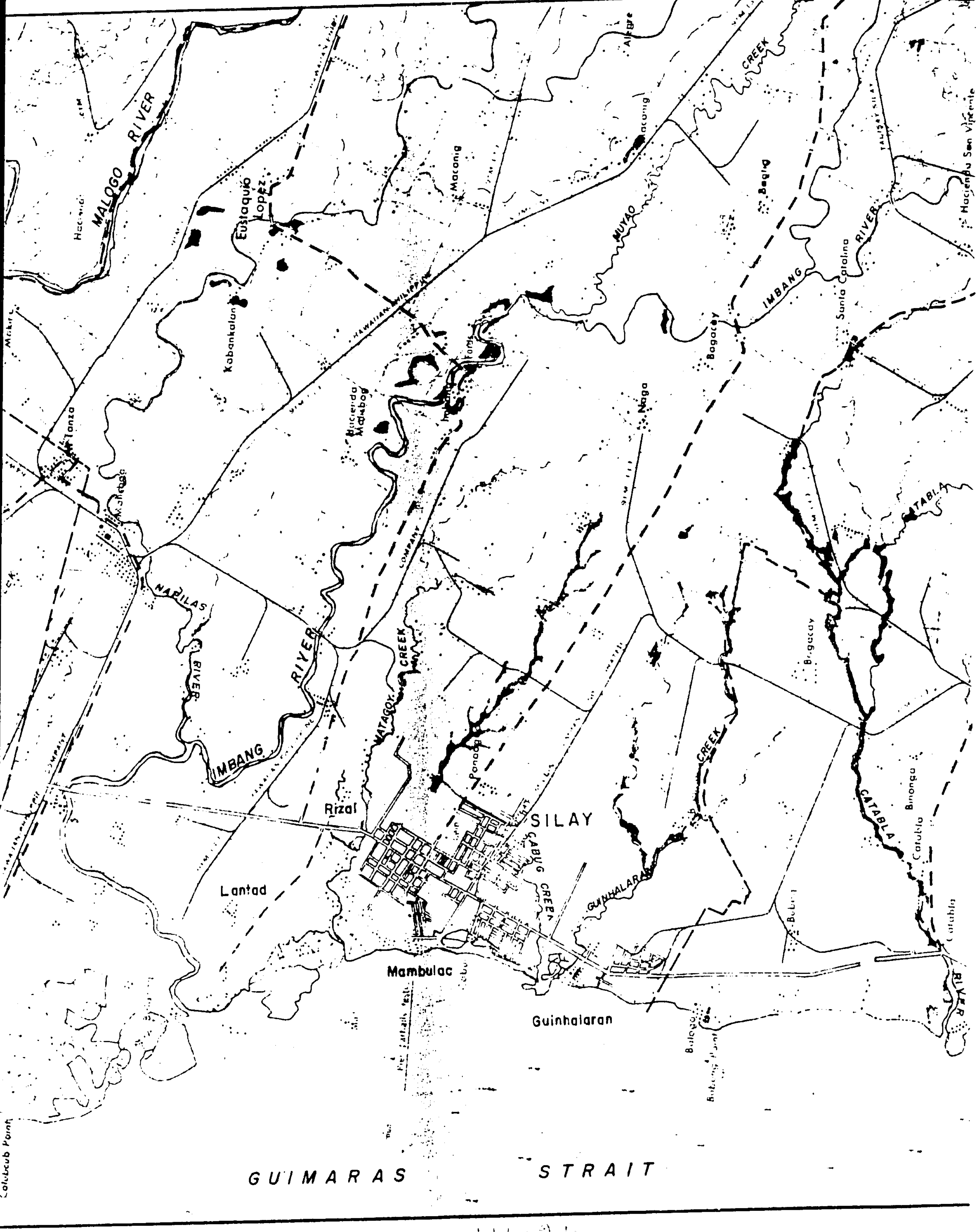
Physical indicators showing the standard of living in the city are listed in Table III-3. These indicators are types of dwelling units, household facilities and utilities.

6/Source: PAGASA Station in Silay City



FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS

LWUA-CDM



MALOGO RIVER
Eustaquio Lopez
Maconig
Kabankalan
HAWAIIAN PHILIPPINE COMPANY
MUYAO
CREEK
Bagtig
IMBANG RIVER
Santa Catalina
Bagacay
Naga
Tanza
NAPILAS RIVER
IMBANG RIVER
MATAGOY CREEK
CATABLA
Rizal
SILAY
CABUG CREEK
GUINHALARAN CREEK
Lantad
Mambulac
Guinhalaran
Binonga
CATABLA RIVER
GUIMARAS STRAIT

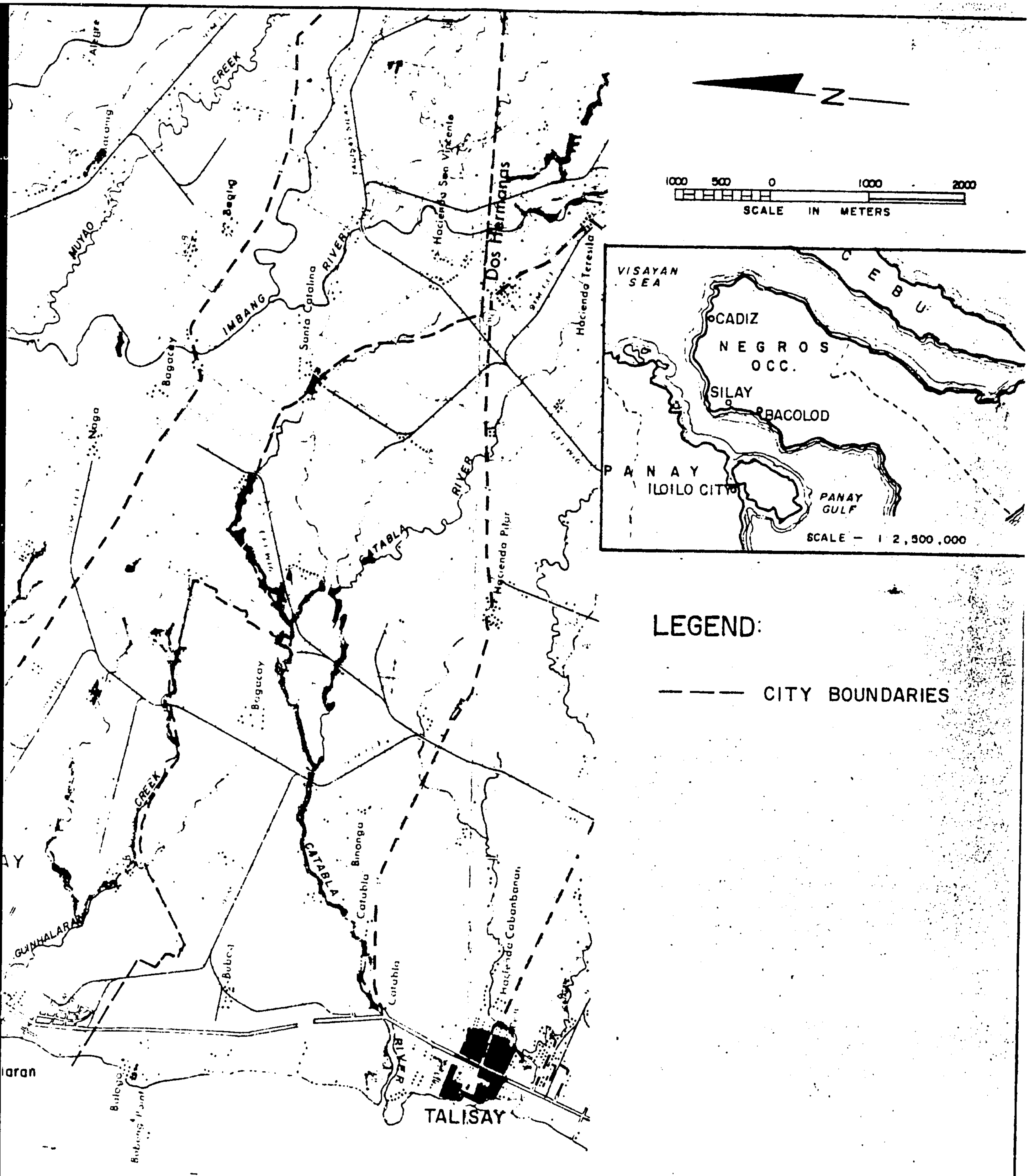


FIGURE III-1
LOCATION MAP
SILAY CITY WATER DISTRICT

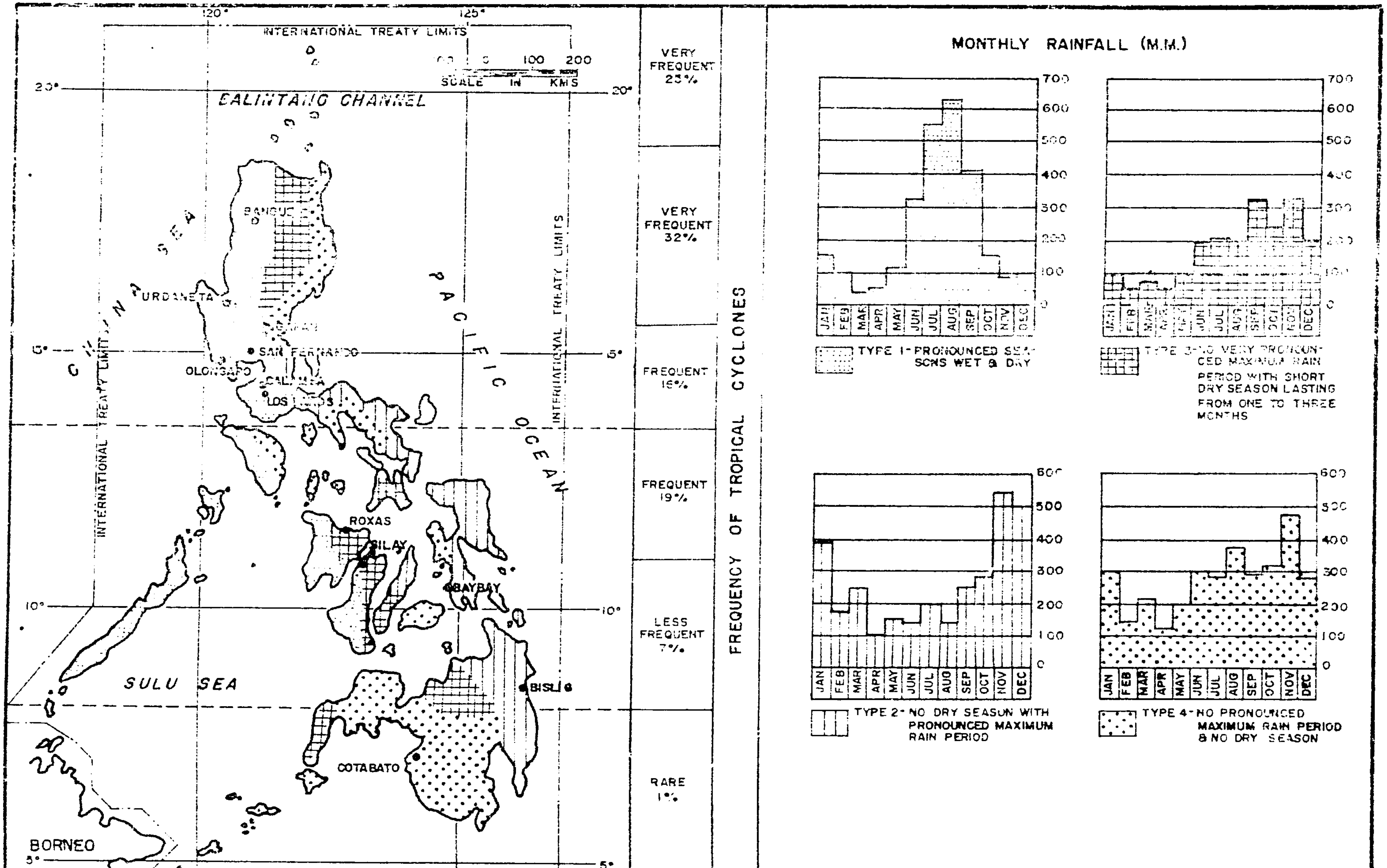


FIGURE III-2
CLIMATE MAP
REPUBLIC OF THE PHILIPPINES

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS

LWUA-CDM

TABLE III-2

POPULATION CHARACTERISTICS[7] (1970)

1.	Total Population	69,200
2.	Growth Rate (1960-70)	1.4% per annum
3.	Density	3.7 persons per hectare
4.	Urban/Rural Composition	urban, 34%; rural, 66%
5.	Sex Composition	male, 50%; female, 50%
6.	Age Composition	0-14 years, 47%; 15-64 years, 51%; 65 years and over, 2%
7.	Employment (% of those 10 years and over)	10 years and over, 47,421 employed, 54%; unemployed, 46%
	a) By class of worker (% of labor force)	wage and salary, 86%; own business, 10%; unpaid family workers, 4%
	b) By industry (% of labor force)	agriculture, forestry and fishing, 55%; manufacturing, 14%; commerce, 6%; services, 18%; construction, utilities and other industries, 7%
8.	Education (% of those 6 years and over)	6 years and over, 54,359 literate, 78%; illiterate, 22%
	a) By attainment (% of those 25 years and over)	25 years and over, 23,241 elementary grades, 60%; high school, 15%; college, 9%; no formal education 16%
	b) Number of Schools	public, 25; private, 2; vocational, 1
9.	Dialects	Hiligaynon, 98%; Cebuano, 1% others, 1%
10.	Religion	Catholic, 98%; others, 2%

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[7] Source: 1970 Census of Population and Housing, National Census and Statistics Office (NCSO).

These data apply to Silay City as a whole.

TABLE III-3

CLASSIFICATION OF HOUSEHOLDS BY TYPE OF FACILITIES[8/] (1970)

1.	Total Households	10,915
2.	Average Household Size	6.3 persons per household
3.	Water Facilities (% of total households)	piped water, 26%; artesian well, 27%; pump, 12%; open well, 23%; spring, 11%; others, 1%
4.	Toilet Facilities (% of total households)	flush/water-sealed, 12%; closed pit, 22%; open pit, 17%; public toilet, 2%; no facilities, 47%
5.	Solid Waste Disposal Service	About 14-18 metric tons of solid wastes is collected daily by the municipal government. These wastes are hauled to a dump site located in a low-lying area south of the poblacion, near the Cabug Creek, and then burned.
6.	Lighting Facilities (% of total households)	electricity, 24%; kerosene, 73%; oil, 2%; others, 1%
7.	Appliances (% of total households)	radio, 59%; TV, 3%; refrigerator, 4%
8.	Cooking Fuel (% of total households)	electricity, 1%; kerosene, 6%; LPG 5%; wood, 84%; others, 4%
9.	Total Dwelling Units	10,635
	a) Type of dwelling unit (% of total units)	single type, 93%; duplex, 4%; apartment, commercial, etc., 3%
	b) Roofing material (% of total units)	durable materials (aluminum/galvanized iron, asbestos, tile/concrete), 38%; non-durable materials (cogon, nipa, etc.), 62%

[8/] Source: 1970 Census of Population and Housing, NCSO
These data apply to Silay City as whole.

Health

Water-borne diseases occur particularly in the more densely populated sections of the city. Public health authorities recognize the correlation between the lack of safe water supply and sewerage facilities and the incidence of water-borne diseases. Table III-4 shows the recorded morbidity and mortality rates per 100,000 population due to water-borne diseases in Silay City from 1964 to 1974. During this period, the average morbidity of 598.4 of Silay was lower than the national average of 666.5; its average mortality of 93.2 was nearly twice the national average of 48.1.

TABLE III-4

REPORTED MORBIDITY AND MORTALITY DUE TO WATER-BORNE DISEASES[9] (1964-74)

Year	Silay City		Philippines	
	Morbidity	Mortality	Morbidity	Mortality
1964	567.0	114.6	846.3	60.2
1965	624.6	88.7	715.8	51.6
1966	548.1	96.3	715.1	61.9
1967	353.5	60.6	572.1	47.6
1968	285.1	77.1	564.8	46.5
1969	456.2	72.0	706.9	46.0
1970	632.7	60.4	612.8	39.0
1971	269.6	99.2	422.5	35.8
1972	648.7	110.5	743.4	49.4
1973	1,063.1	162.6	768.4	50.4
1974	1,133.5	83.4	663.8	40.4
Total	6,582.1	1,025.4	7,331.9	528.8
Average	598.4	93.2	666.5	48.1

Medical services are provided by 2 hospitals, 5 barrio health centers, 135 rural health units and 70 clinics. Health manpower includes over 250 public and private medical practitioners and personnel.

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[9] Source: Disease Intelligence Center, Department of Health

The water-borne diseases, of which records are available, include typhoid, cholera, dysentery and gastro-enteritis. The data represent rates per 100,000 population.

D. ECONOMY[10]

Family Income[11]

In 1971, the province of Negros Occidental was estimated to have 268,900 families, with a combined annual income of ₱1.2 billion. The average family income of ₱4,328 was higher than the country's average of ₱3,736. About 57 percent of the families constituted the low-income (below ₱500-₱2,999) bracket. The middle income (₱3,000-₱5,999) group included 29 percent. The remaining 14 percent received annual incomes of ₱6,000 and over.

City Income

The city income increased from ₱2.1 million in fiscal year 1970-71 to ₱4.0 million in 1975. Expenditures totalled ₱1.8 million in 1971 and ₱3.5 million in 1974-75, indicating surpluses of 4-16 percent, except in 1972-73 when there was a deficit. The city income consisted of revenues from taxation (contributing 80 percent of total income), incidental revenues, and receipts from operations.

The following is a summary of revenues and expenditures for Silay City for fiscal years 1971-72 to 1975-76.

Year	Revenues	Expenditures	Surplus (Deficit)
1970-71	₱2,065,284.24	₱1,808,589.83	₱ 256,795.41
1971-72	2,477,870.41	2,076,029.97	401,840.44
1972-73	1,194,111.24	2,080,275.84	(145,045.03)
1973-74	3,721,485.52	3,209,390.10	507,472.55
1974-75	4,025,107.59	3,857,964.89	167,142.70
1975-76	4,142,892.07	3,472,303.77	670,588.30

Agriculture

The soil and the climate in Silay are ideal for the growth of sugar cane. Located in the province known as the "Sugar Bowl of the Philippines," Silay is one of the most productive sugar-growing areas of the country. Other commercial crops are rootcrops, vegetables and coconut.

Fishing is a means of livelihood of people along the coastal barrios.

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[10] The Philippine economy from 1946 to 1976 is discussed in Appendix E, Volume II.

[11] Only provincial data are available at the NCSO.

Commerce and Industry

Sugar milling and refining are the major manufacturing activities. Other business activities are associated with sugar products.

Silay is one of the 3 large commercial centers in Negros Occidental. In 1976, over 900 business establishments were registered with the city government. Of these establishments, manufacturing accounted for 13 percent, and the wholesale and retail trade, 48 percent.

There are 5 banks and financial institutions serving mostly the sugar farmers.

Transportation

The road network totals about 90 km, classified into 8 percent national roads and 92 percent city roads. National roads are paved with concrete and asphalt. City roads are largely asphalted (74 percent) and gravel-surfaced (26 percent).

Power Supply

The existing power rates charged by the Central Negros Electrical Cooperative, Inc. (CENECO) to the consumers are as follows:

First 14 kwh	----	₱0.50 per kwh (₱3.50 minimum)
Next 36 kwh	----	0.90 per kwh
Next 50 kwh	----	0.80 per kwh
Excess of 100 kwh	--	0.75 per kwh

CHAPTER IV EXISTING WATER SUPPLY FACILITIES

A. GENERAL

The waterworks system of Siley City was originally constructed by the Bureau of Public Works in 1931-32, with 2 deepwells as sources. Three other deepwells were drilled in 1947, 1960 and 1965. Two of the wells, however, were abandoned when these started producing turbid water. Other facilities include two elevated storage tanks (380 and 190 cum capacity), pumping facilities, chlorination tank and distribution pipes. The schematic plan of the existing water system is shown in Figure IV-1.

B. EXISTING WATERWORKS FACILITIES

Source Facilities

The present sources of the SIL-WD are three of the 5 constructed deepwells, all located in the poblacion. The operating sources are pump stations no. 1, 2 and 4; the public market well and pump station no. 3 were abandoned because of turbidity.

The total production from the 3 operating wells was measured to be 3,420 cumd in January 1977. Water from the pump station no. 2 flows directly to the distribution system. Pump stations no. 1 and 4 feed the 380-cum and the 190-cum storage tanks, respectively. Table IV-1 is a description of 3 existing deepwells in the SIL-WD.

Treatment Facilities

A 1-cum chlorination tank constructed at pump station no. 1 used to be the only treatment facility in the SIL-WD. Treatment was done at this pump station by occasional dosage of hypochlorite powder. The chlorination tank, however, was taken out of service when 3 new gas chlorinators were installed at pump stations no. 1, 2 and 4 in December 1976. At present, treatment consists of injecting chlorine gas directly to the distribution mains of the 3 pump stations.

Storage Facilities

The existing system has 2 elevated storage tanks made of reinforced concrete. The capacities of these tanks are 380 cum and 190 cum.

The 380 cum elevated storage tank is located near pump station no. 1 and about 200 meters north of the city hall. Constructed in 1932, the tank has an overflow elevation of 26.4 meters above mean

TABLE IV-1

DATA ON EXISTING DEEPWELL SOURCES
SILAY CITY WATER DISTRICT

Well				Pump				Engine Drive				Operation		
Number	Constructed	Depth (m)	Casing Diameter (mm)	Installed	Type	Number of Stages	RPM	Year Installed	Type	HP	RPM	Pumping Hours/ Day	Actual Discharge Rate(cmd)	Discharge Pressure (m)
1	1931	72	200	Dec 1976	Gear-Driven Vertical Turbine	10	1760	Dec 1976	Clutched diesel	115	1250-1800	14-16	1020-1160	16.2
2	1947	78	200	Apr 1976	Gear-Driven Vertical Turbine	10	1760	Apr 1976	Clutched diesel	34-48	1250-1800	15	1210	11.2
4	1964	76	250	May 1965	Gear-Driven Vertical Turbine	10	1760	May 1965	Clutched diesel	34-48	1250-1800	14-16	1040-1190	7.4

DISTRIBUTION SYSTEM

DIAMETER (MM)	TYPE	LENGTH (M) OF PIPE BY YEAR INSTALLED			TOTAL LENGTH (M)
		1930-1955	1956-1963	1964-1974	
62	GS	—	—	250	250
75	GS	3820	—	2400	6220
100	GS	1180	—	—	1180
100	CCI	—	3840	—	3840
125	GS	210	—	—	210
150	GS	60	—	—	60
150	CCI	—	2370	1370	3740
TOTAL	GS	5270	—	2650	7920
	CCI	—	6210	1370	7580
					15500

APPURTENANCES

	SIZE	NUMBER	REMARKS
VALVES	FROM 75 TO 150 MM	64	SOME ARE INOPERABLE, SOME ARE WITHOUT VALVE BOXES
HYDRANT	75 MM WITH GS RISER	45	SOME ARE INOPERABLE
PUBLIC FAUCETS	—	10	UNMETERED AND UNBILLED CONNECTED TO SOME FIRE HYDRANTS

SERVICE CONNECTIONS, JANUARY 1977

TYPE	METERED	UNMETERED	TOTAL
DOMESTIC	151	623	774
COMMERCIAL	69	50	119
INSTITUTIONAL	—	55 *	55 *
TOTAL	220	728	948

* INCLUDES FREE CONNECTIONS AT GOVERNMENT INSTITUTIONS AND SOME PUBLIC/PRIVATE HOUSEHOLDS

WELL / PUMP STATION

- TURBINE PUMP WITH A
- WELL CASING DIAMETE
- DISCHARGE = 22.4 LP
- PUMPS TO DISTRIBUTI

WELL / PUMP STATION

- TURBINE PUMP WITH A
- CASING DIAMETER = 2
- DISCHARGE = 20.7 LPS
- PUMPS TO THE DISTRI

ELEVATED STORAGE T

- 190 CUM CAPACITY
- REINFORCED CONCRETE
- 22.8 M OVERFLOW EL
- USED ALTERNATELY W
- OPENED TO DISTRIBUT
  EVERY TUESDAY, THU

WELL/PUMP STATION N

- PUMP AND MOTOR TA
- 150 MM CASING DIAME
- WATER WAS REPORTE

ABANDONED

TREATMENT

- GAS CHLORINATORS IN
  IN DECEMBER 1976
- CHLORINATION IS DIRE

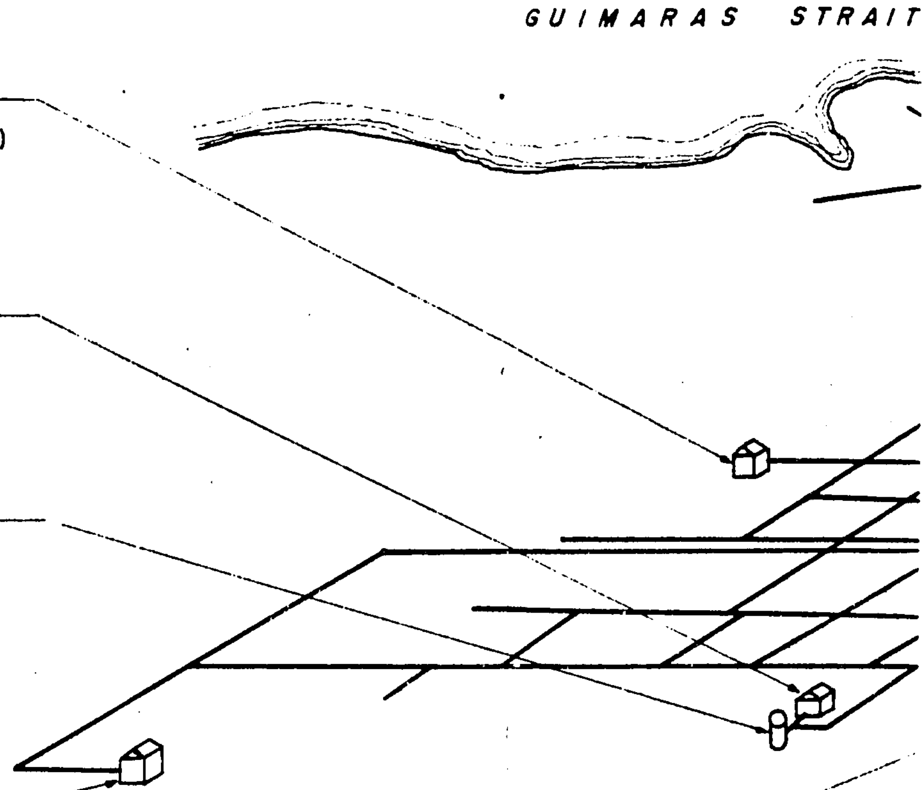
SCHEDULE OF PUM

DAYS	MO
PUMP STA. / TIME	PUM
4:00 AM - 5:00 AM	TO
5:00 AM - 12:30 PM	TO
12:30 PM - 3:30 PM	TO T
3:30 PM - 5:30 PM	
5:30 PM - 6:00 PM	
6:00 PM - 8:00 PM	PUM NO
8:00 PM - 3:00 AM	AT IS R
3:00 AM - 4:00 AM	DIS SYS

STATION NO. 2 (1947)
MP WITH A 34-48HP DIESEL ENGINE (REPLACED 1976)
DIAMETER = 200 MM, WELL DEPTH 78 M
22.4 LPS (15 HOURS PER DAY) AT 11.2 M
ISTRIBUTION SYSTEM

STATION NO. 4 (1964)
P WITH A 34-48 HP DIESEL ENGINE
ETER = 250 MM, WELL DEPTH = 76 M
20.7 LPS (14 TO 16 HOURS PER DAY) AT 7.4 M
HE DISTRIBUTION SYSTEM AND STORAGE TANK

ORAGE TANK NO. 2 (1964)
PACITY
CONCRETE
RFLOW ELEVATION ABOVE MSL
RNATELY WITH ELEVATED STORAGE TANK NO. 1
DISTRIBUTION FROM 1800 TO 0300 HOURS
SDAY, THURSDAY & SATURDAY



STATION NO. 3 (1960)
MOTOR TAKEN OUT 1974
NG DIAMETER AND WELL DEPTH = 100 M
REPORTEDLY TURBID

ABANDONED

PUBLIC MARKET WELL * (1932)

- CASING DIAMETER = 200 MM, WELL DEPTH = 76 M
- WATER WAS REPORTEDLY TURBID

*ELECTRICALLY-OPERATED SUBMERSIBLE PUMP NOW BEING INSTALLED TO SERVE ONLY THE MARKET.

ABANDONED

T

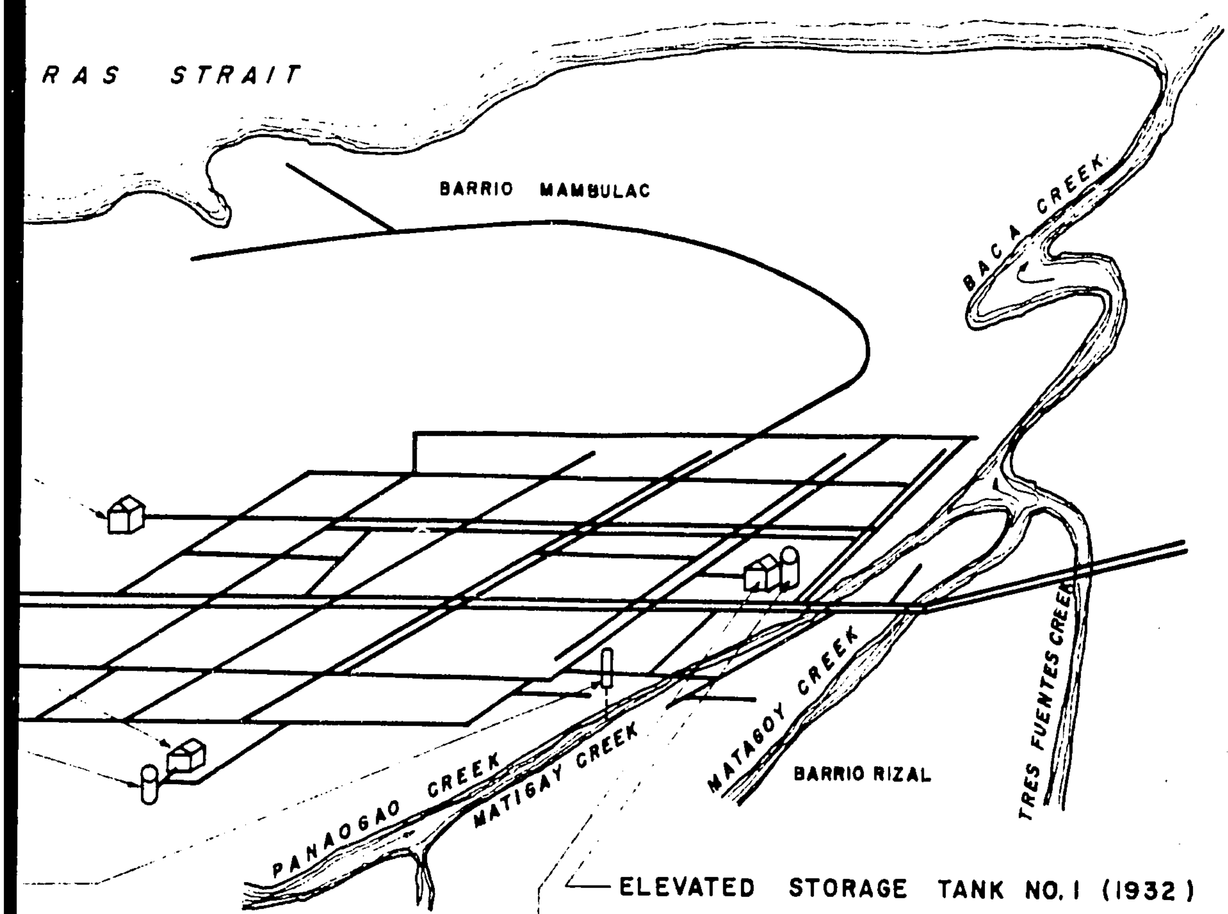
NATORS INSTALLED AT 3 PUMP STATIONS
R 1976
N IS DIRECT TO DISTRIBUTION SYSTEM

SYSTEM PRESSURE

- VERY LOW AT THE EXTREMITIES OF THE DISTRIBUTION LINE. PRESSURE IS GOOD ONLY NEAR THE PUMP STATIONS.

OF PUMP STATIONS, STORAGE TANKS & SUPPLY TO SYSTEM

	MONDAY, WEDNESDAY, FRIDAY & SUNDAY			TUESDAY, THURSDAY & SATURDAY			REMARKS
MP STA.	PUMP STA. NO. 1	PUMP STA. NO. 2	PUMP STA. NO. 4	PUMP STA. NO. 1	PUMP STA. NO. 2	PUMP STA. NO. 4	
:00 AM	TO DISTRIB.	OFF	TO DISTRIB.	TO DISTRIB.	OFF	TO DISTRIB.	DURING TANK FILLING FROM PUMP STATIONS, VALVE TO DISTRIBUTION IS CLOSED
:30 PM	TO DISTRIB.	TO DISTRIB.	-do-	-do-	TO DISTRIB.	-do-	
:30 PM	TO ELEVATED TANK NO. 1	-do-	-do-	-do-	-do-	TO ELEVATED TANK NO. 2	
:30 PM	-do-	-do-	-do-	TO ELEVATED TANK NO. 1	-do-	TO DISTRIB.	
:00 PM	-do-	-do-	-do-	-do-	-do-	-do-	
:00 PM	PUMP STATION NO. 1 OFF, WATER AT TANK NO. 1 IS RELEASED TO DISTRIBUTION SYSTEM	-do-	-do-	TO DISTRIB.	-do-	PUMP STATION NO. 4 OFF, WATER AT TANK NO. 2 IS RELEASED	OFTEN TIMES TANK NO. 2 IS CLOSED AT 4:00 AM
:00 AM		OFF	OFF	OFF	OFF		
:00 AM		OFF	OFF	OFF	OFF		



ELEVATED STORAGE TANK NO. 1 (1932)

- 380 CUM CAPACITY
- REINFORCED CONCRETE
- 26.4 M OVERFLOW ELEVATION ABOVE MSL
- USED ALTERNATELY WITH ELEVATED STORAGE TANK NO. 2
- OPENED TO DISTRIBUTION FROM 1800 TO 0400 HOURS EVERY MONDAY, WEDNESDAY, FRIDAY AND SUNDAY.

WELL/PUMP STATION NO. 1 (1931)

- TURBINE PUMP WITH 115 HP DIESEL ENGINE (REPLACED 1976)
- WELL CASING DIAMETER = 200 MM, WELL DEPTH = 72 M
- DISCHARGE = 20.2 LPS (14 TO 16 HOURS PER DAY) AT 16.2 M
- PUMPS TO DISTRIBUTION SYSTEM AND STORAGE TANK

= 76 M

PUMP NOW
ARKET.

DISTRIBUTION
PUMP STATIONS.

EMARKS
URING TANK G FROM PUMP NS, VALVE TO IBUTION IS ED
TEN TIMES NO.2 IS CLOSED 0 AM

FIGURE IV-1
EXISTING FACILITIES
SILAY CITY WATER DISTRICT

sea level. In 1975, this storage tank was taken out of service because the centrifugal pump that replaced the defective turbine pump at pump station no. 1 had a low pumping head. However, the tank was again put in use when a new turbine pump was installed to replace the centrifugal pump in December 1976.

The 190-cum elevated storage tank is located near existing pump station no. 4 and about 550 meters east of the city hall. The tank has an overflow elevation of 22.8 meters above mean sea level. Constructed in 1964, the tank was being used only for emergency purposes such as fire-fighting and pump breakdown in one of the stations. In January 1977, however, this tank began to be used for regular water supply from pump station no. 4.

Distribution System

The present distribution system covers almost twice the area covered by the original 1931-1932 system. About 34 percent of the present distribution pipes were constructed in 1930-1955; 40 percent in 1956-1963 and the remaining 26 percent in 1964-1974. Fifty-one (51) percent of the pipes are made of galvanized steel; 49 percent are made of centrifugally cast iron. A schematic plan of the existing distribution system is shown in Figure IV-2.

Pipe Sizes and Lengths. At present, the distribution system has about 15.5 km of pipes ranging in size from 62 to 150 mm. Forty (40) percent of the piping system is 75 mm in diameter; 32 percent, 100 mm; 25 percent, 150 mm; and 3 percent, 125 and 62 mm. The following table is a description of the distribution system by diameter, material, length and period of construction.

Diameter (mm)	Type	Length of Pipe (m) 1930-1955	1956-1963	1964-1974	Total
62	GS	-	-	250	250
75	GS	3,820	-	2,400	6,220
100	GS	1,180	-	-	1,180
100	CCI	-	3,840	-	3,840
125	GS	210	-	-	210
150	GS	60		-	60
150	CCI	-	2,370	1,370	3,740
	GS	5,270	-	2,650	7,920
Total	CCI	-	6,210	1,370	7,580
					15,500

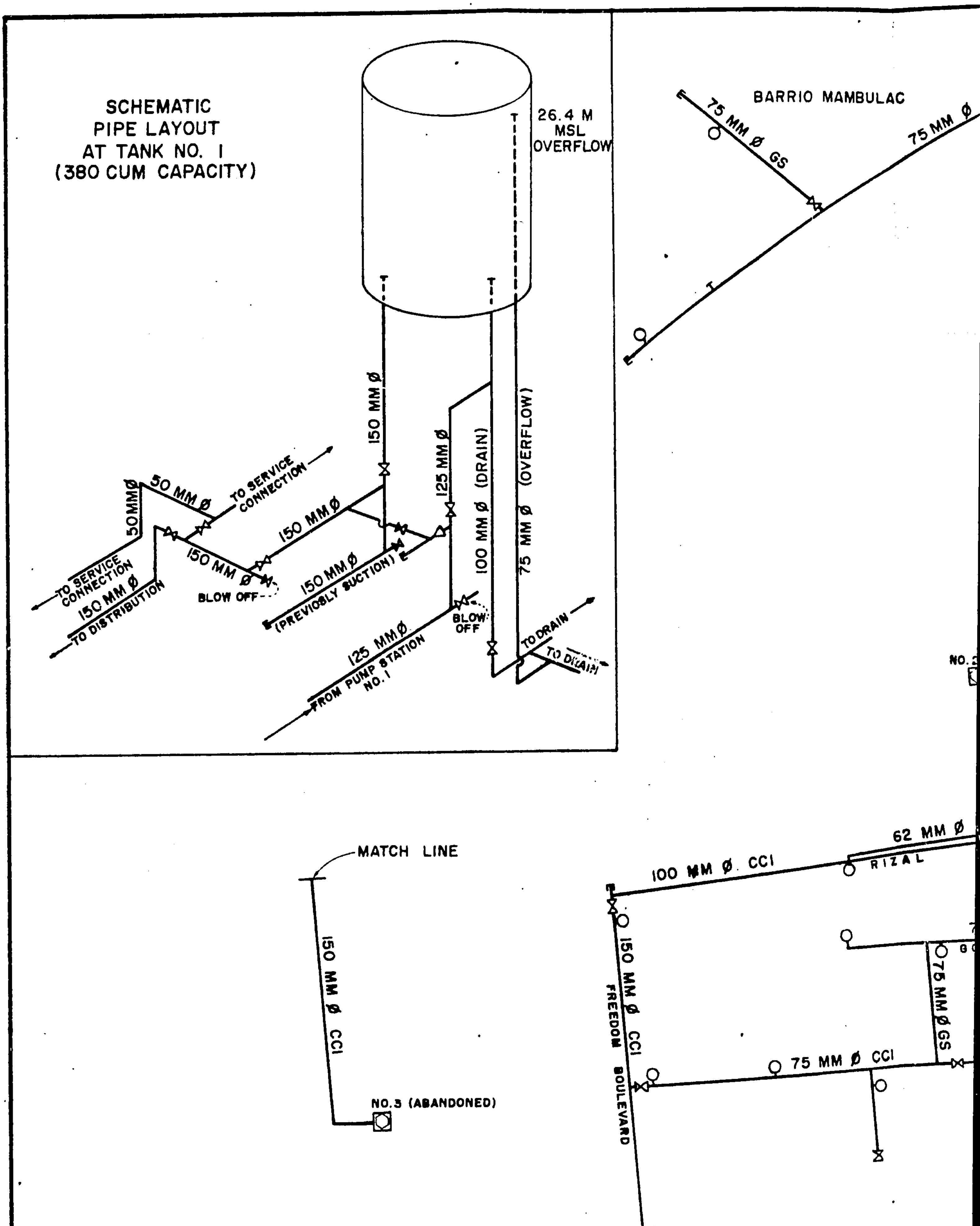
System Pressures. Several 24-hour pressure recordings and a number of spot pressure readings were made in this study. Except near the pump stations, the pressures over the distribution system are low, particularly at the extremities of the system. The pressures generally vary from 0.7 to 10 meters over 24 hours. Minimum pressures occur in the evening and early morning after all the pump stations are shut off and water is supplied only from either one of the storage tanks. Water is released from the storage tanks to the system at a pressure of 4.2 meters. Table IV-2 is a summary of the recorded 24-hour pressures in the system.

Valves and Hydrants. Available information and a field survey made in January 1977 indicate that there are some 64 valves in the system varying in size from 75 to 150 mm; and 45 fire hydrants, all locally made of 75 mm pipe. Some blow-off valves in the system are used by the fire trucks of the city government for drawing off water for fire-fighting use. Some fire hydrants are not operational due to defective valve stems. Even if all hydrants were functioning, they would be of little use for fire-fighting because of the generally low pressure over the distribution system. Five (5) public faucets are connected to these hydrants.

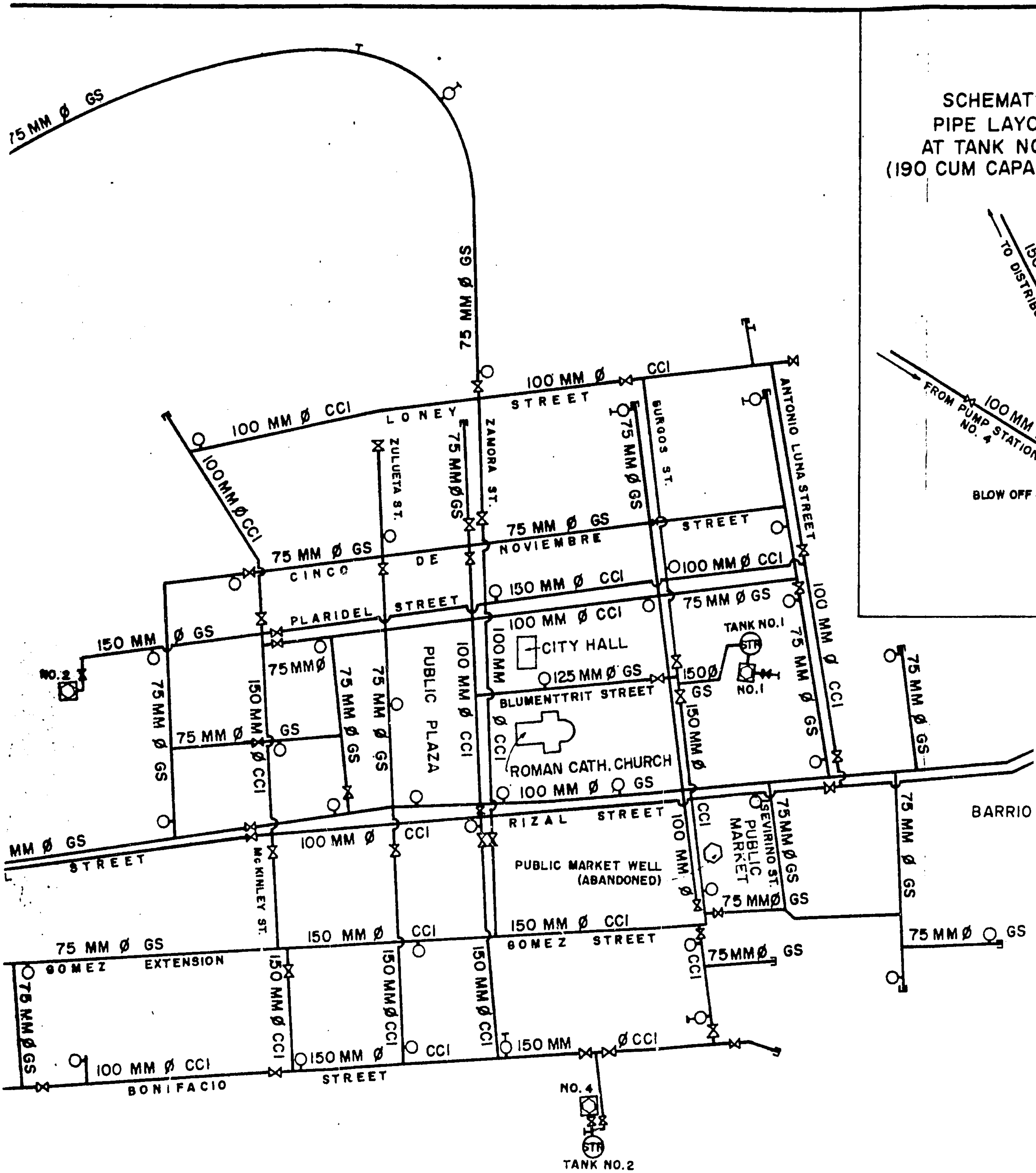
TABLE IV-2

24-HOUR PRESSURE RECORDINGS ON DISTRIBUTION SYSTEM

Number	Fire Hydrant Location	Days Recorded	Pressure Range (m)	Period (hr) of Positive Pressure
1	Abad Santos Street/Bonifacio Street	11/12 Jan 77	0.7-5.0	24
2	J. Rizal Avenue/Freedom Boulevard	11/12 Jan 77	1.9-6.8	24
3	Washington Street/McKinley Street	12/13 Jan 77	0.7-8.7	24
4	Cinco De Noviembre Street/ Silay-Mambulac Road	12/13 Jan 77	0.9-10.0	24
5	Plaridel Street/Burgos Street	13/14 Jan 77	1.7-7.3	24
6	Freedom Boulevard/Lonoy Street	13/14 Jan 77	2.4-7.8	24
7	Pump Station No. 1	15/16 Jan 77	0-26.0	0400-2000
8	Pump Station No. 4	15/16 Jan 77	0-10.6	0400-2000



FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM



SCHEMAT
PIPE LAYO
AT TANK NO
(190 CUM CAPA
FROM PUMP STATION NO. 4
100 MM
BLOW OFF
75 MM Ø GS
100 MM Ø CCI
LONEY STREET
100 MM Ø CCI
75 MM Ø GS
ZULUETA ST.
75 MM Ø GS
ZAMORA ST.
75 MM Ø GS
BURGOS ST.
ANTONIO LUNA STREET
100MM Ø CCI
75 MM Ø GS
CINCO DE NOVIEMBRE STREET
100 MM Ø CCI
150 MM Ø CCI
75 MM Ø GS
PLARIDEL STREET
150 MM Ø GS
100 MM Ø CCI
TANK NO.1
NO.1
NO.2
75 MM Ø GS
75 MMØ
75 MM Ø GS
75 MM Ø GS
PUBLIC PLAZA
100 MM Ø CCI
100 MM Ø CCI
CITY HALL
125 MM Ø GS
150Ø GS
BLUMENTTRIT STREET
150 MM Ø
100 MM Ø CCI
75 MM Ø GS
150 MM Ø CCI
75 MM Ø GS
ROMAN CATH. CHURCH
100 MM Ø GS
RIZAL STREET
MM Ø GS
STREET
100 MM Ø CCI
McKINLEY ST.
PUBLIC MARKET WELL (ABANDONED)
100 MM Ø CCI
PUBLIC MARKET
SEVIRINO ST.
75MM Ø GS
75 MMØ GS
75 MM Ø GS
BARRIO
150 MM Ø CCI
150 MM Ø CCI
GOMEZ STREET
75 MM Ø GS
GOMEZ EXTENSION
75 MMØ GS
75 MMØ GS
150 MM Ø CCI
150 MM Ø CCI
150 MM Ø CCI
CCI
75 MM Ø GS
100 MM Ø CCI
150 MM Ø
CCI
150 MM Ø CCI
BONIFACIO STREET
NO. 4
TANK NO.2

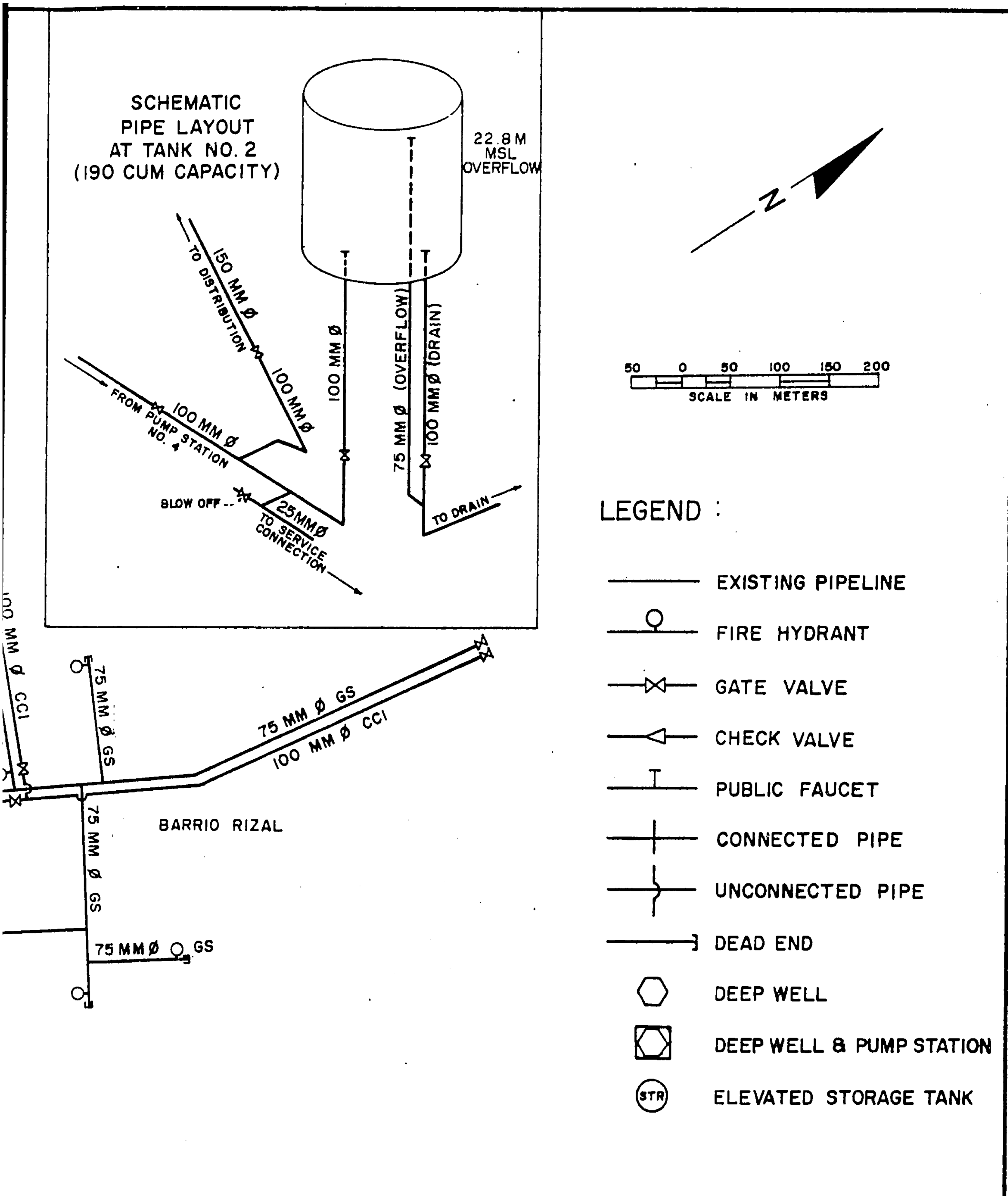


FIGURE IV-2
EXISTING WATER DISTRIBUTION SYSTEM
SILAY CITY WATER DISTRICT

Service Connections. As of January 1977, the SIL-WD had about 948 registered service connections, 23 percent of which are metered, and 77 percent are unmetered. Seventy-two (72) percent of the metered connections have defective water meters. Six (6) percent of the unmetered connections are not billed. These unbilled connections are those at government institutions and also in some private households. These connections were made when the water system was still under the administration of the city government.

By consumer category, 774 or 82 percent of the total connections are domestic, 119 or 13 percent are commercial, and 55 or 5 percent are institutional, including 44 unbilled and unmetered connections. The following table classifies the number of connections in January 1977 into metered and unmetered and by type of consumer. Information on the number of connections by size was not available.

	Number of Service Connections				
	Metered				
Consumer Category	Good	Defective	Total	Unmetered	Total
Domestic	26	125	151	623	774
Commercial	36	33	69	50	119
Institutional	-	-	-	55*	55*
Total	62	158	220	728	948

The SIL-WD had 908 and 994 registered connections in October and December 1976, respectively. The number of service connections fluctuates everymonth due to the district's campaign of disconnecting delinquent consumers and installing new connections and reconnections. At the time of preparation of Chapters IX, X and XI of this report, there were a total of 908 service connections within the water district.

Two (2) illegal connections were found during the pilot area survey in December 1976. The SIL-WD has recently requested the unregistered users to register their service connections as well as the registered concessionaires to renew their applications for connection. This measure is intended to eliminate unbilled and illegal connections.

Public Faucets. There are 10 public faucets in the system, all unbilled and unmetered. Five (5) of these are connected to fire hydrants, and some are connected to blow-off valves in the system.

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*Includes 44 free connections at government institutions and private households.

Operation and Maintenance

The SIL-WD operates and maintains the deep well pumping facilities and distribution system. The Production Division of the water district, which includes the division chief and the pump operators, is in charge of operating and maintaining the system. Plumbing work is done by some of the pump operators. The repair of defective water meters is done by a mechanic under the supervision of the Commercial Division.

The operation program consists primarily of operating the deep well pumping stations and filling and emptying the elevated storage tanks. The pump stations used to be operated 16 hours daily on a staggered schedule to provide a 24-hour water supply. After a new pump was installed at pump station no. 1 and the storage tanks were put in service in January 1977, the pump stations have been operating for an average of 15 hours daily.

The filling schedule of the 380-cum tank is 12:30-6:00 p.m. every Monday, Wednesday, Friday and Sunday; and 3:30-6:00 p.m. every Tuesday, Thursday and Saturday. Water from the tank is released to the distribution system from 6:00 p.m. to 4:00 a.m. every Monday, Wednesday, Friday and Sunday. The 190-cum tank is filled from 12:30 p.m. to 3:30 p.m. every Tuesday, Thursday and Saturday; and its water released from 6:00 p.m. to 3:00 or 4:00 a.m. on the same days. Figure IV-1 shows the operation schedule of the storage tanks.

The maintenance program consists mainly of servicing the pumping units; repairing leaking mains and service lines; and repairing defective service meters.

Two vehicles (a jeep and a $\frac{3}{4}$-ton truck) are currently used by the SIL-WD for its routine operation and maintenance work. These used vehicles were acquired from the USAID in December 1976. Before the vehicles were acquired, the SIL-WD used an old jeep borrowed from the city government.

C. WATER QUALITY

Water samples were taken from the 3 current well sources and other public and private wells on 14-17 September 1976. The results of the analysis of water samples are compared with Philippine National Standards for Drinking Water in Table IV-3.

The analysis shows that the chemical quality of the 3 current well sources is within the permissible limits. The private well at

TABLE IV-3

WATER QUALITY TEST RESULTS
SILAY CITY WATER DISTRICT

Test	Unit	Permissible Limits	Existing Wells: Pump Stn 1 14 Sept 76	Existing Wells: Pump Stn 2 14 Sept 76	Existing Wells: Pump Stn 4 15 Sept 76	Public and Private Wells: General Hospital Well 15 Sept 76	Public and Private Wells: Artesian At Bo. Guinhalaran 15 Sept 76	Public and Private Wells: Panaogao Well at Hacienda Panaogao 17 Sept 76
Physical								
Color	APHA	15	10	10	5	5	10	300***
Turbidity	FTU	5	4	5	4	2	5	80***
Total Dissolved Solid*	mg/l	500	150	163	143	156	188	165
Conductivity	Micromhos/cm	-	230	235	220	240	290	285
Chemical								
pH		7-8.5	7.0	7.0	6.9	6.7	6.9	6.7
Total Alkalinity	mg/l CaCO3	-	125	135	115	115	145	85
Phenolphthalein Alkalinity	mg/l CaCO3	-	0	0	0	0	0	0
Total Hardness	mg/l CaCO3	400	76	73	58	71	80	58
Calcium	mg/l Ca	75	19	22	19	20	23	16
Magnesium	mg/l Mg	50	7	4	3	5	5	4
Total Iron	mg/l Fe	0.3	nil	0.08	0.29	1.26***	0.2	5***
Fluoride	mg/l F	1.5	0	0	0	0	0	nil
Chloride	mg/l Cl	200	5	7	5	5	7	10
Sulfate	mg/l SO	200	1	nil	nil	nil	1	3
Nitrate	mg/l NO_3		7	7	7	7	8	9
Manganese	mg/l Mn	0.1	0	0	0	0	0	0.3**

*Calculated as 65% of conductivity
**Exceeds permissible limits set by the Philippine National Standards for Drinking Water.
—Inferred from limits of individual metals causing hardness.
***Exceeds the excessive limits set by the Philippine National Standards for Drinking Water.

Hacienda Panacgao shows greater color, turbidity, and iron than the excessive limits; the manganese[1] content of 0.3 mg/l is greater than the permissible limit of .1 mg/l. The iron content of the well at the General Hospital also exceeds the excessive limit of .3 mg/l.

Bacteriological quality tests of well water at pump stations 1 and 4 were made in October 1976 (see Annex Tables IV-C-1 and IV-C-2). The test showed that water at pump station no. 4 was negative for coliform organism and water at pump station no. 1 was positive for coliform organism, indicating water contamination. At the time of the bacteriological tests, pump station no. 1 had no sanitary seal; at present, a sanitary seal has already been provided at this well.

D. WATER USE PROFILE

General

The current water consumption in the SIL-WD has been analyzed to determine its water accountability. Data on revenue-producing connections and other service connections were obtained from the water district. Other data were obtained from field measurements of production and a pilot area survey conducted in December 1976 (see Methodology Memoranda No. 1 and 2 and Annex IV-D).

Pilot Area Survey

The pilot area, about 4.6 hectares, is located in the central portion of the present service area. It consists of 140 households with a total population of 984, or an average of 7 persons per household. Interviews of the 140 households show the following: 69 households are registered concessionaires; 2 households are unregistered concessionaires; 30.5[2] households are "borrowers" from registered concessionaires; 15.3[2] households rely on public faucets; 10 households have their own private wells; and 15.2* households are "borrowers" from private well owners. These data have been used to derive the number of consumers of the SIL-WD water supply.

Population Served

Water users can be classified generally into primary users (registered concessionaires) and secondary users (borrowers). In

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[1] Excessive iron and manganese make drinking water unpalatable and stain laundry, porcelain and plumbing fixtures. Manganese stimulates the growth of some micro-organisms in water.

[2] Some households take water from both the water district and other private sources.

addition, other users in the SIL-WD are those using the public faucets for their regular water supply and those with illegal connections. The total of 944 registered connections (as of December 1976) represents the total number of households who are primary users. These include 235 metered households and 709 unmetered households, including 44 unbilled households. Based on the pilot area survey results, the other users are approximately 109 borrower households from metered concessionaires; 330 borrower households from unmetered concessionaires; 212 households using public faucets; and 33 households with illegal connections. Applying the pilot area average of 7 persons per household to the water district, the total users of the SIL-WD water supply are estimated to be 11,396, comprising a total of 1,628 households.

Total Consumption

The water consumption per connection has been determined on the basis of the pilot area survey results. The actual consumption of concessionaires with working meters in the pilot area is about 60.4 cum/mo per connection. This volume of consumption is assumed also to apply to the unmetered concessionaires and households with illegal connections. The actual consumption of metered concessionaires appears high in comparison with that of other cities. This can be attributed to the system's high water production and low water rates. The consumption of borrowers and users of public faucets from the water system is assumed to be 9.3 cum/mo per household.

The total consumption is about 65,065 cum/mo, which is broken down into 57,324 cum/mo for registered concessionaires; 3,776 cum/mo for borrowers; 1,972 cum/mo for public faucet consumers; and 1,993 cum/mo for users with illegal connections.

Accounted-for-Water

The accounted-for-water is the sum of consumption of concessionaires with working meters and inferred consumption at registered connections with defective meters and without meters. Hence, the accounted-for-water is defined as the revenue-producing water for the SIL-WD. Based on the pilot area survey results, the total accounted-for-water in December 1976 was 18,368 cum/mo broken down into: metered consumption, including that of borrowers from metered concessionaires, 4,594 cum/mo; inferred consumption at connections with defective meters, 1,870 cum/mo; and inferred consumption at unmetered connections, 11,904 cum/mo. The water produced from the 3 current well sources for the same month was 112,840 cum. This accounted-for-water represents about 16 percent of the total production.

Unaccounted-for-Water

Unaccounted-for-water does not generate revenue for the district. It consists of underbilled usage at defective metered and unmetered connections; unbilled usage at illegal and free connections[3/], usage of borrowers from defective metered, unmetered and free connections; and usage of households relying on public faucets. It also includes wastage, leakage and other uses. Unaccounted-for-water represents 84 percent of total production.

Underbilled Usage. This represents the unbilled portion of the volume of water consumed by concessionaires with defective meters and by those without meters. Analysis based on data from the pilot area survey and present water rate reveal that actual consumption exceeds the volume of water billed by 42.5 cum/mo per unmetered connection and by 49.0 cum/mo per defective metered connection. Such underbilled usage in December 1976 was about 36,298 cum or 32 percent of total production. This volume of water would produce revenue to the water district if water rates were increased and working meters installed.

Unbilled Usage. This is the volume of water consumed at illegal connections and by unbilled concessionaires such as government institutions and some private households. The pilot area survey indicates that this consumption in December 1976 was about 4,651 cum or 4 percent of total water produced. This volume of water would also produce revenue if all connections were legalized, metered and billed accordingly.

Usage of Borrowers from Defective Metered, Unmetered and Free Connections. This is the consumption of households who request for water from their neighbors with service connections. The pilot area survey shows that the consumption of these borrowers is 9.3 cum/mo per household or a total of about 3,776 cum in December 1976; corresponding to 3 percent of total production. Borrowers' consumption would be revenue-producing if all connections were metered.

[3/] Free connections refer to unbilled connections at government institutions and some private households.

Usage of Households Using Public Faucets. This is the usage of households relying solely from the system's public faucets. The pilot area survey indicates that consumption of these households was 1,972 cum in December 1976 or 2 percent of total water produced.

Wastage, Leakage and Other Uses. Included in this classification are the following: wastage incurred at defective metered, unmetered and illegal connections, wastage at public faucets; water lost due to leaks in the distribution mains, service connections and pump stations; water used for fire fighting, street cleaning and flushing of distribution mains. This category of water consumption is estimated to be 42% of production or 47,775 cum/mo.

Summary of Water Accountability

The water accountability in the SIL-WD is summarized in Table IV-4. The accounted-for-water, about 16 percent of total production, is the sum of billed consumption of registered concessionaires with good and defective meters and those without meters. The unaccounted-for-water includes underbilled usage at defective metered and unmetered connections, unbilled usage at illegal and free connections; usage of borrowers from concessionaires with defective metered, unmetered and free connections; usage of households relying on public faucets; wastage, leakage and other uses. Unaccounted-for-water is estimated to be 84 percent of total production.

E. HYDRAULIC SURVEY DATA

Field measurements of the hydraulic conditions of the SIL-WD were conducted during the period 10-18 January 1977. The purpose of the field measurements is to provide data for a computer model of the existing system and to isolate areas with major operational problems. The field measurements are summarized in Annex Tables IV-E-1 through IV-E-6.

Pump Stations

Pump tests were conducted at pump stations no. 1, 2 and 4 to determine the head-capacity curve for existing pumps (see Annex Figures IV-E-1 through IV-E-3). Efficiency and horsepower curves could not be made because the pumps are directly driven from diesel engines. From these pump curves and pump pressure readings over a 24-hour period, the estimated production as of January 1977 was 3,420 cumd. Annex Tables IV-E-1 and IV-E-2 show the recorded pump tests at pump stations no. 1 and 4.

TABLE IV-4

SUMMARY OF WATER ACCOUNTABILITY
SILAY CITY WATER DISTRICT

Category		Amount of Water (Dec '76) cum/mo	cumd	Percent of Production	
1. Total water production[4/]		112,840	3,640	100%	
Accounted-for-water					
a) Metered consumption (working meters) (71 connections with borrowers)		4,594	148	4.1%	
b) Metered consumption (defective meters) (164 connections)		1,870	60	1.7%	
c) Unmetered consumption (665 flat rate connections)		11,904	384	10.6%	
Sub-Total		18,368	592		16.4%
2. Unaccounted-for-Water					
a) Potentially billable water consumption		44,725	1,443	39.6%	
1) underbilled defective metered connections	(8,036)				
2) underbilled unmetered connections	(28,262)				
3) unbilled illegal connections	(1,993)				
4) unbilled free connections	(2,658)				
5) consumption of borrowers from defective metered connections	(707)				
6) consumption of borrowers from unmetered connections	(3,069)				
b) Consumption of households from public faucets		1,972	64	1.7%	
c) Wastage, leakage and other uses		47,775	1,541	42.3	
Sub-total					83.6%
					100%

4/ Production in December 1976

The current operating schedule obtained from the SIL-WD is illustrated in Annex Figure IV-E-4.

Drawdown recovery curves were obtained for pump stations no. 1 and 4 on 15 and 13 January 1977, respectively. The measured transmissivities are 175 cumd per meter (14,100 gallons per day per foot) at pump station 1 and 164 cumd per meter (13,200 gallons per day per foot) at pump station 4. Annex Figures IV-E-5 and IV-E-6 show the transmissivity curves for these pump stations.

System Pressure

Two continuously recording pressure gages were installed to measure the system pressure within a 24-hour period. Readings were made on 6 locations within the distribution system. These gages were likewise installed at pump stations no. 1 and 4.

Pressure varied from zero to 26 meters during the test period (15-16 January) at pump station 1 while pressure ranged from zero to 10.6 meters at pump station 4 for the same period. The pressure tests on 6 different locations show that pressure generally vary from 0.7 to 10 meters over 24 hours. Minimum pressures occur in the evening and early morning after all the pump stations are shut off and water is supplied from either one of the storage tanks. From 5:00 a.m. to about 8:00 p.m. average pressure is about 4-6 meters indicating low pressures over the distribution system. Table IV-2 and Annex Figures IV-E-9 through IV-E-11 show the recorded 24-hour pressures in the system. (For hydrant locations, refer to Annex Figure IV-E-12.)

Hydrant Flow Tests

The hydrant flow tests were conducted to determine how the Silay distribution system operated under certain measured flow conditions. Flows from fire hydrants on Bonifacio, Rizal, Loney and Cinco de Noviembre Streets were measured during 4 separate flow tests while pressures were recorded at other locations in the distribution system. The results of the flow tests are listed in Annex Tables IV-E-3 through IV-E-6. The tests show that for a given flow out of the system, areas within the central part of the distribution system show average pressure losses while those areas within the extremities of the system (particularly the northern and southern portions) suffer larger pressure drops. No severe fluctuation in pressure was observed in those hydrants affected by flows coming from at least two of the pump stations. Annex Figures IV-E-13 through IV-E-16 show the location of hydrants where flow measurements were conducted.

F. COMPUTER STUDIES

The purpose of conducting computer studies on the existing distribution system is to duplicate, to the greatest extent practicable, the hydraulic conditions observed in the field. By doing this, it is possible to evaluate the impact of improvements on the existing system.

There have been adequate field data gathered for Silay, however, computer studies could not be conducted on the existing system due to several reasons. The data gathered indicates that water production in excess of 60 lps enters the distribution system by pumping or from the storage tanks. For such a sizable volume of water to enter the system and to flow through the existing pipelines, a significant headloss across the distribution system would be required. The data also show that the system operates at a fairly flat hydraulic gradeline, that is, with very little headloss across the system. The Silay distribution system probably has significant leakage close to the pumping stations. Thus, much water is lost and only a small amount reaches other parts of the system, resulting in the flat hydraulic gradeline.

The distribution system must have reasonable integrity (free from major leakage) in order to model the system on the computer. An open discharge caused by a major leak cannot be modelled. If minor leakage is known to occur, then an estimate can be allocated to nodes in the system and an analysis can be made. It appears that a major loss of water is occurring in the Silay distribution system, and without a thorough field investigation, the existing system cannot be modelled on the computer.

Portions of the existing system that could be utilized in the future have been retained and included in computer studies for the future system. The data for these facilities have been based on visual inspection of the existing facilities.

G. DEFICIENCIES OF THE EXISTING SYSTEM

Only three of the 5 constructed wells are currently in use. The two were abandoned for producing turbid water and for lack of pumping facilities.

The two storage tanks are not used during day-time and peak-hour demands; they are used only at night-time when the pump stations are not operating. When filling the tanks, the valves in the distribution system are closed, reducing the water supply and pressure. Interviews with several concessionaires later verified by field surveys, indicate low pressures at the extremities of the system. Some consumers residing north of the poblacion sometimes do not have continuous water supply. Water supplied to one institution without a service meter is being used for irrigation purposes.

Results of the pilot area study indicate that unaccounted-for-water is excessively high. Most service connections are not metered. Some connections are not billed for old political reasons. Illegal connections are known to exist. Public faucets abound in the system and their use is not billed. Connections, such as unmetered, defective metered, free, illegal and public faucets contribute to the large unaccounted-for-water in the system.

About 34 percent of the distribution pipes are 45 years old. Cross-connections between water pipes and polluted drains and improperly repaired leaks in service connections exist in the system.

Water sampling and quality analysis is not regularly done. Meter repair and plumbing facilities are inadequate. Water rates are very low. Domestic, commercial and institutional concessionaires are charged uniform rates.

ANNEX IV-C

WATER QUALITY

ANNEX TABLE IV-C-1

BACTERIOLOGICAL QUALITY TEST RESULTS
SILAY CITY WATER DISTRICT

WELL AND PUMP STATION NO. 1

Collection	Date: 13 Oct '76 Time: 10:20 AM	Receipt	Date: 13 Oct '76 Time: 8:40 AM	Examination	Date: 13 Oct '76 Time: 9:00 AM

Appearance: Clear   Sediment: None

No. of tubes with 10-ml samples each for the tests	Test for Coliform Organisms: Presumptive — Gas in lactose broth at 37°C, 24 hours	Presumptive — 48 hours	Confirmed — BGB	Confirmed — EMB	Completed — Gas in Secondary Lactose broth at 37°C	Completed — Gram Stain	E. Coli. (For fecal coliform detection)
1.	Neg.	Pos.	Pos.	Pos.	Pos.	Gram	Negative
2.	Neg.	Pos.	Pos.	Pos.		Negative	
3.	Neg.	Neg.					
4.	Neg.	Neg.					
5.	Neg.	Neg.					

Colonies per ml of sample in agar plate after 24-hour incubation at 37°C   2,596

MPN: 5.1   Acid test: Ethyl violet test:

Organisms isolated: Intermediate

Remarks:

ANNEX TABLE IV-C-2

BACTERIOLOGICAL QUALITY TEST RESULTS
SILAY CITY WATER DISTRICT

WELL AND PUMP STATION NO. 4

Collection	Date: 13 Oct '76	Receipt	Date: 13 Oct '76	Examination	Date: 13 Oct '76
	Time:		Time: 10:20 AM		Time: 10:30 AM

Appearance:	Clear	Sediment:	None

No. of tubes with 10 ml samples each for the tests	Test for Coliform Organisms						
	Presumptive		Confirmed		Completed		E. Coli.
	Gas in lactose broth at 37°C						
	24 hours	48 hours	BGB	EMB	Gas in Secondary Lactose broth at 37°C	Gram Stain	(For fecal coliform detection)
1.	Neg.	Neg.					
2.	Neg.	Neg.					
3.	Neg.	Neg.					
4.	Neg.	Neg.					
5.	Neg.	Neg.					

Colonies per ml of sample in agar plate after 24-hour incubation at 37°C 0

MPN: 0	Acid test:	Ethyl violet test:

Organisms isolated:

Remarks:

ANNEX IV-D

PILOT AREA SURVEY

ANNEX IV-D

Memorandum

To : L. V. Gutierrez, Jr.

From : P. N. del Rosario

Date : 3 January 1977

Subject: Pilot Area Survey for Silay City Water District

I. GENERAL INFORMATION

A. The pilot area is located southeast of the City Hall and east of the public plaza. It has an area of about 4.6 hectares bounded by Rizal Avenue (highway) on the west, Zamora Street on the north, Bonifacio Street on the east, and McKinley Street on the south.

B. Data on 140 households within the pilot area, a total population of 984, indicate an average of 7 persons/household and a density of 214 persons/hectare.

II. OBJECTIVE

The analysis presented herein attempts to quantify water accountability and the number of primary and secondary users of SIL-WD water supply. In this analysis, accounted-for-water is defined as the water billed based on the prevailing water rate schedule of the district.

III. SURVEY RESULTS

A. Types of Consumers:

1.	Number of connected households	69*
2.	Number of borrower households from connected households	30.5**
3.	Number of households relying on WD public faucets	15.3**
		114.8
4.	Number of households relying solely on own private wells	10
5.	Number of borrowers from private well owners	15.2**
	Total	25.2

*Two (2) are illegal, 55 flat rate, 12 metered with 3 working meters and 9 defective meters.

**Some households take water both from WD concessionaires and private source; it is assumed that 60 percent of such households' water requirement is taken from the WD, and 40 percent from private source.

B. Consumption Figures as Given in the Survey*

	Range of Consumption
1. Metered concessionaire (working meter)	60 – 670 lpcd
2. Unmetered concessionaire (flat rate)	20 – 80 lpcd
3. Private system owner	15 – 90 lpcd
4. Borrower	5 – 80 lpcd

C. Willingness to Pay for Improved Service Per Month:

	Amount Willing to Pay/Month	Number of Households
1. Below average income	Average ₱ 9	24
2. Average income	Average ₱12	90
3. Upper middle income	Average ₱14	15
4. High income**	₱15 to 25 or higher	8

IV. WATER ACCOUNTABILITY ANALYSIS (refer to computations)

A. Summary

1. Accounted-for-water (cum/mo)

a) Metered consumption (working meters)	4,594
b) Metered consumption (defective meters)	1,870
c) Inferred unmetered consumption (flat rate)	11,904
	18,368 (16% of production)

2. Unaccounted-for-water (cum/mo)

a) Potentially billable water — 44,725 (40% of production)

1) Underbilled defective meter use	8,036
2) Underbilled unmetered use	28,262
3) Unbilled illegal consumption	1,993
4) Unbilled free consumption	2,658
5) Usage of borrowers from defective metered, unmetered, and free connection	3,776

*Other households could neither estimate their consumption nor remember WD billing due to delinquency in payment; others have given estimates.

**Will pay any amount the WD will impose provided meter is installed.

b) Usage of households from public faucets — 1,972 (2% of production)

c) Wastage, leakage and other uses — 47,775 (42% of production)

Total Unaccounted-for-water — 94,472 (84% of production)

B. Input Data

1. Water production = 3,640 cumd or 112,840 cum/mo*

2. a) Number of concessionaires = 944 + illegal

Registered concessionaires:

1) Unmetered = 709 billed unmetered = 665
unbilled unmetered = 44 (free connections** at government institutions and some private households)

2) Metered = 235 working meter = 71
defective meter = 164

b) Water rate schedule:

1) Unmetered rate – ₱8.00/mo

2) Metered rate – first 15 cum = ₱7.00 (minimum) or ₱0.47/cum
next 16-30 cum = 0.35/cum
next 31-50 cum = 0.30/cum
next 51-80 cum = 0.25/cum
over 80 cum = 0.20/cum

c) Thus, billed unmetered connection/mo = 15 + $\frac{₱1.00}{₱0.35/\text{cum}}$ = 17.9 cu

3. Pilot area data

a) Total households in the area — 140

b) Total WD concessionaires in area — 69 households (2 illegal included) 49% of 140

1) Unmetered (flat rate) – 55 + 2 illegal connections

2) Metered – 12 Working – 3 – 194 cum/mo
Defective – 9 – 103 cum/mo

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*Production in December 1976 when all pump stations were each operating at 16 hours per day.

**Different from public faucets in the system.

c) Total number of WD borrowers 30.5 22% of 140

d) Total number of households relying on WD public faucets 15.3 11% of 140

e) Total number of households with own water source 10 7% of 140

f) Total number of households borrowing from private source 15.2 11% of 140

g) Actual consumption of connections with working meters 194 cum/mo (borrowers included)

or consumption of each connection 64.7 cum/mo = 2.1 cumd

h) Average consumption of 9 defective metered connection 103 cum/mo (borrowers included)

or 11.4 cum/mo/connection = 0.4 cumd (based on previous consumption)

C. Computations

1. Billed water of WD (accounted-for-water)

a) Connections with working meters	64.7 (71) =	4,594 cum/mo
b) Defective metered connection	11.4 (164) =	1,870 cum/mo
c) Unmetered (flat rate) connection	17.9 (665) =	<u>11,904</u> cum/mo
		18,368 cum/mo 16% of production

2. Unaccounted-for-water = 112,840 - 18,368 = 94,472 cum/mo (84% of Production)

3. Total households relying on WD water = 944 legal connections + illegal connections + borrowers from metered and unmetered connections + households relying on WD public faucets.

a) In pilot area survey, total households relying on WD water = 67 (legal connections) + 2 (illegal) + 5.5 (borrowers from metered connections) + 25 (borrowers from unmetered connections) + 15.3 (relying on public faucets) = 114.8 (82% of total household in pilot area).

$$\frac{\text{legal connections}}{\text{total households relying on WD water}} = \frac{67}{114.8} = .58$$

By ratio and proportion:

$$\frac{\text{944 legal connections}}{.58} = \text{1628 total households dependent on WD water}$$

b) Breakdown of the total 1,628 households dependent on WD water

1.	legal connections		944
2.	illegal connections (2%* of 1,628)		33
3.	Borrowers from:		
	connections with functioning meters	- 33	
	connections with defective meters	- 76	
	billed unmetered connections	-310	
	free unmetered connection	- 20	439
4.	Household relying on WD public faucets*		212
	Total		1,628

4. To compute for potentially billable water, consumption figures for WD concessionaires and borrowers are needed.

a) Consumption of borrowers:

Based on the pilot area, consumption of borrowers varies from 5 - 80 lpcd. Using an average of 43 lpcd (by comparison, borrowers in Metro Cebu WD consumes 35 lpcd, based on the First Ten-Area Feasibility Study) consumption of each household borrower

$$= 43 \left(\frac{\text{liters}}{\text{person/day}}\right) \left(\frac{1 \text{ cum}}{1,000 \text{ l}}\right) \left(\frac{7 \text{ persons}}{\text{household}}\right) = 0.30 \text{ cumd}$$

or 9.3 cum/mo/household

1.	Consumption of borrowers from connections with working meters = (33) (9.3)	307 cum/mo
2.	Consumption of borrowers from defective-metered connections = (76) (9.3)	707 cum/mo
3.	Consumption of borrowers from billed unmetered connections = (310) (9.3)	2,883 cum/mo
4.	Consumption of borrowers from free unmetered connection = (20) (9.3)	186 cum/mo
5.	Consumption of households relying on WD public faucets = (212) (9.3)	1,972 cum/mo

b) Consumption of concessionaires with functioning meters, excluding borrower usage = (64.7) (71) - (33) (9.3) = 4,287 cum/mo or 60.4 cum/mo/connection

5. Underbilled and unbilled consumption

a) Underbilled consumption of:

unmetered connections = (60.4 - 17.9) (665) = 28,262 cum/mo
defective metered connections = (60.4 - 11.4) (164)
= 8,036 cum/mo
Total underbilled consumption 36,298 cum/mo

*Obtained from pilot area ratios

b) Unbilled consumption of:

illegal connections =	(60.4) (33)	= 1,993 cum/mo
free connections	(60.4) (44)	= 2,658 cum/mo
total billed consumption		4,651 cum/mo

c) Unbilled consumption of households relying on public faucets 1,972 cum/mo

6. Potentially billable water = 5a + 5b + usage of borrowers associated with unmetered and defective metered connections

= 36,298 + 4,651 + 3,069 + 707

= 44,725 cum/mo (40% of production)

7. Wastage, leakage and other uses = Production – (Accounted-for-water + potentially billable water + household usage from public faucets)

= 112,840 – (18,368 + 44,725 + 1,972)

= 47,775 cum/mo (42% of production)

ANNEX IV-E

HYDRAULIC STUDIES

ANNEX TABLE IV-E-1

PUMP TEST AT PUMP STATION NO. 1
SILAY CITY WATER DISTRICT

Date of Pump Test: 15 Janauary 1977
Flow Instrument Used: 100 mm orifice pipe with 75 mm orifice plate

Deflection of Water (h)		Discharge		Pressure		Remarks
cm	(inches)	lps	(gpm)	m	(psig)	
192	75.6	22.84	362	1.41	2	Valve fully opened
177	69.7	21.96	348	7.04	10	Valve throttled
156	61.4	20.57	326	14.08	20	" "
133	52.4	19.12	303	21.12	30	" "
112	44.1	17.54	278	28.16	40	" "
84	33.1	15.27	242	35.20	50	" "
63	24.8	13.19	209	42.24	60	" "
44	17.3	10.98	174	49.28	70	" "
29	11.4	9.02	143	56.32	80	" "
15	5.9	6.75	107	63.36	90	" "
3	1.2	2.90	4[illegible]	70.40	100	" "
0	0	0	0	72.54	103	Shut off

From head-capacity curve at pumping pressure of 16.2 meters of water (23 psi), Q = 20.2 lps (320 gpm) (see Annex Figure IV-E-1)

ANNEX TABLE IV-E-2

PUMP TEST AT PUMP STATION NO. 4
SILAY CITY WATER DISTRICT

Date of Pump Test: 14 January 1977
Flow Instrument Used: 100 mm orifice pipe

Deflection of Water (h)		Discharge		Pressure		Remarks
cm	(inches)	lps	(gpm)	m	(psig)	
175	69	21.83	346	3.87	5.5	Valve fully open
155	61	20.50	325	7.74	11.0	Valve throttled to 11 psi
104	41	16.97	269	16.54	23.5	" " " 23.5 "
38	15	10.22	162	30.27	43.0	" " " 40 "
6.5	2.6	4.23	67	42.24	60.0	" " " 60 "
0	0	0	0	47.88	68.0	Valve closed (shut off)

From head-capacity curve at operating pressure of 7.4 meters of water (10.5 psi), Q = 20.7 lps (330 gpm) (see Annex Figure IV-E-3)

ANNEX TABLE IV-E-3

HYDRANT FLOW TEST NO. 1
SILAY CITY WATER DISTRICT

Hydrant Location	Corner Bonifacio & McKinley St (Hydrant Flow Test)		Corner Zulueta & Bonifacio St. (Pressure Test 1)	Corner Gomez St Zulueta St (Pressure Test 2)	Corner Bonifacio & Zamora St (Pressure Test 3)	Remarks
Hydrant Elev. Above Ground (m)	0.59		1.07	1.06	0.93	
Time p.m.	Discharge Q(lps)	Discharge P(m)	P_1(m)	P_2(m)	P_3(m)	
3:55	0	9.8	9.8	9.3	11.7	Valve closed
3:56	11.20	5.2	8.2	7.0	10.6	Valve throttled
3:57	8.40	7.0	8.4	7.6	10.7	" "
3:58	8.76	6.9	8.4	7.6	10.7	" "
4:05	8.76	6.8	8.4	7.4	10.6	" "
4:07	9.08	7.0	8.3	7.5	10.5	" "

Pressure Recorder No. 1 – installed along V. Abad Santos Street, corner Bonifacio Street. Recorder installed at 0.825 m below the fire hydrant. Approximate pressure drop during flow test: 9.6 m − 8.0 m = 1.6 m

Pressure Recorder No. 2 – installed along Freedom Boulevard, corner Rizal Avenue. Recorder installed at 0.95 m below hydrant. Approximate pressure drop during flow test: 11.4 m − 10.6 m = 0.8 m

ANNEX TABLE IV-E-4

HYDRANT FLOW TEST NO. 2
SILAY CITY WATER DISTRICT

Hydrant Location	Along Rizal St 100 m South of Aguinaldo St (Hydrant Flow Test)		Corner Freedom Blvd & Rizal St (Pressure Test 1)	Corner Figueroa St & Rizal St (Pressure Test 2)	Corner Zamora & Rizal St (Pressure Test 3)	Remarks
Hydrant Elev. Above Ground (m)	1.08		0.97	0.46	0.90	
Time (p.m.)	Discharge Q(lps)	(m)	P_1(m)	P_2(m)	P_3(m)	
1:28	0	7.2	8.3	7.4	8.3	Valve closed
1:31	6.86	0.8	3.9	5.3	7.0	Valve fully opened
1:32	6.80	0.7	3.8	5.3	7.0	" " "
1:34	6.93	0.7	3.7	5.3	6.9	" " "
1:36	6.57	0.6	3.7	5.3	7.0	" " "
1:38	7.02	0.6	3.5	5.3	7.1	" " "
1:40	6.75	0.6	3.5	5.6	7.2	" " "
1:42	7.08	0.7	3.7	5.8	7.5	" " "
1:44	0	6.2	6.5	7.9	8.2	Valve closed

Pressure Recorder No. 1 – Installed along Washington Street, corner McKinley Street.
Recorder elevation below hydrant: 79 cm
Approximate pressure drop during flow test:
  8.9 m
− 6.9 m
  2.0 m

Pressure Recorder No. 2 – Installed along Cinco de Noviembre Street, corner Silay-Mambulac Road.
Recorder elevation below hydrant: 81 cm
Approximate pressure drop during flow test:
  9.1 m
− 7.4 m
  1.7 m

ANNEX TABLE IV-E-5

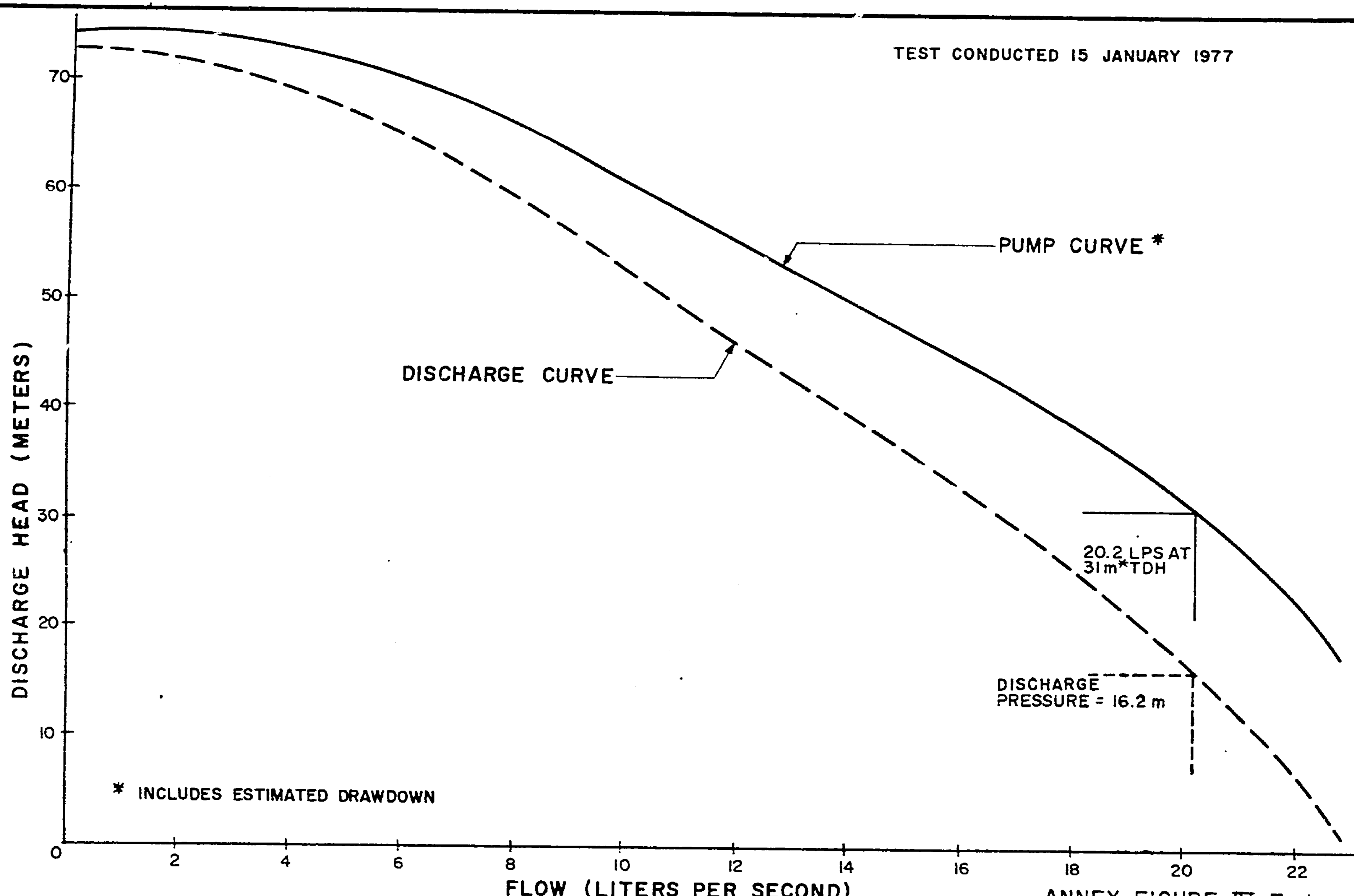
HYDRANT FLOW TEST NO. 3
SILAY CITY WATER DISTRICT

Hydrant Location	Along Zamora Corner Loney St (Hydrant Flow Test)		Corner Loney and McKinley St (Pressure Test 1)	Corner Plaridel and Zamora St (Pressure Test 2)	Corner Rizal and Severino St (Pressure Test 3)	Remarks
Hydrant Elev. Above Ground (m)	0.69		1.03	0.95	0.84	
Time	Discharge					
(a.m.)	Q(lps)	P(m)	P_1(m)	P_2(m)	P_3(m)	
11:20	0	6.5	6.9	6.3	3.7	Valve closed
11:21	11.88	0.6	4.9	4.7	2.4	Valve fully opened
11:22	11.57	0.6	4.8	4.5	2.3	" " "
11:24	11.57	0.6	4.7	4.4	2.3	" " "
11:26	11.48	0.6	4.4	4.4	2.2	" " "
11:28	11.70	0.6	4.4	4.4	2.2	" " "
11:30	11.48	0.5	4.2	4.4	2.0	" " "
11:31	0	5.6	6.3	5.3	3.0	Valve closed
11:32	0	6.0	6.5	5.8	3.3	" "

ANNEX TABLE IV-E-6

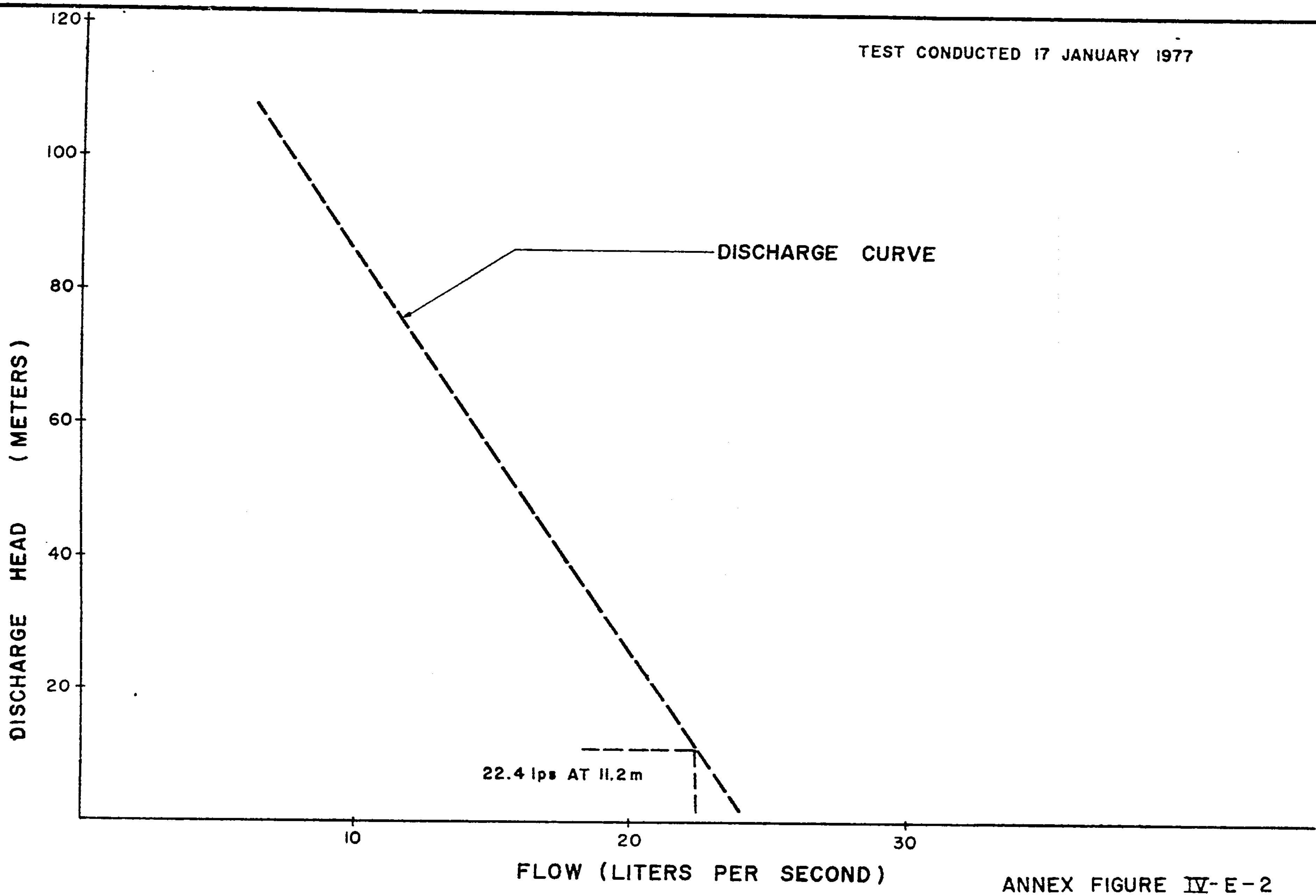
HYDRANT FLOW TEST NO. 4
SILAY CITY WATER DISTRICT

Hydrant Location	Corner Cinco de Noviembre & McKinley St (Hydrant Flow Test)		Corner Zulueta & Cinco de Noviembre St (Pressure Test 1)	Along Zulueta St near Plaza (Pressure Test 2)	Along Blumentritt St (Pressure Test 3)	Corner Rizal & Figueroa St (Pressure Test 4)	Remarks
Hydrant Elev. Above Ground (m)	0.93		0.63	0.85	0.45	0.46	
Time (a.m)	Discharge Q(lps)	Discharge P(m)	P_1(m)	P_2(m)	P_3(m)	P_4(m)	
11:24	0	5.9	6.7	7.2	7.4	4.4	Valve closed
11:25	5.34	-	5.6	7.0	7.0	2.8	Valve opened
11:29	5.81	-	5.0	7.1	6.9	1.1	" "
11:30	6.16	-	4.9	7.0	6.9	1.1	" "
11:31	6.26	-	4.9	6.0	6.6	1.1	" "
11:32	7.18	-	4.9	6.3	6.6	1.1	" "
11:33	7.02	-	4.9	6.3	6.6	1.1	" "
11:34	6.86	-	4.9	6.0	6.6	1.1	" "
11:35	6.93	-	4.9	6.0	6.6	1.1	" "
11:36	7.08	-	4.9	6.3	6.5	1.0	" "
11:37	7.21	-	4.8	6.3	6.5	1.0	" "
11:38	7.29	-	4.6	6.0	6.5	0.9	" "
11:39	7.14	-	4.6	5.6	6.5	0.9	" "
11:40	7.02	-	4.6	6.0	6.5	1.1	" "
11:41	0	5.1	6.0	-	6.3	3.8	" closed
11:42	0	5.6	6.3	-	6.9	4.3	" "
11:43	0	5.6	6.4	-	7.0	4.2	" "



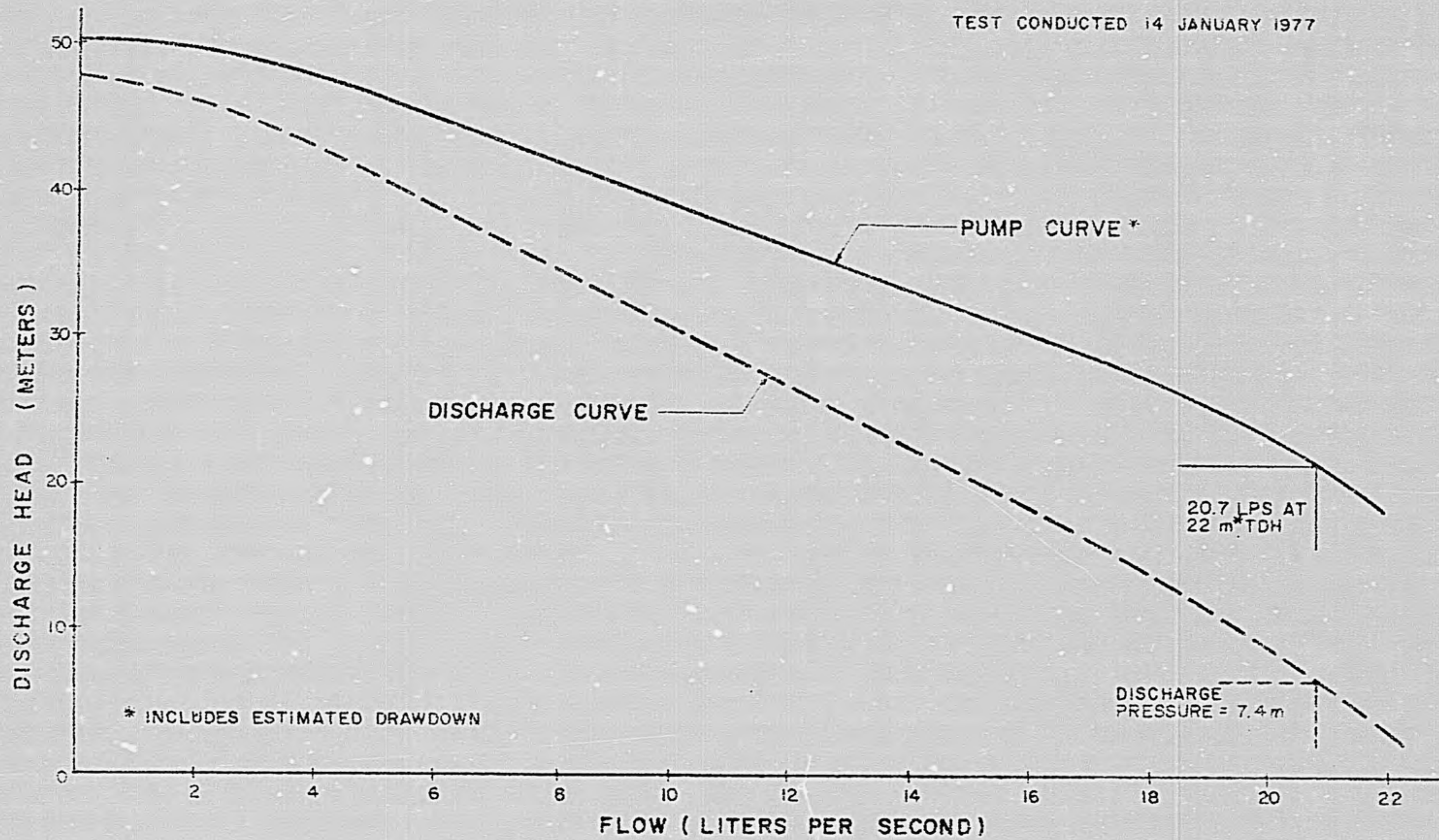
FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

ANNEX FIGURE IV-E-1
HEAD-CAPACITY CURVE AT PUMP STATION NO. 1
SILAY CITY WATER DISTRICT

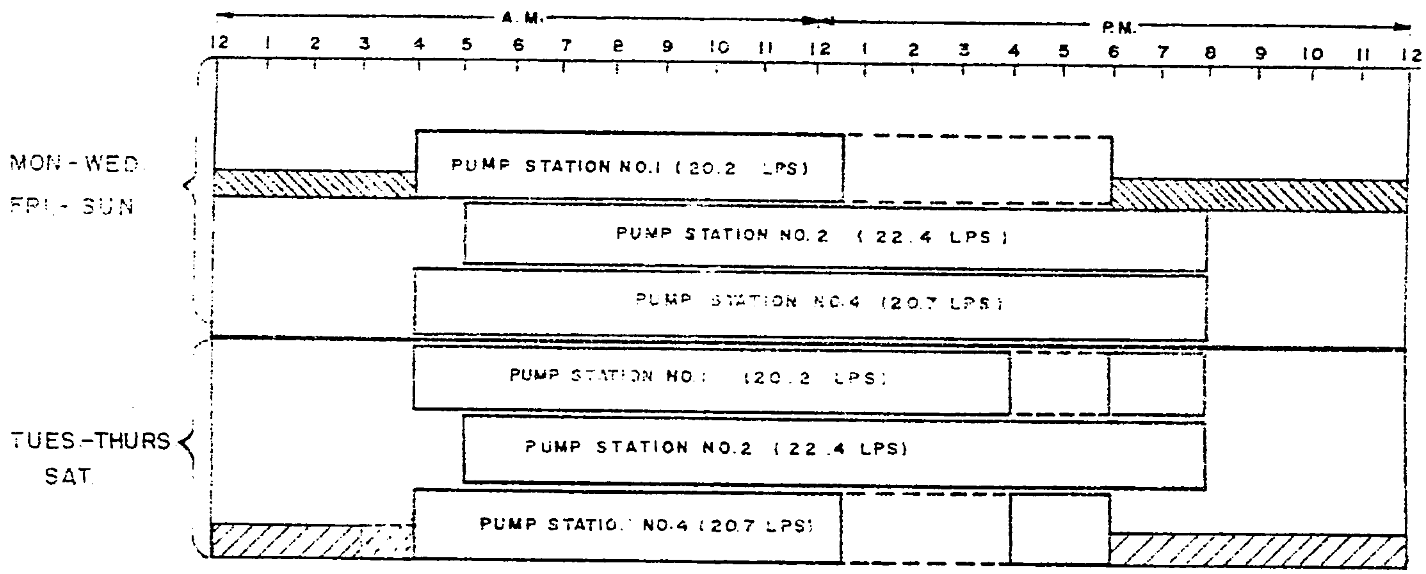


ANNEX FIGURE IV-E-2
HEAD-CAPACITY CURVE AT
WELL/PUMP STATION NO.2
SILAY CITY WATER DISTRICT

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM



ANNEX FIGURE IV-E-3
HEAD-CAPACITY CURVE AT
PUMP STATION NO. 4
SILAY CITY WATER DISTRICT



LEGEND:

PUMP OPERATIONS

DIRECT TO DISTRIBUTION

TANK FILLING

ELEVATED STORAGE TANK

STORAGE TANK NO. 1 RELEASED TO DISTRIBUTION

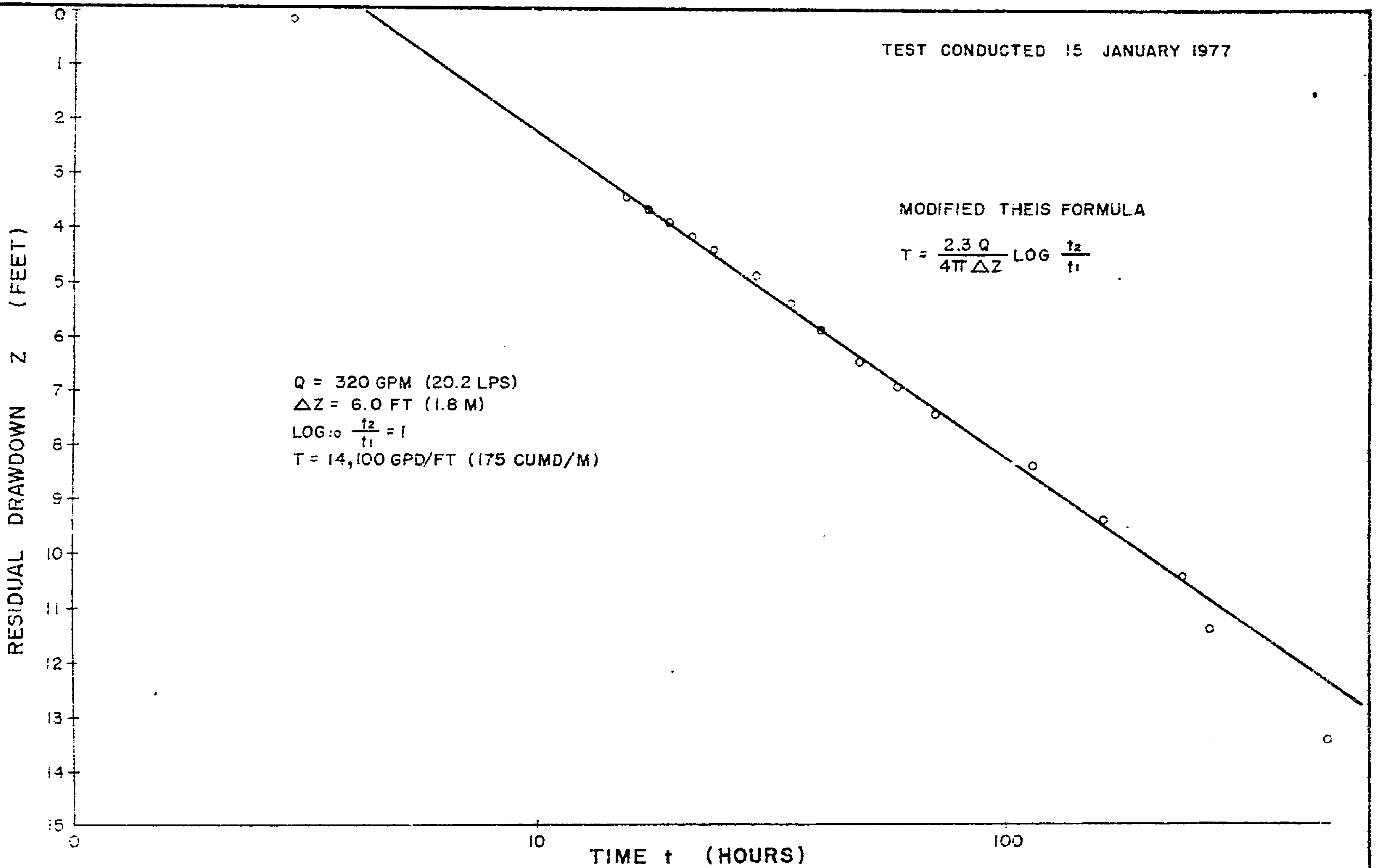
STORAGE TANK NO. 2 RELEASED TO DISTRIBUTION

NOTE:

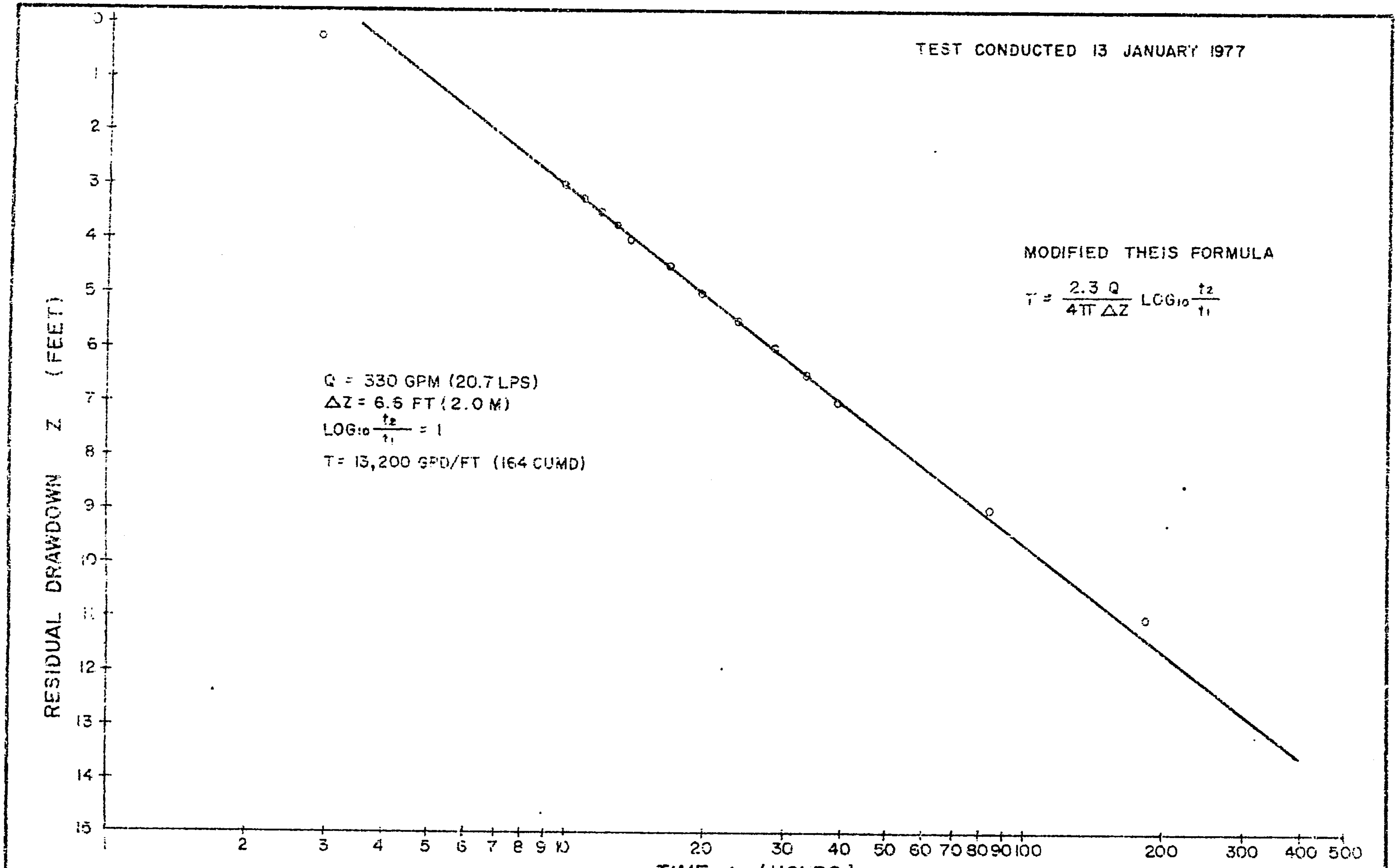
SCHEDULE PRESENTED IS AS OF JANUARY 1977.

FIGURE ANNEX IV-E-4
OPERATION SCHEDULE OF PUMP STATIONS AND STORAGE TANK
SILAY CITY WATER DISTRICT

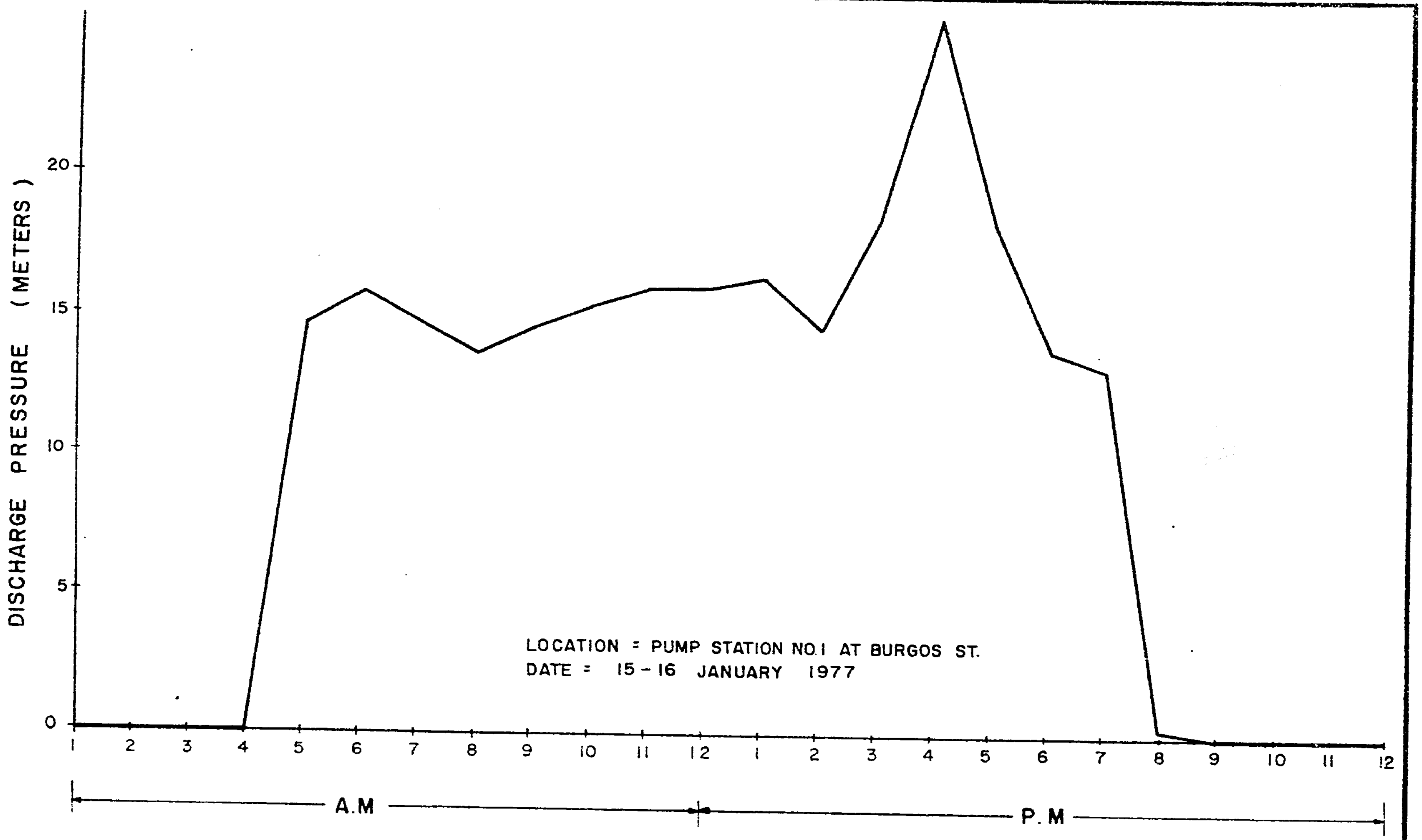
FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM



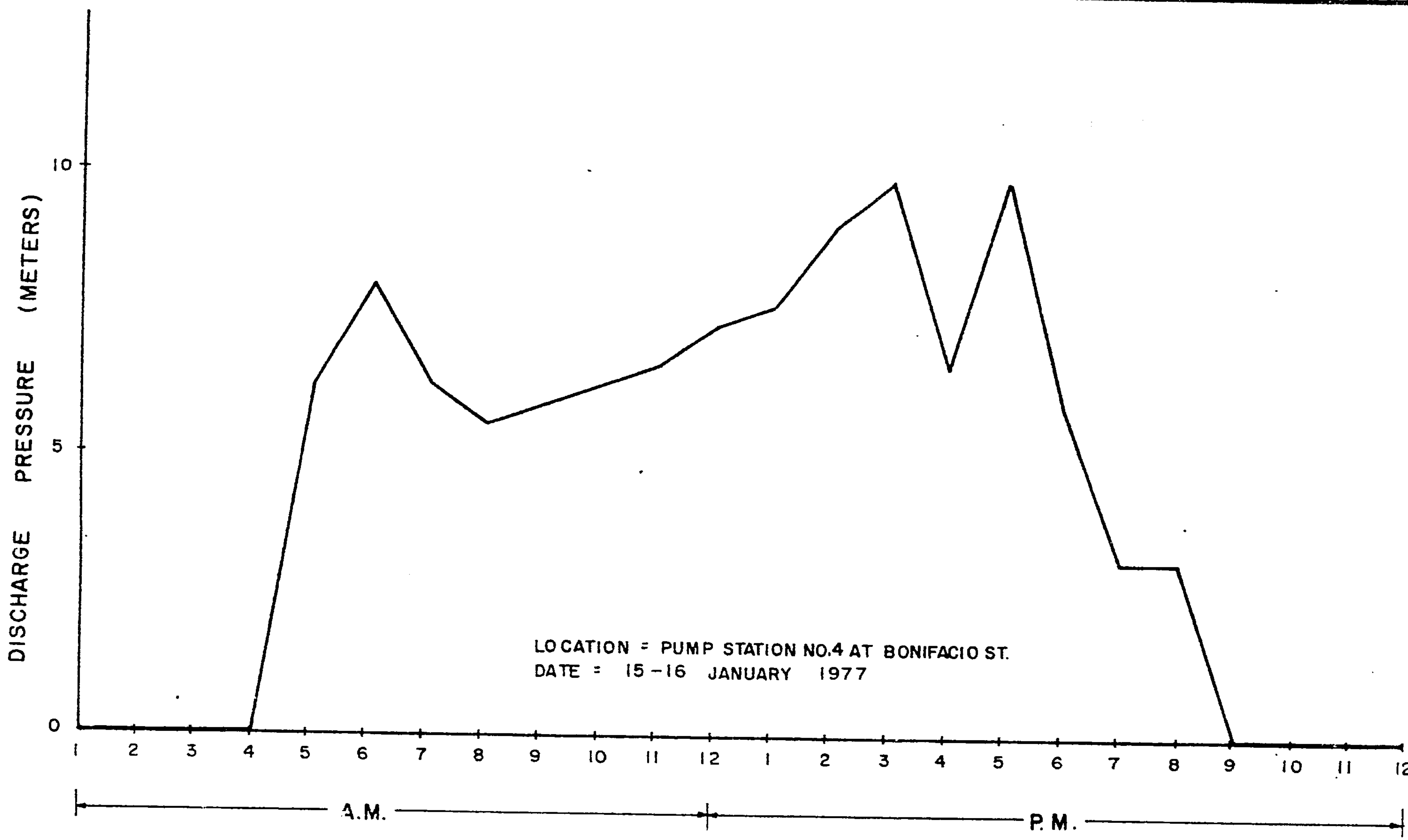
ANNEX FIGURE IV-E-5
TRANSMISSIVITY CURVE AT
WELL/PUMP STATION NO. 1
SILAY CITY WATER DISTRICT



ANNEX FIGURE IV-E-6
TRANSMISSIVITY CURVE AT
WELL/PUMP STATION NO. 4
SILAY CITY WATER DISTRICT

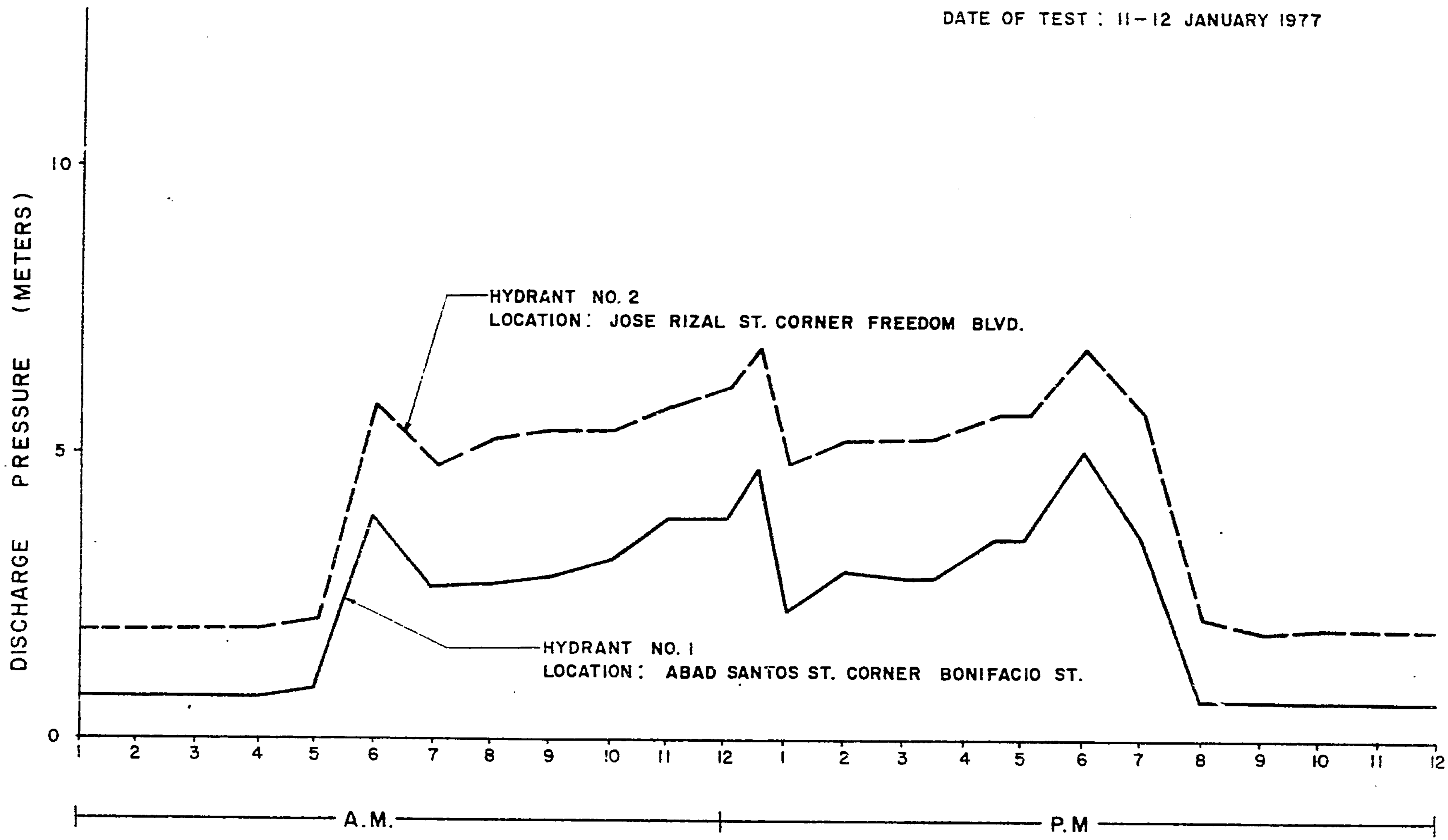


ANNEX FIGURE IV-E-7
24 HOUR DISCHARGE PRESSURE
AT PUMP STATION NO.1
SILAY CITY WATER DISTRICT

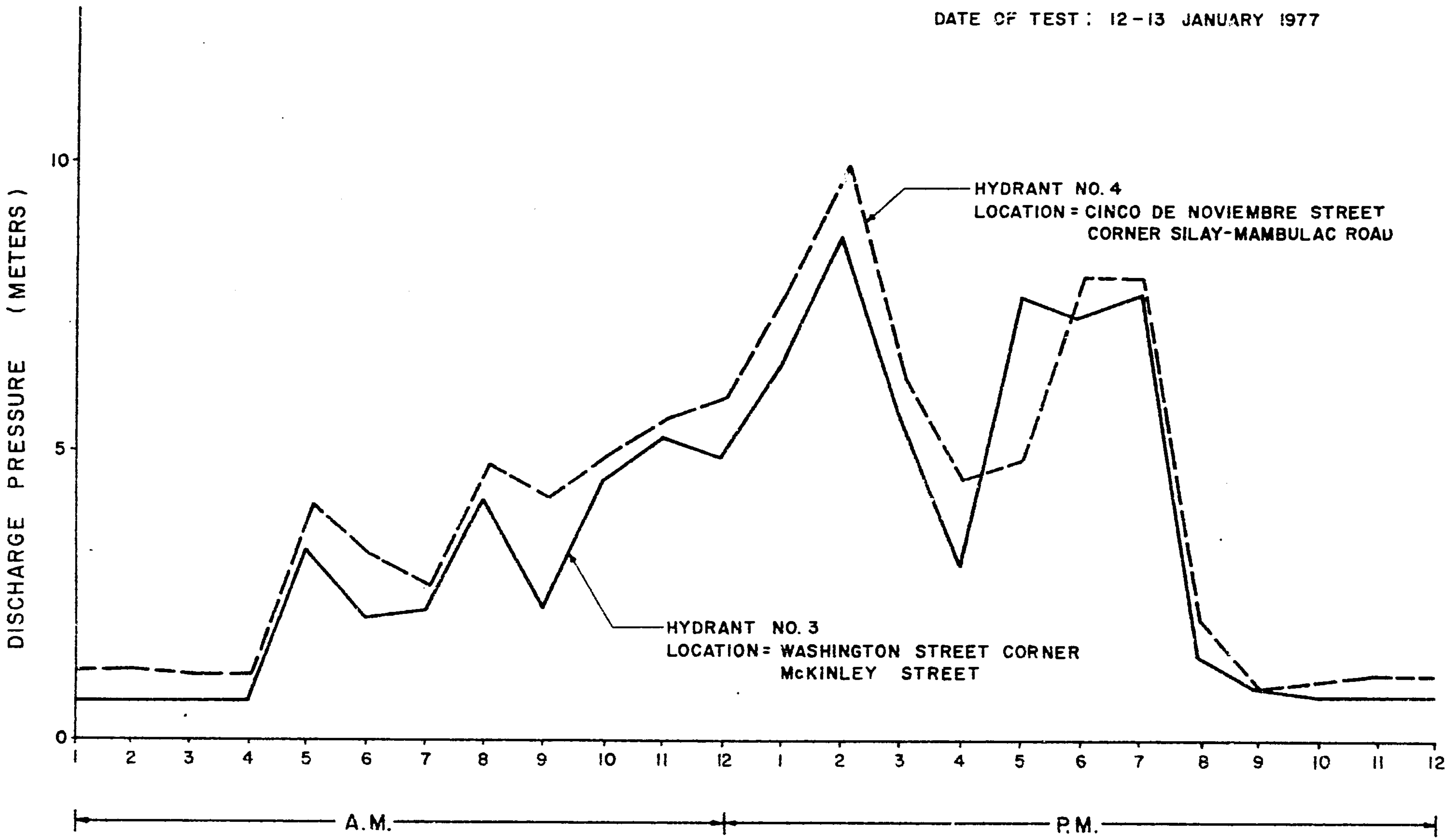


FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

ANNEX FIGURE IV-E-8
24 HOUR DISCHARGE PRESSURE AT PUMP STATION NO. 4
SILAY CITY WATER DISTRICT

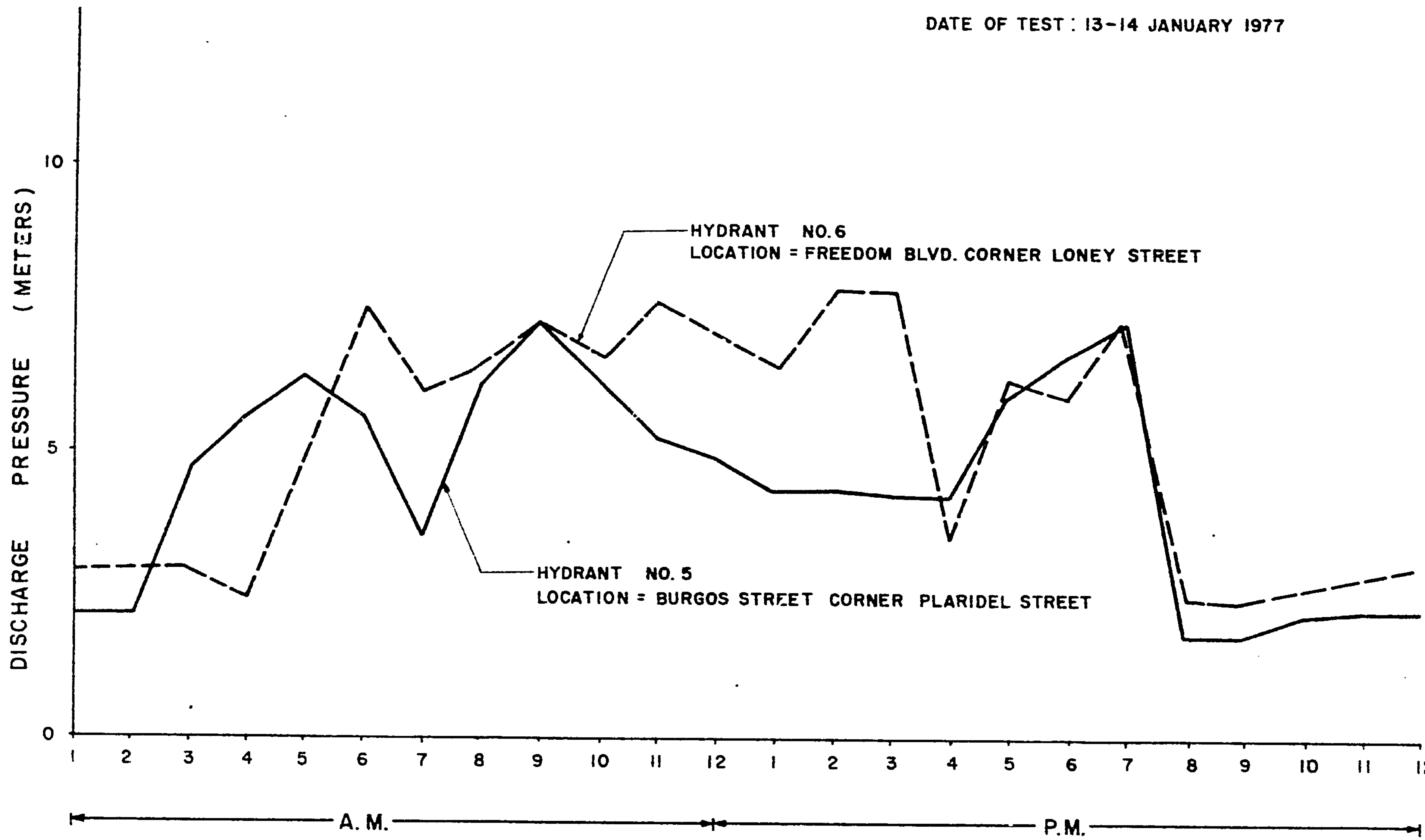


ANNEX FIGURE IV-E-9
24 HOUR SYSTEM PRESSURE AT FIRE HYDRANT NO.1 & 2
SILAY CITY WATER DISTRICT

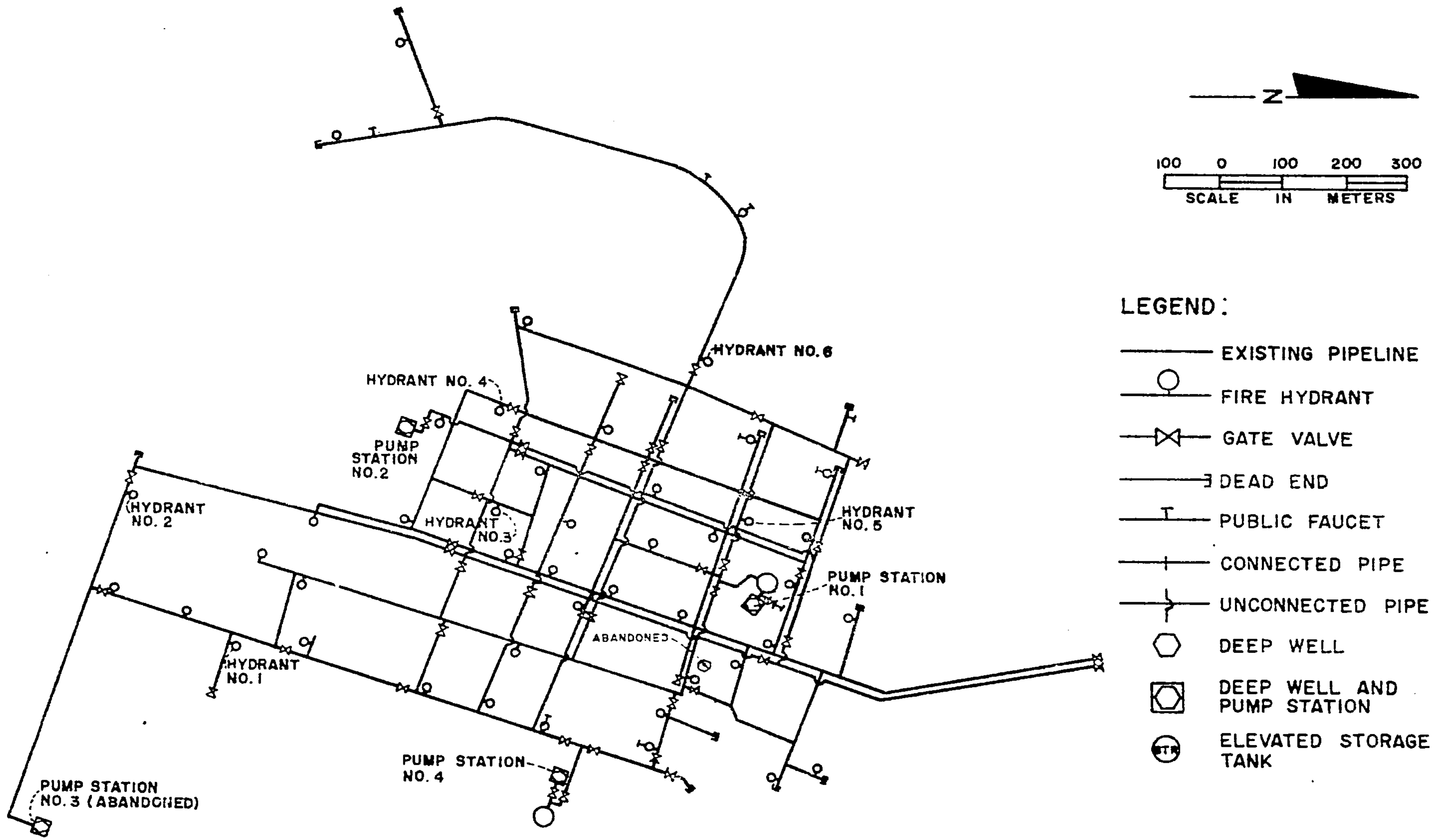


FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

ANNEX FIGURE IV-E-10
24 HOUR SYSTEM PRESSURE AT FIRE HYDRANT NO. 3 & 4
SILAY CITY WATER DISTRICT

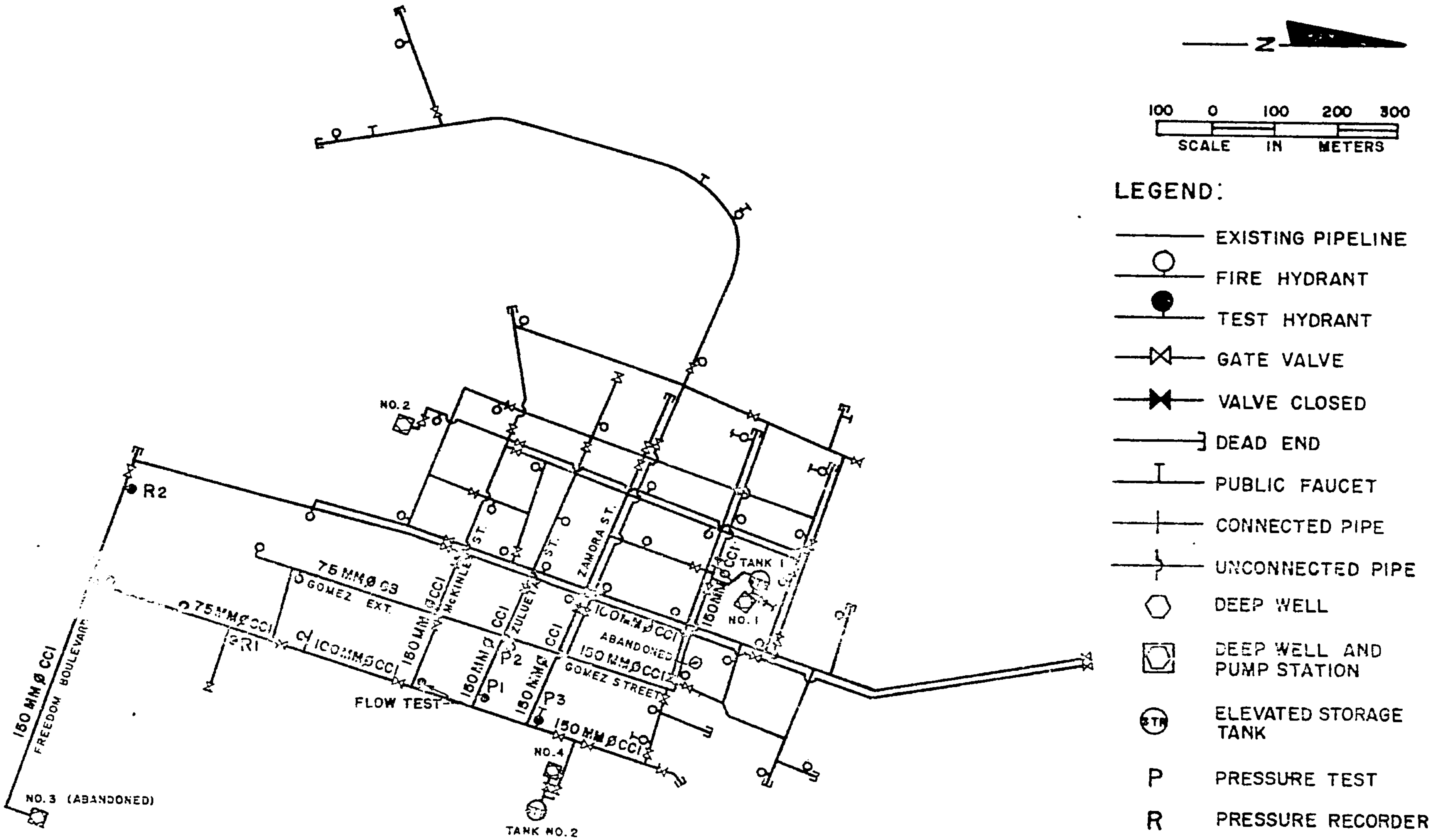


ANNEX FIGURE IV-E-11
24 HOUR SYSTEM PRESSURE
AT FIRE HYDRANT NO. 5 & 6
SILAY CITY WATER DISTRICT



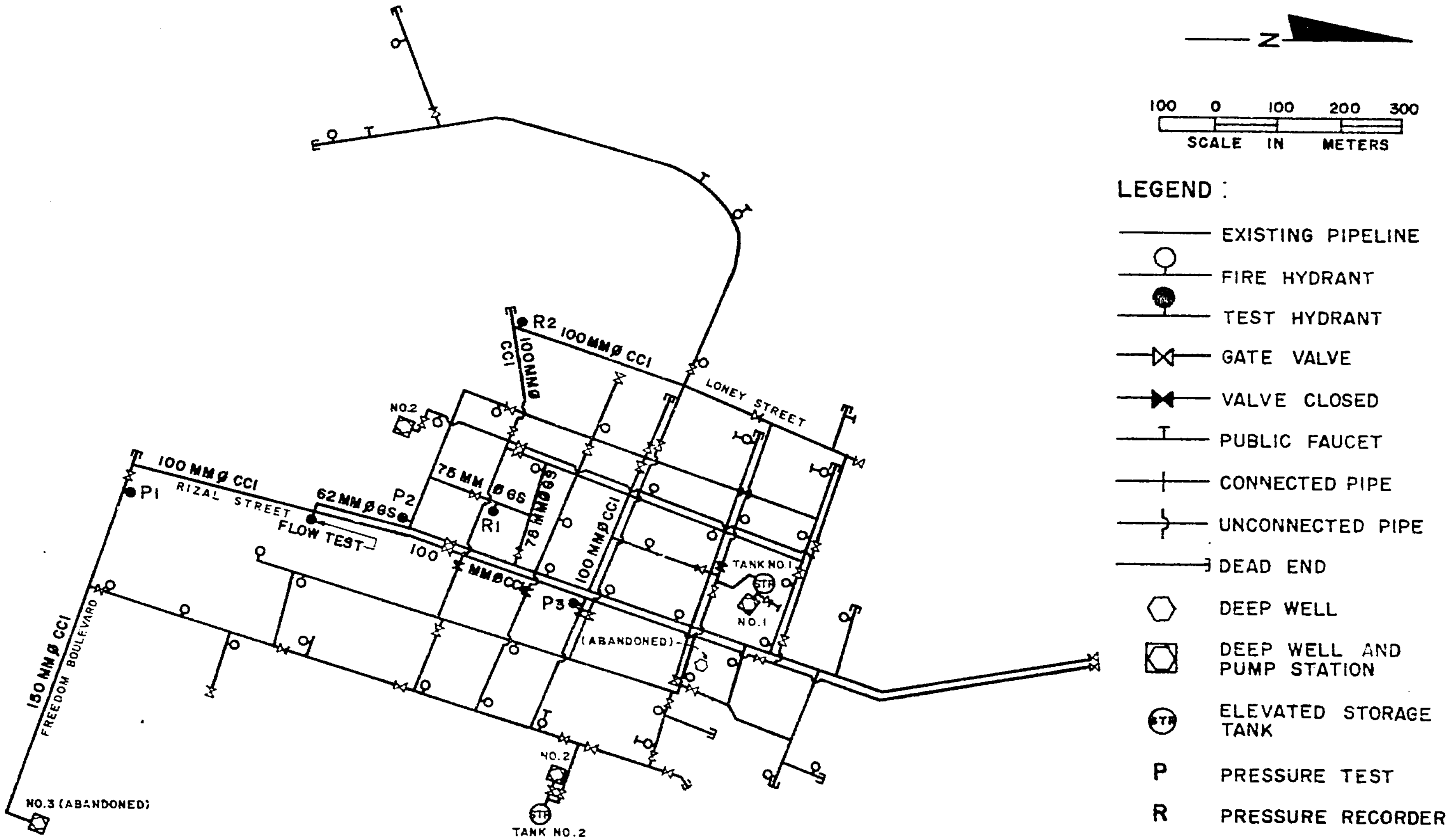
ANNEX FIGURE IV-E-12
HYDRANT LOCATION ON RECORDED SYSTEM PRESSURE
SILAY CITY WATER DISTRICT

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM



DATE OF TEST – 12 JANUARY 1977

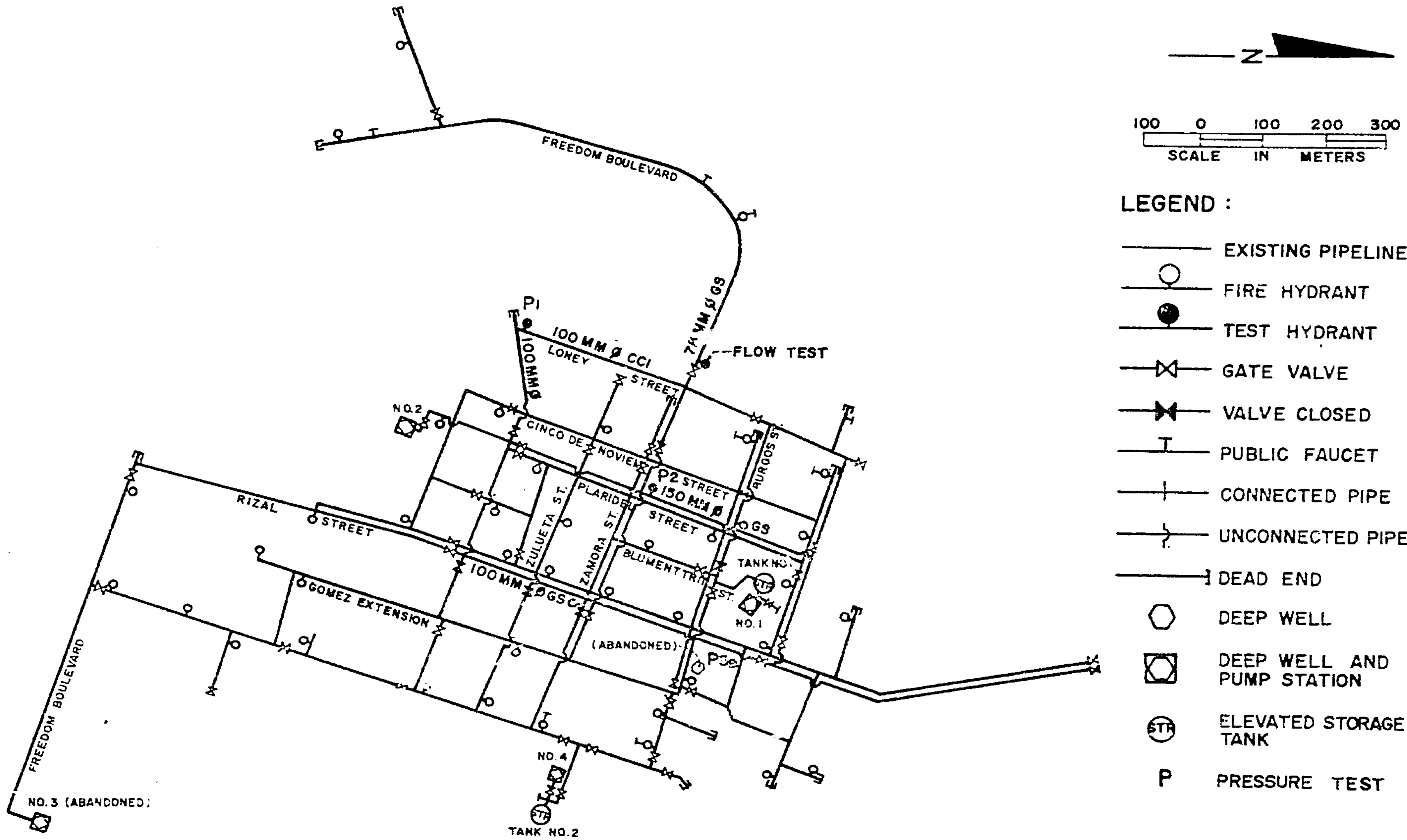
ANNEX FIGURE IV-E-13
HYDRANT FLOW
MEASUREMENT NO. 1
SILAY CITY WATER DISTRICT



DATE OF TEST — 13 JANUARY 1977

ANNEX FIGURE IV-E-14
HYDRANT FLOW
MEASUREMENT NO. 2
SILAY CITY WATER DISTRICT

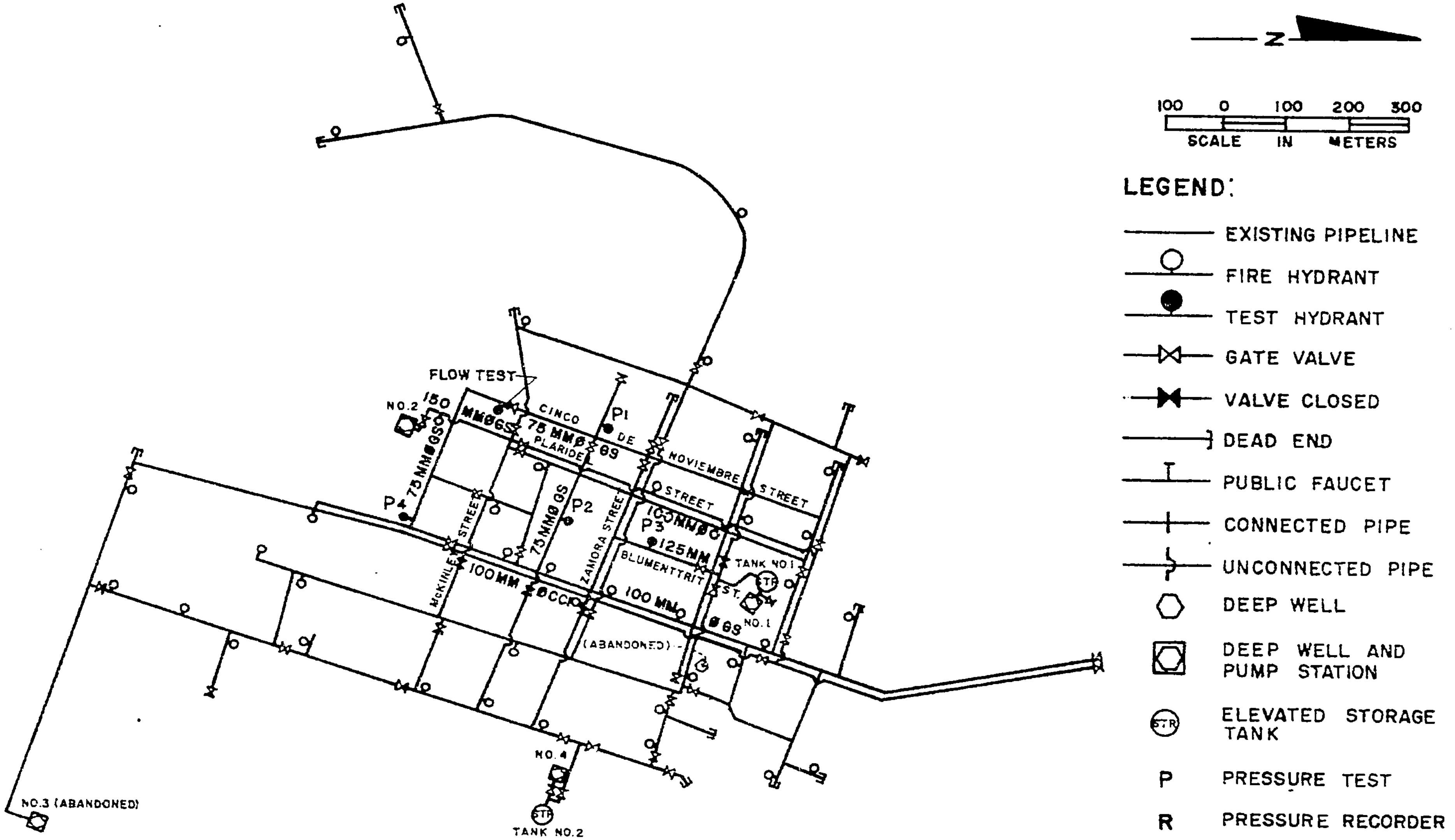
FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM



DATE OF TEST — 15 JANUARY 1977

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS **LWUA-CDM**

ANNEX FIGURE IV-E-15
HYDRANT FLOW MEASUREMENT NO. 3
SILAY CITY WATER DISTRICT



DATE OF TEST – 16 JANUARY 1977

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

ANNEX FIGURE IV-E-16
HYDRANT FLOW MEASUREMENT NO. 4
SILAY CITY WATER DISTRICT

CHAPTER V FEASIBILITY STUDY CRITERIA

A. GENERAL

The planning, design, economic, and financial criteria used in the water supply feasibility studies have been derived from studies of local conditions, accepted practices, standards and methods developed in the First Ten Provincial Urban Areas Feasibility Studies. These criteria, together with the developed basis of cost estimates, have been utilized to evaluate and compare the various alternatives identified in the course of the study.

In the analysis and evaluation of alternatives, feasibility study criteria need not be as refined as those used in the detailed development of the recommended scheme. Consistency is, however, essential. As long as each alternative to be analyzed is judged by similar criteria (or rules), evaluation of alternatives will be accomplished in a fair and consistent manner.

B. PLANNING CRITERIA

This water supply feasibility study has been guided by the following planning criteria (not listed in order of importance):

1. Areawide Approach: Planning of facilities has been done on a regional or areawide basis, taking into account the present district service boundaries and the logical long-term service areas beyond present district or political boundaries.

2. Source of Water: Groundwater and surface water have been given equal consideration as potential sources of water. However, based on the first 10 feasibility studies, groundwater derived from wells, when available, is expected generally to be more economical than conventionally treated surface water.

3. Self-Sufficiency: The recommended plan has been developed to provide the highest quality of water service within the "ability-to-pay" of the consumers.

4. Conservation: In the selection among alternative plans, water, power, chemicals and foreign exchange are considered valuable resources which must be conserved to the greatest extent possible.

5. Stage Development: The recommended long-range construction program has been divided into several stages, each of which satisfies the projected requirements for a specific design year:

Stage	Construction Started by Calendar Year	Target Design Year
Immediate Improvement	1978	1980
Phase I-A	1980	1985
Phase I-B	1986	1990
Phase II-A	1991	1995
Phase II-B	1996	2000

6. Alternative Plan Screening and Selection: From an array of identified plan alternatives, the recommended plan has been selected on the basis of least (present worth) cost and other non-economic parameters. The selected plan has been tested for economic/financial feasibility.

7. Skilled Manpower Shortage: The recommended plan has recognized, in the short term, the apparent shortage in skilled, technical and managerial expertise. Emphasis has been given to the need for district personnel training and certification.

8. Water Quality: The feasibility study has identified present and future water quality problems and includes recommendations for providing a water supply that is safe, healthful and wholesome.

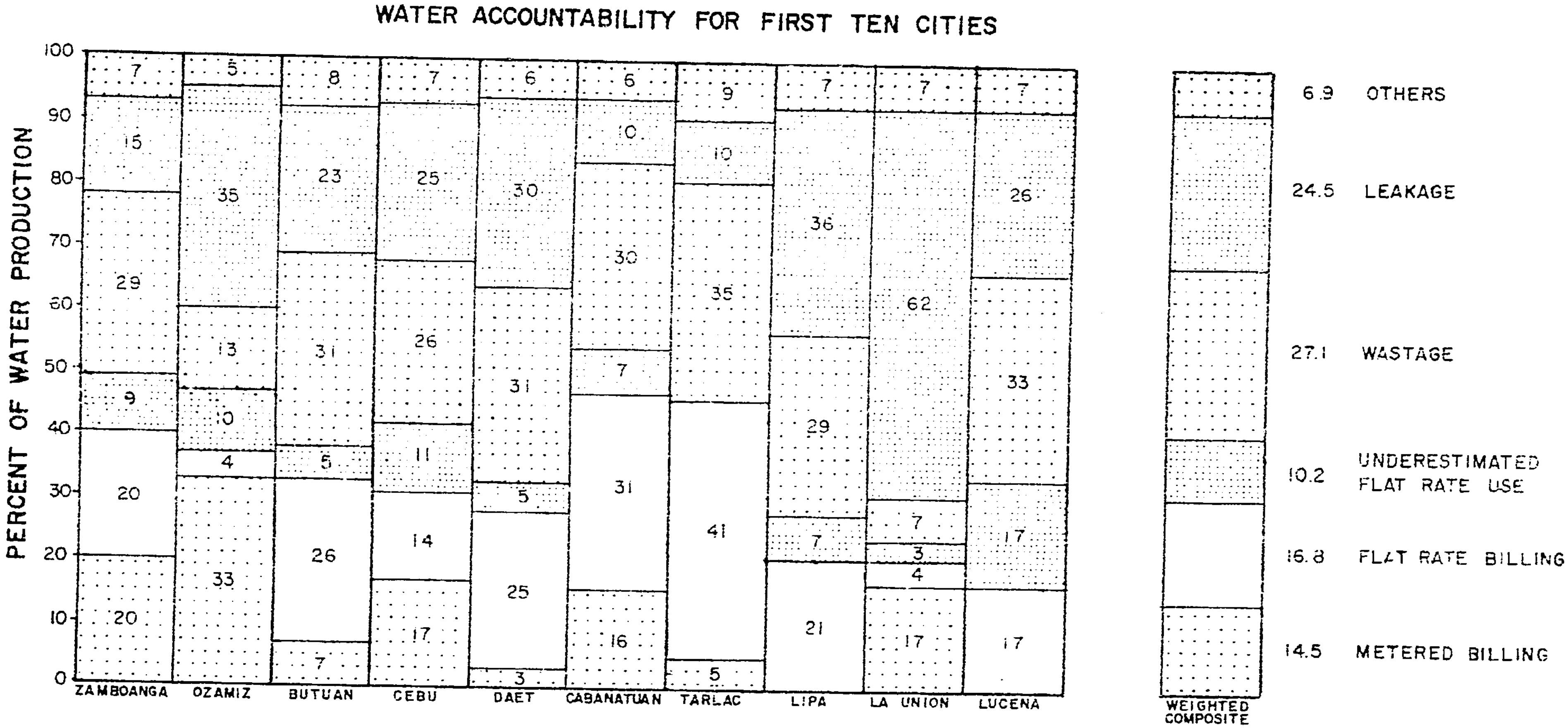
9. Social Soundness: The successful completion of any project must take into account the social acceptability of its recommended programs (Appendix S, Volume II).

C. DESIGN CRITERIA

The basis of design for these feasibility studies is presented in detail in Appendix F, Volume II of this Report. The design criteria are basically similar to those utilized in the First Ten Provincial Urban Areas Feasibility Studies. Minor improvements/modifications have been made as indicated in the Methodology Memoranda included in Volume I of this report.

Water Accountability

As much as possible, water accountability has been determined through field testing and measurement procedures, augmented by data gathered in the pilot area study surveys (see Methodology Memoranda No. 1 and 2). Where field data were not available and the pilot area study survey results were not conclusive, the weighted average of the water accountability results of the First Ten Provincial Areas was used (see Figure V-1).



FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

FIGURE V-1
WATER ACCOUNTABILITY
FIRST 10 CITIES

The breakdown of the water accountability is as follows:

	Percent of Water Production
Metered Billing	14.5
Flat-Rate Billing	16.8
Underestimated Flat-Rate Use	10.2
Wastage	27.1
Leakage	24.5
Others	6.9
	100.0

Water Demand Grouping

A procedure has been developed to classify communities in the Philippines into one of 5 groups for purposes of water demand projections. Available data on population, population growth, housing, income and other economic and technical parameters are used in the classification, with a system of weighting (see Methodology Memorandum No. 3). In general, the water demand requirements per capita through the period 1980-2000 are as follows:

Group 1	261 - 273 lpcd
Group 2	220 - 230 lpcd
Group 3	193 - 199 lpcd
Group 4	174 - 181 lpcd
Group 5	157 - 165 lpcd

The above values include domestic water needs; allowances for nominal commercial, industrial and institutional use; and a decreasing percentage of unaccounted-for-water in time.

For the analysis of existing conditions, actual metered (or connected) customers and "borrowers" are considered separately (see Methodology Memorandum No. 2). However, for short- and long-range planning, it has been assumed that "borrowers" would eventually become metered consumers. Per capita domestic use has been increased each year to account for economic growth within the community. Institutional and commercial water demands have been estimated as a percentage of domestic demand (see Methodology Memorandum No. 3).

Demand Variation

Maximum daily and peak hourly demands have been estimated from field data and available records. For the basic analysis of the water supply facilities, the following ratios have been used:

maximum-day to average-day ratio = 1.2:1
peak-hour to average-day ratio = 1.5:1 - 1.75:1

D. ECONOMIC AND FINANCIAL CRITERIA

Discount Rate

The opportunity cost of capital or discount rate used in this feasibility study is 12 percent. The discount rate has been used for economic screening of the technically viable alternatives (see Chapter IX, Methodology Manual on Water Supply Feasibility Studies, Volume I).

Inflationary Trends

The national economy of the Philippines is discussed in Appendix E, Volume II.

Projections made in this feasibility study assume a general cost escalation rate of 10 percent for the period 1978 through 1980; 8 percent for the period 1981-1985; and 6 percent thereafter. The cost of maintenance and operation is assumed to escalate at 8 percent per annum.

Economic Justification

The economic feasibility of this water supply project is based on 2 parameters: benefit-cost ratio (B/C) and the internal economic rate of return (IERR). These parameters are discussed in Chapter XI.

Financial Criteria

The financial justification of this project is based on the district customers' ability-to-pay, a financial feasibility analysis (see Chapters XX and XXI, Methodology Manual) and a suggested socialized pricing scheme, based on increasing unit cost of water with increasing consumption (see Chapter X).

E. BASIS OF COST ESTIMATES

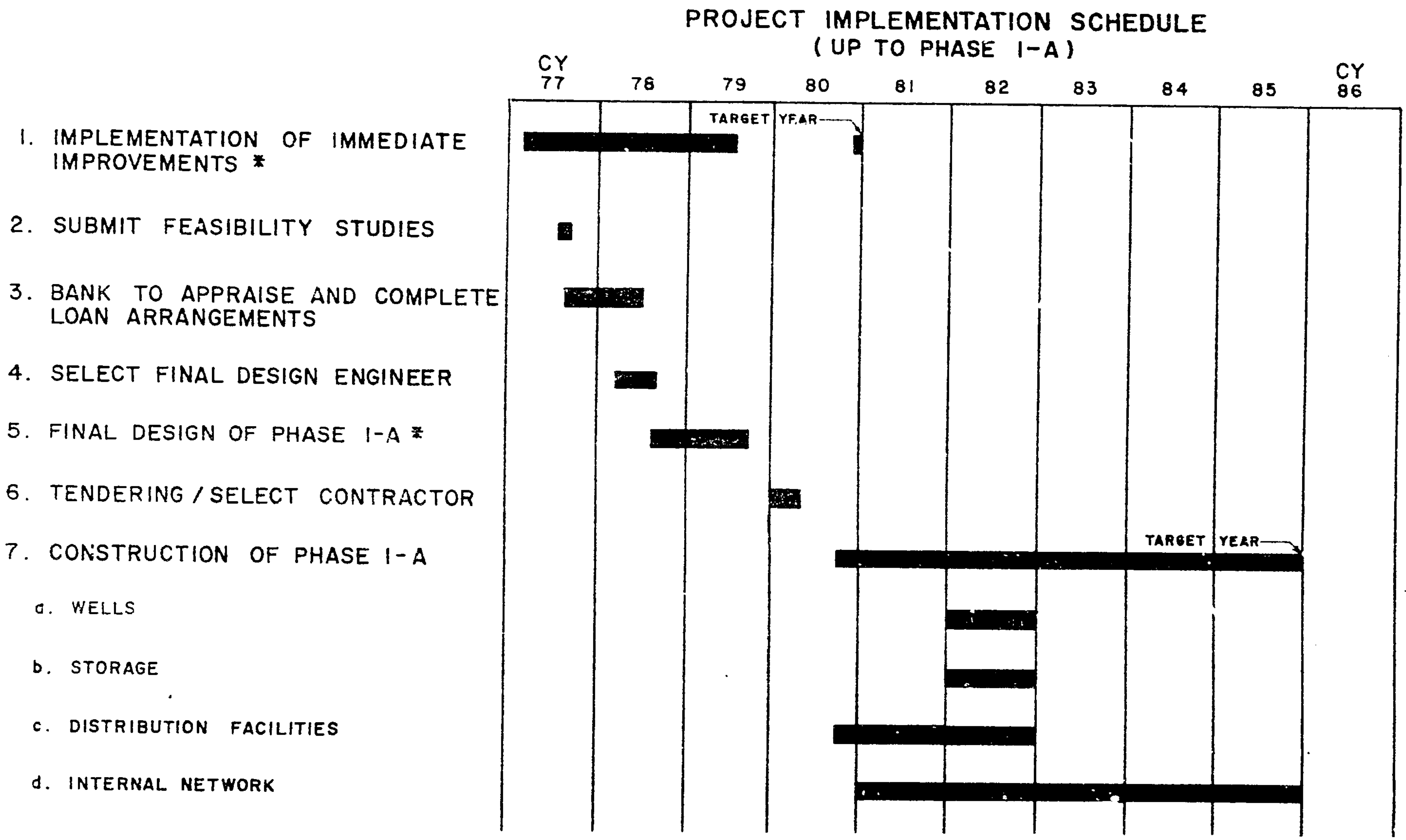
Construction cost curves have been developed for inplace costs of pipelines, deep wells, water treatment plants, pump stations, and storage reservoirs. These cost curves have been used for estimating the relative cost magnitudes of alternative water supply plans. Escalation factors used in calculating the capital cost of recommended improvements in July 1978 prices, as well as the above unit costs, are presented in Appendix G, Volume II.

F. IMPLEMENTATION SCHEDULE

For purposes of feasibility study and economic/financial analyses, an implementation schedule has been assumed. Figure V-2 shows the probable time-table which covers the planning, design, and implementation of the Immediate Improvement Program and Phase I-A. It is assumed in these feasibility studies that the recommended Immediate Improvement Program is to be fully implemented by the LWUA Interim Demonstration Program.

ESTIMATED PHASE I-A SCHEDULE

Final Report Submission	September 1977
Select Final Design Engineer	September 1978
Start Final Design	October 1978
Complete Final Design	September 1979
Start Construction	January 1980
Complete Construction:	
a) Source	1982
b) Distribution	1982
c) Internal Network	1985



* PHASE I-A ASSUMES THE FULL IMPLEMENTATION OF THE IMMEDIATE IMPROVEMENT PROGRAM

FIGURE V-2
PROJECT IMPLEMENTATION SCHEDULE
SILAY CITY WATER DISTRICT

CHAPTER VI

POPULATION AND WATER DEMAND PROJECTIONS

A. GENERAL

A necessary step in developing the preliminary design of a water system is the projection of future population and water demand for the delineated service area. These projections significantly affect facility layouts and sizes, construction staging and the cost of the project. This chapter develops these projections for the SIL-WD.

B. SERVICE AREA POPULATION PROJECTION

The population projections have taken into account the previous population trend in Silay City; present land use and development plan; the physical limits of the urban areas and current and proposed facilities.

The population of Silay from 1948 to 1975 has grown at an average annual rate of 4.1 percent. The annual growth rates have fluctuated during this period from 4.8 percent for 1948-60 to 1.4 percent for 1960-70 and 8.4 percent for 1970-75. The growth rates of Silay are generally higher than those of the Philippines. The following table shows the population and the growth rates of Silay from 1948 to 1975, and the national growth rates.

Year	Population	Annual Growth (%)	National Growth (%)
1948	35,570		
1960	60,324	4.8 (1948-1960)	3.10
1970	69,200	1.4 (1960-1970)	3.0
1975	103,493	8.4 (1970-1975)	2.66

The decline in the average annual growth rate from 1960 to 1970 was attributed largely to the outflow of sugar cane planters and factory workers from Silay, a major sugar-growing city. During this period, the foreign demand for sugar had declined and sugar farming and milling activities consequently slackened. However, the abrupt increase in population from 1970 to 1975 was caused by the expansion of sugar milling activities in the city, the recent diversification of farm crops and the development of housing subdivisions in the urban areas.

The service area for the present and the years 1980, 1990 and 2000 (Figure VI-1) have been developed on the basis of field inspection and discussion with water district and city officials. By the year 2000, the SIL-WD is expected to serve the urban portions of the poblacion (Zones I to V); Barrios Rizal, Mambulao, Guinhalaran and Lantad. The primary factors that will affect the future growth of these areas are:

(1) An increase in population due to an influx of workers and their families. This will be due to the continued expansion of sugar mills in the city and the development of corporate farming systems.

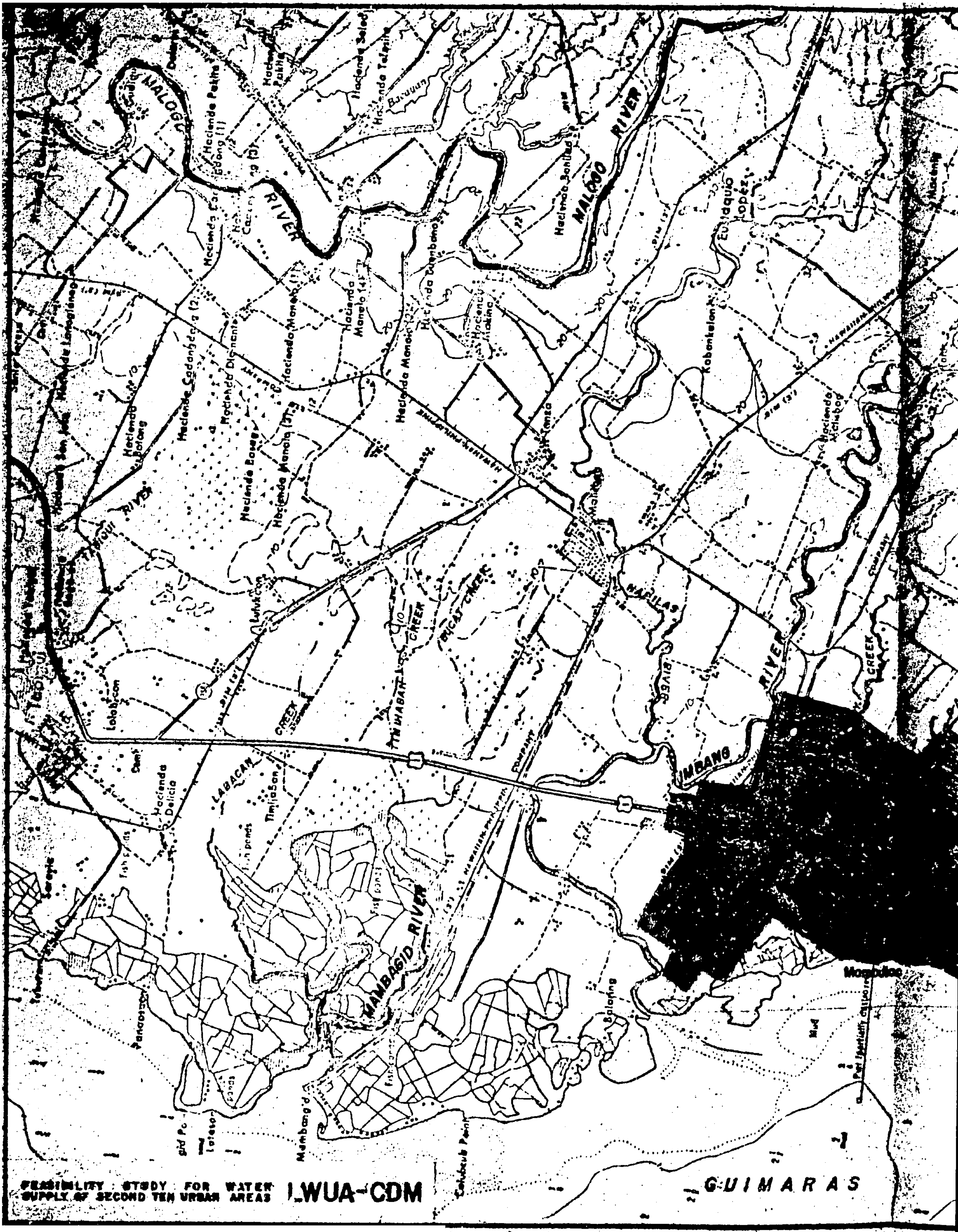
(2) The good access roads, transportation and communication facilities and municipalities. This is expected to induce expansion of commercial establishments outside Bacolod City, from which Silay is only about 15 km.

(3) The development of housing subdivisions in the urban areas of Silay (Elena and Ortiz Subdivisions in the poblacion, Employees and Hofilena Subdivisions in Barrio Mambulao, and Seaview Subdivision in Barrio Guinhalaran).

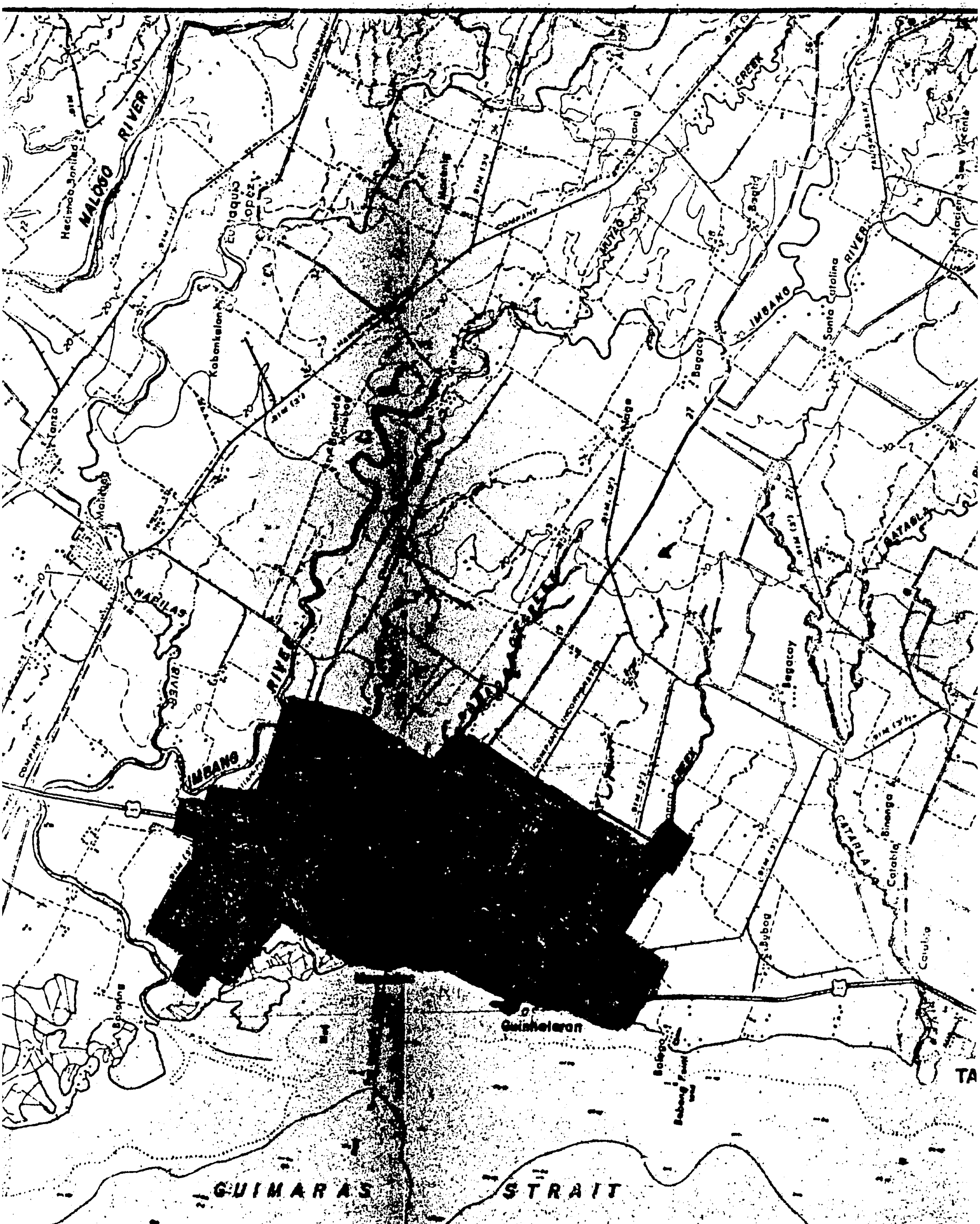
The population projections have been made by applying specific annual growth rates for the poblacion and barrios in the service area. The estimates of growth rates are based on field observations and discussions with local officials and water district personnel. The population growth rates are determined after the service area population densities, urban development plans, employment opportunities, existing industrial activities and proximity of the city to other urban areas of the province, have been considered.

The NEDA-POPCOM projections have not been used because they are considered especially applicable to mixed urban and rural areas but considerably low for entirely urban areas. For the urban areas of Silay City, annual growth rates are expected to be higher than the national and municipal average annual growth rates (for example, the NCSO 1975 population for Silay City (103,493) already exceeds the NEDA-POPCOM 1990 high assumption (92,783) projection.

Projected populations within the service area are shown in Table VI-1 and are summarized as follows:


MALOGO RIVER
RIVER
MALOGO
Hacienda Solidad
Hacienda Manolo
Hacienda Delicia
Hacienda Cadandaca
Hacienda Diamante
Hacienda Bosse
Kabankalan
Eustaquio Lopez
NAPILAS
IMBANG
RIVER
CREEK
BICAS CREEK
LABACAN
MAMBAGID RIVER
Fish ponds
Mambag'd
Mud
GUIMARAS
FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS
LWUA-CDM

VI-2a


MALOGO
RIVER
IMBANG
RIVER
NAPILAS
Bagacay
Santa Catalina
CATABLA
Guinhalaran
GUIMARAS
STRAIT
TA

VI-2b

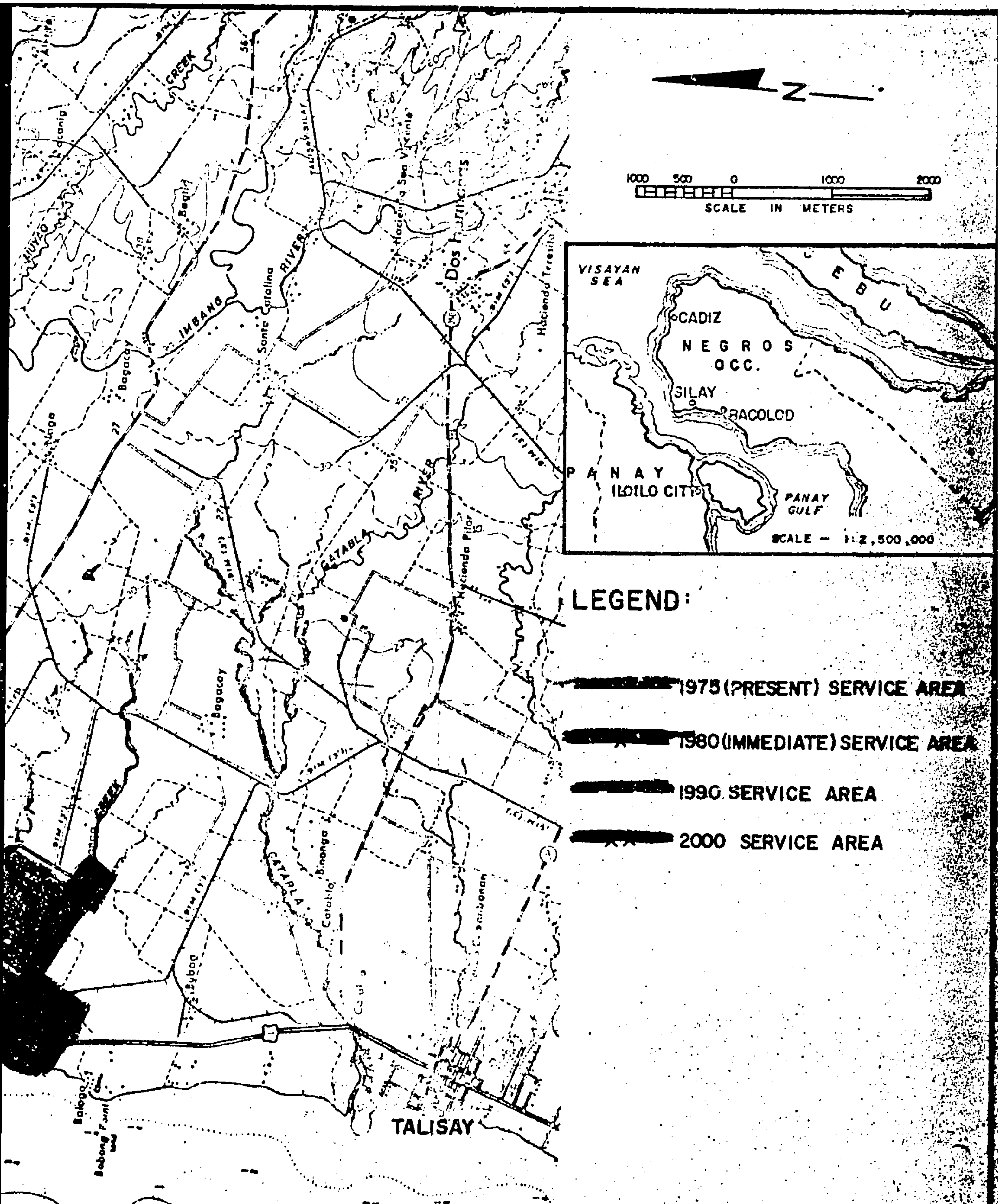


FIGURE VI-1
PRESENT AND FUTURE SERVICE AREA
SILAY CITY WATER DISTRICT

TABLE VI-1

SERVICE AREA POPULATION PROJECTIONS
SILAY CITY WATER DISTRICT

		PRESENT SERVICE AREA			IMMEDIATE SERVICE AREA (1980)			1990 SERVICE AREA			2000 SERVICE AREA		
	Population 1975	Population in Service Area	Service Area (ha)	Density (Persons/Ha)	Population in Service Area	Service Area (ha)	Density (Persons/Ha)	Population in Service Area	Service Area (ha)	Density (Persons/Ha)	Population in Service Area	Service Area (ha)	Density (Persons/Ha)
Poblacion	29,320	14,940	69	216	20,620	123	167	31,270	215	145	42,030	272	154
Rizal	9,716	2,920	14	209	7,090	45	153	12,510	104	120	22,210	200	111
Mambulac	8,543	3,420	21	163	8,200	93	88	18,180	104	175	24,430	107	228
Guinhalaran	8,072	-	-	-	5,530	41	135	14,170	94	151	26,400	256	103
Lantad	6,973	-	-	-	-	-	-	8,480	89	95	15,700	197	80
Total	62,624	21,280	104	205	41,440	302	137	84,610	606	140	130,770	1,032	127

POPULATION PROJECTION

	Total	Poblacion	Rizal	Mambulac	Guinhalaran	Lantad
1975	62,624	29,320	9,716	8,543	8,072	6,973
1980	81,160	37,020	11,820	11,740	11,060	9,550
1990	123,350	55,460	16,680	18,180	18,890	14,140
2000	177,220	77,840	24,680	24,430	29,340	20,930

Year	Total Population[1/]	Overall Annual Growth Rate(%)	Population in Service Area	Service Area (ha)	Average Density in Service Area (persons/ha)
1975	62,624		21,280	104	205
1980	81,160	5.3 (1975-1980)	41,440	302	137
1990	123,350	4.3 (1980-1990)	84,610	606	140
2000	177,220	3.7 (1990-2000)	130,770	1,032	127

The analysis shows that the population in the service area (see Figure VI-2) will increase from 21,280 in 1975 to 130,770 in 2000. Densities in the service area will average between 120 and 200 persons per hectare. The total population in Silay poblacion and 4 barrios will increase almost 3 times from 62,624 in 1975 to 177,220 in 2000. Overall annual growth rates in this area will decline from 5.3 percent in 1975-1980 to 3.7 percent in 1990-2000.

C. PROJECTIONS FOR SERVED POPULATION

Served population in the SIL-WD has been projected to increase significantly within the next two decades. The increase will be a result of: (a) the intense campaign of the SIL-WD to connect as many customers as possible (at present many households without connections rely on public faucets and neighbor's piped water for water supply); (b) the stated desire of residents in the SIL-WD to partake of the benefits of modern piped water system; and (c) the increase in population as well as in service area coverage of the SIL-WD.

Table VI-2 shows the detailed breakdown of the served population projections of the Silay poblacion and the barrios within the service area. These are summarized below:

Year	Projected Served Population	Population in the Service Area	Percent Served
1975 (present)	5,900	21,280	28
1980 (immediate)	15,630	41,440	38
1990	54,870	84,610	65
2000	103,160	130,770	79

1/ Of Silay City Poblacion (Zones I to VI) and 4 barrios.

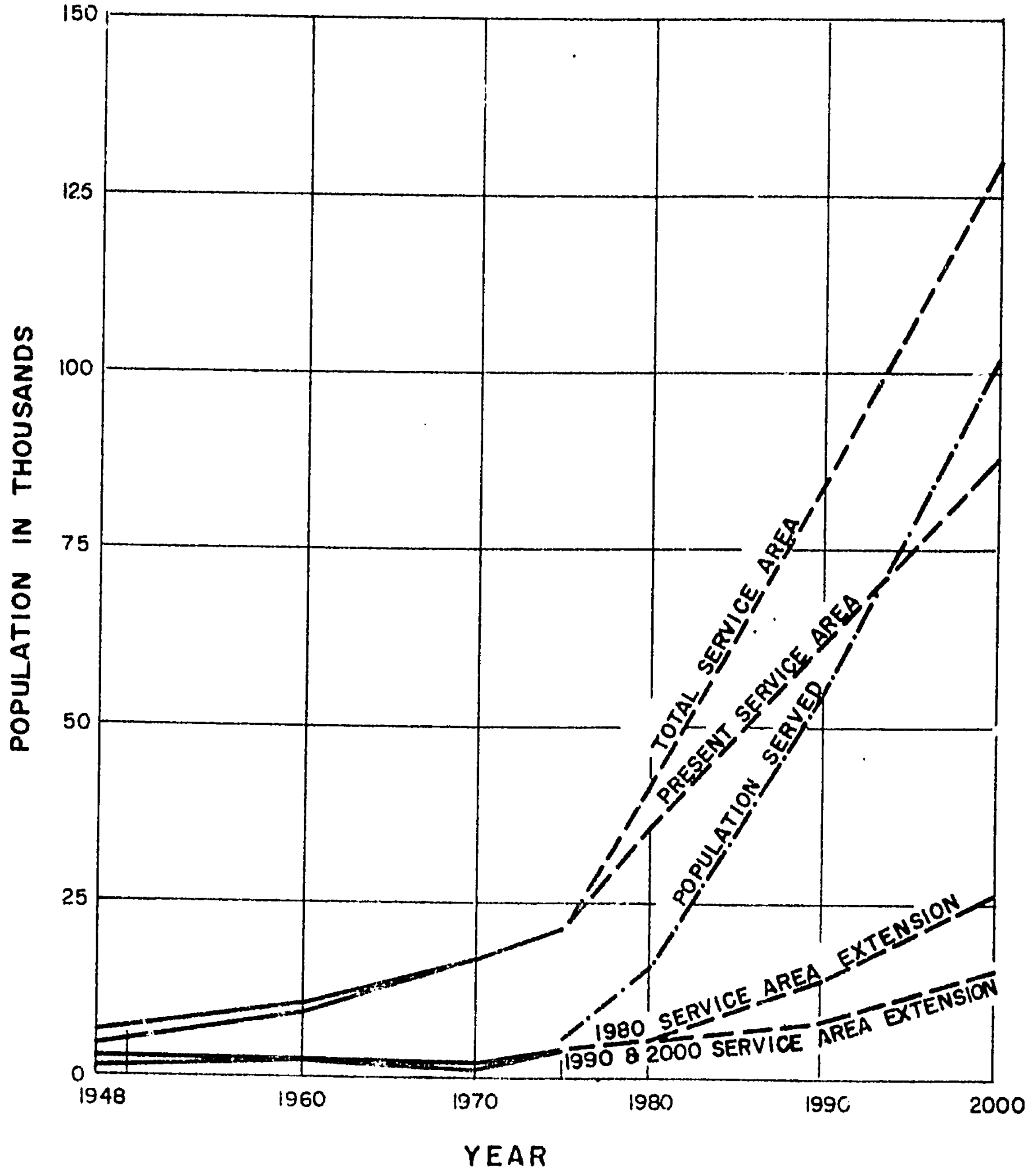


FIGURE VI-2
SERVICE AREA
POPULATION PROJECTION
SILAY CITY WATER DISTRICT

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

TABLE VI-2

SERVED POPULATION PROJECTIONS
SILAY CITY WATER DISTRICT

		Present Service Area	1980 Immediate Service Area	1990 Service Area	2000 Service Area
I.	POBLACION (Zones I-V)				
	A. Population in Service Area	14,941	20,620	31,270	42,030
	B. Number of Service Connections	681*	1,290	3,420	5,670
	C. Connected Population	4,424	8,250	21,890	35,730
	D. % Connected	30	43	70	85
II.	RIZAL				
	A. Population in Service Area	2,920	7,090	12,510	22,210
	B. Number of Service Connections	135*	380	1,170	2,640
	C. Connected Population	878	2,410	7,510	16,660
	D. % Connected	30	34	60	75
III.	MAMBULAC				
	A. Population in Service Area	3,420	8,200	18,180	24,430
	B. Number of Service Connections	92*	470	1,990	3,300
	C. Connected Population	598	3,030	12,730	20,770
	D. % Connected	18	37	70	85
IV	GUINHALARAN				
	A. Population in Service Area	0	5,530	14,170	26,400
	B. Number of Service Connections		300	1,330	3,140
	C. Connected Population		1,940	8,500	19,800
	D. % Connected		25	60	75
V.	LANTAD				
	A. Population in Service Area	0	0	8,480	15,700
	B. Number of Service Connections			660	1,620
	C. Connected Population			4,240	10,200
	D. % Connected			50	65
	TOTAL				
	A. Population in Service Area	21,280	41,440	84,610	130,770
	B. Number of Service Connections	908	2,440	8,570	16,370
	C. Connected Population	5,900	15,630	54,870	103,160
	D. % Connected	28	38	65	79

*Registered connections as of October 1976.

The served population which was 28 percent of the total service area population in 1975 is projected to be 38 percent in 1980, 65 percent in 1990, and 79 percent in 2000. Hence, the served population would increase from 5,900 in 1975 to 103,160 in 2000, or an increase of 17 times in 25 years (see Figure VI-2).

The projected increases in served population are 9,730 from 1975 to 1980; 39,240 from 1980 to 1990; and 48,290 from 1990 to 2000. The projected increases are concentrated in the present service area, the served population of which will include 71 percent of the total served population in 2000. The 2000 served population outside the present service area will represent the remaining 29 percent.

A year by year tabulation of projected served population from 1978 to 2000 is shown in Table VI-3.

D. WATER DEMAND PROJECTIONS

The water demand of the SIL-WD has been projected to increase significantly as a result of continued growth in served population.

Per capita domestic water use, commercial/industrial/institutional use, as well as unaccounted-for-water (expressed as percentage of production), have been estimated for the years 1980, 1990 and 2000 for the service area. Based on analyses (see Methodology Memorandum No. 3), SIL-WD has been classified under Group III, which has the following water use parameters:

	1980	1990	2000
Domestic use, lpcd	105	120	135
Commercial/industrial/institutional, lpcd	14	19	24
Accounted-for-water, lpcd	119	139	159
% Unaccounted-for-water	40	28	20
Unaccounted-for-water	79	54	40
Total Water Demand, lpcd	198	193	199

The present unaccounted-for-water which is about 84 percent of the total water production[4/] is estimated to decrease to 40 percent in 1980, 28 percent in 1990 and 20 percent in 2000. This reduction in unaccounted-for-water will be brought about by (a) initiation of

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[4/] See Chapter IV, Table IV-4.

an extensive leak detection survey and repair; (b) metering of all existing connections; and (c) replacement of old leaking service connections.

Using the above water demand parameters and the projected served populations, the water demands for the design years 1980, 1990 and 2000 are as follows (see Table VI-3 and Figure VI-3):

	1980	1990	2000
Water demand, lpcd	198	193	199
Served population	15,630	54,870	103,160
Average daily water demand, cumd	3,090	10,590	20,530
Maximum-day water demand[5], cumd	3,710	12,710	24,640
Peak-hour water demand[6], cumd	5,410	18,530	35,930

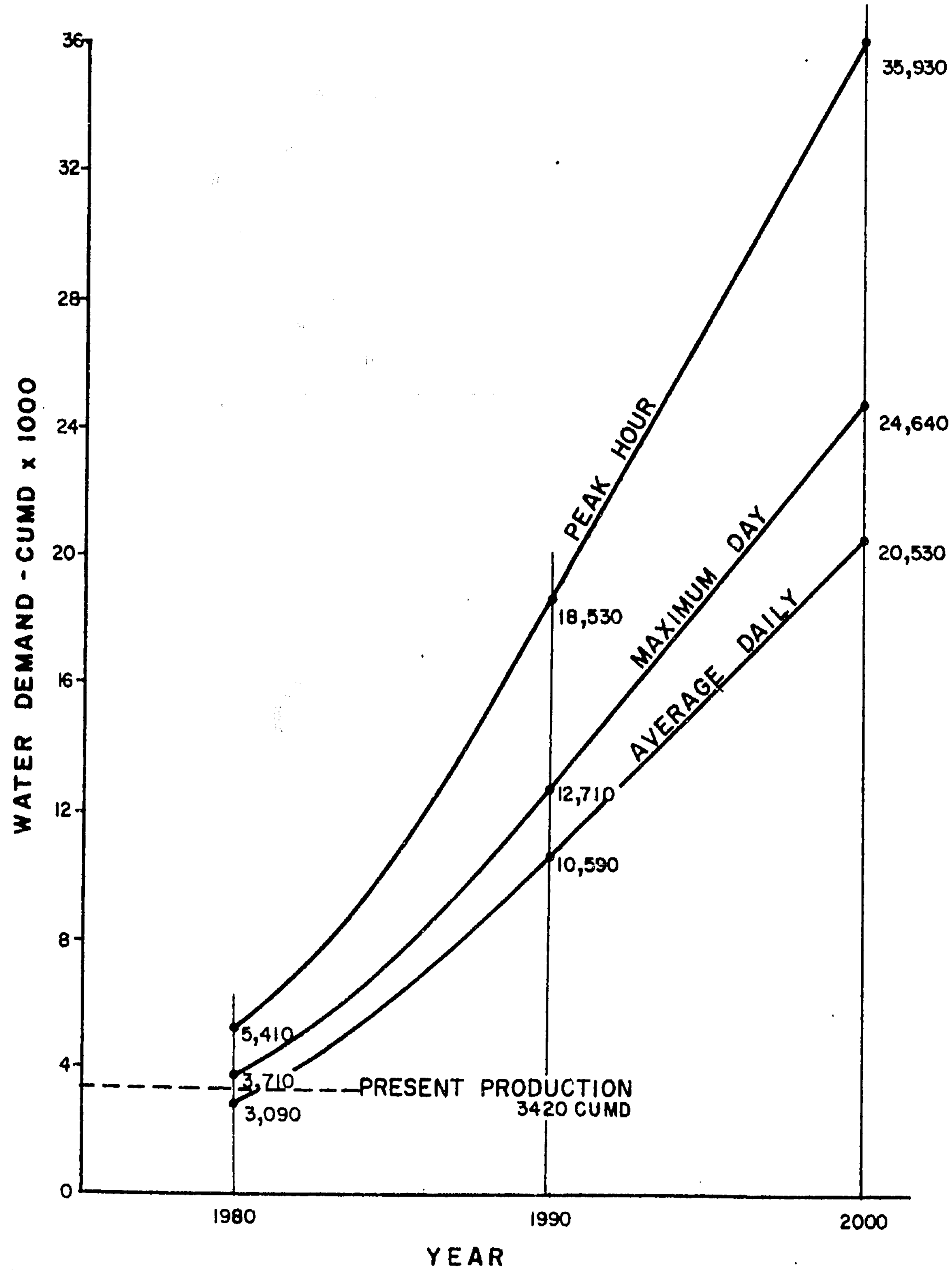
[5] Based on 1.2 times average daily water demand.

[6] Based on 1.75 times average daily water demand.

TABLE VI-3

YEAR BY YEAR SERVED POPULATION AND WATER DEMAND PROJECTIONS
SILAY CITY WATER DISTRICT

Year	Total Population Served	Average-Day Demand (cumd)	Maximum-Day Demand (cumd)	Peak-Hour Demand (cumd)
1978	6,890	2,540	3,040	4,450
1979	9,750	2,540	3,040	4,450
1980	15,630	3,090	3,710	5,410
1981	17,720	3,500	4,200	6,130
1982	20,090	3,960	4,750	6,930
1983	22,780	4,480	5,370	7,830
1984	25,830	5,060	6,080	8,860
1985	29,290	5,730	6,870	10,020
1986	33,200	6,470	7,770	11,330
1987	37,650	7,320	8,790	12,810
1988	42,680	8,280	9,940	14,490
1989	48,400	9,370	11,240	16,400
1990	54,870	10,590	12,710	18,530
1991	58,450	11,320	13,580	19,800
1992	62,250	12,090	14,510	21,160
1993	66,310	12,920	15,500	22,610
1994	70,630	13,800	16,560	24,150
1995	75,240	14,750	17,700	25,810
1996	80,140	15,760	18,910	27,570
1997	85,360	16,830	20,200	29,460
1998	90,920	17,990	21,580	31,470
1999	96,850	19,220	23,060	33,630
2000	103,160	20,530	24,640	35,930



FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

FIGURE VI-3
PROJECTED WATER DEMAND
SILAY CITY WATER DISTRICT

CHAPTER VII WATER RESOURCES

A. GENERAL

The SIL-WD currently obtains all of its water from three wells located within the existing service area. The current water supply is sufficient for the present overall requirement but distribution problems cause local shortages in the city. The possible sources of water for further municipal supply are wells, springs, the Imbang River and the Malogo River.

B. GROUNDWATER RESOURCES

Silay City is located at the edge of Guimaras Strait on the northwest shore of Negros Island. The coastal plain and lower mountain slopes in the area support good wells which are used for domestic, commercial, industrial and irrigation supply. Well water can supply the SIL-WD requirements beyond the year 2000 but salinization of coastal wells may occur if well production becomes too great or too concentrated.

There are springs on the mountain flanks but no large springs are close to Silay Poblacion.

Topography and Geology

Silay Poblacion is at the seaward edge of a flat, gently sloping coastal plain that rises toward the volcanic mountains in the east. The topographic gradient at the sea is about 4 meters per km westwardly, increasing slowly to about 60-meter elevation, 10 km inland, where the slope abruptly increases to about 10 meters per km on the lower flanks of the mountain. This increased slope continues to the upper steep slopes of the complex of volcanic peaks over 1,000 meters high that comprise the central north-to-south spine of Negros Island. The closest of these peaks, at over 1,100-meter elevation, is about 25 km southeast of Silay.

The central cores of the various mountains consist of andesitic volcanic rocks; injections, flows, breccias and ash beds (tuffs). The lower flanks of the mountains are mainly composed of pyroclastics, ash beds and volcanic debris. The coastal plain deposits consist of waterlain gravels, sands, silts and clays, all derived from volcanic parent material (largely ash), and some interbedded volcanic ash deposits. Only a little limestone is found in the coastal plain deposits because the conditions of deposition were not conducive to reef growth or other limestone deposition.

Springs

In the Philippines, springs are very common in topographic and geologic environments similar to that inland of Silay City. A combination of high rainfall on the volcanic mountains (induced by the abrupt topographic relief of the peaks) and the porous and permeable nature of the volcanic rocks leads to a high rate of recharge by infiltration in the mountains. This high rate of recharge establishes a high phreatic or piezometric level in the aquifers. The great topographic relief causes the land surface to intersect this high phreatic or piezometric level and results in natural groundwater discharge, or springs, coming from various permeable zones. Thus, most significant springs occur in areas of high relief.

Large springs are known in the higher areas at a great distance from Silay Poblacion and small springs and seeps occur closer, frequently in gullies or other depressions, but no springs large enough to form a significant part of SIL-WD requirements exist close enough to Silay City to be economically competitive with local wells. Large springs do not occur near the poblacion because of the low relief of the broad coastal plain.

A brief spring exploration program was carried out and the following was discovered:

1. Lantawan Spring is at about 550 meters altitude at the foot of the mountains about 21 km (28 km by road) southeast of Silay Poblacion. The discharge was measured to be 3.1 lps. The spring is used as a barrio water supply.

2. Patag Waterfalls is at about 780-meter altitude at the foot of the mountains about 22 km (35 km by road) southeast of Silay poblacion. The measured discharge was 113 lps. The source of the water was reported to be a spring 2 km upstream but the local residents refused to guide a party there for fear of insurgents or bandits in the hills. The spring is at the head of the Malisbog River, tributary to the Imbang River, and was once used as water supply for a now abandoned hospital. The actual source of the waterfall could not be visited.

3. Kabatangan Springs is a complex of a main spring, 25 lps measured discharge, and two lower springs with a combined measured discharge of 16 lps. They are located at the foot of the mountains on the headwaters of the Matabang River at about 450 meters altitude. They are about 23 km (25 km by road) southeast of Silay Poblacion. The lower two springs are seeps and would be difficult to collect.

Other springs exist in the area but they are reported to be either small or more remote.

Considering the great distance from Silay, the relatively small capacities of the individual springs, the difficulty of collection and amalgamation of various sources, and the rough and remote country involved, springs currently are not a practical alternative to the excellent wells that can be constructed within the SIL-WD service area. In the event that coastal wells ever become saline, springs should be considered as a possible alternative to wells located inland from Silay poblacion, and further spring exploration undertaken at that time.

Wells

Wells are the usual source of domestic, commercial and industrial water supply on the Negros coastal plain near Silay. Some large-capacity wells are used for irrigation in the area also. Water quality is usually good. Figure VII-1 shows the locations of various wells studied for the purposes of this report and Table VII-1 summarizes the available pertinent data of these wells. Many of the wells were not field located and are shown only approximately in Figure VII-1. Annex Figures VII-B-1 through VII-B-7 show stratigraphic logs and additional data of selected wells.

The current water supply of SIL-WD comes from three wells located within the water district. These are all fairly good wells: SIL-WD No. 1 (CDM No. 1) is 71.6 meters deep and produces 20.2 lps at a specific capacity of 2.3 lps/m; SIL-WD No. 2 (CDM No. 2) is 78.3 meters deep and produces 22.4 lps; SIL-WD No. 4 (CDM No. 3) produces 20.8 lps at a specific capacity of 2.7 lps/m. However, these wells are reported to have had specific capacities of 3.0 to 3.5 lps/m originally. The first two wells were drilled 46 and 30 years ago, respectively, and may deteriorate soon considering the construction materials and methods used at the time. A fourth well, SIL-WD No.3, began producing muddy water several years ago and was abandoned. Another 20-year old well (CDM No. 40) under SIL-WD control is intended to supply the marketplace only. This well also had an original specific capacity of 3.0 to 3.5 lps/m. All the SIL-WD operating wells began to produce sand after an earthquake in late 1976, but have been since reported to be sand-free again. Design of future production wells should be such that the probability of damage from earthquakes is minimized. Depth of each SIL-WD well is about 78 meters.

Data on 19 BPW-drilled wells in Silay are also given in Table VII-1, CDM No. 4 through 22. Of these, 11 wells have specific capacities tabulated: three ranging from 0.2 to 0.5 lps/m, six ranging from 1.0 to 2.0 lps/m, and the others being 2.9 and 5.3 lps/m. These are excellent specific capacities from a group of BPW wells, which generally are designed and drilled for limited productive capacity. The BPW wells mostly are less than 30 meters deep with several reaching about 100-meter depth. Other BPW wells in the adjoining

TABLE VII-1

WATER WELL DATA SUMMARY
SILAY WATER DISTRICT

CDM Well Number	BFW Well Number	Location	Nominal Diameter (mm)	Depth From Ground Surface In Meters: Total	Cased	Static Water Level	Pumping Water Level	Test Yield (lps)	Specific Capacity (lps/m)	Year Completed
1		SIL-WD No. 1, Silay	200	71.6	—	1.70	10.44	20.2	2.3	1931
2		SIL-WD No. 2, Silay	200	78.3	—	+0.6(1954)	—	22.4	3.5 (1954)	1947
3		SIL-WD No. 4, Silay	250	76.2	—	2.74	10.44	20.8	2.7	1964
4	17103	Adela, Silay	100	24.4	19.2	3.1	3.7	0.6	1.0	1957
5	11026	Guinhalaran, Silay	150	104.3	97.0	+0.9	—	0.6	—	1957
6	6356	Guimbalaon, Silay	150	34.8	33.2	3.7	7.3	0.6	0.2	1954
7	5511	Silay South Elementary School Compound, Silay	200	78.4	68.6	+1.2	0.0	2.2	1.8	1952
8	7279	Sitio Dowis, Silay	150	24.4	22.0	1.5	1.8	1.6	5.3	1955
9	17105	Bala ing, Silay	100	99.1	50.6	+0.6	0.0	0.9	1.5	1958
10	6357	Nacayao, Silay	150	51.8	45.7	18.3	—	—	—	1954
11	6358	Lopez, Silay	150	30.5	28.3	3.0	—	—	—	1954
12	7278	Public Market, Silay	150	48.8	38.4	1.8	3.4	1.6	1.0	1955
13	376091	Silay Waterworks, Silay	150	30.5	30.0	+2.4	0.9	9.5	2.9	1960
14	17104	Balaring, Silay	100	99.0	50.6	+0.6	—	1.0	—	1958
15	17106	Mambagid, Silay	63	77.7	49.7	0.6	1.2	—	—	1958
16	376021	Dapdap, Silay	100	17.7	16.5	0.9	0.9	0.6	—	1960
17	376022	Veranio, Silay	100	17.9	17.9	4.6	4.9	0.6	2.0	1960
18	376023	Dungcaan, Silay	100	18.3	15.5	0.0	0.6	1.0	1.7	1960
19	376080	Rizal, Silay	100	22.9	21.0	6.4	7.6	0.3	0.2	1960
20	376081	Mambolac Elementary School, Silay	100	21.9	15.8	1.2	1.8	0.3	0.5	1960
21	376083	Purisima Elementary School, Silay	100	19.5	18.9	2.4	—	—	—	1960
22	376082	Rosario Elementary School, Silay	100	31.1	30.5	3.7	—	—	—	1960
23		Hacienda Panaogao 3, Silay	400 350	137.2	53.7 129.3	—	—	63.0	—	—

TABLE VII-1 (continued)

CDM Well Number	BPW Well Number	Location	Nominal Diameter (mm)	Depth From Ground Surface in Meters: Total	Cased	Static Water Level	Pumping Water Level	Test Yield (lps)	Specific Capacity (lps/m)	Year Completed
24		Hacienda Maquina, Silay	300 200	61.0	12.2 48.8	–	–	–	–	1972
25	376086	Bo. Matabang, Talisay	100	20.4	20.4	2.4	–	–	–	1960
26	18854	Sitio Catabla Beach, Talisay	112	29.0	21.8	0.0	6.1	0.8	0.12	1957
27	5164	Poblacion, Talisay	200	69.2	65.2	+1.2	7.6	3.15	0.36	1950
28	5255	McKinley St., Talisay	200	109.1	99.1	+2.4	1.5	5.04	1.29	1951
29	18856	Bo. Bubog, Talisay	100	25.6	22.7	2.4	3.7	0.63	0.48	1957
30	18858	Dr. Orosa Subdivision, Talisay	200	30.5	26.4	3.0	12.8	0.76	0.08	1958
31	18857	Sitio Minuluan, Talisay	100	15.2	13.6	3.0	4.6	0.63	0.39	1957
32	16151	Daan Banwa, Victorias	100	24.4	23.5	0.3	1.2	1.26	1.40	1957
33	6359	Public Plaza, Victorias	100	86.0	23.1	5.5	–	9.45	–	1960
34	17108	Daan Banwa, Victorias	100	21.3	13.1	0.6	1.2	0.63	1.05	1958
35	376076	Nursery, Victorias	100	18.3	17.7	4.6	–	–	–	1960
36	376089	Boulevard, Victorias	100	39.3	38.4	0.6	–	–	–	1960
37	376087	Sitio Bat-us, Victorias	100	17.1	11.3	2.1	–	–	–	1960
38		Stratigraphic Exploration, Silay	125	182.9	158.5		–	–	–	1977
39		Pumping Test Well, Silay	250	166.2	166.2					1977
40		SIL-WD Market Place well, Silay	200	76±	–	0.9	–	–	3.5 (1954)	1932

municipalities of Talisay and Victoria, CDM No. 25 to 37, generally have lower specific capacities.

Numerous large-capacity private wells have been drilled in the area for industrial and irrigation use, such as the wells for the sugar mills at Malisbog and Eustaquio Lopez. A typical well is the Hacienda Panaogao No. 3 (CDM No. 23) which has a diameter of 350 to 400 mm, depth of 137 meters, and a reported production of 63 lps.

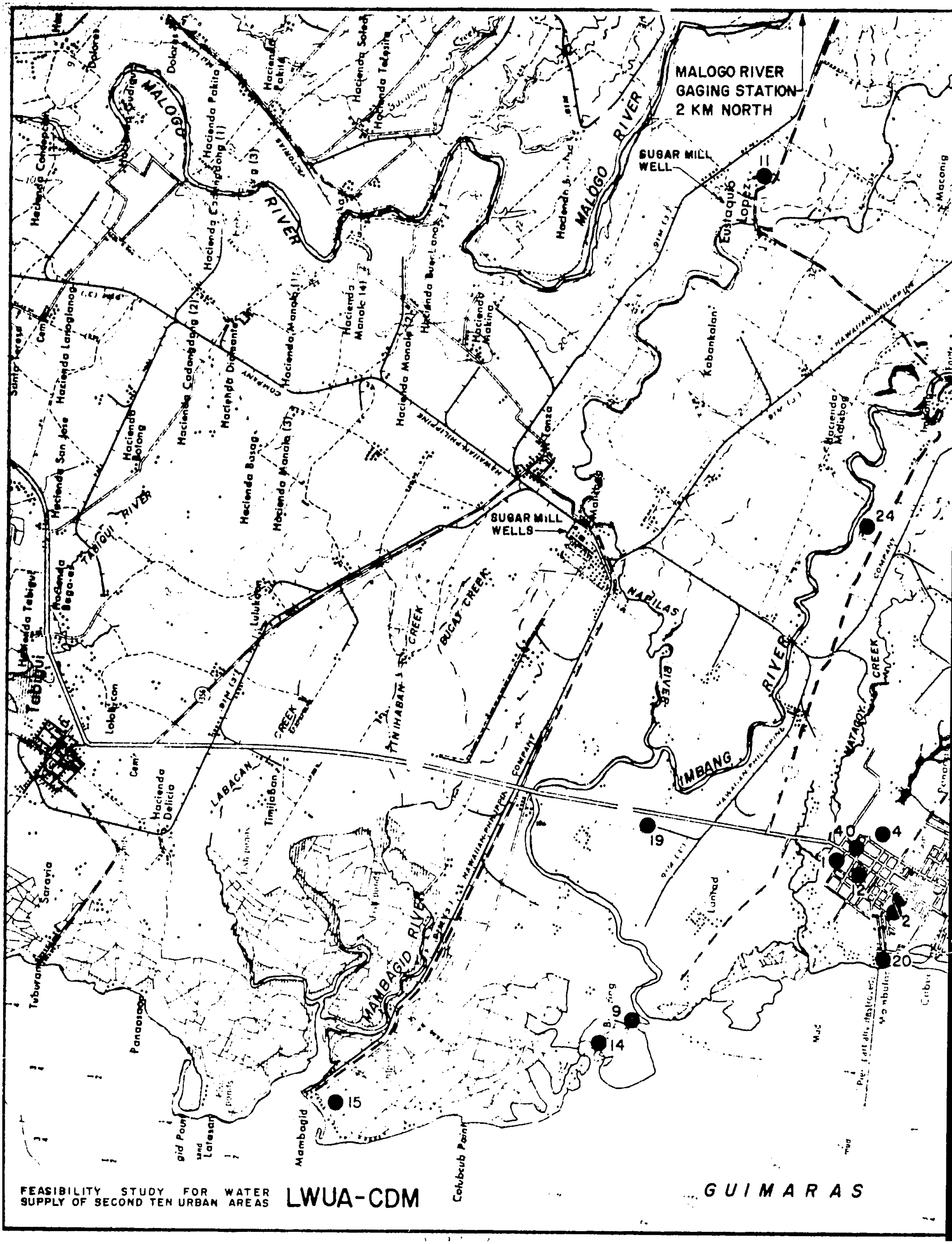
Test Well and Well Testing

Although existing well data indicate that fairly productive wells can be constructed in most of the Silay City area with little trouble, nothing was known of the depth and characteristics of the aquifer near the coast below 100 meters or of water quality at depth. Also, although minimum aquifer transmissivities necessary to produce wells of the specific capacities shown in Table VII-1 can be estimated and recovery tests of two existing wells were made, no definitive hydraulic aquifer parameters were known at any depth. Consequently it was decided to drill and test a 183-meter deep exploratory well in Silay.

The site chosen is southeast of the existing service area several hundred meters beyond the site of abandoned SIL-WD Well No. 3. The site was selected because it is over a kilometer from the sea, because an exploratory well in this area can be converted to a production well which would improve pressure distribution in the system, and because open land was obtainable.

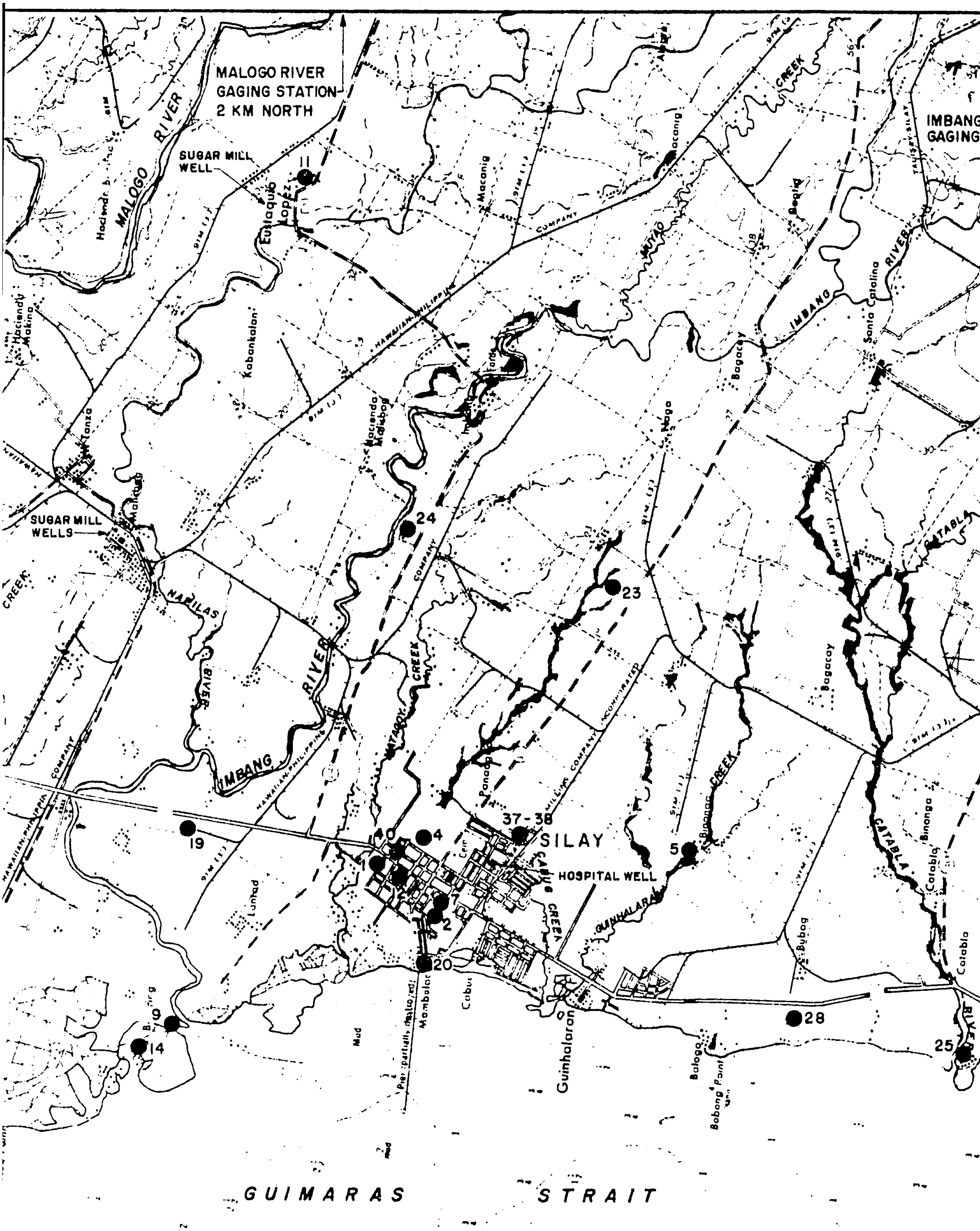
First a 125-mm diameter stratigraphic test hole/cum observation well was drilled to a depth of 183 meters and stratigraphic log prepared (Annex Figure VII-B-6). From the log, a preliminary design (slotted pipe settings and total depth) for the pumping test well was prepared. The 125-mm hole was cased to a depth of 158.5 meters. A 250-mm diameter well was then drilled to 166-meter depth. Samples were collected and a stratigraphic log prepared (Annex Figure VII-B-7). Gamma ray logs (Annex Figure VII-B-8) were run in both wells. The design settings of the slotted pipe sections were refined through study of the samples from the 250-mm well and the casing was installed. The gamma ray logs were of little help in this instance because the entire stratigraphic section is derived from volcanic material, much of which tends to be slightly radioactive and so masks or distorts the usual natural radioactivity contrast between clays and other beds.

A 48-hour continuous pumping test at 37.8 lps was completed, followed by 24-hour recovery test. After recovery, a step-drawdown



FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS

LWUA-CDM


MALOGO RIVER
GAGING STATION
2 KM NORTH
IMBANG
SUGAR MILL
WELL
11
MALOGO
RIVER
SUGAR MILL
WELLS
24
23
NAPILAS
RIVER
IMBANG
RIVER
IMBANG RIVER
CATABLA
19
40
4
37-38
SILAY
1
HOSPITAL WELL
5
2
20
28
9
14
25
GUIMARAS STRAIT

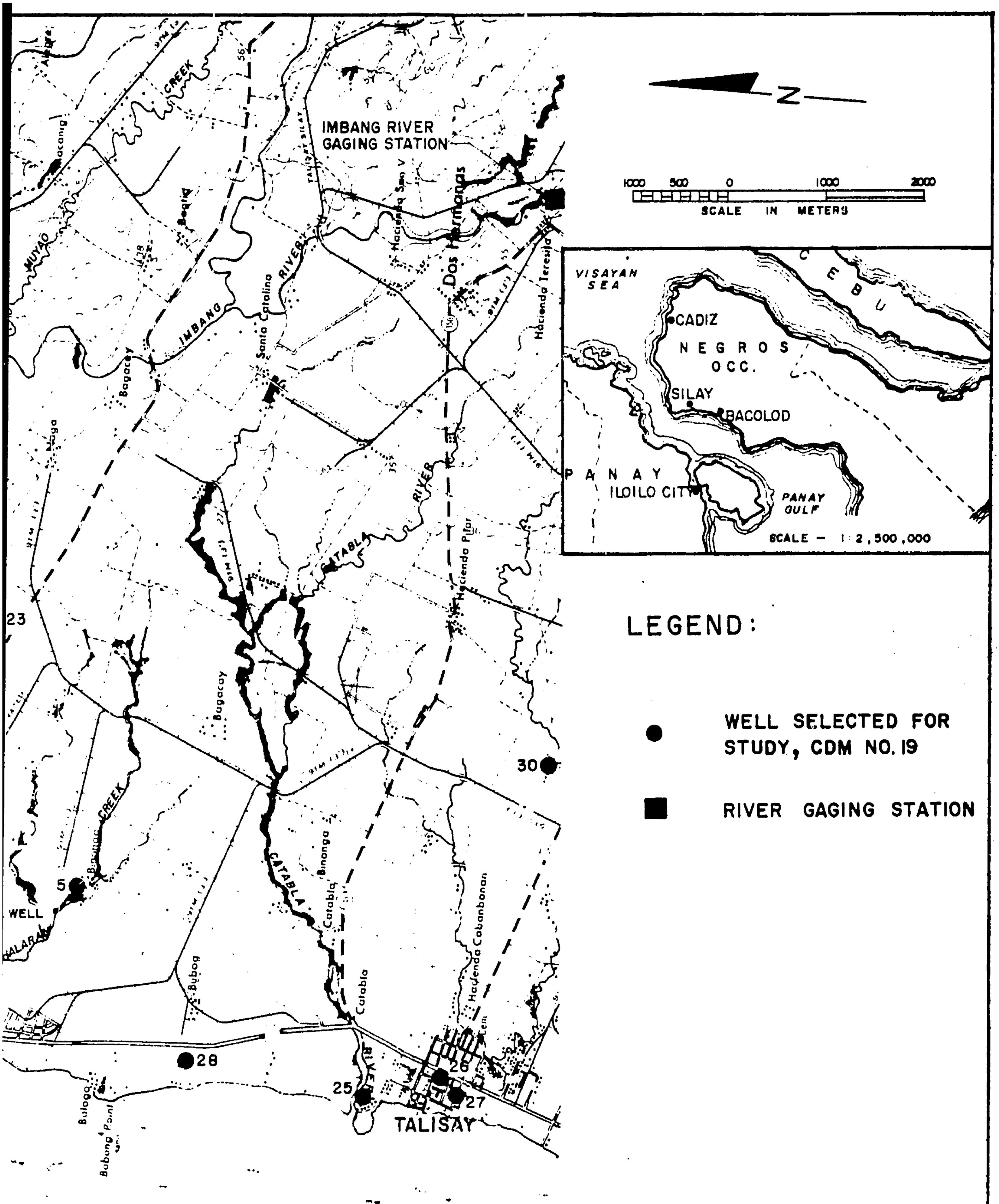


FIGURE VII-1
WELL LOCATION MAP
SILAY CITY AREA

test was carried out at rates of 12.6, 25.2 and 37.8 lps. Water level records were made in both the pumping well and in the observation well. Pump test data are tabulated in Annex Table VII-B-1 and are plotted in Annex Figures VII-B-9 through VII-B-16. Water samples were taken and analyzed. Rate of flow was measured by using a 100-mm orifice (circular weir) on a 125-mm discharge pipe. After some initial troubles were corrected, the pumping equipment ran well and it is believed that specified flow rates were closely maintained during the test period. Depths to water levels in both pumped and observation wells were measured with electric sounding wires.

The details of well construction and aquifer stratigraphy must be considered in interpreting the test data. The part of the aquifer penetrated by the well consists of uncemented sediments of greatly varying grain size and sorting and, consequently, greatly varying permeability. The lateral variation in characteristics is also great as shown by the differences between the logs of CDM-38 and 39, 7.6 meters apart. Screen (slotted casing) in the production well was set opposite only relatively coarse-grained zones to minimize the danger of continual fine sand production, therefore the aquifer response to pumping is very complex, combining partial penetration effects in beds of varying permeability with the effects of lateral changes in permeability as the radius of influence of the well spreads. It is also possible that development was incomplete and the well was slightly unstable, adding to the complexity of response. The observation well casing is open only at the bottom in the gravel zone located at about 160-meter depth. This well is so close to the pumping well that the response of only a very limited aquifer zone was monitored.

The log-log drawdown versus time plot is shown for both pumping and observation wells in Annex Figure VII-B-16. The pumping well curve shows the rapid initial drawdown (within the first minute) and abrupt flattening resulting from the conditions described above. The flatter part of the curve describes general aquifer parameters but is best analyzed in a different plot (Annex Figure VII-B-9). The early part of the observation well curve follows a typical "leaky artesian aquifer" curve but a quantitative analysis cannot be made because the observation well is monitoring conditions in one specific atypical aquifer zone and the flow rate from that zone is unknown.

The semilog drawdown versus time plot for the pumping well is shown in Annex Figure VII-B-9. The plot is somewhat erratic, resulting from conditions previously discussed (or undetected pumping rate variations), but it forms a generally straight line after 5 minutes. The line slope indicates an aquifer transmissivity of 338 cumd/m. The flattening of the slope described by the points at the extreme right end of the curve may indicate the radius of influence reaching either a more transmissive part of the aquifer or a source of recharge. The recovery semilog plot of the same well, Annex Figure VII-B-10, also indicates a similar transmissivity, 342 cumd/m.

The semilog drawdown versus time plot for the observation well is shown in Annex Figure VII-B-12. The plot is quite erratic probably because of changing flow patterns from various screen sections in the pumping well or for reasons previously mentioned. The flat portion at the extreme right may indicate leakage from overlying and underlying beds into the gravel zone. No quantitative estimate of transmissivity for the entire penetrated aquifer can be made from these data because under the test pumping conditions water level response in this limited aquifer zone is not typical of the average aquifer. Nor can an estimate be made of the transmissivity of the individual aquifer zone because the rate of flow from individual aquifer zones is unknown. However, the semilog recovery curve plots for the observation well, Annex Figures VII-B-13 and VII-B-14 do indicate that, under the less stressed, low-flow-rate conditions of recovery, the observation well water levels were responsive enough to overall aquifer conditions to permit transmissivity determinations of 342 and 344 cumd/m. Annex Figure VII-B-1A was also used to derive a storage coefficient of 0.009 which is of questionable validity.

The semilog plots of the step drawdown tests of the pumping well and the observation well are shown in Annex Figures VII-B-11 and VII-B-15. The pumping well plot indicates total well and aquifer losses to produce flow and shows about 3.2 meters of drawdown for the first 12.6 lps and a constant increase of about 5.4 meters of drawdown for each of the two additional 12.6 lps steps. The observation well plot indicates laminar-flow aquifer losses in one zone of the aquifer (the deep gravel) and so is a measure of flow from that zone. It shows about 3 meters of drawdown during step 1, 1.6 meters of additional drawdown during step 2 and 0.6 meter of additional drawdown during step 3. Apparently the deep gravel zone is relatively permeable and supplies a larger share of well production than its thickness alone would imply. Assuming that at higher production rates the hydraulic losses in the deep gravel zone near the well and in its associated screen become large because of turbulent flow, and further assuming that all other well and aquifer flow is laminar then the two drawdown plots indicate that at 12.6 lps the deep gravel contributes about 55 percent of the flow or 6.9 lps, at 25.2 lps the deep gravel contributes about 42 percent of the flow or 10.6 lps, and at 37.6 lps the deep gravel contributes only about 32 percent of the flow or 12.0 lps. The assumptions for this analysis are not entirely true and vertical flow patterns in the aquifer are ignored, but the overall pictures is valid. The deep gravel, although a thin zone, contributes a high percentage of the low volume flow but a decreasing percentage of increasing flow as losses become more significant. In the design of future wells where a thin permeable zone exists, the use of good continuous wire-bound screen and gravel packing will minimize turbulence and increase the flow.

The short-term specific capacity of the pumped well is best observed at about 1,800 minutes after pumping began because the drawdown plot (Annex Figure VII-B-9) flattens beyond this time and the specific capacity may be related to recharge thereafter. The specific capacity at 1,800 is 2.6 lps/m. If well losses of 10 percent are assumed, the aquifer transmissivity necessary to achieve the specific capacity is in close agreement with the figure of about 340 cumd/m determined from the drawdown and recovery plots. Again, it must be recognized that overall aquifer transmissivity will be somewhat greater, probably a minimum of 400 cumd/m, and may be much greater because of partial penetration effects in an anisotropic aquifer.

An attempt was made to run pumping tests on two of the existing SIL-WD wells, No. 1 (CDM-1) and No. 4 (CDM-3). Because of their location in the poblacion, water could not be pumped to waste, so closely controlled discharge was not possible. The wells were pumped into the system and the average rate determined from previously derived pump and system characteristics. After 965 (CDM-1) and 937 (CDM-4) minutes of pumping, the pumps were stopped and water levels measured during the recovery period. The semilog plots, Annex Figure VII-B-17, of the recovery data, Annex Tables VII-B-2 and VII-B-3, indicate transmissivities incompatible with both the current specific capacities and the reported original specific capacities. The data are tabulated below:

	SIL-WD No. 1 (CDM-1)	SIL-WD No. 4 (CDM-3)
1. Transmissivity from pumping test	175 cumd/m	155 cumd/m
2. Pumping test specific capacity	2.3 lps/m	2.7 lps/m
3. Minimum transmissivity implied by "2" above	240 cumd/m	280 cumd/m
4. Reported original specific capacity	3.0 lps/m	
5. Minimum transmissivity implied by "4" above	310 cumd/m	

The transmissivities in items "3" and "5" above are only estimates but the transmissivities from the pumping test are too low relative to the specific capacity data. The discrepancies may result from interference from adjacent wells during the test period or errors in flow estimations. In any case, the aquifer is at least twice as thick as the well depths and the overall aquifer transmissivity must be considerably higher than any of the figures shown above.

Aquifer

The productive aquifer in the Silay City area is the group of uncemented, water-lain deposits underlying the coastal plain. These deposits consist largely of sands, gravels, silts and clays which were derived from the volcanic ash beds and other volcanic rocks to the east and transported to the coast by stream action. They consist of stream, beach, bar, lagoon and delta deposits. They form a section which is similar over wide distances in gross lithology but which is very discontinuous and intricate in detailed lithology. This situation is shown by the differences in wells CDM-38 and 39 which are only 7.6 meters apart.

The thickness of the aquifer in the Silay City area is unknown. The deepest well is the stratigraphic test well CDM-38 which is 183 meters deep, but the aquifer is believed to be much thicker. No wells are known to have been drilled through it.

The most conservative estimate of aquifer transmissivity derived from the test well data is about 340 to 400 cumd/m which is in reasonable conformity with both the observed 30-hour specific capacity of 2.6 lps/m and the stratigraphic section, mostly sandy or gravelly but poorly sorted and with much clayey material. Other wells of fairly large capacity (wherein specific capacity data is most reliable) have, or are reported to have had, specific capacities of about 3.0 to 3.5 lps/m implying minimum transmissivities of over 400 cumd/m for that part of the aquifer contributing to the flow in these relatively shallow wells. However, because of its layered nature (inherent in sediments) and its high clay content, the aquifer is very anisotropic with much greater horizontal permeability than vertical permeability. In an anisotropic aquifer, well specific capacities are due largely to the transmissivity of that portion of the aquifer penetrated by the well while the broader water level response to long-term pumping is dependent on the total transmissivity of the entire aquifer. Even pumping test analyses give results largely indicative of the screened section of the aquifer rather than the total aquifer. Thus actual aquifer transmissivity may be as little as 400 cumd/m if the aquifer is thin (little deeper than the existing wells) or may be 1,000 cumd/m or more if the aquifer is very thick.

The storage coefficient of the aquifer as expressed in well response to short-term pumping will be low, probably in the artesian range, but over longer periods as the water table declines the storage coefficient will greatly increase. The ultimate value will depend on the sediments being dewatered.

<u>Groundwater Flow, Recharge and Discharge Relationships</u>

Recharge to the coastal plain aquifer is mainly from direct infiltration of precipitation and infiltration from flowing streams in the higher land to the east. Local recharge in the Silay City area is inhibited by surface clays in many areas and a high piezometric level in the aquifer which is above ground level in many places. Infiltration from the numerous irrigated fields in the area adds significantly to recharge. The average annual precipitation in the Silay City area is high, about 2.7 meters, and precipitation on the mountains in the east is higher. The combination of high precipitation and a large recharge area indicates a great potential recharge, some of which is currently being rejected because of high piezometric levels in the aquifer.

Natural groundwater flow is from the recharge area westerly toward the sea. Some of the natural discharge is to the ground surface in seeps, springs and contributions to stream flow where the piezometric levels in the upper part of the aquifer are above ground level or water level in the streams. Most of the natural discharge is directly to the sea. Recently, more and more groundwater is being diverted from natural discharge channels to well discharge for irrigation, domestic and industrial use.

Before large-scale artificial withdrawal of water (pumping from large-capacity wells), the local and regional groundwater balance is in a state of dynamic equilibrium where long-term total recharge equals long-term total discharge and groundwater storage is stable.

All well water produced must come from one or more of a limited number of sources; groundwater storage, increased recharge, or diverted groundwater discharge. When a well first begins to operate, all the pumped water comes from local groundwater storage (immediately surrounding the well) as a result of the decreased pressure in the well caused by pumping. This zone of decreased pressure (or lowered piezometric head) spreads radially from the well as stored groundwater flows from the aquifer to the well, and it continues to spread until the area of depressed piezometric levels causes either an increase in recharge (local or distant) or a decrease in pre-established groundwater discharge (local or distant) equal to the pumping rate of the well. When this occurs, a new equilibrium will be established with no further depletion of groundwater storage. If the increased recharge or diverted discharge (or combination thereof) is local, equilibrium will be quickly established with minimal lowering of the areal piezometric surface; but if they are distant, equilibrium will be long delayed resulting in a widespread and large depression in groundwater levels. If no sources of increased recharge or diverted discharge large enough to equal the pumped withdrawal rate can be tapped, then the groundwater levels will continue to drop until the well becomes inoperative or the aquifer is depleted or saline water from the adjacent sea flows into the aquifer.

In the case of Silay, there are a number of prospective sources of additional recharge. The local streams probably will contribute considerable recharge once the piezometric levels in the aquifer are depressed below stream level. At the same time, an appreciable amount of infiltration may begin through the more permeable parts of the surface beds. These local effects will begin fairly soon after large-scale pumping begins and will increase with time as the area of depressed groundwater levels (cone of depression) spreads. Also, the major existing source of recharge to the Silay City area is in the hills to the east and additional recharge from this source probably will begin when the depressed groundwater reaches this source and reduces the existing groundwater flow into surface runoff channels. Another, and very significant contribution to the water to be pumped at Silay City will be the reduction of existing natural groundwater discharge which is now being wasted to surface seeps and to underground flow into the sea. This will occur as a result as the expanding and deepening cone of depression (resulting from pumping) diverts groundwater underflow (now escaping to the west) to the wells to be installed in Silay.

Neither current recharge nor future additional recharge induced by pumping can be quantified with existing data, but groundwater underflow can be estimated. This groundwater flow is to the west as a gradient of about 0.004 in the poblacion area, the groundwater gradient being roughly equal to or a little less than the local topographic gradient. The average overall transmissivity of the aquifer in this area is estimated at a minimum of 400 cumd/m to possibly more than 1,000 cumd/m. According to Darcy's Law of flow:

$$Q/km \text{ (of aquifer width)} = T \times G \times 1000 \text{ m/km}$$

where:

Q = Groundwater underflow (cumd)

T = Aquifer transmissivity (cumd/m)

G = Gradient of the piezometric surface

thus :

$$Q/km = 400 \text{ cumd/m} \times 0.004 \times 1000 \text{ m/km} = 1600 \text{ cumd/km (minimum)}$$
$$Q/km = 1000 \text{ cumd/m} \times 0.004 \times 1000 \text{ m/km} = 4000 \text{ cumd/km (maximum)}$$

The underflow of groundwater can be used to roughly determine the groundwater available for exploitation. The SIL-WD average daily demand is projected to be 10,590 cumd in 1990 and 20,530 cumd in 2000. To obtain all this water from underflow would require diverting and capturing all the underflow in a band about 2.5 to 6 km wide by the year 1990 and 5 to 13 km wide by the year 2000, depending on actual overall aquifer transmissivity. Less than this computed amount of underflow would have to be captured because induced additional recharge, as noted previously, would supply much of the water to be pumped. Also, as piezometric levels lower in the Silay City area, some groundwater underflow from the north and south would be diverted toward Silay City. However, if all or nearly all the groundwater underflow toward the sea were pumped in the Silay area, salt water would intrude the aquifer and ruin the wells for SIL-WD use. Although projecting accurate pumping levels would require producing a model based on much more than the available data, it is apparent that diverted groundwater underflow and induced additional local recharge would provide for Silay's requirements beyond the year 2000 without a prohibitive decline in pumping and groundwater levels and consequent salt water intrusion but only if the wells are properly spaced and operated so as to minimize depression of groundwater levels. However, this is true only if Silay is the major large-scale user of groundwater in the locality that surrounds it.

Unfortunately, the area is short of irrigation water and, considering the fairly good underlying aquifer, large-scale groundwater irrigation has started and will undoubtedly grow. Assuming that one meter net of irrigation water will be required to supplement rainfall, an annual average of about 2,700 cumd of irrigation water would be required per 100 hectares (one sqkm) of irrigated land. Thus, 760 hectares of groundwater-irrigated land would consume the equivalent of SIL-WD total requirement in the year 2000. Considering that there are tens of thousands of hectares of irrigable land in the Silay area, total water demand by the year 2000 could greatly exceed the sum of groundwater underflow and probable potential induced recharge. With available data, it is not possible to predict groundwater levels at various future dates with any certainty; but as more data on aquifer characteristics and response become available, predictions should be made based on model studies. One favorable factor is that as groundwater piezometric levels drop below the clayey surface beds, the storage coefficient of the aquifer will increase greatly and more groundwater will be available from storage thus slowing the drop in groundwater levels.

The implications are that the SIL-WD must obtain firm water rights to its long-range requirements from the National Water Resources Council (NWRC) and introduce a groundwater monitoring and study program for planning purposes. Signs of incipient salinization of water or lowering of piezometric levels to a degree that foreshadows salinization should cause a re-evaluation of planning, curtailment of local groundwater irrigation, and location of further SIL-WD wells far enough inland to avoid salinization danger.

Well Design and Drilling Programs

A general design for an efficient production well for Silay City can be developed from available data. Such design is illustrated in Annex Figure VII-B-18. For greatest efficiency, to avoid excessive drawdown, and to minimize operating costs, these wells should be drilled to the same standards as the recent NIA wells, that is; rotary drilled with careful mud control, carefully sampled, electric logged, screened with continuous wire-wound screen, gravel packed, thoroughly developed, and tested to determine efficient pump parameters. Screen settings must be matched to permeable zones and a carefully designed gravel pack will permit screening more zones of this aquifer of variable grain size without the danger of producing sand in the water. All stratigraphic zones down to a depth of 200 meters (or other chosen total depth) that are indicated as productive by the electric and stratigraphic logs should be screened, because in an anisotropic aquifer such as this, the specific capacity will increase greatly as the screened percentage of total permeable section increases. However, caution as to depth drilled must be observed. At too great a depth, saline water may be encountered or may be approached so closely that it may be drawn into the pumping well. Alternatively, deeper wells may be safer from saline intrusion. Further experience of the aquifer will indicate the best design.

It is anticipated that such wells should produce 32 lps at an average of about 15 meters of initial drawdown, with the poorest wells at about 20 meters of initial drawdown. This is believed to be conservative and is used for preliminary design and estimation purposes. The wells should be located so as to minimize the cost and operational complexity of the distribution system, taking into account that the spacing between wells should be as great as practical (preferably an average of 1 km or more) to minimize drawdown interference and possible saline water intrusion. Also the wells should be located in a line parallel to the coast and as far inland as conveniently practical so as to intercept the maximum amount of groundwater underflow and minimize the possibility of saline intrusion. It should be recognized that few, if any, existing private well drilling firms have the necessary experience, equipment and ability to design and construct rotary-drilled wells of good quality without external professional supervision.

Before the production well drilling program, one or more deep test wells are recommended to be drilled to 500 meters (more or less) to determine total aquifer thickness and to determine water quality at various depths. All such well bores should be sealed throughout any length that is to be abandoned. The upper parts of these test bores can be enlarged and converted to production wells.

A drilling program consisting of wells of 32-lps capacity, spaced 1 to 2 km, in the existing SIL-WD service area, is recommended. Initial wells should be carefully tested and the results from them used to modify the design of succeeding wells. They should be pumped intensively for several years and the aquifer response monitored. The data can then be used as guide for further development of the well system which probably will consist of 32 lps wells spaced about 1 to 2 km apart. Individual well drawdowns, and consequently productions, should be minimized to minimize danger of saline intrusion. This preliminary estimate must be revised and phased into the overall groundwater development plan for the Silay area. Any future development of groundwater for irrigation must be taken into consideration in the design and location of SIL-WD wells.

Induced Infiltration Wells

It is possible that induced infiltration wells could be developed along the Malogo River about 7 to 12 km from the poblacion. The prime advantage of such wells would be realized if they could be located high enough that the SIL-WD could be served by gravity after the initial pumping lift. Further exploration and a test well program would be necessary to determine if such a system would be technically feasible. However, economic studies indicate that water from infiltration wells at a distance would be more costly than water from local deep wells; so further test work on the infiltration well is not currently justifiable. However, induced infiltration wells would be safe from salinization and should be reconsidered if the problem arises.

Monitoring

Basic planning for overall exploitation of groundwater resources in the Silay area will be based on the limited data currently available and those derived from tests of further production wells. However, records of water production from all large-capacity wells and of aquifer response to pumping are necessary to refine the preliminary aquifer parameters and to revise the planning as necessary to avoid the dangers of over-exploitation or the waste of under-exploitation. The SIL-WD should monitor the performance of each of their production wells and observation wells, both to provide data and information for water district use and for distribution to other agencies for overall planning and control. In turn, other nearby water districts and other groundwater users should monitor their operations and provide appropriate data to SIL-WD.

Each production well should have facilities for measuring the total amount of production or rate of production, times of operation and water levels. Routine monthly observations of static and pumping water levels should be recorded and daily records of pumping should be kept. Water samples for bacterial and chemical analyses should be collected monthly. It would also be desirable to monitor static water levels in several observation wells located within the area spanned by SIL-WD wells but far enough from any well to minimize local drawdown effects. Similar routine static water level measurements should be taken in numerous observation wells surrounding the well field at a distance.

The data from this monitoring program will provide better aquifer parameters, indicate the magnitude of recharge, give early warning to

SIL-WD of deterioration in water quality or pump performance so that remedial action can be taken, and indicate any unforeseen decline in regional water level so that individual well yields (which affect local pumping levels) and design and spacing of future wells can be adjusted as necessary. For these purposes, copies of all SIL-WD well monitoring data should be routinely analyzed by SIL-WD (if they have competent staff for such analysis) or by some associated agency competent to perform such analysis. Monitoring of chemical quality is of particular importance in Silay City because of the pronounced danger of sea water intrusion into the aquifer. At the first sign of significantly increased chlorides or other salts in the water, the entire source development plan must be re-evaluated. It may be necessary to do some or all of the following: reduce production from existing wells; change planned locations of future wells; and develop sources other than local wells for further supply.

Summary of Groundwater Resources

Silay City is located over an excellent, widespread, relatively uniform aquifer that can readily supply all its projected water demands past the year 2000 from deep wells each producing up to 32 lps. However, the local and regional drawdown of groundwater levels resulting from such pumping cannot be accurately quantified because available data on aquifer parameters and recharge are insufficient. Other data will become available from pumping tests of the new production wells and from the monitoring program of production and observation wells. A very real danger exists of sea water intrusion and consequent degradation of water quality as a result of concentrated pumping on a large scale. This could be avoided or minimized by locating the SIL-WD wells far inland at higher elevations, but this would greatly increase costs and, considering the economic advantages of deferring capital costs, does not seem justified until some early indications of saline intrusion are noted by the monitoring program. Future well design and well field planning must be modified on the basis of all new data to maintain groundwater production for long-term use.

Induced infiltration wells at the Malogo River or springs at the foot of the mountains may be technologically feasible but economically undesirable as long as wells in the Silay City area produce good water. These alternative sources should be considered if coastal-well water quality deteriorates.

If the intensive use of groundwater for irrigation eventually occurs in the Silay area, over-exploitation of the aquifer with consequent salinization of coastal well waters will result unless careful and intelligent control of this multiple use is enforced. Consequently, it is very important that SIL-WD acquire firm rights to all the groundwater for which the SIL-WD can anticipate a future need from the NWRC. These water rights will confirm access to the water that is vital to the development of Silay City.

C. SURFACE WATER RESOURCES

The only large potential surface water sources within reasonable distance of Silay are the Malogo and Imbang Rivers. The Imbang River originates in the mountains southeast of Silay, flows northwest to pass about 2 km northeast of the poblacion, and then discharges into Guimaras Strait. The Malogo River originates in the mountain east of Silay and flows in a generally northwesterly direction to pass about 7 km northeast of the poblacion where it turns due north to discharge into Guimaras Strait. Both rivers are used for local irrigation of the sugarcane plantations by means of pumps.

Surface Water

Surface water data from the rivers within the vicinity of Silay have been compiled and analyzed to establish the statistical recurrence of average and minimum monthly flows. BPW records of gaging stations on the Imbang and Malogo Rivers with monthly records spanning from 15 to 25 years were tabulated and analyzed using the Gumbel probability method of establishing 10-year and 5-year recurring flows (see Methodology Memorandum No. 4). The analysis shows the following:

	Latitude	Years of Record	Watershed Area (sqkm)	Minimum Flow (cumd/sqkm) 10-year	Minimum Flow (cumd/sqkm) 5-year	Mean Flow (cumd/sqkm) 10-year	Mean Flow (cumd/sqkm) 5-year
Imbang River	123°-02'-47"						
Dos Hermanos	10°-44'-20"	20	33	957	1,350	1,580	1,740
Malogo River	123°-04'-52"	15	129	922	1,300	2,830	3,140
Hda. Cabungahan	10°-49'-03"						

Both rivers have minimum flows large enough to meet the SIL-WD requirements of the year 2000. Imbang River water could be extracted about 2 km from the poblacion (watershed area of 88 sqkm), above the limit of sea water intrusion into the river, and pumped to the necessary head to serve the district. The calculated 10-year minimum flow for this point is 84,200 cumd. Alternatively, water could be extracted from the Imbang River about 11 km from the poblacion (near Dos Hermanos, with a watershed area of 27 sqkm) at an altitude of about 50 meters and would serve the city by gravity flow. The calculated 10-year minimum flow for the Imbang River at this point is 25,800 cumd. Minimum flow of record at the Dos Hermanos gaging station is 28,000 cumd or 848 cumd/sqkm.

The Malogo River water, which could be extracted about 11 km from the poblacion at an altitude of about 50 meters, would also serve the water district by gravity flow (watershed area of 125 sqkm). The estimated 10-year minimum flow for the Malogo River at this point is 115,000 cumd. Minimum flow of record at the Hacienda Cabungahan gaging station is 78,000 cumd or 604 cumd/sqkm.

If either river were to be used for SIL-WD supply, an intake structure, a water treatment plant and a transmission pipeline would be required. If river water were taken at low altitude, a pump station would also be required. Because of these factors, economic analysis indicates that surface water would be more costly than groundwater. Furthermore, water from both rivers is currently used for irrigation and a water rights conflict might develop if either river would be used as SIL-WD source.

D. WATER QUALITY OF POTENTIAL SOURCES

Water samples were taken from many of the sources, both groundwater and surface water, discussed previously. Chemical analyses of these samples were performed to determine the water quality with respect to potability and treatment requirements. The results of these analyses are shown in Tables IV-3 and VII-2 and are briefly discussed below.

Groundwater

Since groundwater essentially passes through a filtration process while flowing through a granular aquifer (such as in the SIL-WD area), and is not exposed to surface pollution, color and turbidity or suspended solids are usually not present. For this reason, unless other deleterious substances (such as excessive hardness, dissolved gases or dissolved iron) are present, treatment, other than disinfection, is generally not required.

Water analyses of samples taken from the three existing SIL-WD wells and 3 other Silay wells are shown in Table IV-3. All of the chemical parameters of well waters analyzed fall below the "permissible limits of the Philippine National Standards for Drinking Water in all respects except for iron content in the General Hospital well which exceeds the "excessive" limits, and turbidity, color, iron content and manganese content in the Panaogao well which are all above "permissible" or "excessive" limits. However, ths limits are not prohibitive but only guidelines, and where the iron and manganese content is not extremely high and where no known complaints about the water have been received, the water is acceptable for domestic use without extensive treatment.

TABLE VII-2

WATER QUALITY TEST RESULTS
POTENTIAL SOURCES
SILAY CITY WATER DISTRICT

Test	Unit	Permissible Limits	Test Well CDM-39 11 June 1977	Malogo River Central AIDSISA 17 Sept 1976	Malogo River Bo. Cap. Ramon 17 Sept 1976
Physical					
Color	APHA	15	8	5	10
Turbidity	FTU	5	10**	3	4
Total Dissolved Solid*	mg/l	500	169	53	55
Conductivity	Micromhos/cm		260	82	84
Chemical					
pH		7-8.5	7.0	6.0**	6.3**
Total Alkalinity	mg/l $CaCO_3$		146	25	25
Phenolpthalein Alkalinity	mg/l $CaCO_3$		0	0	0
Total Hardness	mg/l $CaCO_3$		109	18	22
Calcium	mg/l Ca	75	24	7	12
Magnesium	mg/l Mg	50	12	0	1
Total Iron	mg/l Fe	0.3	0.82**	1.0**	0.7**
Fluoride	mg/l F	1.5	0	0	0
Chloride	mg/l Cl	200	6	5	7
Sulfate	mg/l SO	200	0	12	15
Nitrate	mg/l NO_3		8	8	8
Manganese	mg/l Mn	0.1	1.05***	0	0

*Calculated as 65% of conductivity.
**Exceeds permissible limits set by the Philippine National Standards for Drinking Water.
***Exceeds the excessive limits set by the Philippine National Standards for Drinking Water.

A water analysis of a sample taken from the Silay test well (CDM-39) is shown in Table VII-2. The water is of good quality for domestic use except for high iron content, manganese content and turbidity. The turbidity, which is not excessive, is probably a result of precipitation of the iron and manganese after oxidation resulting from exposure to air. The iron content exceeds the "permissible" limits but not the "excessive" limits of the Philippine National Standards while the manganese content is unusually high, exceeding the "excessive" limits. This combined iron and manganese content may cause some discoloration problems in laundry and cooking which would result in consumer's complaints. In this event, the iron and manganese may have to be sequestered to prevent precipitation or else removed by precipitation and filtration.

Excessive iron and manganese content in groundwater is a general problem in this region, occuring in Bacolod and elsewhere. The specific occurrence of such water is usually erratic and difficult or impossible to predict. It is possible that the iron and manganese could be reduced in the water from the test well by sealing off one zone of the multi-zoned aquifer, and it is also possible that the water may improve with continued pumping.

The water that will be produced from future SIL-WD wells can be expected to be similar to the tested well waters, that is of fairly good quality.

The waters from Kabatangan Springs and Patag Waterfalls (spring source?) were analyzed with portable field kits. These waters are of excellent quality, low in iron, manganese, chloride and hardness and very low in conductivity.

Surface Water

Water from surface sources is generally high in color, turbidity and suspended solids during periods of rainfall. Even during non-rainy periods surface water usually requires complete treatment including chemical addition, mixing, coagulation, flocculation, sedimentation, filtration and disinfection.

The results of chemical analyses performed on 2 samples of water from the Malogo River are shown in Table VII-2. The results indicate that concentration of color and turbidity is relatively low for surface waters in general, but complete treatment would nevertheless be required particularly during the rainy season when turbidity would be much higher. Both samples showed iron content and pH exceeding the "permissible" limits set by the Philippine National Standards for Drinking Water, but high dissolved iron content is unusual in aerated surface waters of normal chemistry and it is considered that the iron is not in solution but is particulate matter contained in the water or that the low pH contributes to unusual iron solubility. The unusually low pH is not explained but would necessitate pH adjustment adding to the cost of water treatment.

ANNEX VII-B

WELL DATA

ANNEX TABLE VII-B-1

CONSTANT RATE PUMPING TEST - SILAY TEST WELL

Data:		
	Start Pumping	9 June 1977, 11:00 am
	Start Recovery	11 June 1977, 11:00 am
	Start Step-drawdown	12 June 1977, 6:00 pm
	Pumping Rate	37.8 lps
	Discharge Pipe Diameter	125 mm (5 in)
	Orifice Diameter	100 mm (4 in)
	Original Static Water Level	4.05 m

DRAWDOWN

Pumping Time (min)	Pumping Well Data Water Level (m)	Pumping Well Data Drawdown (m)	Observation Well Data Water Level (m)	Observation Well Data Drawdown (m)
0	4.05	0	3.87	0
1	10.40	6.35	4.70	0.83
2	11.44	7.39	5.77	1.90
3	12.86	8.81	6.82	2.95
4	14.05	10.00	7.58	3.71
5	14.59	10.54	7.93	4.06
6	14.51	10.46	8.17	4.30
7	14.68	10.63	8.30	4.43
8	14.75	10.70	8.40	4.53
9	14.84	10.79	8.46	4.59
10	14.77	10.72	8.49	4.62
11	14.79	10.74	8.51	4.64
12	14.79	10.74	8.45	4.58
13	14.85	10.80	8.45	4.58
14	14.89	10.84	8.45	4.58
15	14.91	10.86	8.46	4.59
16	14.88	10.83	8.47	4.60
17	14.91	10.86	8.48	4.61
18	14.91	10.86	8.49	4.62
19	14.93	10.88	8.50	4.63
20	14.96	10.91	8.51	4.64
22	15.16	11.11	8.54	4.67
24	15.27	11.22	8.56	4.69
26	15.35	11.30	8.58	4.71
28	15.36	11.31	8.60	4.73
30	15.42	11.37	8.62	4.75

ANNEX TABLE VII-B-1 (continued)

Pumping Time (min)	Pumping Well Data: Water Level (m)	Pumping Well Data: Drawdown (m)	Observation Well Data: Water Level (m)	Observation Well Data: Drawdown (m)
32	15.48	11.43	8.64	4.77
34	15.51	11.46	8.66	4.79
36	15.56	11.51	8.68	4.81
38	15.54	11.49	8.68	4.81
40	15.59	11.54	8.71	4.84
45	15.61	11.56	8.79	4.92
50	15.85	11.80	8.83	4.96
55	15.73	11.68	8.86	4.99
60	15.81	11.76	8.88	5.01
70	15.92	11.87	8.93	5.06
80	15.99	11.94	8.97	5.10
90	16.22	12.17	9.02	5.15
100	16.36	12.31	9.10	5.23
110	16.46	12.41	9.15	5.28
120	16.46	12.41	9.17	5.30
150	16.71	12.66	9.25	5.38
180	17.26	13.21	9.31	5.44
240	17.58	13.53	9.39	5.52
300	17.76	13.71	9.42	5.55
360	17.80	13.75	9.38	5.51
420	17.89	13.84	9.38	5.51
480	17.83	13.78	9.35	5.48
540	17.87	13.82	9.59	5.72
600	18.03	13.98	9.13	5.26
660	18.08	14.03	9.19	5.32
720	18.20	14.15	9.21	5.34
780	18.11	14.06	9.20	5.33
840	18.20	14.15	9.22	5.35
900	18.36	14.31	9.24	5.37
960	18.36	14.31	9.22	5.35
1020	18.38	14.33	9.22	5.35
1080	18.28	14.23	9.22	5.35
1140	18.26	14.21	9.23	5.36
1200	18.31	14.26	9.24	5.37
1260	18.30	14.25	9.25	5.38
1320	18.29	14.24	9.26	5.39
1380	18.28	14.23	9.21	5.34
1440	18.37	14.32	9.26	5.39
1500	18.37	14.32	9.27	5.40
1560	18.70	14.65	9.33	5.46

ANNEX TABLE VII-B-1 (Continued)

Pumping Time (min)	Pumping Well Data		Observation Well Data	
	Water Level (m)	Drawdown (m)	Water Level (m)	Drawdown (m)
1620	18.60	14.55	9.26	5.39
1680	18.64	14.59	9.27	5.40
1740	18.62	14.57	9.18	5.31
1800	18.69	14.64	9.10	5.23
1860	18.70	14.65	9.04	5.17
1920	18.62	14.57	9.04	5.17
1980	18.65	14.60	9.04	5.17
2040	18.67	14.62	9.10	5.23
2100	18.66	14.61	9.06	5.19
2160	18.62	14.57	9.06	5.19
2220	18.66	14.61	9.08	5.21
2280	18.69	14.64	9.09	5.22
2340	18.67	14.62	9.08	5.21
2400	18.61	14.56	9.07	5.20
2460	18.61	14.56	9.07	5.20
2500	18.58	14.53	9.04	5.17
2580	18.61	14.56	9.04	5.17
2640	18.60	14.55	9.05	5.18
2700	18.66	14.61	9.06	5.19
2760	18.66	14.61	9.08	5.21
2820	18.62	14.57	9.07	5.20
2880	18.62	14.57	9.08	5.21

ANNEX TABLE VII-B-1 (Continued)

RECOVERY

Time Since Pumping Started (t)	Time Since Recovery Started (t')	Ratio t/t'	Pumping Well Data: Residual Drawdown (m)	Pumping Well Data: Recovery (m)	Observation Well Data: Residual Drawdown (m)	Observation Well Data: Recovery (m)
2880	0	–	14.57	0	5.30	0
2881	1	2881	5.76	8.81	5.14	0.16
2882	2	1441	4.71	9.86	4.88	0.42
2883	3	961	4.13	10.44	4.60	0.70
2884	4	721	3.83	10.74	4.34	0.96
2885	5	577	3.65	10.92	4.10	1.20
2886	6	481	3.49	11.08	3.87	1.43
2887	7	412.4	3.37	11.20	3.68	1.62
2888	8	361	3.27	11.30	3.51	1.79
2889	9	321	3.17	11.40	3.38	1.92
2890	10	289	3.05	11.52	3.26	2.04
2891	11	262.8	2.99	11.58	3.18	2.12
2892	12	241	2.93	11.64	3.08	2.22
2893	13	222.5	2.87	11.70	3.00	2.30
2894	14	206.7	2.82	11.75	2.94	2.36
2895	15	193	2.73	11.84	2.87	2.43
2896	16	181	2.70	11.87	2.83	2.47
2897	17	170.4	2.66	11.91	2.77	2.53
2898	18	161	2.61	11.96	2.72	2.58
1899	19	152.6	2.56	12.01	2.68	2.62
2900	20	145	2.52	12.05	2.64	2.66
2902	22	131.9	2.50	12.07	2.57	2.73
2904	24	121	2.38	12.19	2.50	2.80
2906	26	111.8	2.29	12.28	2.43	2.87
2908	28	103.9	2.26	12.31	2.37	2.93
2910	30	97	2.21	12.36	2.33	2.97
2912	32	91	2.16	12.41	2.27	3.03
2914	34	85.7	2.10	12.47	2.23	3.07
2916	36	81	2.07	12.50	2.19	3.11
2918	38	76.8	2.02	12.55	2.14	3.16
2920	40	73	1.98	12.59	2.10	3.20
2925	45	65	1.90	12.67	2.02	3.28
2930	50	58.6	1.82	12.75	1.94	3.36
2935	55	53.4	1.75	12.82	1.87	3.43
2940	60	49	1.68	12.89	1.81	3.49
2950	70	42.1	1.56	13.01	1.71	3.59
2960	80	37	1.46	13.11	1.61	3.69

ANNEX TABLE VII-B-1 (Continued)

Time Since Pumping Started (t)	Time Since Recovery Started (t')	Ratio t/t'	Pumping Well Data: Residual Drawdown (m)	Pumping Well Data: Recovery (m)	Observation Well Data: Residual Drawdown (m)	Observation Well Data: Recovery (m)
2970	90	33	1.41	13.16	1.52	3.78
2980	100	29.8	1.33	13.24	1.44	3.86
2990	110	27.2	1.26	13.31	1.38	3.92
3000	120	25	1.21	13.36	1.32	3.98
3030	150	20.2	1.04	13.53	1.18	4.12
3060	180	17	0.97	13.60	1.10	4.20
3120	240	13	0.76	13.81	0.88	4.42
3180	300	10.6	0.66	13.91	0.76	4.54
3240	360	9	0.54	14.03	0.63	4.67
3300	420	77.9	0.47	14.10	0.58	4.72
3360	480	7	0.42	14.15	0.53	4.77
3420	540	6.3	0.37	14.20	0.49	4.81
3480	600	5.8	0.32	14.25	0.44	4.86
3540	660	5.4	0.29	14.28	0.40	4.90
3600	720	5	0.27	14.30	0.36	4.94
3660	780	4.7	0.24	14.33	0.34	4.96
3720	840	4.4	0.21	14.36	0.32	4.98
3780	900	4.2	0.18	14.39	0.29	5.01
3840	960	4	0.15	14.42	0.26	5.04
3900	1020	3.8	0.13	14.44	0.23	5.07
3960	1080	3.7	0.11	14.46	0.27	5.09
4020	1140	3.5	0.09	14.48	0.19	5.11
4080	1200	3.4	0.06	14.51	0.17	5.13
4140	1260	3.3	0.04	14.53	0.15	5.15
4200	1320	3.2	0.02	14.55	0.09	5.21
4260	1380	3.1	0.02	14.59	0.04	5.26
4320	1440	3	0.03	14.60	0	5.30

ANNEX TABLE VII-B-1(Continued)

STEP-DRAWDOWN PUMPING TEST

Pumping Time (min)	Pumping Rate (lps)	Pumping Well Data		Observation Well Data	
		Water Level (m)	Drawdown (m)	Water Level (m)	Drawdown (m)
0	12.6	3.96	0	3.84	0
1	12.6	6.06	2.10	4.37	0.53
2	12.6	6.02	2.06	4.92	1.08
3	12.6	6.11	2.15	5.34	1.50
4	12.6	6.18	2.22	5.62	1.78
5	12.6	6.33	2.37	5.86	2.02
6	12.6	6.36	2.40	6.04	2.20
7	12.6	6.42	2.46	6.15	2.31
8	12.6	6.47	2.51	6.20	2.36
9	12.6	6.51	2.55	6.26	2.42
10	12.6	6.53	2.57	6.28	2.44
11	12.6	6.57	2.6	6.31	2.47
12	12.6	6.60	2.64	6.33	2.49
13	12.6	6.59	2.63	6.35	2.51
14	12.6	6.61	2.65	6.37	2.53
15	12.6	6.62	2.66	6.38	2.54
16	12.6	6.62	2.66	6.40	2.56
17	12.6	6.64	2.68	6.41	2.57
18	12.6	6.66	2.70	6.44	2.60
19	12.6	6.68	2.72	6.45	2.61
20	12.6	6.68	2.72	6.47	2.63
22	12.6	6.69	2.73	6.46	2.62
24	12.6	6.71	2.75	6.46	2.62
26	12.6	6.72	2.76	6.50	2.66
28	12.6	6.74	2.78	6.52	2.68
30	12.6	6.75	2.79	6.52	2.68
32	12.6	6.76	2.80	6.54	2.70
34	12.6	6.78	2.82	6.55	2.71
36	12.6	6.81	2.85	6.56	2.72
38	12.6	6.82	2.86	6.57	2.73
40	12.6	6.82	2.86	6.59	2.75
45	12.6	6.85	2.89	6.61	2.77
50	12.6	6.88	2.92	6.60	2.76
55	12.6	6.[illegible]	2.93	6.61	2.77
60	12.6	6.89	2.93	6.61	2.77
70	12.6	6.90	2.94	6.63	2.79
80	12.6	6.90	2.94	6.65	2.81
90	12.6	6.94	2.98	6.69	2.85

ANNEX TABLE VII-B-1(Continued)

Pumping Time (min)	Pumping Rate (lps)	Pumping Well Data Water Level (m)	Pumping Well Data Drawdown (m)	Observation Well Data Water Level (m)	Observation Well Data Drawdown (m)
310	25.2	12.37	8.41	8.29	4.45
320	25.2	12.40	8.44	8.30	4.46
330	25.2	12.45	8.49	8.32	4.48
340	25.2	12.49	8.53	8.35	4.51
350	25.2	12.48	8.52	8.35	4.51
360	25.2	12.56	8.60	8.36	4.52
390	25.2	12.61	8.65	8.40	4.56
420	25.2	12.61	8.65	8.40	4.56
480	25.2	12.74	8.78	8.45	4.61
481	37.8	15.42	11.46	7.01	3.17
482	37.8	15.55	11.59	7.77	3.93
483	37.8	15.80	11.84	8.64	4.80
484	37.8	16.04	12.08	8.71	4.87
485	37.8	16.17	12.21	8.72	4.88
486	37.8	16.30	12.34	8.75	4.91
487	37.8	16.45	12.49	8.75	4.91
488	37.8	16.63	12.67	8.75	4.91
489	37.8	16.69	12.73	8.77	4.93
490	37.8	16.84	12.88	8.78	4.94
491	37.8	16.78	12.82	8.79	4.95
492	37.8	16.67	12.71	8.79	4.95
493	37.8	16.82	12.86	8.80	4.96
494	37.8	16.85	12.89	8.81	4.97
495	37.8	16.92	12.96	8.82	4.98
496	37.8	16.95	12.99	8.83	4.99
497	37.8	17.06	13.10	8.83	4.99
498	37.8	17.04	13.08	8.85	5.01
499	37.8	17.09	13.13	8.85	5.01
500	37.8	17.13	13.17	8.86	5.02
502	37.8	17.11	13.15	8.86	5.02
504	37.8	17.12	13.16	8.87	5.03
506	37.8	17.17	13.21	8.89	5.05
508	37.8	17.28	13.32	8.90	5.06
510	37.8	17.27	13.31	8.90	5.06
512	37.8	17.31	13.35	8.90	5.06
514	37.8	17.33	13.37	8.85	5.01
516	37.8	17.33	13.37	8.80	4.96
518	37.8	17.30	13.34	8.78	4.94
520	37.8	17.33	13.37	8.78	4.94
525	37.8	17.22	13.26	8.78	4.94

ANNEX TABLE VII-B-1 (Continued)

Pumping Time (min)	Pumping Rate (lps)	Pumping Well Data: Water Level (m)	Pumping Well Data: Drawdown (m)	Observation Well Data: Water Level (m)	Observation Well Data: Drawdown (m)
100	12.6	7.00	3.04	6.72	2.88
110	12.6	7.01	3.05	6.74	2.90
120	12.6	7.01	3.05	6.76	2.92
150	12.6	7.08	3.12	6.80	2.96
180	12.6	7.08	3.12	6.80	2.96
240	12.6	7.13	3.17	6.85	3.01
241	25.2	9.29	5.33	7.19	3.35
242	25.2	9.57	5.61	7.37	3.53
243	25.2	9.76	5.80	7.50	3.66
244	25.2	10.28	6.32	7.56	3.72
245	25.2	10.98	7.02	7.67	3.83
246	25.2	11.19	7.23	7.76	3.92
247	25.2	11.34	7.38	7.84	4.00
248	25.2	11.41	7.45	7.90	4.06
249	25.2	11.48	7.52	7.95	4.11
250	25.2	11.53	7.57	7.97	4.13
251	25.2	11.54	7.58	8.00	4.16
252	25.2	11.62	7.66	8.01	4.17
253	25.2	11.66	7.70	8.03	4.19
254	25.2	11.68	7.72	8.05	4.21
255	25.2	11.79	7.83	8.06	4.22
256	25.2	11.83	7.87	8.08	4.24
257	25.2	11.84	7.88	8.09	4.25
258	25.2	11.86	7.90	8.10	4.26
259	25.2	11.92	7.96	8.10	4.26
260	25.2	11.94	7.98	8.11	4.27
262	25.2	11.95	7.99	8.13	4.29
264	25.2	12.02	8.06	8.13	4.29
266	25.2	12.07	8.11	8.16	4.32
268	25.2	12.07	8.11	8.17	4.33
270	25.2	12.07	8.11	8.17	4.33
272	25.2	12.12	8.16	8.18	4.34
274	25.2	12.17	8.21	8.19	4.35
276	25.2	12.17	8.21	8.20	4.36
278	25.2	12.17	8.21	8.21	4.37
280	25.2	12.20	8.24	8.21	4.37
285	25.2	12.23	8.27	8.23	4.39
290	25.2	12.30	8.34	8.24	4.40
295	25.2	12.32	8.36	8.25	4.41
300	25.2	12.31	8.35	8.27	4.43

ANNEX TABLE VII-B-1(Continued)

Pumping Time (min)	Pumping Rate (lps)	Pumping Well Data		Observation Well Data	
		Water Level (m)	Drawdown (m)	Water Level (m)	Drawdown (m)
530	37.8	17.48	13.52	8.78	4.94
535	37.8	17.36	13.40	8.79	4.95
540	37.8	17.37	13.41	8.79	4.95
550	37.8	17.44	13.48	8.83	4.99
560	37.8	17.56	13.60	8.84	5.00
570	37.8	17.63	13.67	8.84	5.00
580	37.8	17.76	13.80	8.86	5.02
590	37.8	17.75	13.79	8.87	5.03
600	37.8	17.81	13.85	8.86	5.02
630	37.8	17.82	13.86	8.90	5.06
660	37.8	17.93	13.97	8.85	5.01
720	37.8	18.27	14.31	9.02	5.18

ANNEX TABLE VII-B-2

SIL-WD NO. 4 (CDM-3)
PUMPING RATE BEFORE RECOVERY
20.8 LPS FOR 937 MINUTES
DATE 13 JAN 1977

Well diameter 250
Static water level 2.74

Time since test pumping started (t)	Time since recovery started (t')	Ratio t/t'	Water Level (m)	Residual Drawdown (m)
937	0	-	10.44	7.70
938.5	1.5	626	6.70	3.96
942	5.0	188	6.10	3.36
948	11.0	86	5.49	2.75
960.5	23.5	41	4.88	2.14
965	28	34	4.72	1.98
971	34	29	4.57	1.83
977	40	24	4.42	1.68
986	49	20	4.27	1.53
997	60	17	4.11	1.37
1008	71	14	3.96	1.22
1014.5	77.5	13	3.87	1.13
1024	87	12	3.81	1.07
1034	97	11	3.73	0.99
1045	108	10	3.66	0.92
1440	503	2.9	2.82	0.08

ANNEX TABLE VII-B-3

SIL-WD NO. 1 (CDM-1)
PUMPING RATE BEFORE RECOVERY
20.2 LPS FOR 965 MINUTES
DATE 15 JAN 1977

Well diameter 200 mm
Total depth 71.6 m
Static water level 1.7 m

Time since test pumping started (t)	Time since recovery started (t')	Ratio t/t'	Water Level (m)	Residual Drawdown (m)
965	0	-	10.44	8.74
966	1	966	6.40	4.70
967	2	484	5.79	4.09
968.5	3.5	277	5.18	3.48
969	4	242	4.88	3.18
971	6	162	4.57	2.87
973.5	8.5	115	4.27	2.57
978.5	13.5	72	3.96	2.26
981.5	16.5	59	3.81	2.11
985	20	49	3.66	1.96
989	24	41	3.50	1.80
993	28	35	3.35	1.65
999.5	34.5	29	3.20	1.50
1007.5	42.5	24	3.05	1.35
1012	47	21.5	2.97	1.27
1018	53	17.2	2.90	1.20

DESCRIPTIVE DATA	
WELL NO. (CDM)	5
(OTHER)	BPW 11026
LOCATION	BARRIO GUINHALARAN
CITY	SILAY
PROVINCE	NEGROS OCCIDENTAL
CONST. BY	
DRILLER	DEOGRACIAS SANTOS
STARTED	JUNE 16, 1957
COMPLETED	DECEMBER 13, 1957
OWNER	
STATUS	
CASING DIAMETER	150 MM (6 IN.)
CASING LENGTH	97 M. (318 FT.)

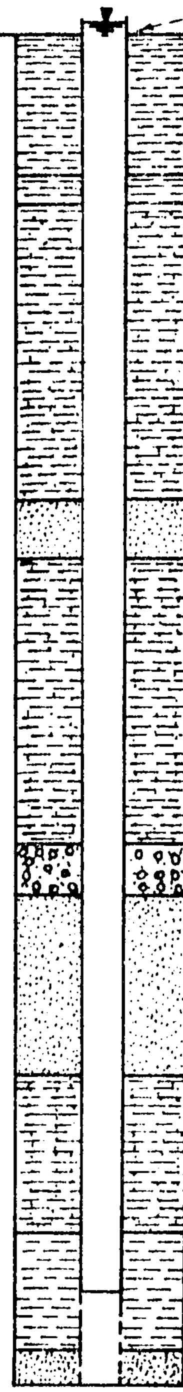
DRILLER'S TEST DATA

DATE	1957
STATIC WATER LEVEL	+ 1.0 M (3 FT.)
PUMPING WATER LEVEL	
TEST PUMP YIELD	FREE-FLOWING AT 10 GPM (0.6 LPS)

REMARKS:

WATER QUALITY DATA:

GRAPHIC LOG



DEPTH (M)	DEPTH (FT)	STRATIFICATION
		GROUND SURFACE
		CLAY
11.0	36	STICKY CLAY
12.2	42	SANDY CLAY
35.7	117	SAND
40.2	132	SANDY CLAY
62.8	206	SAND AND GRAVEL
66.4	218	QUICK SAND
80.8	265	SANDY CLAY
93.0	305	CLAY
97.0	318	
102.1	335	SAND
104.3	342	

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS **LWUA-CDM**

ANNEX FIGURE VII B-1
WELL DATA SHEET
WELL CDM-5

DESCRIPTIVE DATA

WELL NO. (CDM) 7
(OTHER) BPW 5511
LOCATION SILAY SOUTH ELEM. SCHOOL
CITY SILAY
PROVINCE NEGROS OCCIDENTAL
CONST. BY BPW
DRILLER
STARTED JULY 16, 1952
COMPLETED SEPTEMBER 18, 1952
OWNER
STATUS FREE-FLOWING AT 20 GPM (1.3 LPS)
CASING DIAMETER 200 MM (8 IN.)
CASING LENGTH 68.6 M (257 FT.)

DRILLER'S TEST DATA:

DATE 1952
STATIC WATER LEVEL +1.2 M (4 FT.)
PUMPING WATER LEVEL 0
TEST PUMP YIELD FLOWING 2.2 LPS.

REMARKS:

FLOWING AT GROUND LEVEL AT 35 GPM (2.2 LPS)
STRAINER FROM 68.6 M (225 FT) TO 78.3 M (257 FT.)

WATER QUALITY DATA:

GRAPHIC LOG

GROUND SURFACE

DEPTH (M)	DEPTH (FT)	STRATIFICATION
		BLUE CLAY
6.7	22	
		FINE SAND
12.2	40	
		COARSE SAND WITH GRAVEL
16.8	55	
		BLUE CLAY
24.4	80	
		FINE SAND
30.5	100	
		BLUE CLAY
36.6	120	
		CLAY WITH GRAVEL
39.6	130	
		FINE SAND
45.7	150	
		BLUE CLAY
51.8	170	
		SANDY CLAY
64.0	210	
		HARD SAND
68.6	225	
		SANDY CLAY
71.6	235	
		COARSE SAND
78.4	257	

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

ANNEX FIGURE VII B-2
WELL DATA SHEET
WELL CDM-7

DESCRIPTIVE DATA

WELL NO. (CDM) 9
(OTHER) BPW 17105
LOCATION BARRIO BALARING
CITY SILAY
PROVINCE NEGROS OCCIDENTAL
CONST. BY
DRILLER
STARTED DECEMBER 23, 1957
COMPLETED MAY 7, 1958
OWNER
STATUS
CASING DIAMETER 100 M (4 IN.)
CASING LENGTH 50.6 M (166 FT.)

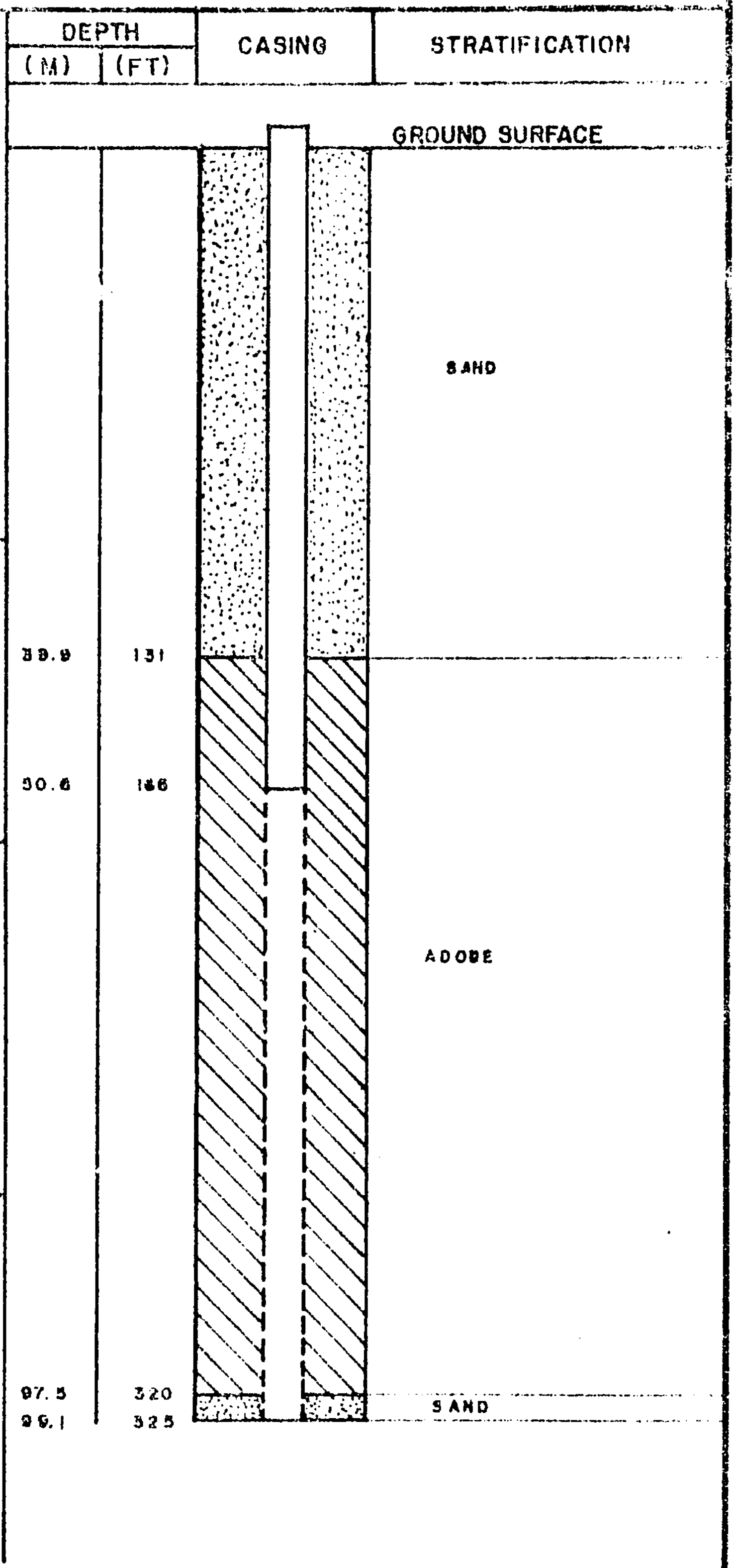
DRILLER'S TEST DATA:

DATE 1958
STATIC WATER LEVEL + 0.6 M (2 FT.)
PUMPING WATER LEVEL
TEST PUMP YIELD FREE FLOWING AT 15 GPM (0.9 LPS)

REMARKS:

WATER QUALITY DATA:

GRAPHIC LOG



FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

ANNEX FIGURE [illegible]
WELL DATA SHEET
WELL CDM-9

DESCRIPTIVE DATA	
WELL NO. (CDM)	23
(OTHER)	3
LOCATION	HACIENDA PANAOGAO
CITY	SILAY
PROVINCE	NEGROS OCCIDENDAL
CONST. BY	C.B HOOVER WELL DRILLER
DRILLER	P.S DE LEON
STARTED	
COMPLETED	
OWNER	DOMINADOR JISON
STATUS	
CASING DIAMETER AND LENGTH	400 MM (16 IN.) - 0 TO 53.6 M; 350 MM (14 IN.) - 53.6 TO 129.2 M

DRILLER'S TEST

- DATE
- STATIC WATER LEVEL
- PUMPING WATER LEVEL
- TEST PUMP YIELD

REMARKS:

400 MM SOLID WELL CASING - 0 TO 18.2 M
400 MM PERFORATED WELL CASING - 18.2 TO 53.6 M
350 MM PERFORATED WELL CASING - 53.6 TO 129.2 M
REPORTED CAPACITY — 1000 GPM (63 LPS)

WATER QUALITY DATA:

SEE TABLE VII-3, EXCESSIVE Fe, Mn, COLOR AND TURBIDITY

GRAPHIC LOG

DEPTH (M)	DEPTH [illegible]	CASING	STRATIFICATION
			GROUND SURFACE
3.0	10		BROWN SHALE
6.4	21		GRAVEL AND SAND
8.5	28		SANDY SHALE
12.5	41		GRAVEL AND SAND
18.2	60		SANDY SHALE
27.4	90		SANDY STONE
61.0	200		SANDY SHALE
70.1	230		STICKY CLAY
74.7	245		SANDY SHALE
883	280		STICKY CLAY
99.1	325		VOLCANIC SAND
123.4	405		SANDY SHALE
129.2	424		
137.2	450		SANDY STONE

ANNEX FIGURE VII B-4
WELL DATA SHEET
WELL CDM-23

DESCRIPTIVE DATA

WELL NO. (CDM) 24

(OTHER)

LOCATION HACIENDA MAQUINA

CITY SILAY

PROVINCE NEGROS OCCIDENTAL

CONST. BY CHARLIE B. HOOVER

DRILLER

STARTED APRIL 20, 1972

COMPLETED JUNE 20, 1972

OWNER MONSERAT LOPEZ

STATUS

CASING DIAMETER AND LENGTH 300 MM (12 IN.) SOLID - 0 TO 12.2 M; 200 MM (8 IN.) PERFORATED - 12.2 TO 61.0 M.

DRILLER'S TEST DATA:

DATE

STATIC WATER LEVEL

PUMPING WATER LEVEL

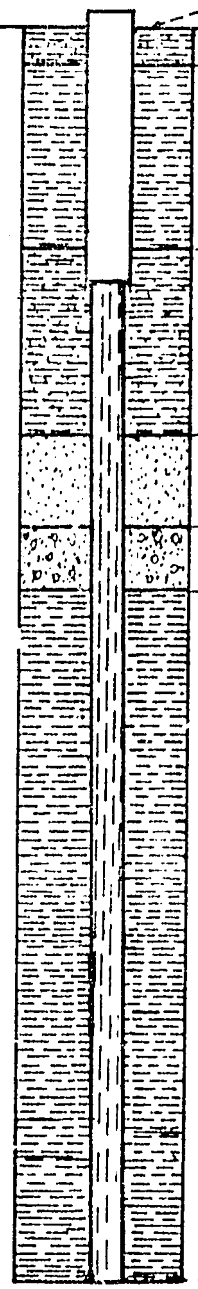
TEST PUMP YIELD

REMARKS:

WATER QUALITY DATA:

GRAPHIC LOG

DEPTH (M)	DEPTH (FT)	STRATIFICATION
		GROUND SURFACE
1.8	6	SANDY CLAY
10.7	35	BLUE SHALE
12.2	40	
19.8	65	SANDY SHALE
24.4	80	FINE SAND
27.4	90	GRAVEL AND SAND
61.0	200	BLUE SHALE



ANNEX FIGURE VII B-5
WELL DATA SHEET
WELL CDM-24

DESCRIPTIVE DATA	
WELL NO. (CDM)	38
(OTHER)	STRATIGRAPHIC EXPLORATION
LOCATION	FREEDOM BLVD, FORTUNA SUBDIVISION
CITY	SILAY
PROVINCE	NEGROS OCCIDENTAL
CONST. BY	GOLDWATER DRILLING & MACHINERY
DRILLER	V. QUERUBIN
STARTED	
COMPLETED	FEBRUARY 16, 1977
OWNER	CDM- LWUA
STATUS	OBSERVATION WELL
CASING DIAMETER	125 MM
CASING LENGTH	158.5 M

DRILLER'S TEST DATA

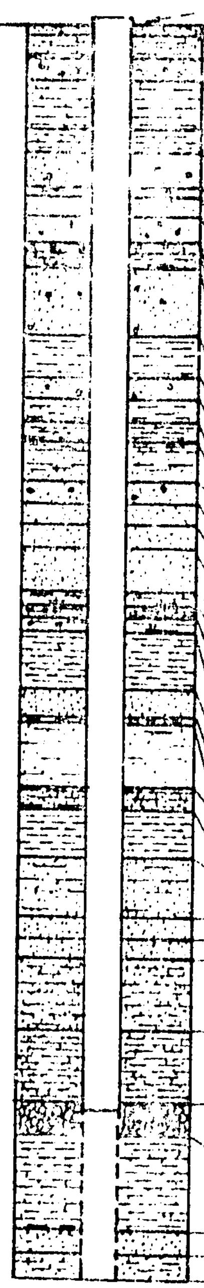
DATE	9-13 JUNE 1977
STATIC WATER LEVEL	3.87 M
PUMPING WATER LEVEL	OBSERVATION WELL
TEST PUMP YIELD	
SPECIFIC CAPACITY	

REMARKS:

OPEN HOLE BELOW 158.5 M
CDM NO.38 IS 7.6 FROM CDM NO.39

WATER QUALITY DATA:

GRAPHIC LOG



DEPTH (M)	DEPTH (FT)
0.6	2
4.9	16
7.9	26
15.2	50
16.5	60
21.8	7[illegible]
24.4	[illegible]
27.4	[illegible]0
31.1	102
[illegible]	[illegible]
34.8	114
45.1	148
51.2	168
54.3	178
57.3	188
60.4	198
66.5	218
69.5	228
72.6	238
75.6	248
82.3	270
[illegible]	277
[illegible]	280
88.4	290
97.6	320
100.3	329
101.2	332
110.1	361
114.0	374
120.7	396
129.9	426
132.9	436
136.0	446
146.3	480
157.0	515
161.6	530
175.6	576
179.0	587
182.9	600

STRATIFICATION

- BROWN SILT AND FINE SAND
- BROWN CLAY WITH SAND
- GRAY SAND, POORLY SORTED, SUB ANGULAR WITH MED. GRAVEL
- SAND, SIZE F-M
- CLAY, DARK BROWN, SILTY, SANDY
- BROWN SANDY CLAY SAND SIZE VF-F
- MED-FINE BROWN SAND
- SUB-ANGULAR WITH FINE GRAVEL
- LIGHT GRAY CLAYEY TUFF
- DARK GRAY SANDY CLAY WITH FINE GRAVEL
- BROWN TO GRAY CLAY SILTY SANDY
- GRAY MED. SAND WITH MED. GRAVEL
- GRAY CLAY SANDY
- GRAY FINE TO MED SAND WITH SOME FINE GRAVEL
- TAN CLAY
- GRAY-BROWN SAND WITH GRANULES
- LIGHT GRAY SANDY CLAY
- GRAY SANDY CLAY
- GRAY CLAYEY SAND, FINE
- GRAY SAND, FINE COARSE WITH FINE GRAVEL
- GRAY-BROWN FINE SAND
- SAND AS ABOVE WITH CSE GRAINS
- V-FINE TO FINE TAN SAND
- GRAY SILT, CLAYEY, SANDY
- GRAY-BLUE STICKY CLAY WITH FINE GRAVEL
- YELLOW TO BROWN STICKY CLAY WITH GRANULES
- YELLOW SANDY CLAY, SAND IS FINE - V. FINE
- GRAY SAND FINE TO MED GRAINS
- LIGHT TAN CLAY
- TAN TO LIGHT GRAY CLAYEY TUFF
- GRAY STICKY CLAY WITH FINE SAND
- GREENISH TAN STICKY CLAY
- LIGHT GRAY, CLAYEY, SILTY, SAND FINE - MED. GRAIN
- V-FINE TAN SILTY SAND
- FINE GRAY SAND
- FINE TO MED. TAN- GRAY SAND SILTY CLAY WITH SOME GRANULES
- GRAY SANDY CLAY SAND IS FINE TO MEDIUM
- GRAVEL, MED. WITH SOME COARSE SAND
- BROWN TO TAN SANDY CLAY
- FINE-MED BROWN SAND
- FINE SAND, SILTY

NOTES:

GRAVEL PARTICLES ARE SUB-ROUNDED TO SUB-ANGULAR FRAGMENTS OF VOLCANIC ROCK.

SAND GRAINS ARE GENERALY SUB-ROUNDED TO SUB-ANGULAR FRAGMENTS OF VOLCANIC ROCK, OR QUARTZ CRYSTALS, OR CRYSTALS OF BLACK MINERALS.

ALL SEDIMENTS APPEAR TO BE DERIVED FROM VOLCANIC ROCK OR VOLCANIC ASH.

ANNEX FIGURE VII B - 6

WELL DATA SHEET
OBSERVATION WELL
CDM - 38

DESCRIPTIVE DATA	GRAPHIC LOG

WELL NO. (CDM) 39
(OTHER) PUMPING TEST WELL
LOCATION FREEDOM BOULEVARD
FORTUNA SUBDIVISION
CITY SILAY
PROVINCE NEGROS OCCIDENTAL
CONST. BY GOLDWATER DRILLING & MACHINERY
DRILLER V. QUERUBIN
STARTED FEBRUARY 26, 1977
COMPLETED
OWNER CDM - LWUA
STATUS TEST WELL
CASING DIAMETER 250 MM
CASING LENGTH 166.2 M

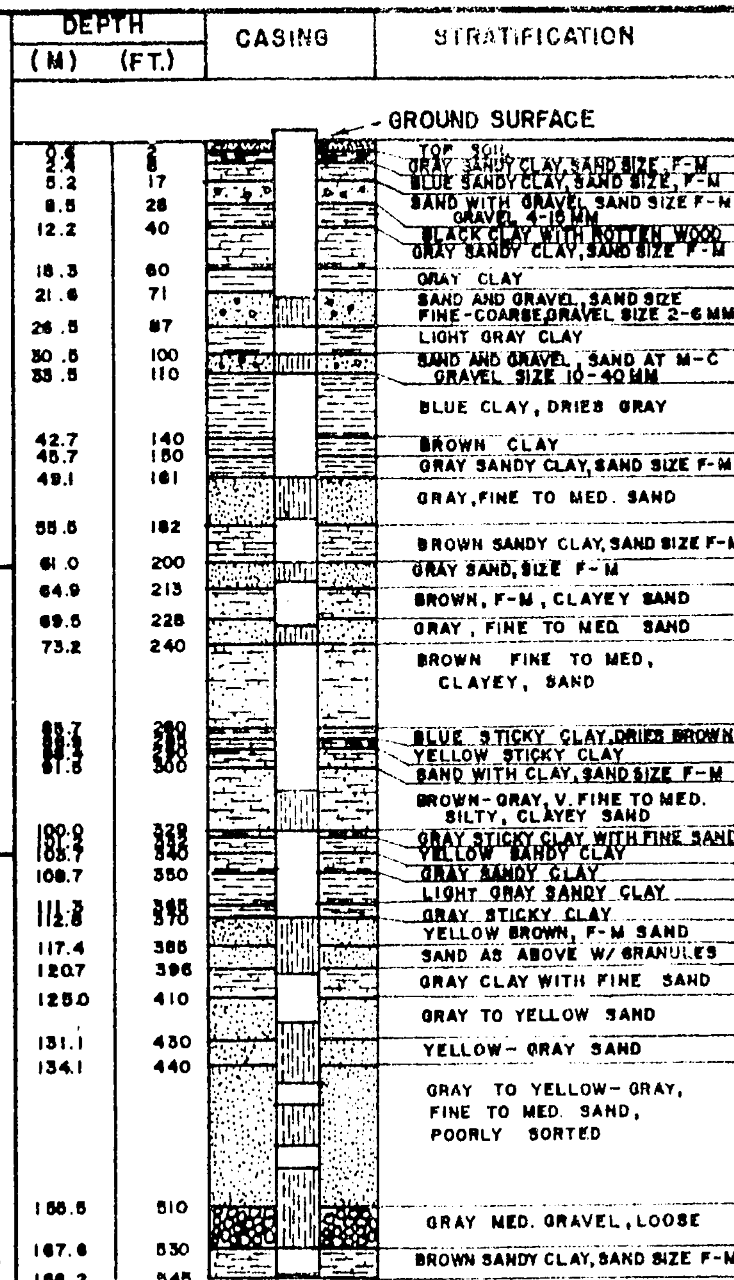
DRILLER'S TEST DATA:

DATE 9-13 JUNE 1977
STATIC WATER LEVEL 4.05 M
PUMPING WATER LEVEL 18.62 M
TEST PUMP YIELD 37.8 LPS
SPECIFIC CAPACITY 2.59 LPS/M

REMARKS:

SLOTTED CASING INTERVALS;
22.0 - 26.5 M
30.5 - 33.5 M
49.1 - 55.2 M
61.0 - 64.0 M
70.1 - 73.1 M
94.5 - 100.6 M
112.8 - 122.0 M
128.0 - 137.2 M
140.2 - 146.3 M
149.4 - 161.6 M
TOTAL SLOTTED; 62.5 M.
CEMENT PLUG IN BOTTOM OF CASING; 0.6 M
CDM NO. 39 IS 7.6 M FROM CDM NO. 38

WATER QUALITY DATA:



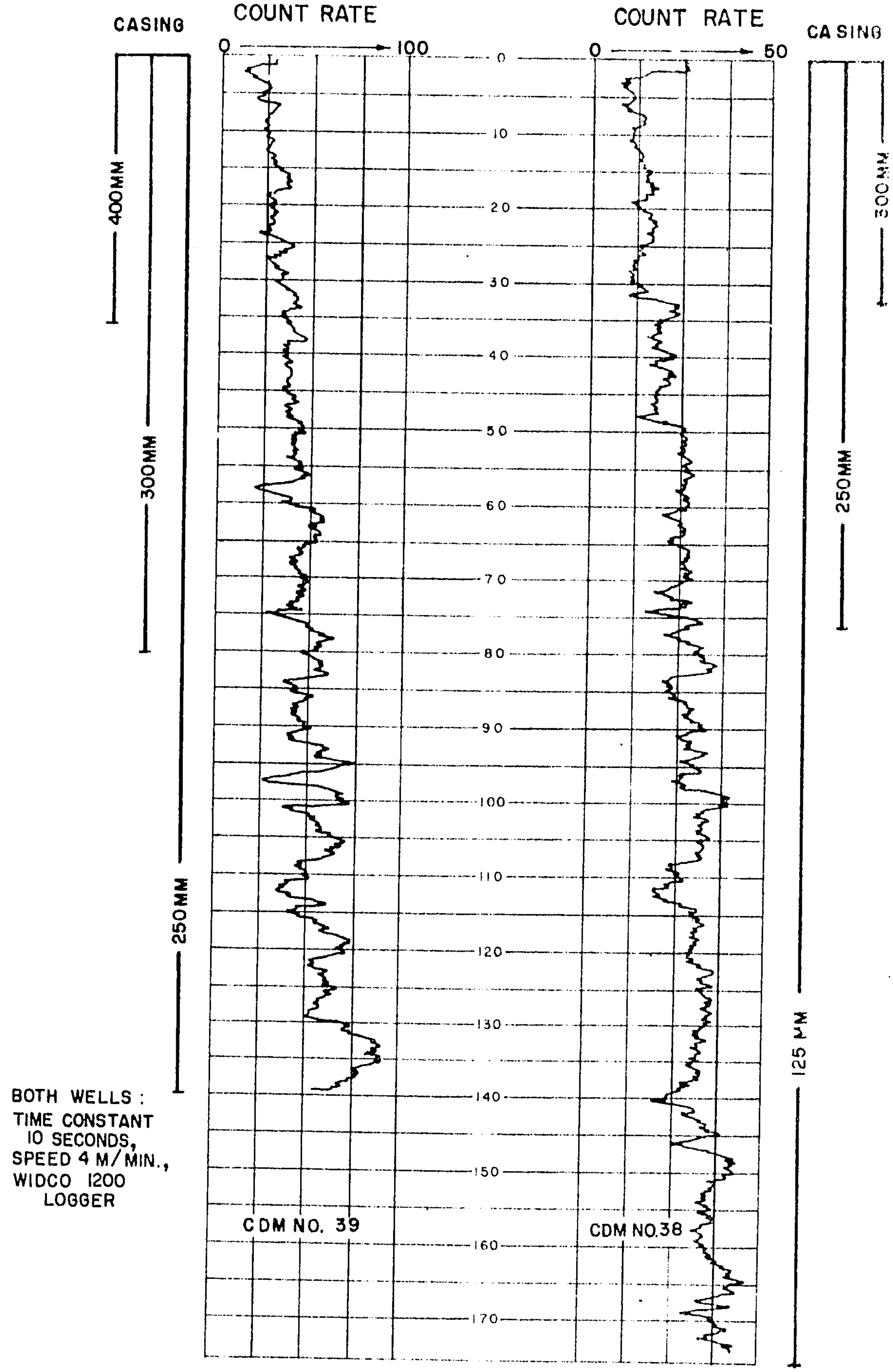
NOTES:

GRAVEL PARTICLES ARE SUB-ROUNDED TO SUB-ANGULAR FRAGMENTS OF VOLCANIC ROCK.

SAND GRAINS ARE GENERALY SUB-ROUNDED TO SUB-ANGULAR FRAGMENTS OF VOLCANIC ROCK, OR QUARTZ CRYSTALS, OR CRYSTALS OF BLACK MINERALS.

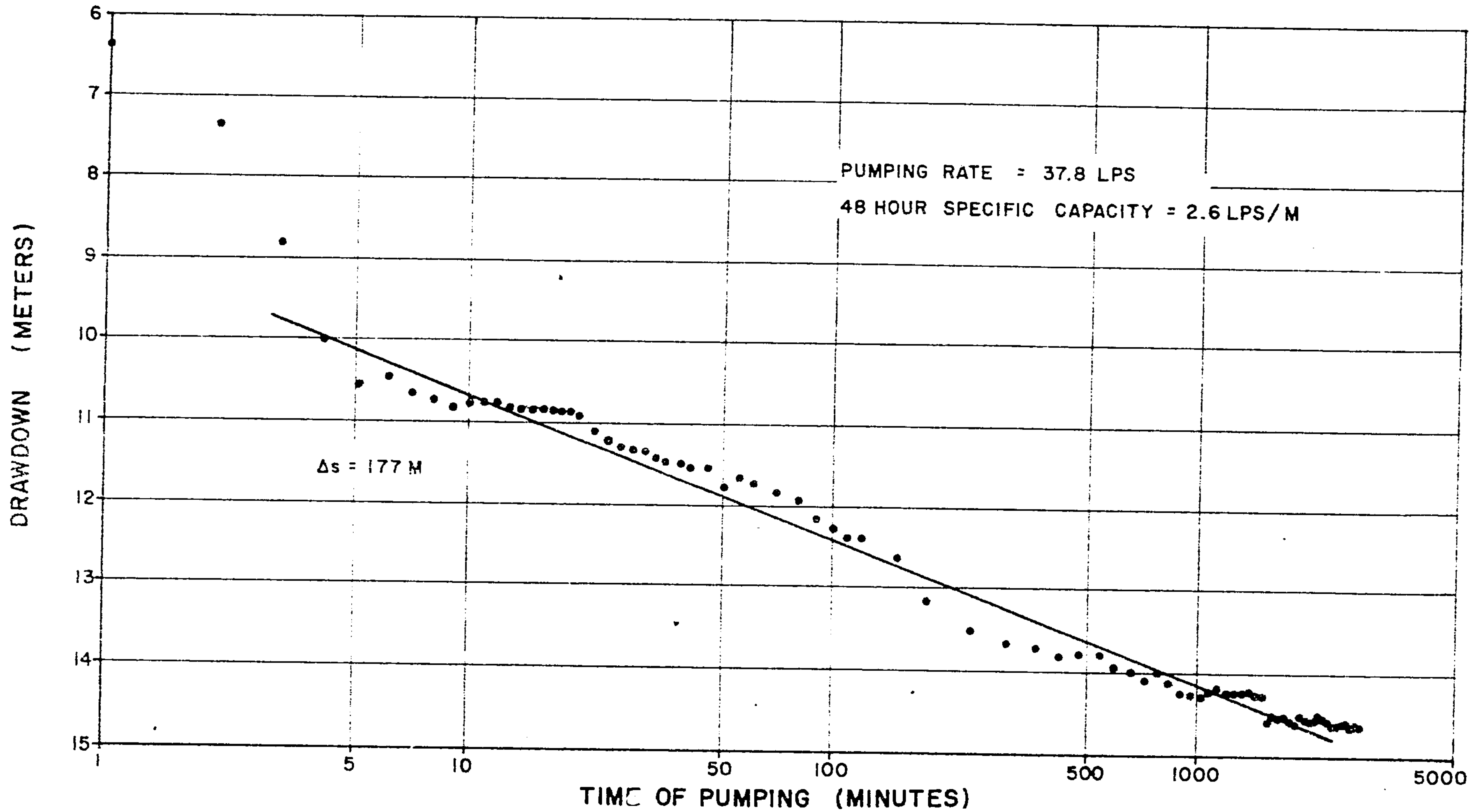
ALL SEDIMENTS APPEAR TO BE DERIVED FROM VOLCANIC ROCK OR VOLCANIC ASH.

ANNEX FIGURE VII B-7
WELL DATA SHEET
SILAY TEST WELL CDM-39



ANNEX FIGURE VII-B-8
GAMMA RAY LOGS
SILAY TEST WELLS
CDM NO. 38 AND 39

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM



ANALYSIS BY JACOB'S MODIFICATION OF THE THEIS NON-EQUILIBRIUM FORMULA

$$T = \frac{0.183\,Q}{\Delta s}$$

Q = 3270 CUMD

T = 338 CUMD/M

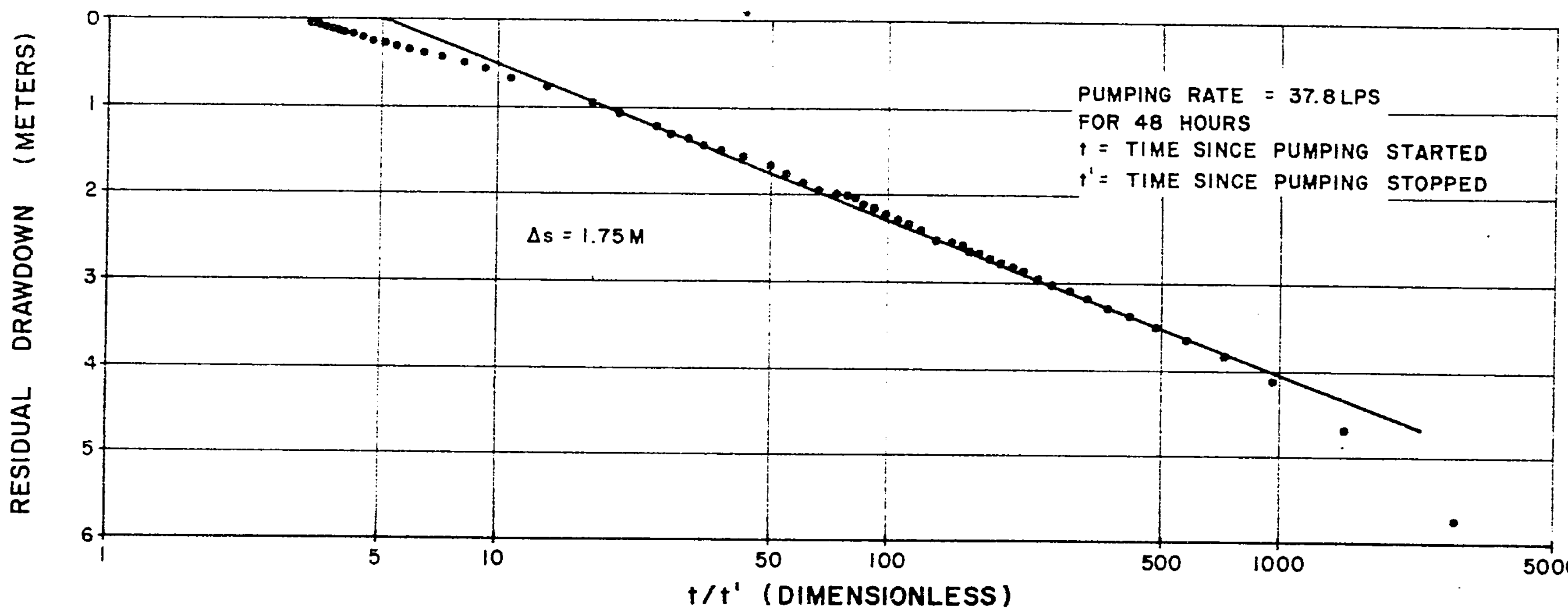
FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS **LWUA-CDM**

ANNEX FIGURE VII-B-9

CONSTANT RATE PUMPING TEST

PUMPING WELL CDM 39

SILAY CITY WATER DISTRICT



ANALYSIS BY JACOB'S MODIFICATION
OF THE THEIS NON-EQUILIBRIUM
FORMULA

$$T = \frac{0.183\,Q}{\Delta s}$$

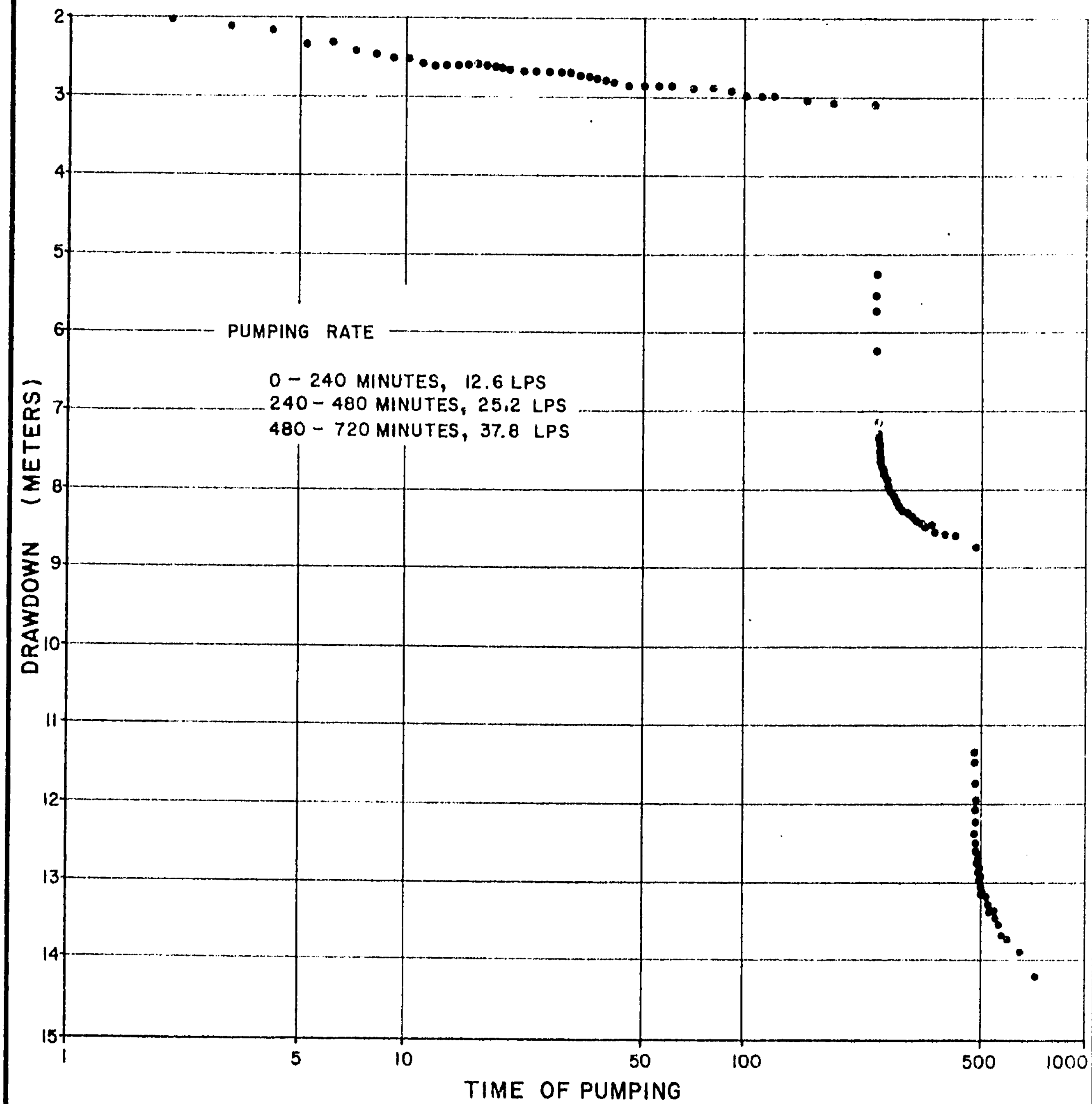
Q = 3270 CUMD

T = 342 CUMD/M

ANNEX FIGURE VII-B-10

RECOVERY FROM CONSTANT RATE PUMPING TEST

PUMPING WELL CDM-39
SILAY CITY WATER DISTRICT



FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS

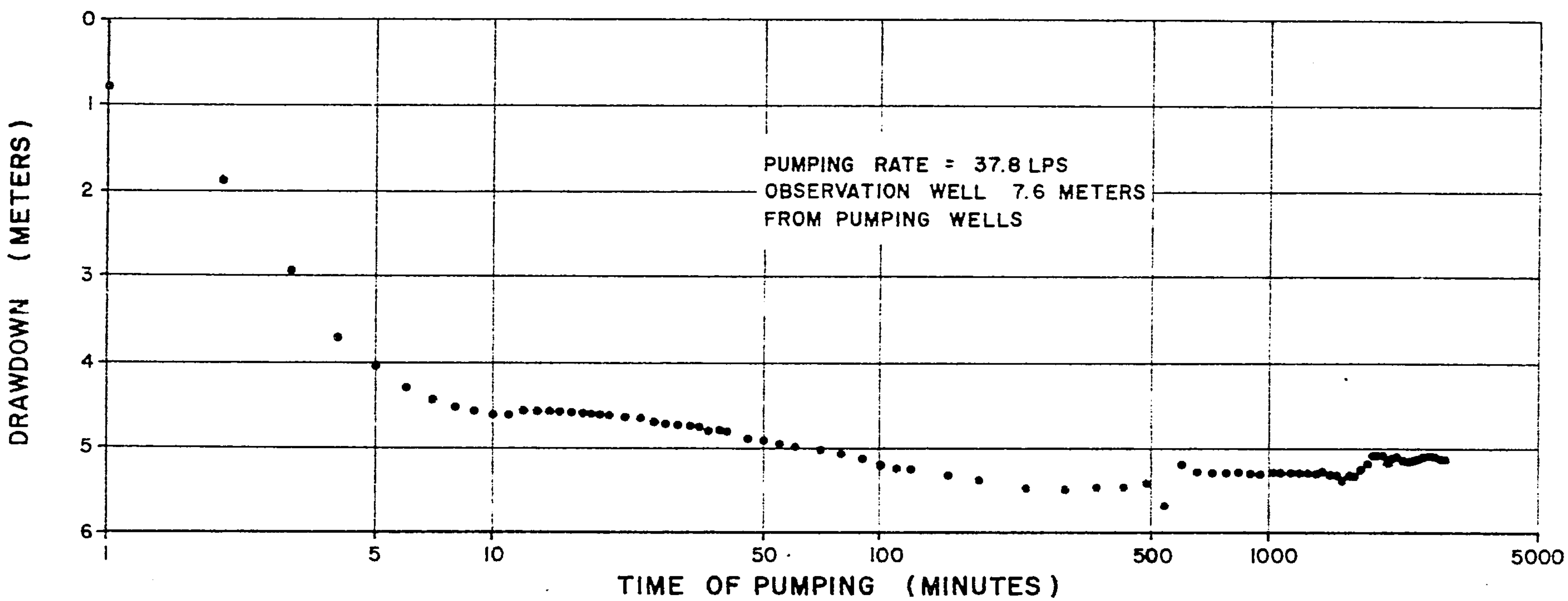
LWUA-CDM

ANNEX FIGURE VII-B-11

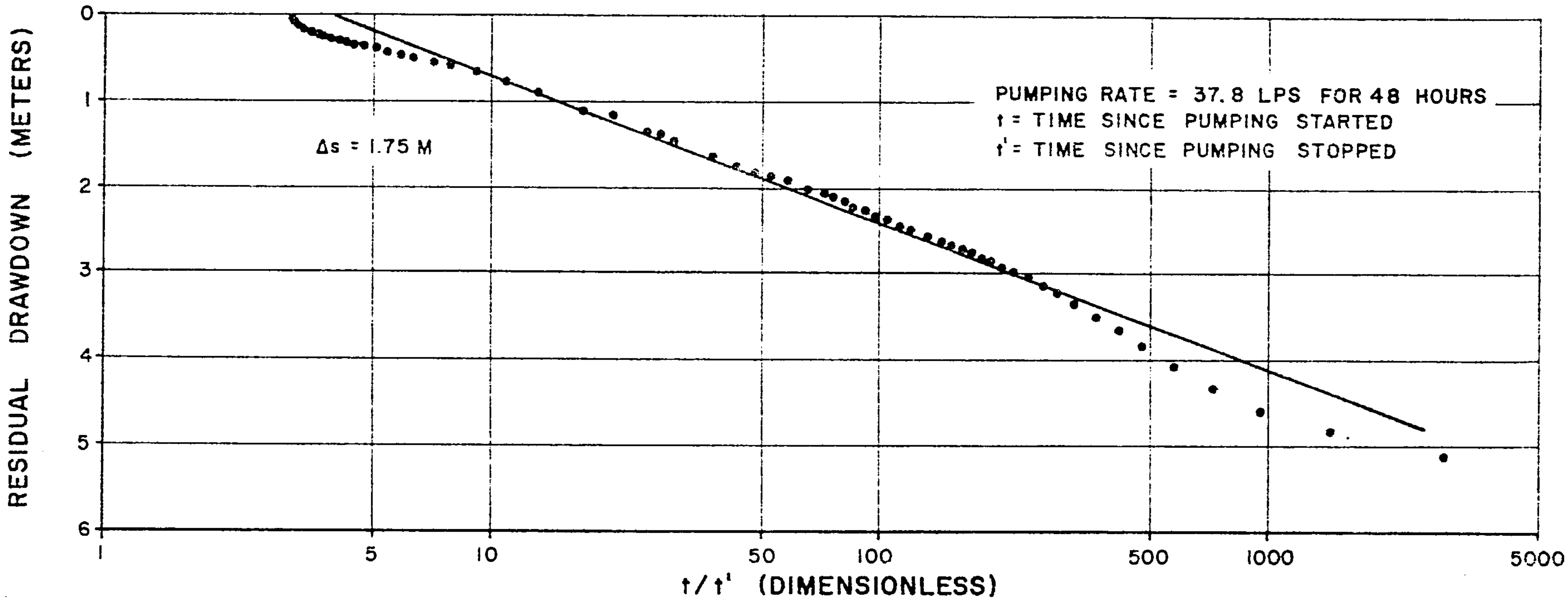
STEP DRAWDOWN TEST

PUMPING WELL CDM-39

SILAY CITY WATER DISTRICT



ANNEX FIGURE VII-B-12
CONSTANT RATE PUMPING TEST
OBSERVATION WELL CDM-38
SILAY CITY WATER DISTRICT



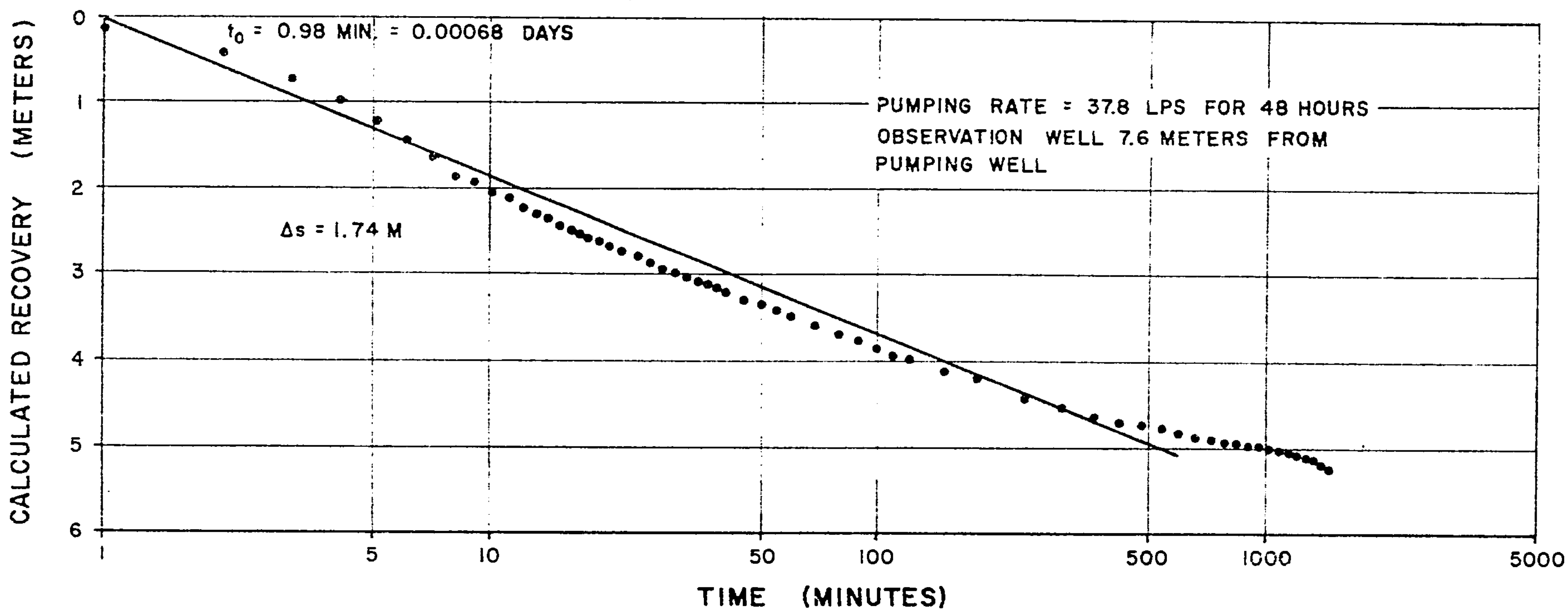
ANALYSIS BY JACOB'S MODIFICATION OF THE THEIS NON-EQUILBRIUM FORMULA

$$T = \frac{0.183\,Q}{\Delta s}$$

Q = 3270 CUMD

T = 342 CUMD/M

ANNEX FIGURE VII-B-13
RECOVERY FROM CONSTANT RATE PUMPING TEST
OBSERVATION WELL CDM 38
SILAY CITY WATER DISTRICT



ANALYSIS BY JACOB'S MODIFICATION OF THE THEIS NON-EQUILIBRIUM FORMULA

$$T = \frac{0.183\,Q}{\Delta s} \qquad S = \frac{2.25\,Tt_0}{r^2}$$

Q = 3270 CUMD S = 0.009

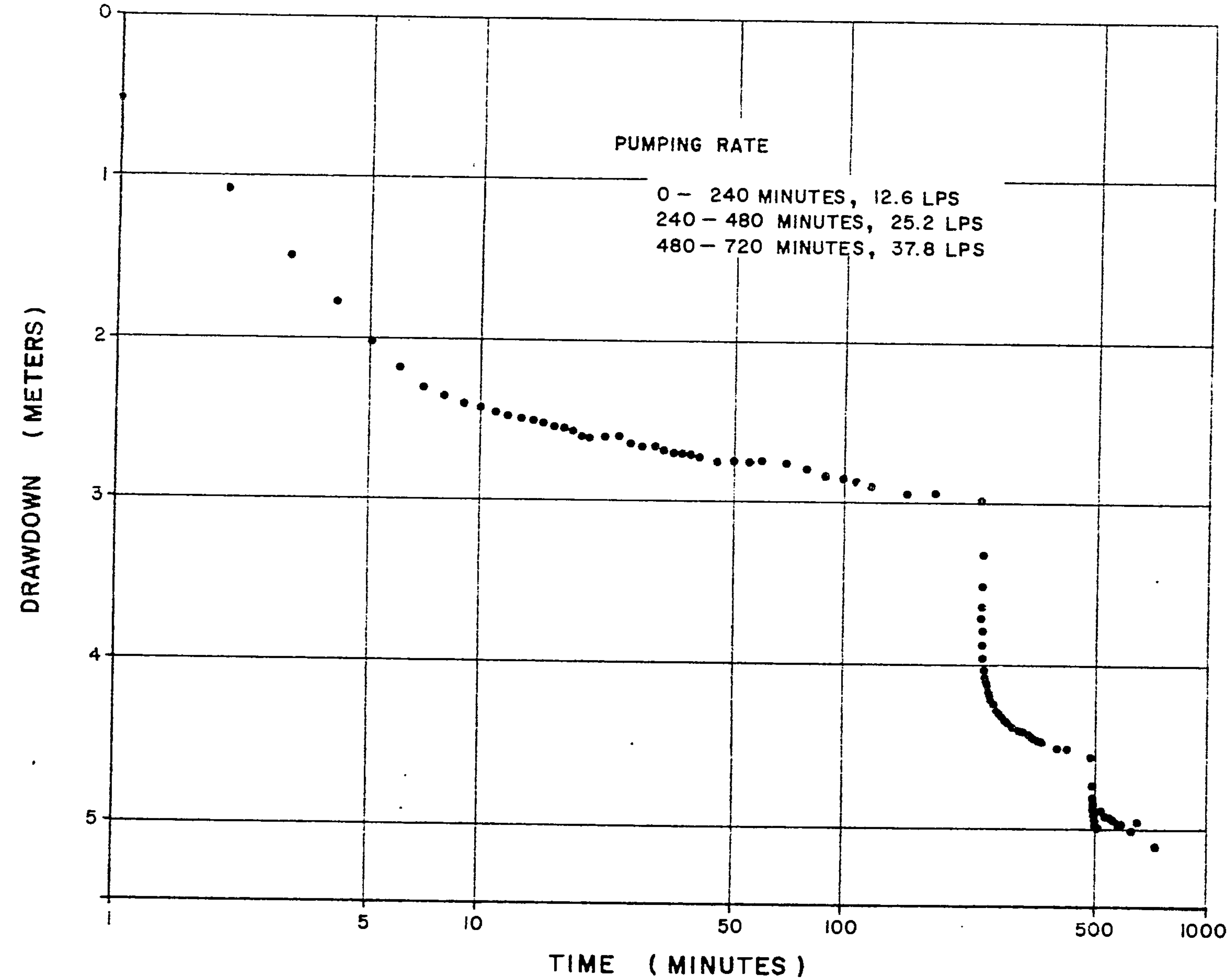
T = 344 CUMD/M

ANNEX FIGURE VII-B-14

RECOVERY FROM CONSTANT RATE PUMPING TEST

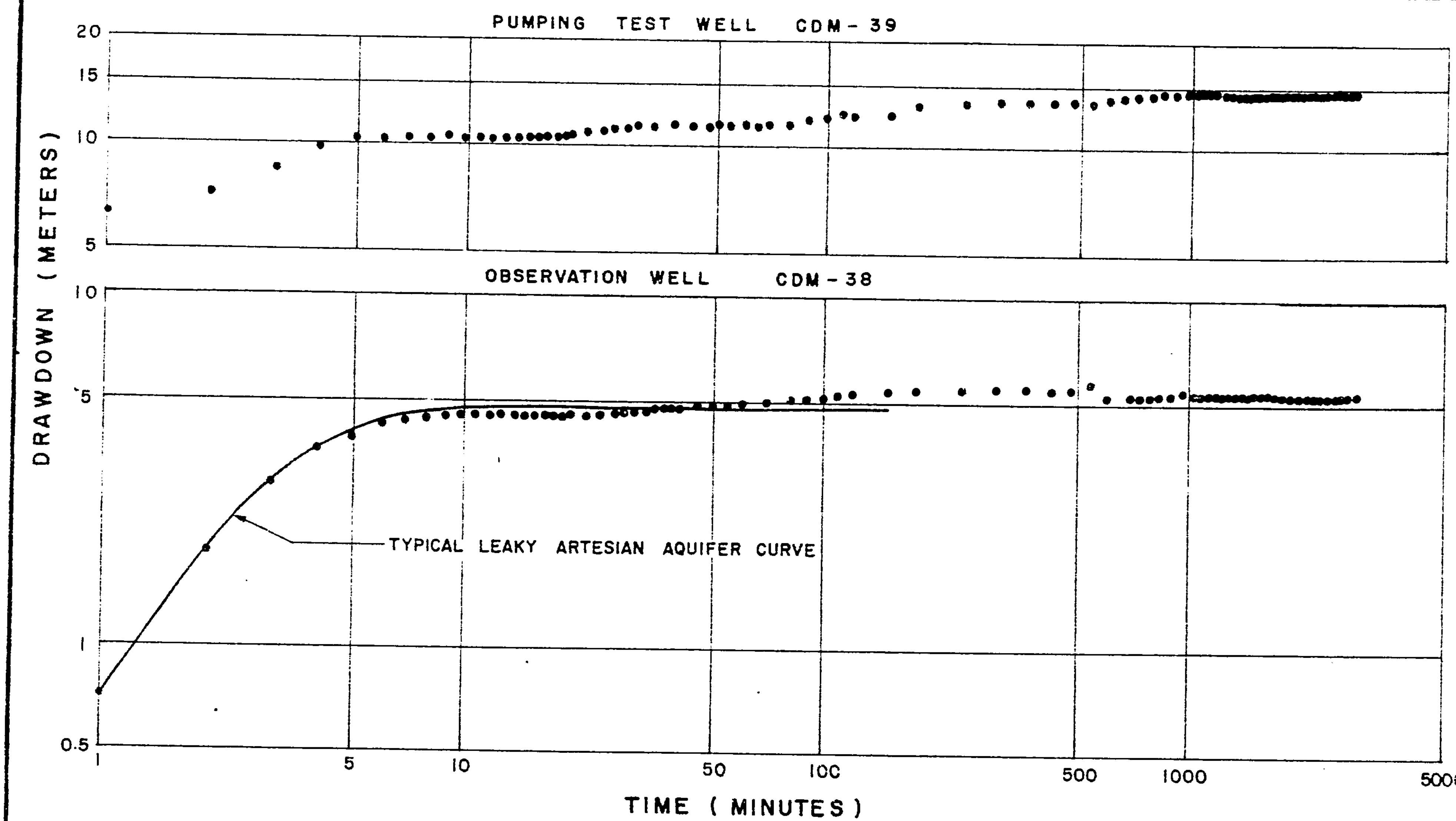
OBSERVATION WELL CDM 39

SILAY CITY WATER DISTRICT

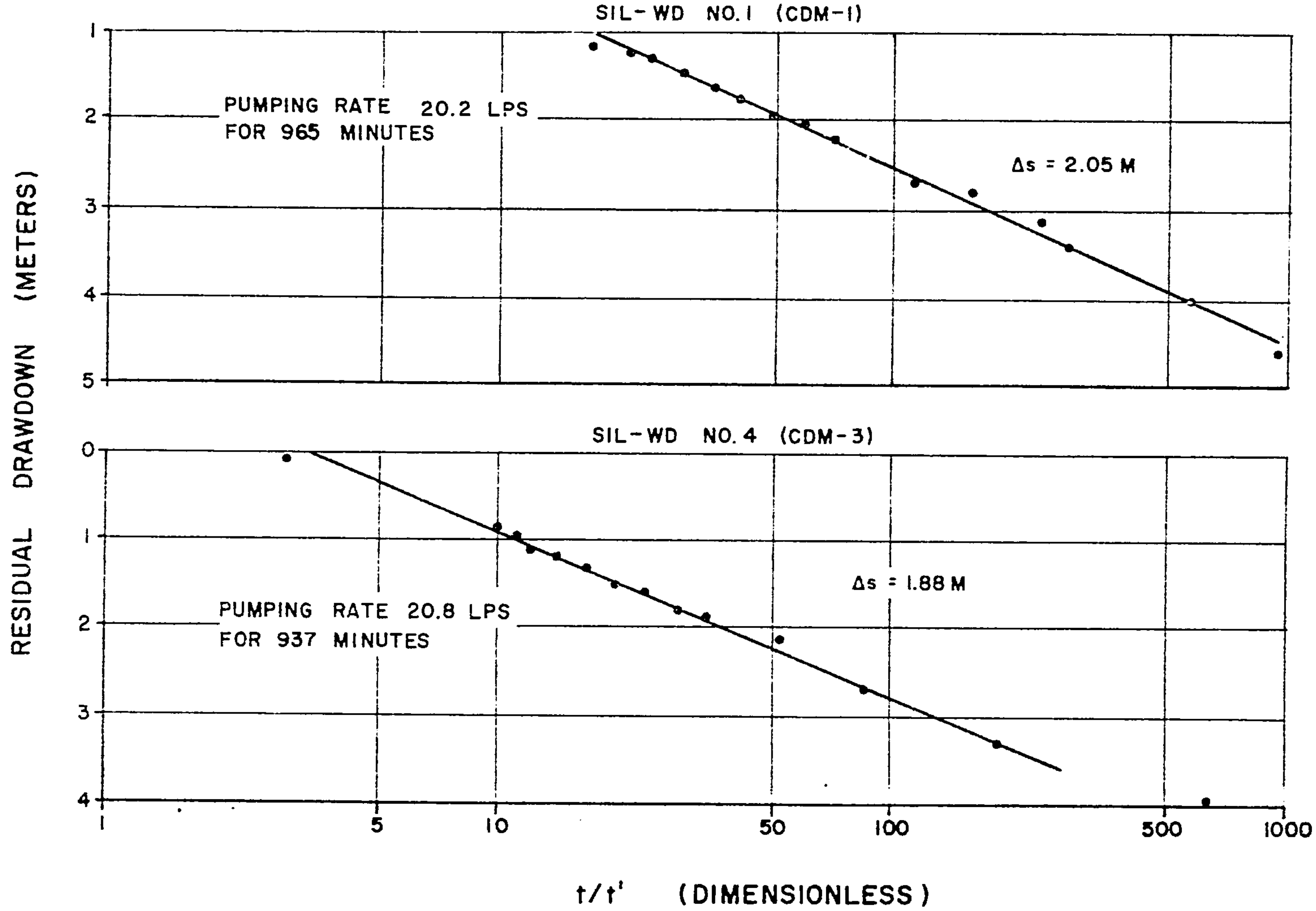


FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

ANNEX FIGURE VII-B-15
STEP DRAWDOWN TEST
OBSERVATION WELL CDM-38
SILAY CITY WATER DISTRICT



ANNEX FIGURE VII-B-16
LOG-LOG DRAWDOWN CURVES
PUMPING TEST WELL CDM-39
OBSERVATION WELL CDM-38
SILAY CITY WATER DISTRICT



ANALYSIS BY JACOB'S MODIFICATION OF THE THEIS NON-EQUILIBRIUM FORMULA

$$T = \frac{0.183\,Q}{\Delta s}$$

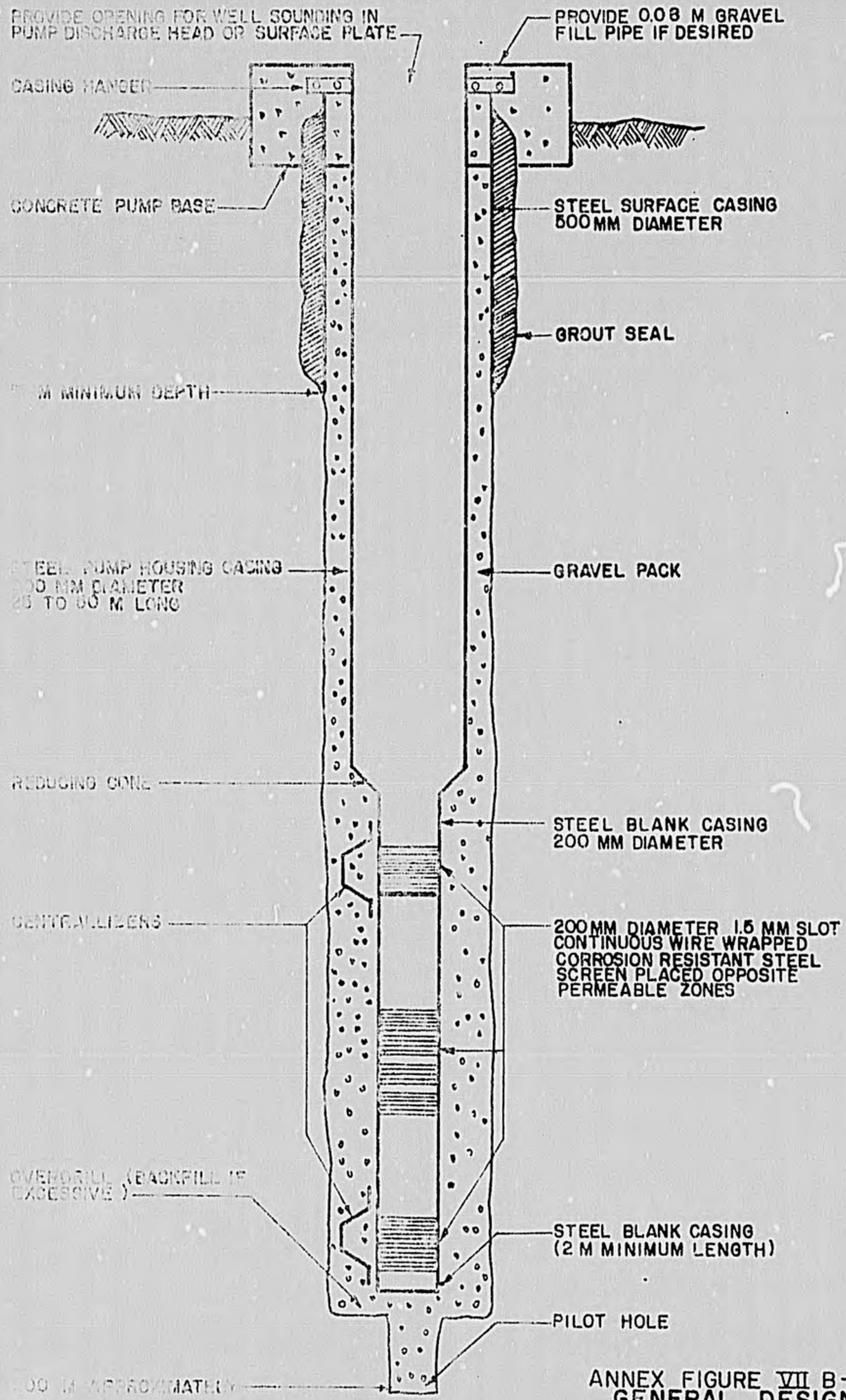
Q = 1740 CUMD
T = 155 CUMD/M

Q = 1800 CUMD
T = 175 CUMD/M

t = TIME SINCE PUMPING STARTED
t' = TIME SINCE PUMPING STOPPED

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS — LWUA-CDM

ANNEX FIGURE VII-B-17
RECOVERY AFTER CONSTANT RATE PUMPING
CDM-1 AND CDM-2
SILAY CITY WATER DISTRICT



ANNEX FIGURE VII B-18
GENERAL DESIGN
GRAVEL PACKED WELL
ROTARY DRILLED
SILAY CITY WATER DISTRICT

SUPPLEMENT TO FIGURE VII-B-18

GENERAL CONSTRUCTION SUGGESTIONS

Gravel Packed Well - Rotary Drilled

1. Drill oversized hole to 15-meter minimum depth (more if conditions require), set and grout 500 mm surface casing.

2. Drill small diameter pilot hole inside surface casing to 200 or 300 meters (or less if in an area where saline groundwater at depth is anticipated).

3. Run electric log.

4. Examine samples and electric log to locate suitable permeable zones. Abandon site if sufficient permeable material is not found.

5. Ream pilot hole diameter to largest diameter that can be drilled inside the surface casing to a depth about five meters below the lowest permeable zone.

6. Install string of casing and screen with screen opposite all permeable zones. Pump housing casing to be 25-meter minimum length, maximum length dependent on depth of upper screened zone and anticipated maximum water levels during life of well.

7. Place gravel of proper size and gradation.

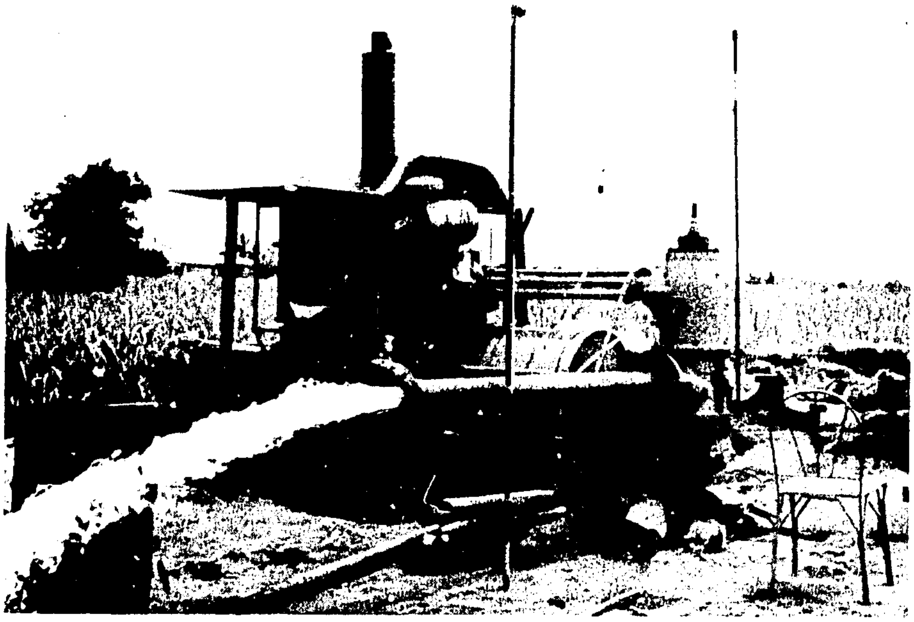
8. Clean and develop well thoroughly.

9. Test well.

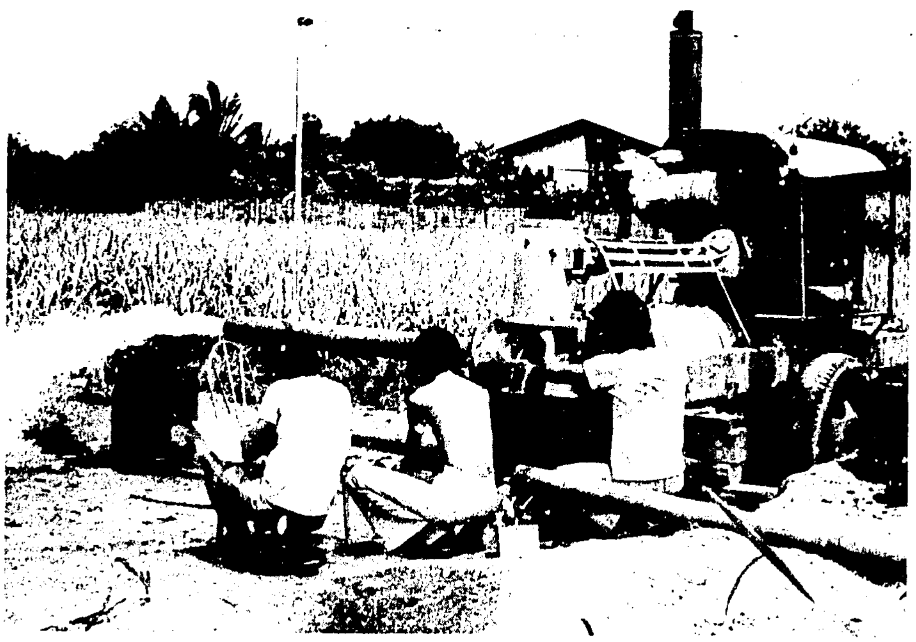
10. Design pump.

11. Construct well head facilities.

12. Install pump.



TEST PUMPING UNIT
DISCHARGING 38 LPS
THROUGH 200MM
ORIFICE ON 250MM
PIPE



MEASURING PUMPING
WATER LEVEL IN
CASING WITH ELECTRIC
SOUNDING WIRE

FLOW MEASURING
PIEZOMETER BEHIND
ORIFICE PLATE-
WATER DISPOSAL IN
CANE FIELD

ANNEX FIGURE VII-B-19
PUMPING TEST
SILAY CITY

CHAPTER VIII ANALYSIS AND EVALUATION OF ALTERNATIVES

A. GENERAL

This chapter identifies and evaluates the alternatives available for source development, transmission, treatment, distribution and storage facilities. Other water conservation and augmentation alternatives are also briefly discussed.

B. WATER SUPPLY SOURCE ALTERNATIVES

The water resources of the Silay City area are discussed in Chapter VII. The possible sources of supply considered for the SIL-WD are: (1) deep wells in or near the service area; (2) deep wells on the 50-meter contour line, about 11 km inland from the service area; (3) induced infiltration wells on the Malogo River, 14 km away (by road); and (4) surface water from the Imbang River, about 2 km from the poblacion. Springs adequate to supply SIL-WD are not known to exist within a reasonable distance.

Water from the three possible well sources will be suitable for use by SIL-WD without treatment other than routine disinfection. Water from the Imbang River will require complete treatment, including coagulation, settling, filtration and disinfection.

A comparative analysis of the present worth cost of providing additional water to SIL-WD from each of the four sources considered has been made. The results of the analysis are summarized in Table VIII-1. In all of the analyses, it has been assumed that the three operational wells in the service area constructed before 1966 would continue to deteriorate and would be out of service by 1985. In the first alternative, using wells in and near the service area, some of the peak-hour demand will be met by provision and use of additional wells. In the other three alternatives, it will be less costly to meet peak-hour demand from elevated storage and the cost of this additional storage is provided in the cost estimates for these alternatives.

The analysis indicates that providing SIL-WD with water from wells in and near the service area is the cheapest of the four alternatives. This alternative is cheaper by ₱7 million considering costs through the year 2000, than the other two well alternatives which cost about the same. The alternative using water from the Malogo River, after complete treatment, costs ₱20 million more than the alternative using wells near the service area, again considering present worth cost through the year 2000.

TABLE VIII-1

COMPARATIVE PRESENT WORTH COSTS OF ADDITIONAL SUPPLY ALTERNATIVES[1]

Items[2]	Construction Cost (₱ x 1,000)	Present Worth Cost[3] (₱ x 1,000)
From Wells near the Service Area		
Well and Pump House	7,788	2,094
Transmission Pipelines	8,110	2,268
Replacement of Machinery	100	5
Operation and Maintenance	-	3,207
Total Present Worth Cost		₱7,574
From Infiltration Wells on the Malogo River		
Well and Pump House	1,880	509
Transmission Pipelines	27,470	11,436
Replacement of Machinery	140	7
Operation and Maintenance	-	1,536
Storage	3,976	1,262
Total Present Worth Cost		₱14,750
From Wells at 50 m Contour 11 km from Silay-WD		
Well and Pump House	5,368	1,435
Transmission Pipelines	22,070	9,052
Replacement of Machinery	200	11
Operation and Maintenance	-	2,628
Storage	3,976	1,262
Total Present Worth Cost		₱14,388
From Imbang River		
Pump Stations	10,072	5,230
Treatment Facilities Including Storage	27,900	13,369
Transmission Pipelines	3,600	1,689
Replacement of Machinery	5,600	507
Operation and Maintenance	-	7,122
Total Present Worth Cost		₱27,917

1/Based on an estimated staging program. Refer to Annex VIII-B for details.

2/Those items which would be common to all the alternatives studied have not been included in the cost comparisons.

3/Includes salvage values. Present worth costs are 1978 present worth costs.

C. PROPOSED SOURCE AND TRANSMISSION

Wells in and near the service area are proposed for future supply to the SIL-WD, since this alternative is the least costly among the sources considered and its water quality is satisfactory.

It is possible that additional withdrawals from wells near the service area, in combination with additional withdrawals from existing wells or wells to be constructed for irrigation or sugar mills, will induce salt water from the sea to travel inland underground. After a time, such salt water encroachment could pollute the wells planned to be installed near the city. Since wells farther from the sea would become contaminated with sea water more slowly than those near the sea, the new wells are therefore to be constructed not in the city, but in a line inland from the city, about 1 km from the sea. If, despite this precaution, salt water does appear in the new wells after some years, it will then be necessary to seek new sources at that time, probably the other two well alternatives considered. A present worth analysis has shown that obtaining additional supply from wells near the service area will be cheaper than the other alternatives even if these wells can be used only 6 or 7 years before salt water encroachment occurs (refer to Table VIII-B-5). There is currently no indication of such encroachment, even in the well in the city only 500 meters from the sea.

The transmission mains required for the recommended alternative would have a total length of about 12 km, with wells located 1 km apart.

D. TREATMENT ALTERNATIVES

Analyses indicate that chemical constituents of groundwater in Silay, except total iron, manganese, color and turbidity, are within the permissible limits set by the Philippine National Standards for Drinking Water.

The limits set for color, turbidity, manganese and iron were established based on aesthetic and economic considerations rather than public health reasons. Color, which is usually due to natural mineral or vegetable origin may dull clothes or stain food and fixtures. Turbidity is attributable to suspended and colloidal matters caused by mineral substances, clay or silt. It is undesirable for some industrial processes such as ice-making, bottled beverages and brewing, textiles, pulp and paper, steam boilers and turbine operations and also laundries. Turbidity in groundwater is commonly due to poor well construction. Iron frequently accompanies manganese and exists in soils and minerals in insoluble form. Iron and manganese leach from soil and rocks into groundwaters that are devoid of dissolved oxygen and are high in carbon dioxide content. In addition to these salts, products of metallic corrosion further increase the iron content of piped water.

Analysis of Malogo River water indicates an iron content in excess of the permissible limits. Since surface water usually has enough dissolved oxygen in it soluble iron and manganese could hardly occur. The indicated iron content of Malogo River may be attributed to clay (fine mud) particles present in the water. Although excessive concentrations of iron and manganese cause unpleasant taste, stain and discolor laundry and fixtures, the normal dietary intake is far higher than the amount that would be tolerated aesthetically.

Therefore, in order to preserve the good quality of water throughout the distribution system, the only treatment proposed is disinfection at each well source. Disinfection may be accomplished with various methods which are discussed in Appendix J, Volume II. For economic and practical reasons (availability of equipment, supply and application and lasting effectiveness), chlorination is the recommended process of disinfection.

E. DISTRIBUTION ALTERNATIVES

General

This section presents the distribution alternatives considered for the SIL-WD. The recommended improvement program for the water system is discussed in Chapter IX.

The components of a water distribution system and some of the alternatives in planning a system are discussed in Appendix K. The design criteria for the distribution system are given in Appendix F. Appendices F and K were largely developed for the First Ten Provincial Urban Areas and are applicable to moderate-size communities. The Second Ten Provincial Urban Areas are generally much smaller and the parameters presented in Appendices F and K must be applied with discretion.

Particular attention has been given to the requirements of fire flow in the SIL-WD. In general, fire flow is applied at various locations in a system coincidentally with maximum-day demands, and the pipelines are sized to convey the required flow at specified head losses. In large communities, the total peak-hour flow is greater than the maximum-day flow plus fire flow and therefore relatively minor adjustments are required in the pipe system to provide fire flow. In the smaller communities, especially small barrios some distance from the poblacion, the fire flow alone can be 3 or 4 times the total peak-hour demand.

Providing adequate fire flow to areas where the fire flow may be far greater than the ultimate peak demand is rarely justified economically; but, as a general rule, some fire protection should be provided. Included in this study is information on the available fire flow at various locations where the system has been designed for conditions other than fire flow.

The flows used for design of the various components of the distribution system are as follows (see Water Demand Projections, Chapter VI):

	1980	1990	2000
Water Demand, lpcd	198	193	199
Served Population	15,630	54,870	103,160
Average Daily Water Demand, cumd	3,090	10,590	20,530
Maximum-Day Water Demand, cumd	3,710	12,710	24,640
Peak-Hour Water Demand, cumd	5,410	18,530	35,930

Pressure Zones

The ground elevation within the future service area of the SIL-WD through the year 2000 ranges from a low of 0.5 meter in Barrio Hambulac to a high of 10.0 meters in Barrio Rizal. The majority of the service area, including the poblacion, is situated at an elevation of about 4.5 meters. The system can be operated adequately if an HGL of 26.4 meters is maintained at the existing storage tank; therefore, only a single pressure zone has been considered for the SIL-WD.

Storage Facilities

Storage facilities are provided in a distribution system to meet hourly fluctuations in demand over the day. The usual requirement for operational storage is 15-20 percent of the maximum-day volume, assuming the source of supply is capable of providing water at a rate equal to maximum-day demand.

In the flat areas, storage is usually provided by means of an elevated storage tank. This type of tank is very costly in the Philippines because it must be designed to withstand high seismic loadings. An alternative method of meeting demand fluctuations has been investigated for Silay.

As previously discussed, the least-cost, long-term source alternative for Silay is pumped groundwater. It is possible to install additional pumping capacity above the maximum-day demand rate in order to meet part of the peak-hour fluctuations and thereby reduce the amount of storage required. Methodology Memorandum No. 6 discusses the rationale for providing additional pumping capacity and presents a curve used in estimating the required storage volume based on various supply rates. An economic analysis comparing the costs of providing additional supply and of storage for Silay is presented in Table VIII-2.

Typically, where a comparison is made between various quantities of elevated storage and well capacities, providing additional capacity is more economical. However, in Silay, wells would have to be located a significant distance from the shoreline to minimize salt water intrusion; therefore, some wells would actually be located outside of the year 2000 service area. Transmission mains would be required from those wells outside the ultimate service area, increasing the cost of developing well capacity. Table VIII-2 includes the additional transmission main costs and the analysis shows that an intermediate quantity of storage is the most economical to provide.

The recommended storage tank sizes and well development program are described in detail in Chapter IX.

Distribution System

The analysis for the distribution system of SIL-WD generally followed the guidelines of Appendices F and K. Unlike for the First Ten Provincial Urban Areas, computer analysis for Silay considered pipelines smaller than 200 mm in diameter. Silay would have very few pipelines greater than 200 mm even in the year 2000.

The distribution analysis did not include studies of various alternative pipeline configurations because the location of pipes is controlled by the location of roadways, the barrios to be served, and the well supplies.

The location of an elevated storage tank was analyzed using the computer to determine the optimum location from a hydraulic standpoint. Southern portions of the service area around Barrio Guinhalaran could not be served effectively with storage located only at the existing site.

The wells for SIL-WD are situated in a generally north-south direction parallel to the shoreline. The existing tank is located between the wells and the shore toward the northern end of the service area. In order to operate the wells in the southern portion of the system with the existing storage tank, the hydraulic gradeline near those wells would be too high.

TABLE VIII-2

ALTERNATIVE STORAGE VERSUS ADDITIONAL SUPPLY ANALYSIS[1/]

	Alternative 1 (Maximum Storage)	Alternative 2 (Intermediate Storage)	Alternative 3 (Minimum Storage)
Storage Required (Percent)[2/]	13	6	2
(Total Volume, cum)	3,080	1,380	580
Present Worth Cost (₱ x 1000)			
Storage[3/]	₱1,350	₱ 470	₱ 20
Wells	1,140	1430	1,610
Transmission Mains[4/]	-	100	420
Operation and Maintenance	650	720	800
Total	₱3,140	₱2,720	₱2,850

[1/] Analysis includes all facilities to the year 2000.

[2/] Percentage of maximum-day demand.

[3/] Only includes additional storage to existing 380-cum storage tank. The existing 190-cum tank would be abandoned since it has an overflow elevation lower than the recommended static HGL.

[4/] Includes cost of transmission mains from wells located outside the year 2000 service area.

A second tank site was selected near the intersection of Rizal Street and Freedom Boulevard. A tank at this location reduces the amount of friction head on the wells in the southern portion of the service area and reduces the operating hydraulic gradeline to a more acceptable level. The friction head is reduced mainly because the new tank is located adjacent to new, adequately sized pipelines. The existing tank is located within the existing distribution system which should be retained for service, but the pipes are not adequately sized to convey water to the storage tank from the southern portion of the distribution system.

The analysis of the flow requirements indicates that approximately 60 to 70 percent of the storage should be located at the new site while the remainder would be located at the existing site. Altitude-control valves and tank level monitors would have to be constructed at both tanks. One of the tanks can completely fill before the second one under various flow conditions because the tanks are not adjacent to each other. The tank levels would have to be monitored closely by the pump station operator as a check on the operation of the automatic altitude valve.

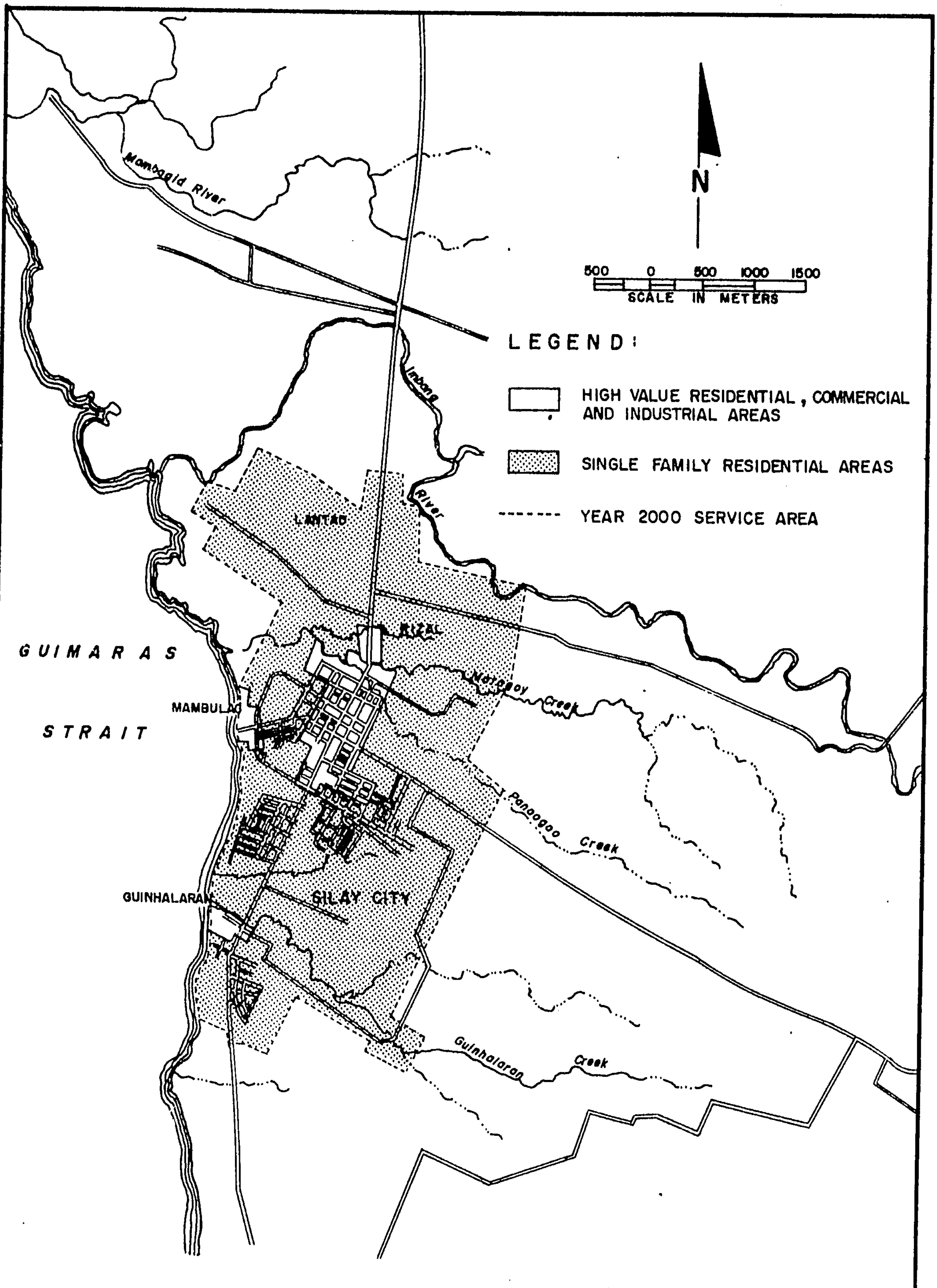
The recommendations for storage tank construction are included in Chapter IX.

Fire Protection

Fire protection does exist in SIL-WD although not at a completely adequate level. There are 45 hydrants (most are operational) and three blow-off valves at the pumping stations where the fire department can obtain water for fire-fighting. The pressure in most of the system is low (0.7 to 10 m) so that the quantity of water available at most hydrants is not completely adequate.

As outlined in Appendix K, there are two standards of fire protection, one for the high-value residential, commercial and industrial areas and another for the single-family residential areas. In the high-value residential, commercial and industrial areas, an available fire flow of 20 lps at two adjacent fire hydrants should be provided, while in the single-family residential areas, only 10 lps at two adjacent hydrants. Figure VIII-1 shows the outline of the fire service areas in SIL-WD. The percentage of fire protection referred to in this chapter is the ratio of the available flow to the standards above.

The immediate improvement program (1978-1980), which is aimed at providing adequate domestic service to existing consumers and increasing the number of consumers to provide a larger financial base to pay for future improvements, does not include full fire protection. If the program were designed to provide full fire protection to the consumers, the cost of the improvements required would become too high for the program to be feasible.



FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS **LWUA-CDM**

FIGURE VIII-1
FIRE PROTECTION AREAS
SILAY CITY WATER DISTRICT

The improvements to the distribution system recommended for the immediate improvement program, along with the existing facilities, would be capable of providing about 50 percent of the required fire flow to remote sections of SIL-WD such as Guinhalaran, provided adequate supply and 24-hour operation are achieved. The poblacion would have full fire protection provided that the excessive leakage is repaired and cross-ties within the distribution mains are made.

For design year 1990, the distribution improvements would be able to provide about 100 percent fire protection although full protection is not the goal for 1990. The 1990 improvements are designed to provide adequate average-day service under a number of operating configurations. The capacity for fire protection would increase due to changes required for operational considerations. The quantity of fire protection available is also dependent on the location of wells. There is sufficient number of wells located across the SIL-WD that can meet fire requirements in 1990.

Full fire protection is provided for in the year 2000 recommended improvements.

The preceding discussion of fire protection relates only to the capacity provided in the distribution mains. In providing fire protection, an adequate number of fire hydrants in the various service areas has also to be considered. The primary criterion for providing fire hydrants would be the degree of development in a specific area. In Chapter IX, a schedule of fire hydrant construction is included, based on the projected development of the SIL-WD. This schedule can be modified as development requires, provided the necessary distribution mains have been provided.

System Operation

This section includes various operational aspects of the alternative distribution systems. While there are no alternative distribution systems for SIL-WD, there are, however, definite operational problems.

As previously discussed, the location and capacity of the wells can affect the operation of the system with regard to meeting demands and pressure requirements. Computer analyses were conducted on several combinations of demands and operating wells, given that the distribution system would be capable of meeting required pressures for average-day demands. In the analyses, only usual operating problems, such as one well being out of service or an error in judgment as to which wells should be operating, were considered.

Unusual operating problems, such as meeting maximum or peak demands at minimum pressures when 2 or more wells are not in operation, were not considered. The cost of providing adequate service under all possible operational conditions would be prohibitive so that only those operating conditions that would reasonably occur were analyzed.

As a general rule, the distribution system should be operated by utilizing as many wells as possible outside the poblacion to meet water demands. This procedure has the effect of maintaining a high HGL in the outlying areas, while the storage tank maintains an adequate gradeline within the poblacion. This operational mode usually applies when the demand in the system is relatively high. During periods of very little demand such as at night when the storage tanks would be refilling, if only wells outside the poblacion are operated, pressures at those points may increase to unacceptable levels. A more efficient procedure at low flows would be first, to operate as many wells outside the poblacion area as necessary to maintain adequate pressures, and then, operate as many pumps as necessary near the poblacion to refill the storage tanks within a reasonable time.

Besides problems of pressure in the system due to well operation, the schedule of operation has also to be considered. The pump operation schedule is based on the water level within the storage tank and pressures in various sections of the system. If the tank level drops, a sufficient number of wells would have to be operated to refill the tank. However, the major problem in this operation schedule is the time available to control the number of wells in operation as the water level and pressure fluctuate. In the year 2000, for instance, the recommended volume of storage (1,380 cum) would provide the operator about 6 hour to change the number of wells operating. This estimate is based on the assumption that the tank is one-half empty and that too many or few wells would be operating at 31.5 lps.

As experience is gained in the operation of wells, a schedule of operation based on normal demand schedules may be devised. If a satisfactory schedule is devised, the system may go unattended for several hours.

Internal Network

A general but complete discussion of the internal network for distribution system is included in Appendix K. The small size of the SIL-WD does not affect the application of the recommendations contained in Appendix K since these are the minimum pipeline sizes recommended for any municipality. The cost data contained in Appendix K would be multiplied by a factor of 1.21 to obtain mid-1978 costs in this report.

F. OTHER ALTERNATIVES FOR WATER CONSERVATION AND AUGMENTATION

In areas where water is a scarce resource, there are several alternative measures of conserving water. These alternatives depend on sophisticated technology in the case of water reuse and desalting or on governmental policy in the case of land management. Appendix M, Volume II is a discussion of these conservation and augmentation alternatives.

ANNEX VIII-B

COMPARATIVE PRESENT WORTH COSTS OF SOURCE/TRANSMISSION ALTERNATIVES

TABLE VIII-B-1

COMPARATIVE COST OF ADDITIONAL SUPPLY FROM WELLS NEAR THE SERVICE AREA

Year of Construction	Item	Cost of Construction (₱ x 1000)	1978 Present Worth Cost (₱ x 1000)
1980	Well and Pump House	708	556
1980	Transmission Main	270	202
1982	Well and Pump House	708	437
1982	Transmission Main	1,350	787
1985	Well and Pump House	708	299
1985	Transmission Main	1,350	533
1987	Well and Pump House	708	229
1987	Transmission Main	830	249
1989	Well and Pump House	708	173
1989	Transmission Main	830	185
1990	Well and Pump House	708	148
1990	Transmission Main	660	126
1992	Well and Pump House	708	106
1992	Transmission Main	660	89
1994	Well and Pump House	708	72
1994	Transmission Main	540	49
1996	Well and Pump House	708	44
1996	Transmission Main	540	29
1997	Replace Pumping Machinery	100	5
1998	Well and Pump House	708	20
1998	Transmission Main	540	13
1999	Well and Pump House	708	10
1999	Transmission Main	540	6
1982–2000	Operation and Maintenance – New supply only		3,207
	Total 1978 P.W. Cost		₱7,574 x 1000

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NO. VIII-B-2

TABLE VIII-B-3

COMPARATIVE COST OF ADDITIONAL SUPPLY
FROM WELLS AT 50-METER CONTOUR, 11 KILOMETERS FROM SIL-WD

Year of Construction	Item	Cost of Construction (₱ x 1000)	1978 Present Worth Cost (₱ x 1000)
1980	Well and Pump House	671	526
1980	Transmission Main	9,750	7,289
1980	Storage	1,204	900
1984	Well and Pump House	671	322
1984	Transmission Main	330	149
1987	Well and Pump House	671	217
1987	Transmission Main	270	81
1989	Storage	1,386	309
1989	Well and Pump House	671	163
1989	Transmission Main	270	60
1992	Well and Pump House	671	101
1992	Transmission Main	10,580	1,430
1994	Well and Pump House	671	68
1994	Transmission Main	330	30
1995	Replace Pumping Machinery	100	9
1997	Well and Pump House	671	29
1997	Transmission Main	270	10
1997	Storage	1,386	53
1999	Well and Pump House	671	9
1999	Transmission Main	270	3
1999	Replace Pumping Machinery	100	2
1980-2000	Operation and Maintenance	-	2,628
		Total 1978 P.W. Cost	₱14,388 x 1000

TABLE VIII-B-4

COMPARATIVE COST OF ADDITIONAL SUPPLY
FROM IMBANG RIVER

Year of Construction	Item	Cost of Construction (₱ x 1000)	1978 Present Worth Cost (₱ x 1000)
1980	River Pumping Station	3,694	2,843
1980	Treatment Works	13,260	10,101
1980	Clear Water Storage	690	516
1980	Pumping Station	1,939	1,492
1980	Transmission Main	1,800	1,346
1990	River Pumping Station	2,500	504
1990	Treatment Works	13,260	2,621
1990	Clear Water Storage	690	131
1990	Pumping Station	1,939	391
1990	Transmission Main	1,800	343
1995	Replace Machinery	5,600	507
1980–2000	Operation and Maintenance		7,122
		Total 1978 P.W. Cost	₱27,917 x 1000

TABLE VIII-B-5

COMPARATIVE COST OF ADDITIONAL SUPPLY
FROM WELLS NEAR THE SERVICE AREA UP TO 1987 AND
FROM WELLS AT 50 METER CONTOUR, 11 KILOMETERS FROM SIL-WD

Year of Construction	Item	Cost of Construction (₱ x 1,000)	1978 Present Worth Cost (₱ x 1,000)
1980	Well and Pumphouse	708	556
1980	Transmission Main	270	202
1982	Well and Pump House	708	437
1982	Transmission Main	1,350	787
1985	Well and Pumphouse	708	299
1985	Trnamission Main	1,350	533
1987	Well and Pump House	2,013	651
1987	Transmission Main	10,350	3,100
1987	Storage	1,204	361
1989	Storage	1,386	309
1989	Well and Pumphouse	671	163
1989	Transmission Main	270	60
1992	Well and Pump House	671	101
1992	Transmission Main	10,580	1,430
1994	Well and Pump House	671	68
1994	Transmission Main	330	30
1995	Replace Pumping Machinery	100	9
1997	Well and Pump House	671	29
1997	Transmission Main	270	10
1997	Storage	1,386	53
1999	Well and Pump House	671	9
1999	Transmission Main	270	3
1999	Replace Pumping Machinery	100	2
1980-2000	Operation and Maintenance		2,628
		Total 1978 P.W. Cost	₱11,830 x 1,000

ANNEX TABLE VIII-B-6

ECONOMIC SERVICE LIFE OF WATER SUPPLY FACILITIES[1]

Item	Economic Service Life, Years
Embankment Dams[2]	
Embankment	50
Structure	50
Equipment	50
Water Treatment Plants	
Structure	50
Equipment	15
Groundwater Wells	
Well	25
Structure	25
Equipment	15
Transmission Facilities	
Pipes	50
Valves	50
Distribution Facilities	
Pipes	50
Valves	50
Internal Network	
Pipes	50
Valves	50
Hydrants	50
Service Connections	
Service Pipes	50
Water Meter	15
Disinfection Facilities	
Structure	50 (may depend on associated facility)
Equipment	15
Storage Facilities	
Structure	50
Equipment (specialized, other than pipes and valves)	15

1/The economic service lives presented here have been used throughout this report wherever facility replacement or present worth analysis has been required.

2/Although the physical life expectancy of certain facilities, such as dam embankments, is greater than the economic service life indicated, the latter more realistically reflects the useful life of the facility.

ANNEX TABLE VIII-B-6 (Continued)

Item	Economic Service Life, Years
Miscellaneous Structures	50
Miscellaneous Mechanical Equipment	15
Vehicles	7